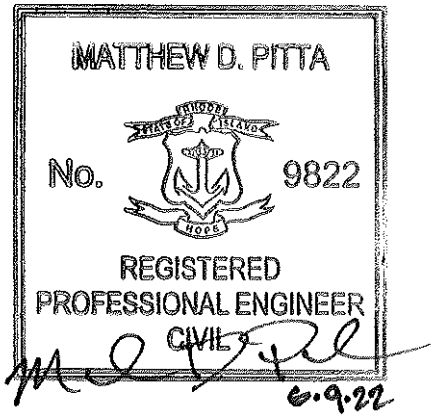
BUCKLIN POINT WWTF
FINAL CLARIFIER, UV DISINFECTION AND OTHER MISCELLANEOUS IMPROVEMENTS

CONTRACT NO. 308.10C

VOLUME 2 OF 2
DIVISION 13 SPECIAL CONSTRUCTION
DIVISION 16 ELECTRICAL

The Narragansett Bay Commission

JUNE 2022



CDM Smith

TABLE OF CONTENTS

END OF TABLE OF CONTENTS

SECTION 13305 - IDENTIFICATION FOR WATER AND WASTEWATER EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Nameplates.
2. Tags.
3. Stencils.
4. Labels.
5. Lockout devices.

B. Related Requirements:

1. Section 099000 - Painting and Coating: Execution requirements for painting specified by this Section.

1.3 PREINSTALLATION MEETINGS

A. Convene minimum one week prior to commencing Work of this Section.

1.4 SUBMITTALS

A. Product Data: Submit manufacturers catalog literature for each product required.

B. Shop Drawings: Submit list of wording, symbols, letter size, spacing of labels, and color coding for equipment identification and schedule, including equipment number, location, function, and manufacturer's name and model number.

C. Samples: Submit two nameplates, labels, and tags for each size used on Project.

D. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.

E. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

F. Qualifications Statement:

1. Submit qualifications for manufacturer.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Section 01736 “Spare Parts”: Requirements for maintenance materials.

B. Extra Stock Materials: Furnish two containers of spray-on adhesive.

C. Tools: Furnish special crimpers and other devices required for Owner to reinstall tags.

1.6 QUALITY ASSURANCE

A. Perform Work according to The Narragansett Bay Commission standards.

B. Maintain one copy of each standard affecting the Work of this Section on-Site.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Manufacturers:

1. Craftmark Pipe Markers,
2. Kolbi Pipe Marker Co.,
3. Pipemarker.com (Brimar Industries, inc.),
4. Seton Identification Products
5. Substitutions: Section 01630 - ”Substitutions”.
6. Furnish materials according to The Narragansett Bay Commission standards.

B. Description: Laminated three-layer plastic with engraved black letters on light, contrasting background color.

2.2 TAGS

A. Plastic Tags:

1. Manufacturers:

a. Brady ID,
b. Craftmark Pipe Markers,
c. Kolbi Pipe Marker Co.,
d. Marking Services, Inc.,
e. R&R Identification Co.
f. Seton Identification Products

2. Description:

a. Laminated three-layer plastic with engraved black letters on light, contrasting background color.
b. Minimum Tag Size and Configuration: 1-1/2-inch diameter.
c. Provide with brass hooks suitable for attaching the tag.
d. Stamp or etch tags with identifying information on schedule coded in a system provided by the Owner.

B. Metal Tags:

1. Manufacturers:

a. Brady ID,
b. Craftmark Pipe Markers,
c. Kolbi Pipe Marker Co,
d. Marking Services, Inc.,
e. Pipemarker.com (Brimar Industries, Inc.),
f. R&R Identification Co.
g. Seton Identification Products

2. Description:

a. Aluminum construction; stamped letters.
b. Minimum Tag Size and Configuration: 1-1/2-inch diameter with finished edges.
c. Provide with brass hooks suitable for attaching the tag.
d. Stamp or etch tags with identifying information on schedule coded in a system provided by the Owner.

C. Information Tags:

1. Manufacturers:

a. Brady ID,
b. Seton Identification Products

2. Description:

a. Clear plastic with printed CAUTION and message.
b. Minimum Tag Size: 3-1/4 by 5-5/8 inch.
c. Furnish grommet and self-locking nylon ties.

1. Tag Chart: Typewritten, letter-size list of applied tags and location, in anodized aluminum frame.

2.3 STENCILS

A. Manufacturers:

1. Kolbi Pipe Marker Co,
2. Marking Services, Inc.,

3. Pipemarker.com (Brimar Industries, Inc.),
4. R&R Identification Co.
5. Seton Identification Products
6. Furnish materials according to The Narragansett Bay Commission standards.

B. Description:

1. Clean-cut symbols.
2. Letter Height: 1-3/4 inch.

C. Stencil Paint: As specified in Section 09900 – "Painting"; semi-gloss enamel.

2.4 LABELS

A. Manufacturers:

1. Brady ID,
2. Seton Identification Products
3. Furnish materials according to The Narragansett Bay Commission standards.

B. Description:

1. Aluminum construction.
2. Minimum Size: 1.9 by 0.75 inch.
3. Adhesive backed, with printed identification.

2.5 LOCKOUT DEVICES

A. Lockout Hasps:

1. Manufacturers:

a. Brady ID,
b. Master Lock Company, LLC

2. Description:

a. Anodized aluminum construction.
b. Furnish hasp with erasable label surface.
c. Minimum Size: 7-1/4 by 3 inches.

PART 3 - EXECUTION

3.1 PREPARATION

A. Section 01730 "Execution" for requirements for installation preparation.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Prepare surfaces as specified in Section 09900 - Painting and Coating for stencil painting.

3.2 INSTALLATION

A. Identify equipment with stencil painting.

B. Identify inline pumps and other small devices with tags.

C. Identify control panels and major control components outside panels with plastic nameplates.

D. Apply stencil painting as specified in Section 09900 – "Painting"

E. Install identifying devices after completion of coverings and painting.

F. Install plastic nameplates with corrosion-resistant mechanical fasteners or adhesive.

G. Labels:

1. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer.
2. For unfinished covering, apply paint primer before applying labels.

H. Install tags using corrosion-resistant chain.

END OF SECTION 13305

13340-A Appendix A Instrument Device Schedule (Sorted by Drawing No., and then by Loop No., and then by Spec No.)
NBC Bucklin Point - New Final Clarifiers and UV Disinfection Facility
Instrumentation Equipment Only (No valves)

Note: Column "G", "Range/Trip Point" will indicate the range of an analog instrument, i.e. 5 to 15 meters and the trip point will be the measurement that causes the switch to change states, i.e. 5 meters (for a level switch)
Devices are listed in order of appearance on the P&IDs and not by loop number.

February 2021

Drawing No.	ISA Tagname	Loop No.	Loop Suffix	Description	Size	Range	Low-Low Alarming Point	Low Alarming Point	High Alarming Point	High-High Alarming Point	Units	Power	Location & Function	Provided by	Spec. Ref.	Installation Detail (I Drawing unless otherwise stated)
I-4	TSH	111-1	-	High Temperature Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 High Motor Temperature	11	11218	-
I-4	SSL	111-1	-	Low Speed Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 Low Speed Swtich	11	11218	-
I-4	FSL	112-1	-	Low Flow Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 Grease Pump Low Flow Switch	11	11218	-
I-4	TSH	113-1	-	High Temperature Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 Gear Box Lubrication System High Oil Temperature	11	11218	-
I-4	FSL	113-1	-	Low Flow Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 Gear Box Lubrication System Low Oil Flow	11	11218	-
I-4	PSL	113-1	-	Low Pressure Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 Gear Box Lubrication System Low Oil Pressure	11	11218	-
I-4	LSL	113-1	-	Low Level Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 1 Gear Box Oil Reservoir Low Level	11	11218	-
I-4	TSH	111-4	-	High Temperature Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 High Motor Temperature	11	11218	-
I-4	SSL	111-4	-	Low Speed Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 Low Speed Swtich	11	11218	-
I-4	FSL	112-4	-	Low Flow Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 Grease Pump Low Flow Switch	11	11218	-
I-4	TSH	113-4	-	High Temperature Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 Gear Box Lubrication System High Oil Temperature	11	11218	-
I-4	FSL	113-4	-	Low Flow Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 Gear Box Lubrication System Low Oil Flow	11	11218	-
I-4	PSL	113-4	-	Low Pressure Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 Gear Box Lubrication System Low Oil Pressure	11	11218	-
I-4	LSL	113-4	-	Low Level Switch	-	-	-	-	-	-	-	-	Influent Pump Station Screw Pump 4 Gear Box Oil Reservoir Low Level	11	11218	-
I-5	LIT/FIT	510-1	-	Radar Level Flow Transmitter	-	0-10000	-	-	-	-	GPM	120 VAC UPS	Final Clarifier No. 1 Effluent Flow	13	13722	C
I-5	LE	510-1	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 1 Effluent Flow	13	13722	C
I-5	LIT	510-1	-	Sludge Blanket Level Transmitter	-	0-15.75	-	0.5	2.5	-	feet	120 VAC UPS	Final Clarifier No. 1 Sludge Blanket Level	13	13766	D
I-5	LE	510-1	A	Sludge Blanket Level Probe	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 1 Sludge Blanket Level	13	13766	D
I-5	LIT/FIT	510-2	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 2 Effluent Flow	13	13722	C
I-5	LE	510-2	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 2 Effluent Flow	13	13722	C
I-5	LIT/FIT	510-3	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 3 Effluent Flow	13	13722	C
I-5	LE	510-3	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 3 Effluent Flow	13	13722	C
I-5	LIT	510-3	-	Sludge Blanket Level Transmitter	-	0-15.75	-	0.5	2.5	-	feet	120 VAC UPS	Final Clarifier No. 3 Sludge Blanket Level	13	13766	D
I-5	LE	510-3	A	Sludge Blanket Level Probe	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 3 Sludge Blanket Level	13	13766	D
I-5	LIT/FIT	510-4	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 4 Effluent Flow	13	13722	C
I-5	LE	510-4	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 4 Effluent Flow	13	13722	C
I-6	LIT/FIT	510-5	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 5 Effluent Flow	13	13722	C
I-6	LE	510-5	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 5 Effluent Flow	13	13722	C
I-6	LIT	510-5	-	Sludge Blanket Level Transmitter	-	0-15.75	-	0.5	2.5	-	feet	120 VAC UPS	Final Clarifier No. 5 Sludge Blanket Level	13	13766	D
I-6	LE	510-5	A	Sludge Blanket Level Probe	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 5 Sludge Blanket Level	13	13766	D
I-6	LIT/FIT	510-6	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 6 Effluent Flow	13	13722	C
I-6	LE	510-6	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 6 Effluent Flow	13	13722	C
I-7	FIT	509-7	-	Magnetic Flow Meter Transmitter	-	0-15000	-	-	-	-	GPM	120 VAC UPS	Final Clarifier No. 7 Influent Flow	13	13701	B
I-7	FE	509-7	-	Magnetic Flow Meter Flow Tube	48"	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 7 Influent Flow	13	13701	B
I-7	FIT	509-8	-	Magnetic Flow Meter Transmitter	-	0-15000	-	-	-	-	GPM	120 VAC UPS	Final Clarifier No. 8 Influent Flow	13	13701	B

13340-A Appendix A Instrument Device Schedule (Sorted by Drawing No., and then by Loop No., and then by Spec No.)
NBC Bucklin Point - New Final Clarifiers and UV Disinfection Facility
Instrumentation Equipment Only (No valves)

Note: Column "G", "Range/Trip Point" will indicate the range of an analog instrument, i.e. 5 to 15 meters and the trip point will be the measurement that causes the switch to change states, i.e. 5 meters (for a level switch)
Devices are listed in order of appearance on the P&IDs and not by loop number.

February 2021

Drawing No.	ISA Tagname	Loop No.	Loop Suffix	Description	Size	Range	Low-Low Alarming Point	Low Alarming Point	High Alarming Point	High-High Alarming Point	Units	Power	Location & Function	Provided by	Spec. Ref.	Installation Detail (I Drawing unless otherwise stated)
I-7	FE	509-8	-	Magnetic Flow Meter Flow Tube	48"	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 8 Influent Flow	13	13701	B
I-7	WSH	510-7	-	High Torque Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 7 High Torque Switch	11	11257	-
I-7	WSHH	510-7	-	High-High Torque Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 7 High-High Torque Switch	11	11257	-
I-7	LIT/FIT	510-7	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 7 Effluent Flow	13	13722	C
I-7	LE	510-7	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 7 Effluent Flow	13	13722	C
I-7	LIT	510-7	-	Sludge Blanket Level Transmitter	-	0-15.75	-	0.5	2.5	-	feet	120 VAC UPS	Final Clarifier No. 7 Sludge Blanket Level	13	13766	D
I-7	LE	510-7	A	Sludge Blanket Level Probe	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 7 Sludge Blanket Level	13	13766	D
I-7	ZS	510-7	-	Proximity Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 7 Skimmer Proximity Switch	11	11257	-
I-7	WSH	510-8	-	High Torque Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 8 High Torque Switch	11	11257	-
I-7	WSHH	510-8	-	High-High Torque Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 8 High-High Torque Switch	11	11257	-
I-7	LIT/FIT	510-8	-	Radar Level Flow Transmitter	-	0-144	-	-	-	-	MGD	120 VAC UPS	Final Clarifier No. 8 Effluent Flow	13	13722	C
I-7	LE	510-8	B	Radar Level Meter Sensor	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 8 Effluent Flow	13	13722	C
I-7	LIT	510-8	-	Sludge Blanket Level Transmitter	-	0-15.75	-	0.5	2.5	-	feet	120 VAC UPS	Final Clarifier No. 8 Sludge Blanket Level	13	13766	D
I-7	LE	510-8	A	Sludge Blanket Level Probe	-	-	-	-	-	-	-	Powered By Transmitter	Final Clarifier No. 8 Sludge Blanket Level	13	13766	D
I-7	ZS	510-8	-	Proximity Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 8 Skimmer Proximity Switch	11	11257	-
I-7	LIT	516-7	-	Radar Level Transmitter								120 VAC UPS	Final Clarifier No. 7 Scum Well Level	13	13722	F
I-7	LE	516-7	-	Radar Level Meter								Powered By Transmitter	Final Clarifier No. 7 Scum Well Level	13	13722	F
I-7	LSHH	516-7	-	High High Level Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 7 Scum Well High High Level	13	13729	E
I-7	LIT	516-8	-	Radar Level Transmitter								120 VAC UPS	Final Clarifier No. 8 Scum Well Level	13	13722	F
I-7	LE	516-8	-	Radar Level Meter								Powered By Transmitter	Final Clarifier No. 8 Scum Well Level	13	13722	F
I-7	LSHH	516-8	-	High High Level Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 8 Scum Well High High Level	13	13729	E
I-7	TSH	520-7	-	High Temperature Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 7 Scum Pump High Motor Temperature	11	11558	-
I-7	MSH	520-7	-	High Moisture Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 7 Scum Pump High Motor Moisture	11	11558	-
I-7	TSH	520-8	-	High Temperature Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 8 Scum Pump High Motor Temperature	11	11558	-
I-7	MSH	520-8	-	High Moisture Switch	-	-	-	-	-	-	-	-	Final Clarifier No. 8 Scum Pump High Motor Moisture	11	11558	-
I-9	TSH	530-3	-	High Temperature Switch	-	-	-	-	-	-	-	-	Waste Sludge Pump No. 3 High Motor Temperature	11	11217	-
I-9	PSL	530-3	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Waste Sludge Pump No. 3 Low Suction Pressure	11	13736	A
I-9	PI	530-3	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Waste Sludge Pump No. 3 Suction Pressure Indication	11	13731	A
I-9	PI	530-3	B	Pressure Guage	-	0-30	-	-	-	-	PSIg	-	Waste Sludge Pump No. 3 Discharge Pressure Indication	11	13731	
I-9	TSH	530-4	-	High Temperature Switch	-	-	-	-	-	-	-	-	Waste Sludge Pump No. 4 High Motor Temperature	11	11217	-
I-9	PSL	530-4	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Waste Sludge Pump No. 4 Low Suction Pressure	11	13736	A
I-9	PI	530-4	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Waste Sludge Pump No. 4 Suction Pressure Indication	11	13731	A
I-9	PI	530-4	B	Pressure Guage	-	0-30	-	-	-	-	PSIg	-	Waste Sludge Pump No. 4 Discharge Pressure Indication	11	13731	
I-9	FIT	539	-	Magnetic Flow Meter Transmitter	-	0-1.88	-	-	-	-	MGD	120 VAC UPS	Return Sludge Pump Station No. 3 Waste Sludge Flow	13	13701	B
I-9	FE	539	-	Magnetic Flow Meter Flow Tube	12"	-	-	-	-	-	-	Powered By Transmitter	Return Sludge Pump Station No. 3 Waste Sludge Flow	13	13701	B

13340-A Appendix A Instrument Device Schedule (Sorted by Drawing No., and then by Loop No., and then by Spec No.)
NBC Bucklin Point - New Final Clarifiers and UV Disinfection Facility
Instrumentation Equipment Only (No valves)

Note: Column "G", "Range/Trip Point" will indicate the range of an analog instrument, i.e. 5 to 15 meters and the trip point will be the measurement that causes the switch to change states, i.e. 5 meters (for a level switch)
Devices are listed in order of appearance on the P&IDs and not by loop number.

February 2021

Drawing No.	ISA Tagname	Loop No.	Loop Suffix	Description	Size	Range	Low-Low Alarming Point	Low Alarming Point	High Alarming Point	High-High Alarming Point	Units	Power	Location & Function	Provided by	Spec. Ref.	Installation Detail (I Drawing unless otherwise stated)
I-9	TSH	540-8	-	High Temperature Switch	-	-	-	-	-	-	-	-	Return Sludge Pump No. 8 High Motor Temperature	11	11217	-
I-9	PSL	540-8	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Return Sludge Pump No. 8 Low Suction Pressure	11	13736	A
I-9	PI	540-8	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Return Sludge Pump No. 8 Suction Pressure Indication	11	13731	A
I-9	PI	540-8	B	Pressure Guage	-	0-50	-	-	-	-	PSIg	-	Return Sludge Pump No. 8 Discharge Pressure Indication	11	13731	
I-9	FIT	540-8	-	Magnetic Flow Meter Transmitter	-	0-7.2	-	-	-	-	MGD	120 VAC UPS	Return Sludge Pump No. 8 Flow	13	13701	B
I-9	FE	540-8	-	Magnetic Flow Meter Flow Tube	12"	-	-	-	-	-	-	Powered By Transmitter	Return Sludge Pump No. 8 Flow	13	13701	B
I-9	TSH	540-9	-	High Temperature Switch	-	-	-	-	-	-	-	-	Return Sludge Pump No. 9 High Motor Temperature	11	11217	-
I-9	PSL	540-9	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Return Sludge Pump No. 9 Low Suction Pressure	11	13736	A
I-9	PI	540-9	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Return Sludge Pump No. 9 Suction Pressure Indication	11	13731	A
I-9	PI	540-9	B	Pressure Guage	-	0-50	-	-	-	-	PSIg	-	Return Sludge Pump No. 9 Discharge Pressure Indication	11	13731	
I-9	FIT	540-9	-	Magnetic Flow Meter Transmitter	-	0-7.2	-	-	-	-	MGD	120 VAC UPS	Return Sludge Pump No. 9 Flow	13	13701	B
I-9	FE	540-9	-	Magnetic Flow Meter Flow Tube	12"	-	-	-	-	-	-	Powered By Transmitter	Return Sludge Pump No. 9 Flow	13	13701	B
I-9	TSH	540-10	-	High Temperature Switch	-	-	-	-	-	-	-	-	Return Sludge Pump No. 10 High Motor Temperature	11	11217	-
I-9	PSL	540-10	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Return Sludge Pump No. 10 Low Suction Pressure	11	13736	A
I-9	PI	540-10	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Return Sludge Pump No. 10 Suction Pressure Indication	11	13731	A
I-9	PI	540-10	B	Pressure Guage	-	0-50	-	-	-	-	PSIg	-	Return Sludge Pump No. 10 Discharge Pressure Indication	11	13731	
I-9	FIT	540-10	-	Magnetic Flow Meter Transmitter	-	0-7.2	-	-	-	-	MGD	120 VAC UPS	Return Sludge Pump No. 10 Flow	13	13701	B
I-9	FE	540-10	-	Magnetic Flow Meter Flow Tube	12"	-	-	-	-	-	-	Powered By Transmitter	Return Sludge Pump No. 10 Flow	13	13701	B
I-9	TSH	540-11	-	High Temperature Switch	-	-	-	-	-	-	-	-	Return Sludge Pump No. 11 High Motor Temperature	11	11217	-
I-9	PSL	540-11	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Return Sludge Pump No. 11 Low Suction Pressure	11	13736	A
I-9	PI	540-11	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Return Sludge Pump No. 11 Suction Pressure Indication	11	13731	A
I-9	PI	540-11	B	Pressure Guage	-	0-50	-	-	-	-	PSIg	-	Return Sludge Pump No. 11 Discharge Pressure Indication	11	13731	
I-9	FIT	540-11	-	Magnetic Flow Meter Transmitter	-	0-7.2	-	-	-	-	MGD	120 VAC UPS	Return Sludge Pump No. 11 Flow	13	13701	B
I-9	FE	540-11	-	Magnetic Flow Meter Flow Tube	12"	-	-	-	-	-	-	Powered By Transmitter	Return Sludge Pump No. 11 Flow	13	13701	B
I-9	TSH	540-12	-	High Temperature Switch	-	-	-	-	-	-	-	-	Return Sludge Pump No. 12 High Motor Temperature	11	11217	-
I-9	PSL	540-12	-	Low Pressure Switch	-	0-5	-	0.5	-	-	PSIg	-	Return Sludge Pump No. 12 Low Suction Pressure	11	13736	A
I-9	PI	540-12	A	Pressure Guage	-	0-5	-	-	-	-	PSIg	-	Return Sludge Pump No. 12 Suction Pressure Indication	11	13731	A
I-9	PI	540-12	B	Pressure Guage	-	0-50	-	-	-	-	PSIg	-	Return Sludge Pump No. 12 Discharge Pressure Indication	11	13731	A
I-9	FIT	540-12	-	Magnetic Flow Meter Transmitter	-	0-7.2	-	-	-	-	MGD	120 VAC UPS	Return Sludge Pump No. 12 Flow	13	13701	B
I-9	FE	540-12	-	Magnetic Flow Meter Flow Tube	12"	-	-	-	-	-	-	Powered By Transmitter	Return Sludge Pump No. 12 Flow	13	13701	B
I-11	FIT	356-1	-	Magnetic Flow Meter Transmitter	-	0-13	-	-	-	-	MGD	120 VAC UPS	RSL Flow to Aeration Tank No. 1	13	13701	B
I-11	FE	356-1	-	Magnetic Flow Meter Flow Tube	20"	-	-	-	-	-	-	Powered By Transmitter	RSL Flow to Aeration Tank No. 1	13	13701	B
I-11	FIT	356-2	-	Magnetic Flow Meter Transmitter	-	0-13	-	-	-	-	MGD	120 VAC UPS	RSL Flow to Aeration Tank No. 2	13	13701	B
I-11	FE	356-2	-	Magnetic Flow Meter Flow Tube	20"	-	-	-	-	-	-	Powered By Transmitter	RSL Flow to Aeration Tank No. 2	13	13701	B
I-11	FIT	356-3	-	Magnetic Flow Meter Transmitter	-	0-13	-	-	-	-	MGD	120 VAC UPS	RSL Flow to Aeration Tank No. 3	13	13701	B

13340-A Appendix A Instrument Device Schedule (Sorted by Drawing No., and then by Loop No., and then by Spec No.)
NBC Bucklin Point - New Final Clarifiers and UV Disinfection Facility
Instrumentation Equipment Only (No valves)

Note: Column "G", "Range/Trip Point" will indicate the range of an analog instrument, i.e. 5 to 15 meters and the trip point will be the measurement that causes the switch to change states, i.e. 5 meters (for a level switch)
Devices are listed in order of appearance on the P&IDs and not by loop number.

February 2021

Drawing No.	ISA Tagname	Loop No.	Loop Suffix	Description	Size	Range	Low-Low Alarming Point	Low Alarming Point	High Alarming Point	High-High Alarming Point	Units	Power	Location & Function	Provided by	Spec. Ref.	Installation Detail (I Drawing unless otherwise stated)
I-11	FE	356-3	-	Magnetic Flow Meter Flow Tube	20"	-	-	-	-	-	-	Powered By Transmitter	RSL Flow to Aeration Tank No. 3	13	13701	B
I-11	FIT	356-4	-	Magnetic Flow Meter Transmitter	-	0-13	-	-	-	-	MGD	120 VAC UPS	RSL Flow to Aeration Tank No. 4	13	13701	B
I-11	FE	356-4	-	Magnetic Flow Meter Flow Tube	20"	-	-	-	-	-	-	Powered By Transmitter	RSL Flow to Aeration Tank No. 4	13	13701	B
UV-I-1	AIT	600	-	Ultraviolet Transmittance Analyzer Transmitter	-	0-100	-	-	-	-	%	120 VAC UPS	UV System Influent Channel UV Transmittance	11 (UV)	11656	-
UV-I-1	AE	600	-	Ultraviolet Transmittance Analyzer Probe	-	-	-	-	-	-	-	Powered By Transmitter	UV System Influent Channel UV Transmittance	11 (UV)	11656	-
UV-I-1	LSH	611	1	Electrode High Level Switch	-	-	-	-	-	-	-	-	UV Channel 1 Influent High Level	11 (UV)	11656	UV-I-5: A
UV-I-1	LSH	611	2	Electrode High Level Switch	-	-	-	-	-	-	-	-	UV Channel 2 Influent High Level	11 (UV)	11656	UV-I-5: A
UV-I-1	LSH	611	3	Electrode High Level Switch	-	-	-	-	-	-	-	-	UV Channel 3 Influent High Level	11 (UV)	11656	UV-I-5: A
UV-I-1	LSL	611	1	Electrode High Level Switch	-	-	-	-	-	-	-	-	UV Channel 1 Effluent Low Level	11 (UV)	11656	UV-I-5: A
UV-I-1	LSL	611	2	Electrode High Level Switch	-	-	-	-	-	-	-	-	UV Channel 2 Effluent Low Level	11 (UV)	11656	UV-I-5: A
UV-I-1	LSL	611	3	Electrode High Level Switch	-	-	-	-	-	-	-	-	UV Channel 3 Effluent Low Level	11 (UV)	11656	UV-I-5: A
UV-I-1	ZSL	614	1A	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 1, Bank A Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	1B	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 1, Bank B Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	1C	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 1, Bank C Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	1D	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 1, Bank D Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	2A	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 2, Bank A Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	2B	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 2, Bank B Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	2C	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 2, Bank C Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	2D	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 2, Bank D Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	3A	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 3, Bank A Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	3B	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 3, Bank B Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	3C	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 3, Bank C Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	ZSL	614	3D	Position Switch	-	-	-	-	-	-	-	24 VDC (From UV PDC)	UV Channel 3, Bank D Bank-In-Place Position Switch	11 (UV)	11656	-
UV-I-1	AE	617	1A	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 1, Bank A Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	1B	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 1, Bank B Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	1C	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 1, Bank C Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	1D	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 1, Bank D Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	2A	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 2, Bank A Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	2B	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 2, Bank B Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	2C	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 2, Bank C Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	2D	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 2, Bank D Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	3A	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 3, Bank A Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	3B	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 3, Bank B Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	3C	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 3, Bank C Ultraviolet Intensity	11 (UV)	11656	-
UV-I-1	AE	617	3D	Ultraviolet Intensity Sensor	-	-	-	-	-	-	-	-	UV Channel 3, Bank D Ultraviolet Intensity	11 (UV)	11656	-

13340-A Appendix A Instrument Device Schedule (Sorted by Drawing No., and then by Loop No., and then by Spec No.)
NBC Bucklin Point - New Final Clarifiers and UV Disinfection Facility
Instrumentation Equipment Only (No valves)

Note: Column "G", "Range/Trip Point" will indicate the range of an analog instrument, i.e. 5 to 15 meters and the trip point will be the measurement that causes the switch to change states, i.e. 5 meters (for a level switch)
Devices are listed in order of appearance on the P&IDs and not by loop number.

February 2021

Drawing No.	ISA Tagname	Loop No.	Loop Suffix	Description	Size	Range	Low-Low Alarming Point	Low Alarming Point	High Alarming Point	High-High Alarming Point	Units	Power	Location & Function	Provided by	Spec. Ref.	Installation Detail (I Drawing unless otherwise stated)
UV-I-1	LIT	618	1	Radar Level Transmitter	-	0-7	-	-	-	-	Feet	Loop Powered	UV Channel 1 Effluent Level	11 (UV)	11656	F
UV-I-1	LE	618	1	Radar Level Element	-	0-7	-	-	-	-	Feet	Loop Powered	UV Channel 1 Effluent Level	11 (UV)	11656	F
UV-I-1	LIT	618	2	Radar Level Transmitter	-	0-7	-	-	-	-	Feet	Loop Powered	UV Channel 2 Effluent Level	11 (UV)	11656	F
UV-I-1	LE	618	2	Radar Level Element	-	0-7	-	-	-	-	Feet	Loop Powered	UV Channel 2 Effluent Level	11 (UV)	11656	F
UV-I-1	LIT	618	3	Radar Level Transmitter	-	0-7	-	-	-	-	Feet	Loop Powered	UV Channel 3 Effluent Level	11 (UV)	11656	F
UV-I-1	LE	618	3	Radar Level Element	-	0-7	-	-	-	-	Feet	Loop Powered	UV Channel 3 Effluent Level	11 (UV)	11656	F
UV-I-2	LIT	660	-	Radar Level Transmitter	-	0-12	-	-	-	-	Feet	120 VAC UPS	Flood Pump Station Wetwell Level	13	13722	F
UV-I-2	LE	660	-	Radar Level Element	-	0-12	-	-	-	-	Feet	Powered By Transmitter	Flood Pump Station Wetwell Level	13	13722	F
UV-I-2	LSHH	660	-	High High Level Switch	-	-	-	-	-	-	-	-	Flood Pump Station Wetwell High-High Level	13	13729	E
UV-I-2	TSH	665-1	-	High Temperature Switch	-	-	-	-	-	-	-	-	Flood Pump No. 1 High Motor Temperature	11	11220	-
UV-I-2	MSH	665-1	-	High Moisture Switch	-	-	-	-	-	-	-	-	Flood Pump No. 1 High Motor Moisture	11	11220	-
UV-I-2	TSH	665-2	-	High Temperature Switch	-	-	-	-	-	-	-	-	Flood Pump No. 2 High Motor Temperature	11	11220	-
UV-I-2	MSH	665-2	-	High Moisture Switch	-	-	-	-	-	-	-	-	Flood Pump No. 2 High Motor Moisture	11	11220	-
UV-I-2	TSH	665-3	-	High Temperature Switch	-	-	-	-	-	-	-	-	Flood Pump No. 3 High Motor Temperature	11	11220	-
UV-I-2	MSH	665-3	-	High Moisture Switch	-	-	-	-	-	-	-	-	Flood Pump No. 3 High Motor Moisture	11	11220	-
UV-I-2	TSH	665-4	-	High Temperature Switch	-	-	-	-	-	-	-	-	Flood Pump No. 4 High Motor Temperature	11	11220	-
UV-I-2	MSH	665-4	-	High Moisture Switch	-	-	-	-	-	-	-	-	Flood Pump No. 4 High Motor Moisture	11	11220	-
UV-I-2	TSH	675-1	-	High Temperature Switch	-	-	-	-	-	-	-	-	Drain Pump High Motor Temperature	11	-	-
UV-I-2	MSH	675-1	-	High Moisture Switch	-	-	-	-	-	-	-	-	Drain Pump No. 1 High Motor Moisture	11	-	-
UV-I-2	LIT	675	-	Radar Level Transmitter	-	0-13	1	-	-	-	Feet	120 VAC UPS	Drain Pump Wetwell Level	13	13722	F
UV-I-2	LE	675	-	Radar Level Element	-	0-13	-	-	-	-	Feet	Powered By Transmitter	Drain Pump Wetwell Level	13	13722	F
UV-I-2	LIT	680	-	Radar Level Transmitter	-	0-13	-	-	-	-	Feet	120 VAC UPS	Outfall Level	13	13722	F
UV-I-2	LE	680	-	Radar Level Element	-	0-13	-	-	-	-	Feet	Powered By Transmitter	Outfall Level	13	13722	F
UV-I-2	LSHH	680	-	High High Level Switch	-	-	-	-	-	-	-	-	Drain Pump Wetwell High-High Level	13	13729	E
UV-I-3	LSHH	2749	5	High High Level Switch	-	-	-	-	-	-	-	-	Manhole EMH-P100A High-High Level	13	13729	E
UV-I-3	LSHH	2749	6	High High Level Switch	-	-	-	-	-	-	-	-	Manhole EMH-P100B High-High Level	13	13729	E
UV-I-3	LSHH	2749	7	High High Level Switch	-	-	-	-	-	-	-	-	Manhole EMH-C102 High-High Level	13	13729	E
EP-I-1	LIT/FIT	630	-	Radar Level Transmitter	-	0-11 (Level) 0-50 (Flow)	-	-	-	-	Feet (Level) MGD (Flow)	120 VAC UPS	Dry Weather Effluent Pump Station Influent Level/Flow	13	13722	F
EP-I-1	LE	630	-	Radar Level Element	-	0-11 (Level)	-	-	-	-	Feet	Powered By Transmitter	Dry Weather Effluent Pump Station Influent Level/Flow	13	13722	F
EP-I-1	LIT	651	-	Radar Level Transmitter	-	0-13	-	-	-	-	Feet	120 VAC UPS	Dry Weather Effluent Pump Station Wetwell Level	13	13722	F
EP-I-1	LE	651	-	Radar Level Element	-	0-13	-	-	-	-	Feet	Powered By Transmitter	Dry Weather Effluent Pump Station Wetwell Level	13	13722	F

SECTION 13340 - INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.2 SUMMARY

A. Section includes the general requirements for furnishing, installing, and servicing PCSS provided instruments.

B. Coordinate all instrument environmental ratings with area classifications as shown on the electrical drawings. Environmental rating must meet the requirements of the “Enclosure Types” section of the General Notes of the Electrical Drawings.

C. Related Requirements:

1. Refer to individual instrument specifications.
2. Refer to Section 13612 “Process Control System Testing.”
3. Refer to Section 13613 “ Process Control System Training.”

1.3 DEFINITIONS

A. PCSS – Process Control System Supplier as defined in Section 13610 – Process Control and Enterprise Management System General Provisions

1.4 ACTION SUBMITTALS

A. Submit complete documentation for all field instruments in one comprehensive submittal. Use ISA-TR20.00.01-2001 (updated in 2004-2006) data sheet format as a cover sheet for each instrument prior to data sheets. Submit a complete Bill of Materials (BOM) or Index that lists all instrumentation equipment. The list shall be sorted by Loop Number.

B. Submit separate data sheets for each instrument type including:

1. Plant Equipment Number and ISA tag number per the Drawings.
2. Product (item) name used herein and on the Drawings.
3. Manufacturer's complete model number.
4. Location of the device.
5. Input - output characteristics.

6. Range, size, and graduations in engineering units.
7. Include construction details, material descriptions, dimensions of individual components and profiles.
8. Instrument or control device sizing calculations where applicable.
9. Indicate which instruments will be provided with certified calibration data (i.e., all flow metering devices) as part of O&M manual.
10. Include rated capacities, operating characteristics, electrical characteristics and furnished specialties and accessories Two-wire or four-wire device type as applicable.
11. Indicate which instruments will be provided with manufacturer's maintenance services if specified.

C. Instrument Vendor Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of instrument.
4. Include diagrams for power, signal, and control wiring.

D. Submit catalog cuts for all instruments. Submit descriptive literature for each hardware component, which fully describes the units being provided.

E. Submit index and data sheets in electronic format on 8-1/2" x 11" formats. Electronic format shall be in Microsoft Excel or Word. Submit electronic copy on DVD disk or USB thumb drive.

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 "Process Control and Enterprise Management Systems General Provisions" for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 "Process Control and Enterprise Management Systems General Provisions" for any PCSS requirements regarding closeout submittals for instruments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Refer to individual instrument specifications for spare parts requirements.

B. Refer to Section 13610 "Process Control and Enterprise Management Systems General Provisions" for PCSS requirements regarding submission of maintenance materials

1.8 QUALITY ASSURANCE

A. Refer to individual instrument specifications for quality assurance requirements as well as which specific instruments require manufacturer's start-up and training services.

B. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for overall quality assurance requirements for PCSS scope of work.

PART 2 - PRODUCTS

2.1 INSTRUMENT TAGS

A. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as indicated in the Drawings, shall be provided on each piece of equipment supplied under this Section and related sections. Equipment shall be tagged before shipping to the site.

B. Provide 1/8-in by 3/8-in, Type 316 stainless steel button head machine screws.

C. All supplied instrument transmitters and instrument transmitter elements shall have a stainless steel identification tag attached to each transmitter and element prior to shipment. Tag shall be attached via stainless steel chain or stainless-steel wire (24 gauge min) to a non-removable part of the device. The tag size shall be a minimum of 1inch H x 3”W. Tag shall include the ISA alphanumeric instrument number as indicated in the P&ID, loop, and detail drawings. The alphanumeric instrument number shall be stamped into the tag and shall have a minimum of 3/16-in high alphanumeric characters.

PART 3 - EXECUTION

3.1 GENERAL

A. See execution requirements in Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

B. Unless specifically indicated, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, 5-valve manifolds for calibration, testing and blow down service shall also be provided. For chemical or corrosive fluids, diaphragm seals with flushing connections shall be provided.

3.2 INSTALLATION

A. See installation requirements in individual specification sections.

3.3 APPENDIX A – Instrument Device Schedule

END OF SECTION 13340

SECTION 13610 - PROCESS CONTROL AND ENTERPRISE MANAGEMENT SYSTEMS GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes procurement of the services of a Process Control System Supplier (PCSS) to furnish and install all materials, equipment, labor and services, required to achieve a fully integrated and operational system as specified herein, in "Related Requirements" under this Article, and in related drawings, except for those services and materials specifically noted.

B. The PCSS will also serve as the Applications Engineering System Supplier (AESS).

C. The work to be performed by the PCSS includes:

1. Fabrication of a new PLC Remote Input/Output Control Panel (RIOP-6B) to be installed in the new Return Sludge Pump Station 3.
2. Connection of RIOP-6B to existing SCADA system and configuration of RIOP-6B equipment for integration into the existing SCADA system.
3. Modification of existing CPP-6 to accommodate new instrumentation added to Final Clarifiers 1 thru 6.
4. Modification of CPP-3 Panel 2 and RIOP-3A to accept signals related to the new VFD driven Influent Screw Pumps 1 and 4.
5. Modification of CPP-4 Panel 2 to accept new Return Sludge flow meter signal.
6. Fabrication of a new Remote Input/Output panel (RIOP-5C) to be installed in the new UV Building electrical room.
7. Modification of CPP-5 Panel 1 to connect to RIOP-5C and the vendor provided UV System PLC panel.
8. Modification of CPP-5 Panel 1 to accept signals related to the new UV System.
9. PCSS will provide AESS Services as indicated in the contract documents including:

    a. Programming and configuration the new RIOP-6B equipment to monitor and control the two new Final Clarifiers and associated equipment, as well as the 6 existing clarifiers and Return Sludge Pump Stations 1 & 2. and equipment in the new Return Sludge Pump Station.
    b. Programming and configuration of the existing CPP-6 equipment to add new signals and include programming only for manual operation and software interlocks of connected equipment.
    c. Update programming of CPP-3 for new influent pump station monitoring and controls.

d. Update programming of CPP-4 to accommodate new return sludge flow meter signal.
e. Addition of new RSPS-MCC power monitoring points to SCADA software.
f. Addition of new graphics for the new Final Clarifiers, Return Sludge Pump Station 3, and associated equipment.
g. Update configuration and programming of CPP-5 to add new points connected to RIOP-5C and provided controls and monitoring of the facilities at the new UV Building including the UV system, flood pump station, and other items as shown in the drawings in described in the specifications.
h. Addition of new graphics for the UV system.
i. Addition of new graphics for the flood pump station.
j. Addition of new graphics for monitoring/control of miscellaneous items at the new UV Building.
k. Addition of new UV-MCC power monitoring points to the SCADA software.
l. Modification of existing graphics to accommodate new equipment and instrumentation in existing process areas.
m. Coordination with the UV system vendor to test all feedback and control between the plant SCADA system and the UV system.

10. Provide all instrumentation listed as being provided by Division 13 in the drawings or specifications.

D. Include auxiliary and accessory devices necessary for system operation or performance, such as transducers, relays, signal amplifiers, intrinsic safety barriers, signal isolators, software, and drivers to interface with existing equipment or equipment provided by others under other Sections of these specifications, whether indicated on the Drawings or not.

E. All equipment and installations shall satisfy applicable Federal, State and local codes. Refer to Electrical drawings for area classifications for Class and /Division ratings.

F. Use the equipment, instrument, and loop numbering scheme indicated on the Drawings and in the specifications in the development of the submittals. Do not deviate from or modify the numbering scheme.

G. Related Requirements:

1. Section 13340 – Instrumentation for Process Systems.
2. Section 13612 – Process Control System Testing.
3. Section 13613 – Process Control System Training.
4. Section 13614 – Process Control Descriptions.
5. Section 13631 – Programmable Logic Controllers.
6. Section 13661 – Switches and Routers.
7. Section 13675 – Industrial Enclosures.
8. Section 13678 – Panel Wiring.
9. Section 13679 – Uninterruptible Power Supply.
10. Section 13684 – Configuration of HMI Software.
11. Section 13685 – Configuration of Controller Software.
12. Section 13701 – Magnetic Flow Meters.
13. Section 13722 – Radar Level Meters.
14. Section 13729 – Level Switches.
15. Section 13731 – Pressure and Differential Pressure Gauges.

16. Section 13736 – Pressure and Differential Pressure Switches.
17. Section 13739 – Diaphragm Seals.
18. Section 13766 – Suspended Solids-Sludge Density Analyzers.
19. Section 13789 – Position, Speed, and Motion Measurement Devices.
20. Section 13798 – Relays.
21. Section 13799 – Isolators, Intrinsically Safe Barriers, and Surge Suppressors.
22. Section 13801 – Power Supplies.

1.3 DEFINITIONS

A. PCSS – Process Control System Supplier.

B. AESS - Applications Engineering System Supplier.

C. MOPO - Maintenance of Plant Operations.

1.4 PREINSTALLATION MEETINGS

A. Conduct a project kickoff coordination meeting within two weeks after submitting the Project Plan. The purpose of the meeting is to discuss the PCSS's Project Plan, to summarize the PCSS's understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery deadline dates; provide a forum to coordinate hardware and software related issues; and request any additional information required from the Owner. The meeting will last up to 4 hours.

B. Conduct a submittal review coordination meeting after the Hardware, Panel Drawing, and Loop Drawing Submittal package has been reviewed by the Engineer and returned to the PCSS. The purpose of this meeting is to review comments made on the submittal package; to refine scheduled deadline dates; coordinate equipment installation activities; and provide a forum for any further required coordination between the PCSS and AESS. The meeting will last up to 4 hours.

C. Attendance at MOPO workshop. Refer to Section 01810 “Maintenance of Plant Operation and Sequence of Construction.”

D. As required on-site or conference call coordination meetings with Engineer, Contractor, Manufacturers, and AESS as required prior to any field start-up or activity testing begins.

E. Schedule the mandatory coordination meetings as described herein. Hold the meetings at the Owner's designated location and include attendance by the Owner, the Engineer, the Contractor, the PCSS's Project Engineer, and the AESS Project Engineer, if applicable. Other Division 136XX specifications may require additional meetings. Prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date. Schedule the meeting for a minimum of one week before the requested meeting date.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of equipment, control panels, and instrumentation as specified herein.
4. Include diagrams for power, signal, and control wiring.

C. Qualifications Submittal:

1. For non-listed PCSS', submit, within 30 calendar days after Notice to Proceed, detailed information on staff and organization to indicate compliance with the Quality Assurance requirements of this Section. The Qualifications submittal is required to be submitted and approved before any further submittals will be accepted. Failure to meet the minimum requirements shall be grounds for rejection as a PCSS. The Qualifications Submittal shall, as a minimum, contain the following:

    a. Copies of ISA CCST Level 1 certificates for all field technicians or resumes demonstrating field experience.
    b. Notarized statement from the firm's financial institution demonstrating ability for the firm to meet the obligations necessary for the performance of the work.
    c. Copy of UL-508 certificate for panel fabrication facilities.
    d. Project references for water or wastewater projects as defined in the "Quality Assurance" paragraphs.
    e. Documentation to demonstrate the ability to complete this project including: resumes of key staff, financial capacities, details on engineering, design, fabrication, and field service capacity, and location of staff responsible for responding to the site within four hours to resolve startup issues.

D. Project Plan, Deviation List, and Schedule Submittal:

1. Submit, within 45 calendar days after Notice to Proceed, a Project plan. The Project Plan is required to be submitted and approved before further submittals shall be accepted. The Project Plan shall contain the following:

    a. Overview of the proposed control system describing the understanding of the project work, a preliminary system architecture drawing, interfaces to other systems, schedule, startup, and coordination. Include a general discussion of startup, switchover (Maintaining Plant Operations during system transition), approach to testing and training, and other tasks as required by these specifications.
    b. Preliminary list of PLC hardware, including version numbers, solely to determine compliance with the requirements of the Contract Documents prior to beginning development of system programming. Review and approval of hardware systems as part of this Project Plan stage shall not relieve the PCSS of meeting all the

functional and performance requirements of the system as specified herein. Substitution of manufacturer or model of these systems after the submittal is approved is not allowed without Engineer approval.

c. Project personnel and organization including the PCSS project manager, project engineer, and lead project technicians. Include resumes of each these individuals and specify in writing their commitment to this project. These do not need to be submitted again if already submitted in the Qualification submittal.

d. Sample formats of the shop drawings to be submitted and in conformance with the requirements of the Specifications. At a minimum include samples of panel fabrication drawings, control system architecture and I/O wiring diagrams**.**

2. Exceptions to the Specifications or Drawings shall be clearly defined in a Deviation List. The Deviation List shall consist of a paragraph by paragraph review of the Specifications indicating acceptance or any proposed deviations, the reason for exception, the exact nature of the exception and the proposed substitution so that an evaluation may be made by the Engineer. If no exceptions are taken to the specifications or drawings the PCSS shall make a statement as such. If there is no statement by the PCSS, then it is acknowledged that no exceptions are taken.

3. The PCSS must coordinate their work with the General Contractor's overall schedule and is responsible for ensuring a schedule is included in this submittal that incorporates all PCSS milestones including but not limited to the following:

   a. Schedule for all subsequent project submittals. Include the time required for Contractor submittal preparation, Engineer's review time, and a minimum of two complete review cycles.
   b. Proposed dates for all project coordination meetings.
   c. Hardware purchasing, fabrication, and assembly (following approval of related submittals).
   d. Software purchasing and configuration (following approval of related submittals).
   e. Shipment of instrument and control system equipment.
   f. Installation of instrument and control system equipment.
   g. Testing: Schedule for all testing.
   h. Schedule for system cutover, startup, and/or going on-line for each major system. At a minimum include the schedule for each process controller and HMI server/workstation provided under this Contract.
   i. Schedule for all training including submittal and approval of O&M manuals, factory training, and site training.
   j. Listing of all major graphics and PLC programs intended to be created or modified for this project. Indicate if graphic or program is new or existing.

4. Component and Wiring Identification and Tagging Plan

   a. All components provided by PCSS require a tag, label, or nameplate. Review specifications and provide a table indicating the tagging and labeling scheme used by the PCSS:

      1) Instruments.
      2) Panel Hardware.
      3) Standalone hardware or communication equipment.
      4) Wires and communication cables.

b. Provide detailed information so the Engineer may review the following characteristics for each type of tag, label, or nameplate for the different types of components provided above:

1) Size or range of size of the tag, label or nameplate.
2) Font style.
3) Material.
4) Color(s).

E. Input/Output (I/O) List Submittal:

1. Submit, within 60 days after Notice to Proceed, a complete system Input/Output (I/O) address list for equipment connected to the control system under this Contract. This includes I/O connected to new panels provided under this contract as well as I/O modified in existing panels.
2. I/O list shall be based on the P&ID's, the Drawings, the design I/O list (if included), and requirements in the Specifications.
3. The I/O list shall be submitted in both a Microsoft Excel readable electronic file format and an 8-1/2 inch by 11-inch hard copy.
4. The I/O list shall reflect all active and spare I/O points. Add points to accommodate spare I/O as required in the specifications.
5. The I/O list shall be arranged such that each control panel has a dedicated worksheet. At a minimum, I/O worksheet shall include the following information:

a. TAG NUMBER(S): As indicated on the Drawings, the identifier assigned to a device that performs a function in the control system. As part of this information, the loop number of the tag shall be broken out to allow for sorting by loop.
b. DESCRIPTION: A description of the function of the device (text that includes signal source, control function, etc.) Include the text "Spare Points" for all I/O module points that are not connected to equipment.
c. PHYSICAL LOCATION: The Control Panel designation of where the I/O point is wired to.
d. PHYSICAL POINT ADDRESS: Rack, Slot, and Point (or Channel) assignment for each I/O point.
e. I/O TYPE: use DO - Discrete Output, DI - Discrete Input, AO - Analog Output, AI - Analog Input, PI - Pulse Input, or PO - Pulse Output.
f. RANGE/STATE: The range in engineering units corresponding to an analog 4-20 mA signal, or, the state at which the value of the discrete points are "1" and the state at which the value of discrete points are “0”.
g. ENGINEERING UNITS: The engineering units associated with the Analog I/O.
h. ALARM LIMITS: Include alarm limits based on the control descriptions and the Drawings.
i. P&ID - the P&ID or drawing where the I/O point appears on. Mark as "NA" (Not Applicable) if the I/O point is derived from a specification requirement and is not on the P&IDs.
j. LOGICAL POINT ADDRESS: I/O address of each point

6. The I/O list shall be sorted in order by:

a. Physical location.
b. I/O Type.

c. Loop Number.
d. Device Tag.

7. Once the I/O list is approved, the PLC I/O addresses shall not be modified without approval by the Engineer.

F. MOPO and Sequencing Submittal

1. The PCSS shall assist in the development of the Contractor's MOPO and sequencing submittal to ensure an orderly transition from the existing control system to the new control system. The PCSS may not proceed with the submission of any hardware and software submittals until this submittal is approved. See Section 01810 – Maintenance of Plant Operation and Sequence of Construction.
2. Include step-by-step procedures and required durations to install, commission, and place into operation the new RIOP-6B and RIOP-5C Panels. Include step-by-step procedures and require durations to install, commission, and place into operation any new signals and programming into existing PLC Control Panels. Include step-by-step procedures for implementing new graphics and historian updates. The procedures shall include a minimum two week notification to the Owner for any system alterations that affect operation of the facility including parties involved at each phase.
3. Provide a spreadsheet indicating point-by-point transition of all I/O points.
4. Provide network architecture phasing plans showing the condition of the new and existing network at each phase of construction.

G. Field Instruments Submittal:

1. Refer to Section 13340 "Instrumentation for Process Systems" for submittal requirements.

H. Control System Architecture, Hardware and Software Packages Submittal:

1. Refer to the sections below for equipment required as part of the Hardware and Software Packages submittal:

   a. Section 1363X - Sections for Control System Equipment.
   b. Section 1366X - Sections for Network and Communication Equipment.
   c. Section 1367X - Sections for Control System Equipment Panels and Racks.
   d. Section 1368X - Sections for Process Control Software.

2. For each hardware and software packages component specified in the sections above, submit a cover page that lists, at a minimum, date, specification number, product name, manufacturer, model number, location(s), and power required. Preferred format for the cover page is ISA-TR20.00.01-2001 (updated in 2004-2006), general data sheet; however, other formats will be acceptable provided they contain all required information.
3. Complete system architecture drawing(s) showing in schematic form showing the interconnections between major hardware components including, control panels, computers, networking equipment, control panels with PLC systems and I/O modules, local operator interfaces, process equipment vendor panels with PLCs, and networked peripherals such as power monitors, security cameras, etc. The PCSS is required to provide unique network architecture drawings for the following networks:

a. SCADA

4. The system architecture drawing(s) shall be developed in accordance with the following information and guidelines at a minimum:

   a. Show power connections to each piece of equipment or grouping of equipment with voltage and power sources noted such as 120VAC UPS battery, 24VDC battery, or 120VAC from LP (lighting panel). Indicate specific UPS number or circuit number whenever possible.
   b. All communication cable types should be uniquely identified with a specific linetype and cable characteristics clearly indicated in a key or legend located on drawing(s). For example, 50/125 micron multimode mode fiber, or CAT-6E Ethernet copper cabling. Any multiconductor communication cables will be clearly labeled above each individual communication with a note added to drawing that states if no quantity exists above a linetype, there is only one communication cable between devices. If a multi-conductor cable has multiple colors, legend shall clearly indicate which colors are used for which networks (i.e., a multi-pair fiber optic cable used for dedicated networks such as SCADA, Electrical, Security, HVAC, etc.).
   c. All communication cables need to be assigned a unique cable identification label and shown in either a table or above the communication line.
   d. Network protocols shall be clearly identified for each communication path or for system and indicated in a key or legend as appropriate. Examples are Allen-Bradley EtherNet/IP, Modbus TCP/IP, or DNP3.
   e. Any device that has multiple ports or connection points, shall clearly indicate which port or connection number the communication cable is terminating at. For multiple devices, this could be shown once in a key or legend and noted on architecture as appropriate.
   f. For each PLC control panel or network communication enclosure provided by PCSS, the architecture drawing shall clearly reference other drawings provided by the PCSS for detailed panel wiring diagrams with a note near that PLC panel or communication enclosure indicating referenced drawing numbers. A placeholder is acceptable at the time of submission if these drawings are to be submitted at a later date.
   g. Use symbology and/or icons whenever possible to represent a device and differentiate between devices that are different form factors (i.e. tower computer vs. desktop computer vs. rack mounted). Vendor CAD libraries are preferred for symbols.
   h. The intent of this specification requirement is to develop a diagram that will allow a qualified technician to interconnect all equipment without having to refer to additional manuals or literature.
   i. Sheet size shall be 11"x17" minimum and using more than one sheet is acceptable with a logical breakout between sheets (i.e., head end on one sheet and plant control system on another). Line continuations must between drawings must be clearly identified.

I. Panel Layout Drawings and Wiring Diagrams Submittal:

1. Panel Layout Drawings: Submit Drawings for all panels specified. Panel assembly and elevation drawings shall be drawn to scale and detail all equipment in or on the panel.

Panel drawings shall be 11 inches x 17 inches in size. At a minimum, the panel drawings shall include the following:

a. A legend sheet clearly indicating all symbols used on drawings and with voltage, color and size of each wire clearly indicated and in accordance with requirements of Section 13678 – Panel Wiring.
b. Interior and exterior panel elevation drawings to scale.
c. Nameplate schedule.
d. Conduit access locations.
e. Panel construction details.
f. Cabinet assembly and layout drawings to scale. Assembly drawing shall include a bill of material on the drawing with each panel component clearly defined. Bill of material shall be cross-referenced to the assembly drawing so that a non-technical person can readily identify all components of the assembly by manufacturer and model number.
g. Fabrication and painting specifications including color (or color samples).
h. Construction details, NEMA ratings, intrinsically safe barrier information, gas sealing recommendations, purging system details, etc. for panels located in hazardous locations or interfacing to equipment located in hazardous areas.
i. For every control panel, heating and cooling calculations for each panel supplied indicating conformance with cooling requirements of the supplied equipment and environmental conditions. Calculations shall include the recommended type of equipment required for both heating and cooling.
j. Submit evidence that all control panels shall be constructed in conformance with UL 508 and bear the UL seal confirming the construction. Specify if UL compliance and seal application shall be accomplished at the fabrication location or by field inspection by UL inspectors. Costs associated with obtaining the UL seal and any inspections shall be borne by Contractor.

2. Wiring Diagrams Submittal:

a. Where direct hardwired interfaces exist between the PCSS control panels and vendor provided control panels furnished under other Divisions, Contractor shall provide to PCSS approved submittals in order for PCSS to provide complete wiring diagrams showing all wiring connections in the I/O system. This includes but is not limited to terminal block numbering, relay contact termination and contact status when energized/de-energized, instruments, equipment, and control panel names. These drawings shall be included in Final O&M submittal. Leaving this information blank on Final Documentation drawings is not acceptable.
b. Panel wiring diagrams depicting wiring within and on the panel as well as connections to external devices. If ISA Loop Wiring Diagrams are specified below, equipment external to the control panel and related external connections do not need to be shown on the Panel Wiring Diagrams. Panel wiring diagrams shall include power and signal connections, UPS and normal power sources, all panel ancillary equipment, protective devices, wiring and wire numbers, and terminal blocks and numbering. Field device wiring shall include the device ISA-tag and a unique numeric identifier. Diagrams shall identify all device terminal points that the system connects to, including terminal points where I/O wiring lands on equipment not supplied by the PCSS. Wiring labeling used on the drawings shall match that shown on the Contract Documents or as developed by the PCSS and approved by the Engineer. I/O wiring shall be numbered with rack number, slot

number, and point number. Two-wire and four-wire equipment shall be clearly identified, and power sources noted. Submit final wire numbering scheme. Panel drawings shall be 11" x 17" in size.

c. ISA Loop Wiring Diagrams: Not required.

J. Human Machine/Operator Interface Submittals:

1. Refer to Section 13684 “Configuration of HMI Software” for specific submittal requirements.

K. Controller Program Submittal:

1. Refer to Section 13685 “Configuration of Controller Software” for specific submittal requirements.

L. Testing Plan Submittals:

1. Refer to Section 13612 “Process Control System Testing” for specific testing submittal requirements.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For any named PCSS, submit a statement on company letterhead indicating that the requirements in the “Quality Assurance” paragraph below are met by the firm.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For all PCSS supplied hardware to include in operation and maintenance manuals.

1. Submit in accordance with Section 01731 “Operation and Maintenance Data.”
2. The operations and maintenance manuals shall, at a minimum, contain the following information:

a. Table of Contents:

1) A Table of Contents shall be provided for the entire manual with the specific contents of each volume clearly listed. The complete Table of Contents shall appear in each volume.

b. Instrument and Equipment Lists:

1) The following lists shall be developed in Microsoft Excel format:
a) An instrument list or spreadsheet for all instruments supplied including tag number, description, specification section and paragraph number, manufacturer, model number, calibrated range, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.

b) An equipment list or spreadsheet for all non-instrument devices supplied listing description, specification section and paragraph number, manufacturer, model number, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.

c. Equipment Operations and Maintenance Information:

1) ISA-TR20.00.01-2001(updated in 2004-2006) data sheets shall be provided for all field instruments. For non-field instrumentation devices, provide a cover page for each device, piece of equipment, and OEM software that lists date, specification number, product name, manufacturer, model number, Location(s), and power required. Preferred format for the cover page is ISA-TR20.00.01-2001(updated in 2004-2006), general data sheet; however, other formats will be acceptable provided they contain all required information.
2) Vendor O&M documentation for each device, piece of equipment, or OEM software shall be either new documentation written specifically for this project or modified standard vendor documentation. All standard vendor documentation furnished shall have all portions that apply clearly indicated with arrows or circles. All portions that do not apply shall be neatly lined out or crossed out. Groups of pages or sections that do not apply at all to the specific model supplied shall be removed.
3) Provide the record documentation of the completed test forms with sign-offs as specified in Section 13612 - Process Control System Testing.
4) Include instrument/equipment calibration and configuration forms developed as specified in Section 13612 - Process Control System Testing.

d. As-Built Drawings:

1) Complete as-built drawings, including all drawings and diagrams specified in this section under the "Submittals" section. These drawings shall include all termination points on all equipment the system is connected to, including terminal points of equipment not supplied by the PCSS. Provide electronic files for all drawings produced. Drawings shall be in AutoCAD ".dwg" format and in Adobe Acrobat format.
2) As built documentation shall include information from submittals, as described in this Specification, updated to reflect the as-built system. Errors in or modifications to the system resulting from the Factory and/or Functional Acceptance Tests shall be incorporated in this documentation.

B. Operations and Maintenance Data - Software Maintenance Manual

1. Software Listings and Databases- Submit hard copies of the same information required in the "Controller Program Submittal" except include files updated to reflect the as built system. Include PDF versions of these files on the DVDs specified below.
2. PID Loop Tuning Parameters - Submit annotated chart recorder traces or computer system trend screen printouts showing tuned control loop response to plus and minus 40 percent of full span step changes of loop setpoint for each individual loop. For cascade loops, submit charts showing response of the secondary loop with secondary setpoint on manual and also response of the entire cascade control loop in automatic mode. Include a description of tuning methodology used.

3. Supply hardcopies of configuration information for the HMI systems, reporting systems, Historian Systems, and any other programs developed under this Contract.
4. Machine Readable Documentation - Provide two sets of as built software documentation on DVDs or USB thumb drives in original electronic format for all PLC, HMI systems, reporting systems, Historian Systems, and any other programs developed under this Contract. All changes made during or after testing, start-up, and commissioning shall be incorporated.
5. Include final version of the system standards and conventions manual reflecting as-programmed conditions.
6. System Configuration Section:

    a. A printout (or screen capture) of all configuration screens for every device requiring PCSS configuration. This includes, but is not limited to PLC processors**,** PLC redundancy**,** EtherNet/IP and any other communication modules, HMI software, and other software.

C. Operations and Maintenance Data - Operators' Manual:

1. Provide Operator's Manuals prior to final acceptance of the system.
2. This manual shall be separately bound and shall contain all information necessary for the operator to monitor and control the plant from the control system. The manuals shall be written in non-technical terms and shall be organized for quick access to each detailed description of the operator's procedure. Manuals shall contain, but not be limited to, the following information:

    a. A comprehensive table of contents of the manual.
    b. A simple overview of the entire system indicating the function and purpose of major control system components described by area or building.
    c. A detailed description of the operation of the HMI and OIT including all appropriate displays. Including a screenshot of each HMI and OIT display screen and annotating each function in text is an acceptable format for presenting this information.
    d. Step-by-step procedures for starting up or shutting down critical component of the control system such as server or a control panel.
    e. Login / logout procedures for the operator interface system(s).
    f. Complete, step-by-step procedures for printing reports and entering manual data.
    g. Complete, step-by-step procedures for performing system or selected file backup and restoration including archiving historical data. Include recommended archiving schedule for historical data and/or frequency system performs an automatic back-up with a listing of all applications that are backed up or need to be backed up.
    h. Operational description for operating HMI computer equipment and peripherals including printers, CD-ROMs, removable bulk storage devices, UPS, etc. Description shall include procedures for typical maintenance and troubleshooting tasks.
    i. A complete glossary of terms and definition of acronyms.
    j. List of personnel to be contacted for warranty and emergency services, including name, address, telephone number, pager or cell phone number, fax number, and email address.

D. Software and Firmware Operational Documentation:

1. Original Licensed Software:

    a. Submit original software licenses and keys for all software provided under this Contract. Submit original paper based and electronic documentation for all software provided. Submit license agreement information including serial numbers, license agreements, User Registration Numbers and related information. All software provided under this Contract shall be licensed to the Owner at the time of purchase. Provide media in software sleeves within O&M manual.

2. Electronic O&M Information:

    a. In addition to the hard copy of O&M data, provide an electronic version of all equipment manuals and data sheets, along with any software back-up of configuration files, on DVD or USB thumb drive. Electronic documents shall be supplied in Adobe Acrobat format.
    b. Provide electronic files for all custom-developed manuals including training manuals. Text shall be supplied in both Microsoft Office format and Adobe Acrobat format.
    c. Provide electronic files for all drawings produced. Drawings shall be in AutoCAD ".dwg" format and in Adobe Acrobat format. Drawings shall be provided using the AutoCAD eTransmit feature to bind external references, pen/line styles, fonts, and the drawing file into individual zip files.
    d. Each computer system hardware device shall be backed up onto DVD or USB thumb drive after Substantial Completion and shall be turned over to the Owner.
    e. If specified in the training section, provide digital copies of all training videos. Videos shall be in a format that is readable by standard DVD players and by standard PC DVD drives. Format shall be a minimum of 800 by 600 pixels and shall include sound.

3. The cover and edge of each volume shall contain the information as specified in Section 01782 “Operation and Maintenance Data.”

1.8 MAINTENANCE MATERIAL SUBMITTAL

A. Furnish extra materials from the same product run**,** that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Refer to individual specification sections in Division 1363X through 1379X for spare equipment requirements and provide one comprehensive spare parts submittal for project

B. All spare parts shall be packed in individual cartons and labeled with indelible markings clearly indicating component(s) inside. Complete ordering information paperwork including manufacturer's contact information (address and phone number), part name, part number, equipment name and tag number(s) for which the part is to be used (if applicable) shall be supplied with the required spare parts. The spare parts shall be delivered and stored in a location directed by the Owner or Engineer.

1.9 QUALITY ASSURANCE

A. The PCSS as a minimum shall be responsible for the technical supervision of the installation by providing on site supervision to the installers of the various components.

B. The Process Control System Supplier (PCSS) shall be a "systems integrator" regularly engaged in the design and the installation of instrumentation systems and their associated subsystems as they are applied to the municipal water and wastewater industry. For the purposes of this Specification Section, a "systems integrator" shall be interpreted to mean an organization that complies with all of the following criteria:

1. Employs personnel on this project who have successfully completed ISA or manufacturers training courses on general process instrumentation and configuration and implementation of the specific programmable controllers, computers, and software proposed for this project. Key personnel shall hold ISA CCST Level 1 certification or have a minimum of 10 years of verifiable plant startup experience. Key personnel shall include, as a minimum, the lead field technician.
2. Has successfully completed work of similar or greater complexity on at least three previous projects within the last five years. Successful completion shall be defined as a finished project completed on time, without any outstanding claims or litigation involving the PCSS. Potential references shall be for projects where the PCSS's contract was of similar size to this project.
3. Has been actively engaged in the type of work specified in this Section for a minimum of five years.

C. The PCSS shall maintain a permanent, fully staffed and equipped service facility within 400 miles of the project site with full time employees capable of designing, fabricating, installing, calibrating, and testing the systems specified herein. At a minimum, the PCSS shall be capable of responding to on-site problems within 24 hours of notice. Provide an on-site response within 4 hours of notification starting at two months before scheduled startup to two months after startup completion.

D. Listed suppliers will not be required to submit qualifications, see “Informational Submittals” for required Qualification Data. Contractors interested in listing an equal to the above listed suppliers shall submit PCSS' qualifications for review and approval as specified herein.

E. The selected PCSS shall be one of the following:

1. Optimation, Joe Doherty, (603) 589-7700
2. Avanceon, Duane Grob, (610) 458-8700

F. Being listed in this specification does not relieve any potential PCSS from meeting the qualifications specified in this Section.

1.10 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service:

1. Coordinate with Owner to test functionality of all planned connections to existing SCADA equipment prior to modifying any installation associated with this equipment.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 01600 "Materials and Equipment" for delivery, storage, and handling requirements.

1.12 FIELD CONDITIONS

A. Environmental Requirements. Refer Electrical Drawings for specific environmental and hazardous area classifications.

B. Elevation: Equipment shall be designed to operate at the project ground elevation.

C. Temperature:

1. Outdoor areas' equipment shall operate between -22 to 122 F degrees ambient.
2. Equipment located in indoor locations shall operate between 50 to 95 F degrees ambient minimum.
3. Storage temperatures shall range from 32 to 122 F degrees ambient minimum.
4. Additional cooling or heating shall be furnished if required by the equipment as specified herein.
5. Relative Humidity. Air-conditioned area equipment shall operate between 20 to 95 percent relative, non-condensing humidity. All other equipment shall operate between 5 to 100 percent relative, condensing humidity.

D. None of the control system equipment located in the control room shall be shipped to the site until the control room areas comply with specified ambient temperature and humidity and free of dust and debris.

1.13 WARRANTY

1. Warranty Period: 1 year from date of Substantial Completion as defined in the Division 01 Sections unless noted otherwise in individual specification sections.

PART 2 - PRODUCTS

2.1 GENERAL

A. Electrical Requirements for Control System:

1. Equipment shall operate on a 60 Hertz alternating current power source at a nominal 120 volts, plus or minus 10 percent, except where specifically noted. Regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.
2. With the exception for field device network connected devices, all electronic instrumentation shall utilize linear transmission signals of isolated 4 to 20 mA DC (milliampere direct current) capable of driving a load up to 750 ohms, unless specified

otherwise. However, signals between instruments within the same panel or cabinet may be 1-5 VDC (volts direct current).

3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero-based signals will be allowed.
4. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless noted otherwise.
5. Switches and/or signals indicating an alarm, failure or upset condition shall be wired in a fail-safe manner as shown on the P&IDs,**.** A fail-safe condition is when an open circuit generates an alarm state (i.e. contact opens).
6. Materials and equipment shall be UL approved whenever such approved equipment and materials are available.
7. All equipment furnished shall be designed and constructed so that in the event of power interruption, the systems specified herein shall go through an orderly shutdown with no loss of memory and shall resume normal operation without manual resetting when power is restored, unless otherwise noted.
8. Surge protection requirements for control system power, signal, and communication lines are specified in Section 13799 "Isolators, Intrinsically Safe Barriers, and Surge Suppressors."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine all products and materials before installation. Reject any products or materials that are wet, moisture damaged, or mold damaged.

B. Examine walls, floors, roofs, and process areas and connections for suitable conditions where all products and materials will be installed.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION

A. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at only one ground point for each shield.

B. Provide sunshades for equipment mounted outdoors in direct sunlight. Include sunshades standoffs to allow air circulation around the cabinet. Orient equipment outdoors to face to the North to minimize the impact of glare and ultraviolet exposure on digital readouts.

3.3 IDENTIFICATION

A. Provide identification system for all PCSS provided hardware, instrumentation, and communication cabling. Provide details as specified in "Project Plan".

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Refer to Section 13612 “Process Control System Testing.”

B. Refer to Section 13613 “Process Control System Training.”

C. Engage a factory-authorized service representative to perform startup service as specified in individual hardware and instrument specifications.

D. On-site coordination meetings with Engineer, Contractor, and Vendors**,** as required during active construction period.

END OF SECTION 13610

SECTION 13612 - PROCESS CONTROL SYSTEM TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes Process Control System Testing.
B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13701 – Magnetic Flow Meters.
3. Section 13722 – Radar Level Meters.
4. Section 13729 – Level Switches.
5. Section 13731 – Pressure and Differential Pressure Gauges.
6. Section 13736 – Pressure and Differential Pressure Switches.
7. Section 13739 – Diaphragm Seals.
8. Section 13766 – Suspended Solids-Sludge Density Analyzers.
9. Section 13789 – Position, Speed, and Motion Measurement Devices.
10. Section 13798 – Relays.
11. Section 13799 – Isolators, Intrinsically Safe Barriers, and Surge Suppressors.
12. Section 13801 – Power Supplies.

C. Furnish all labor, materials, equipment and incidentals required to complete the testing of all devices and systems furnished and installed as detailed on Drawings, and as specified herein.
D. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for other general requirements.

1.3 ACTION SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
B. Testing Submittals - Submit, in one submittal, the following testing related documents:

1. Status signoff forms:

a. Develop and submit project specific I/O Status and Automatic Control Strategy signoff forms to be used during factory and field testing to organize and track each loop's inspection, adjustment, calibration, configuration, and testing status and sign off. Include sign-off forms for each testing phase showing all loops.

1) Example forms are shown in the Appendices.

2) Separate forms for factory and field testing can be used, or they can be combined, at the discretion of the PCSS.
3) Submit testing forms prior to start of testing.

2. Testing Procedures:

a. Submit detailed procedures proposed to be followed for each of the tests specified herein. The test procedures serve as the basis for the execution of the required tests to demonstrate that the system meets and functions as specified.
b. Documents shall be structured in an orderly and easy to follow manner to facilitate an efficient and comprehensive test.
c. Test procedures shall indicate all pre-testing setup requirements, all required test equipment, and simulation techniques to be used.
d. Test procedures shall be structured in a cause and effect manner where the inputs are indicated, and the outputs are recorded.
e. Test procedures shall include the demonstration and validation under normal operating conditions and under various failure scenarios as specified in Contract Documents.
f. Testing may not start until all Testing Submittals have been approved.

C. Test Documentation:

1. Upon completion of each required test, document the test by submitting a copy of the signed off Testing Status forms. Testing shall not be considered complete until the signed-off forms have been submitted and approved. Submittals of other test documentation, including "highlighted" wiring diagrams with field technician notes, are not acceptable substitutes for the formal test documentation.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING - GENERAL

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
B. Results of all testing shall be tracked on a project specific status sign off form or similar document. PCSS shall be responsible for maintaining the sheet. Appendix of this Section has an example template for this sheet.
C. Tests the PCSS is required to perform are as follows:

1. Factory Testing:

a. Unwitnessed Factory Test (UFT).
b. Witnessed Factory Test (WFT).

2. Field Testing:

a. Operational Readiness Test (ORT).
b. Functional Demonstration Test (FDT).

D. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment, and data, provide all special testing materials and equipment required for a suitable means of simulation.
E. PCSS shall coordinate all required testing with Contractor, affected Subcontractors, Engineer, and Owner.
F. No equipment shall be shipped to jobsite until Engineer or Owner has received all Factory Testing results and approved the system as ready for shipment.
G. Engineer reserves the right to test or re-test any functions.
H. Correction of Deficiencies:

1. Deficiencies in workmanship and/or items not meeting specified testing requirements shall be corrected to meet specification requirements at no additional cost to Owner.
2. Testing, as specified herein, shall be repeated after correction of deficiencies is made until specified requirements are met. This work shall be performed at no additional cost to Owner.

3.2 FACTORY TESTING - UNWITNESSED FACTORY TEST (UFT)

A. Purpose of UFT is for PCSS to check system prior to Engineer and/or Owner attending factory testing. This type of testing shall be part of any quality firm's internal QA/QC procedures.
B. Temporary network connections will be required to confirm the network configuration. Temporary wiring of primary elements, final control elements, and field-mounted transmitters is not required.
C. Hardware to be tested shall include all control system devices shown on System Architecture drawings and provided by PCSS.
D. Temporary workstations, loaded with all new and modified HMI graphics, shall be utilized for factory testing to ensure proper HMI functionality, as described below.
E. Tests to be performed shall include, but not be limited to, the following. Each of these tests shall be specifically addressed in Test Procedure submittal.

1. All panels and enclosures being provided shall undergo a thorough inspection to verify integrity of cabinet enclosures, frame structures, paint work and finish, etc. Review panel drawings to ensure they accurately reflect panel layout and wiring.
2. Perform a system audit to verify all components have been staged for test and have been documented properly with correct model numbers, serial numbers, etc. Following documentation of audit shall be provided at factory test and submitted as part of O&M Manual Documentation:

a. For each microprocessor-based component connected to control communication backbone in system (PLCs, managed switches, protocol converters, communication cards on final field devices, radios, etc.), list firmware revision, vendor and local distributor information, and system, warranty information, configuration parameters (e.g., communication settings, fail position settings, etc.)

3. Panel wire pull tests shall be performed to ensure all wiring has been connected with appropriate torque to prevent wires from coming loose.

4. UPS shall be tested to verify UPS switch power correctly while keeping all UPS powered loads online. Testing of UPS to determine if they have been sized correctly to maintain specified run time shall be performed during field testing.
5. A 100 percent I/O point checkout shall be performed to verify proper operation of input/output points from panel terminations to HMI and OIT nodes. At a minimum, I/O checkout shall consist of four steps.

    a. Discrete input signals shall be jumpered at field terminal blocks in control panels to verify proper status in HMI and OIT nodes.
    b. Analog input signals shall be connected to a signal generator at field terminal blocks in control panels to verify proper status in HMI and OIT nodes and signals shall be verified at zero percent, 50 percent, and 100 percent of full scale.
    c. Discrete output signals shall be tested by switching equipment to manual control at HMI and OIT nodes and turning the output on or other means to turn the output on. Then verify the output is on by connecting a digital multimeter to measure continuity at field termination blocks, thus verifying command from PLC has properly executed contact closure.
    d. Analog output signals shall be tested by switching the equipment to manual control at HMI and OIT nodes and turning output on or other means to turn the output on. Then verify output by utilizing a digital multimeter to measure current or voltage generated at field termination blocks.

6. All control strategies shall be verified using simulation or other means to verify logic performs as expected. Verify faults and logical failure conditions for control strategies such instrument failures, equipment failures, loss of communication between HMI Server and PLC, loss of peer-to-peer communication, out of range testing (over and under scale) for analog inputs, and all other strategies specified in control strategy document.
7. For each hardware enclosure, inspection shall include, but not be limited to, cabinet enclosures, frame structure, paint work and finish, dimensions, and hardware operability (i.e., fans, door hinges, keylocks, etc.).
8. For each panel, inspection shall include, but not be limited to, I/O subsystem physical layout, power supply sizing and mounting, cable routing, wire runs across hinges properly installed, fans and blowers unobstructed and mounted to maximize air flow, power conditioning correctly installed, and overall layout and installation of components meets manufacturer's recommendations and standard industry accepted practices.
9. All other control panel circuitry.
10. Following systems tests shall be performed:
    a. Demonstrate total power failure and recovery. UPS shall be removed for this test.

F. Upon successful completion of UFT, PCSS shall submit a record copy of test results as specified in PART 1. As part of this test results submittal, notify Engineer and Owner in writing that system is ready for WFT. No other notice of Factory test will be accepted. Engineer and/or Owner shall schedule a test date within 30 days of receipt of this submittal.

3.3 FACTORY TESTING - WITNESSED FACTORY TEST (WFT)

A. Purpose of WFT is to allow Engineer or Owner representatives to witness functionality, performance, and stability of entire hardware and software system as a complete integrated system. WFT shall be run by PCSS and conducted at PCSS's facility.
B. Required Documents for Test:

1. Clean set of approved panel drawings and wiring diagrams.
2. Set of Contract Documents - all drawings and specifications.
3. All design-change related documentation.
4. Master copy of the PCSS developed factory testing signoff forms.
5. Testing procedures.

C. System shall operate continuously throughout WFT without failure, except where initiated per established test procedures. Unanticipated failures may, at Owner or Engineer's option, result in overall WFT being deemed unsuccessful. All deficiencies identified during these tests shall be corrected and re-tested prior to completing WFT or shipment of panels to jobsite as determined by Owner/Engineer.

D. Tests to be performed during the WFT shall include, but not be limited to, the following:

1. A repeat of all tests specified in the UFT.

E. Daily schedule during these tests shall be as follows:

1. Morning meeting to review the day's test schedule.
2. Scheduled tests and sign-offs.
3. End of day meeting to review day's test results and to review or revise next day's test schedule.
4. Unstructured testing period by witnesses.

F. Upon successful completion of WFT, PCSS shall submit a record copy of test results as specified in PART 1.

3.4 FIELD TESTING - OPERATIONAL READINESS TEST (ORT)

A. Purpose of ORT is to check that process equipment, instrument installation, instrument calibration, instrument configuration, field wiring, control panels, and all other related system components are ready to monitor and control the processes. This test will determine if equipment is ready for operation.

B. This test shall take place prior to FDT and startup. Prior to starting this test, relevant process equipment shall be installed and mechanically tested, instruments installed, control panels installed, and field wiring complete.

C. Required Documents for Test:

1. Master copy of the PCSS developed field testing signoff forms.
2. Testing procedures.
3. Calibration forms.

D. These inspections, calibrations, and tests do not require witnessing. However, Engineer may review and spot-check testing process periodically. All deficiencies found shall be corrected by PCSS prior to commencement of Functional Demonstration Test.

E. PCSS shall maintain Sign-off forms and Calibration forms at job site and make them available to Engineer/Owner at any time.

F. Following tests shall be performed as part of ORT:

1. Instrument calibration, configuration, and set-up.
2. Input/Output (I/O) Testing to HMI and OITs.

3. Testing of control strategies.

G. Instrument calibration, configuration, and set-up:

1. Calibrate, configure, and set-up all components and instruments to perform specified functions.
2. Calibration form:

   a. For any component or instrument requiring dip switch settings, calibration, or custom configuration, maintain a calibration form in field documenting this information. These forms shall provide a summary of the actual settings used in the field to allow an Instrument technician to replace the device entirely and configure it to function as it did before.
   b. This information shall be added to Instrument data sheet, shall be added to a copy of manufacturer's standard "Configuration Sheet", or a separate form shall be created.

      1) If a separate form, the form shall list Project Name, Loop Number, ISA Tag Number, I/O Module Address, Manufacturer, Model Number/Serial Number, Output Range and Calibrated Value.

   c. Some examples of required information are:

      1) For Discrete Devices: Actual trip points and reset points.
      2) For Instruments: Any configuration or calibration settings entered into instrument
      3) For Controllers: Mode settings (PID).
      4) For I/O Modules: Dip switch settings, module configuration (if not documented in native programming documentation).

   d. See Sections 137XX – For test procedures specific to certain equipment and instrumentation.
   e. Maintain a copy of these forms in field during testing and make them available for inspection at any time.
   f. For any device that allows a software back-up of configuration files to a laptop, make configuration files available to Engineer/Owner for inspection. Submit as part of Final System Documentation as specified in Section 13610.

H. I/O Testing:

1. Purpose of I/O testing is to check that process equipment, instrument installation, calibration, configuration, field wiring, and control panels are set-up correctly to monitor and control the processes. This test is commonly referred to as a "loop test" or an I/O checkout.
2. PCSS in conjunction with Contractor shall test signals under process conditions. Preferred test method will always be to execute test wherever possible to end elements. For example, preferred test will prove valve open/close limit switches by operating valve, not by installing a jumper on limit switch contacts. However, if equipment or process is not available to test a signal over its entire calibrated range, PCSS may test using a simulation method and make a note on sign-off form.
3. The following I/O tests shall be performed:

a. Discrete Input: At device or instrument, change signal condition from inactive to active state. Observe and record results on all indicators within loop such as HMI screens, OIT screens, pilot lights, horns, beacons, etc.
b. Analog Input: Test analog signal over entire engineering range at various intervals including 0, 50%, and 100% as well as on increasing and decreasing range. Observe and record results on all indicators within loop such as HMI screens, OIT screens, recorders, digital indicators, etc.
c. Discrete output signals shall be tested by switching equipment to manual control at the HMI and OIT nodes and turning output on or using other means to turn output on. Then verify and record equipment responds accordingly.
d. Analog output signals shall be tested by switching equipment to manual control at HMI and OIT nodes and turning output on or other means to turn output on. Then verify and record equipment responds accordingly.

I. Testing of Automatic Control Strategies:

1. All automatic control strategies shall be verified using actual process equipment and instruments, or other means, to verify logic performs as expected. Verify faults and logical failure scenarios for control strategies such as instrument failures, equipment failures, loss of communication between HMI Server and PLC, loss of peer-to-peer communication, out of range testing for analog inputs, loss of power, and all other strategies specified in control strategy document.

J. Repeat all systems tests specified under factory testing.
K. UPS shall be tested to verify UPS switch power correctly while keeping all UPS powered loads online. Also, test sizing of UPS by switching off line power to UPS and verify if they maintain specified run time.
L. Demonstrate communication failure at and recovering self-healing ring testing.
M. For all panels with enclosures modified by this Contract, internal control panel temperature shall be tested under full running conditions to ensure proper cooling/ventilation is being provided.
N. Upon successful completion of ORT, PCSS shall submit a record copy of test results as specified in PART 1 and request scheduling of FDT.

3.5 FIELD TESTING - FUNCTIONAL DEMONSTRATION TEST (FDT)

A. After facility is started-up and running treatment process in automatic control to extent possible, a Functional Demonstration Test shall be performed. Purpose of FDT is to allow Engineer or Owner representatives to witness actual functionality, performance, and stability of system while connected to process equipment.
B. Required Documents for Test:

1. Set of panel drawings and wiring diagrams from ORT with corrections noted.
2. Set of Contract Documents - all drawings and specifications.
3. All design-change related documentation.
4. Signed-off master copy of the PCSS developed field testing signoff forms.
5. Testing procedures.
6. Copy of completed calibration forms.
7. One copy of all O & M Manuals for PCSS supplied equipment.

C. A witnessed FDT shall be performed on each process area. To extent possible, repeat testing performed during ORT.
D. Daily schedule specified to be followed during factory tests shall also be followed during FDT.
E. After coordinating with Operations, a "Black Start" of the new equipment shall be performed to confirm plant operation recovers as specified in Contract Documents. Black start means shutting off power to the new equipment and turning it back on.
F. Punch list items and resolutions noted during test shall be documented on Punch list/Resolution form (see Specification Section 01650). In event of rejection of any part or function test procedure, PCSS shall perform repairs, replacement, and/or retest within 10 days.
G. Upon successful completion of the FDT, PCSS shall submit a record copy of test results as specified in "Part 1 - General".

END OF SECTION 406121

APPENDIX **40 61 21-**A: EXAMPLE INPUT/OUTPUT (I/O) STATUS SIGN OFF FORM

An example template for I/O Status signoff form to be used for documenting testing results to Owner is attached. PCSS is required, prior to testing, to create a project specific I/O Status signoff form based on attached template or approved equal. PCSS may obtain an electronic copy of template from Engineer or develop it on their own.

APPENDIX **40 61 21**-B: EXAMPLE AUTOMATIC CONTROL STRATEGIES SIGN OFF FORM

An example template for Automatic Control Strategies signoff form to be used for documenting testing results to Owner is attached. PCSS is required, prior to testing, to create a project specific Automatic Control Strategies signoff form based on attached template or approved equal. PCSS may obtain an electronic copy of template from Engineer or develop it on their own.

4-Jun-14

[Project Name] Appendix A - Input/Output (I/O) Status Sign-Off Form

All Sections below are required to be filled out by PCSS as part of Field Testing.
Instrument Alarm Setpoint - Setpoint for any alarms set by PCSS
Wiring Complete - Signal wired from field device to PLC
I/O Tested - Signal tested from field device to SCADA HMI

PLC	Signal Tag	Description	Range or Active State when closed	P&ID	Signal	Rack	Slot	Channel	Instrument Alarm Setpoint	Calibrate, config., and Wiring complete	Date	PCSS I/O testing	Date	I/O Testing to the HMI	Date	Notes
PLC-SC	LIT-4000-1	Secondary Clarifier No. 1 Sludge Level	0-10 ft	8	AI	2	1	0								
PLC-SC	LIT-4010-3	Secondary Clarifier No. 3 Sludge Level	0-10 ft	8	AI	2	1	1								
PLC-SC	SI-4100-1	RAS Pump No. 1 Speed Feedback	0-100%	14	AI	2	1	2								
PLC-SC	SI-4100-4	RAS Pump No. 4 Speed Feedback	0-100%	15	AI	2	1	3								
PLC-SC	FIT-4102-1	RAS Flow Pumps 1-3	0-1900 GPM	14	AI	2	1	4								
PLC-SC	SI-4110-1	WAS Pump No. 1 Speed Feedback	0-100%	14	AI	2	1	5								
PLC-SC	N/A	Spare Slot	N/A	N/A	Spare	2	5	N/A								
PLC-SC	SC-4100-1	RAS Pump No. 1 Speed Setpoint	0-100%	14	AO	2	7	0								
PLC-SC	SC-4100-2	RAS Pump No. 2 Speed Setpoint	0-100%	14	AO	2	7	1								
PLC-SC	SC-4100-3	RAS Pump No. 3 Speed Setpoint	0-100%	14	AO	2	7	2								
PLC-SC	SC-4110-1	WAS Pump No. 1 Speed Setpoint	0-100%	14	AO	2	7	3								
PLC-SC	Spare	Spare	N/A	N/A	AO	2	7	4								
PLC-SC	Spare	Spare	N/A	N/A	AO	2	7	5								
PLC-SC	TSH-4000-1	Secondary Clarifier No. 1 High Temp	Normal	8	DI	3	1	0								
PLC-SC	XA-4000-1	Secondary Clarifier No. 1 Motor Overload	Normal	8	DI	3	1	1								
PLC-SC	WAH-4000-1	Secondary Clarifier No. 1 High Torque	Normal	8	DI	3	1	2								
PLC-SC	WAHH-4000-1	Secondary Clarifier No. 1 High High Torque	Normal	8	DI	3	1	3								
PLC-SC	YRI-4000-1	Secondary Clarifier No. 1 On/Off	On	8	DI	3	1	4								
PLC-SC	YCI-4000-1	Secondary Clarifier No. 1 In Remote	In Remote	8	DI	3	1	5								
PLC-SC	YFI-4100-1	RAS Pump No. 1 VFD Fault	Normal	14	DI	3	1	6								
PLC-SC	FAL-4100-1	RAS Pump No. 1 Low Flow	Normal	14	DI	3	1	7	50 GPM	RJM	12/18/2011	JAS	12/22/2011	MIC	12/29/2011	Example completed line
PLC-SC	Spare	Spare	Normal	14	DI	3	1	8								
PLC-SC	YRI-4100-1	RAS Pump No. 1 Running	Running	14	DI	3	1	9								
PLC-SC	YCI-4100-1	RAS Pump No. 1 In Remote	In Remote	14	DI	3	1	10								
PLC-SC	YFI-4110-1	WAS Pump No. 1 VFD Fault	Normal	14	DI	3	1	11								
PLC-SC	FAL-4110-1	WAS Pump No. 1 Low Flow	Normal	14	DI	3	1	12								
PLC-SC	Spare	Spare	Normal	14	DI	3	1	13								
PLC-SC	YRI-4110-1	WAS Pump No. 1 Running	Running	14	DI	3	1	14								
PLC-SC	YCI-4110-1	WAS Pump No. 1 In Remote	In Remote	14	DI	3	1	15								
PLC-SC	HSS-4000-2	Secondary Clarifier No. 2 Start Command	Start	8	DO	4	6	0								
PLC-SC	Spare	Spare	N/A	N/A	DO	4	6	1								
PLC-SC	HSS-4100-2	RAS Pump No. 2 Start Command	Start	14	DO	4	6	2								
PLC-SC	HSS-7000-2	Sludge Holding Tank Blower No. 2 Start Command	Start	17	DO	4	6	3								
PLC-SC	HSS-4100-5	RAS Pump No. 5 Start Command	Start	15	DO	4	6	4								
PLC-SC	Spare	Spare	N/A	N/A	DO	4	6	5								
PLC-SC	HSS-4105-1	Secondary Scum Pump No. 2 Start/Stop	Start	15	DO	4	6	6								
PLC-SC	HSS-4110-2	WAS Pump No. 2 Start/Stop Commanded	Start	15	DO	4	6	7								
PLC-SC	7160-FQI-1	Sludge Loadout LCP Pumping Indicator	Pumping	17	DO	4	6	8								
PLC-SC	Spare	Spare	N/A	N/A	DO	4	6	9								
PLC-SC	HSS-7115-2	Sludge Holding Tank Mixer No. 2 Start	Start	17	DO	4	6	10								
PLC-SC	Spare	Spare	N/A	N/A	DO	4	6	11								
PLC-SC	HSO-7117-2	Sludge Holding Tank Discharge Valve No. 2 Open CMD	Open	17	DO	4	6	12								
PLC-SC	HSC-7117-2	Sludge Holding Tank Discharge Valve No. 2 Close CMD	Close	17	DO	4	6	13								
PLC-SC	HSS-7120-2	TS Transfer Pump No. 2 Start Command	Start	17	DO	4	6	14								
PLC-SC	Spare	Spare	N/A	N/A	DO	4	6	15								

Page 1 of 1

4-Jun-14

[Project Name] Appendix B - Automatic Control Strategies Sign-Off Form

All Sections below are required to be filled out by PCSS as part of Testing

Auto. Control Strategies. - Loop operational in Automatic as defined in Control Stategies

Control Strategies Loop #	Control Strategy Description	P&ID	Auto. Control Strategy	Date	Notes
LOOP 281 - 284	LOW FLOW PUMPS	8			
LOOP 290	LOW EQ CHANNEL FLOW NO.4	8			
LOOP 300	MICROFILTRATION AIR SUPPLY LOW PRESSURE	10			
LOOP 351, 352	SITE LIFT STATION PUMP NO.1 AND NO. 2	12			
LOOP 355	SITE LIFT STATION HIGH AND LOW LEVEL CONTROL	12			
LOOP 371, 372	SLUDGE HOLDING TANK NO.1 AND NO. 2 LEVEL	14			
LOOP 381, 382	SLUDGE TRANSFER PUMPS	14			
LOOP 385	SLUDGE TRANSFER PUMPS REMOTE START/STOP COMMAND	14			
LOOP 700	EFFLUENT PUMPING STATION LEVEL	14			
LOOP 701, 702, 703	EFFLUENT PUMP NO.1	14			
LOOP 840	POST AERATION CHANNEL AIR FLOW CONTROL	15			
LOOP 900	SLUDGE TRANSFER PUMPS DISCHARGE FLOW	8			
LOOP 971	CENTRIFUGE SLUDGE FEED PUMP NO.1	8			
LOOP 1001	CENTRIFUGE NO.1 SLUDGE FEED FLOW CONTROL	8			
LOOP 1411, 1412	SODIUM HYPOCHLORITE STORAGE TANKS LEVEL	8			
LOOP 1421, 1422	SODIUM HYPOCHLORITE PUMPS	8			
LOOP 1430	SODIUM HYPOCHLORITE STORAGE TANKS CONTAINMENT AREA HIGH LEVEL DETECTION	14			
LOOP 2051, 2052, 2053	DIESEL ENGINE GENERATOR STATUS	14			
LOOP 2055	TRANSFER SWITCH STATUS	14			
LOOP 2060	GENERATOR KILOWATTS MONITORING	14			
APPENDIX ONE	EQUIPMENT RESTART DURING A POWER LOSS WITH THE GENERATOR RUNNING	14			
APPENDIX TWO	EQUIPMENT RESTART WITH POWER RESTORED AFTER A POWER LOSS	14			
N/A	SELF-HEALING CAPABILITIES OF NETWORK	N/A			
N/A	REDUNDANT SCADA SERVER FAILOVER AND RECOVERY	N/A			

Page 1 of 1

SECTION 13613 - PROCESS CONTROL SYSTEM TRAINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes Process Control Description Training.

B. Related Requirements:

1. Section 13684 "Configuration of HMI Software" for AESS Control System Training Requirements.
2. Section 13701 – Magnetic Flow Meters.
3. Section 13722 – Radar Level Meters.
4. Section 13729 – Level Switches.
5. Section 13731 – Pressure and Differential Pressure Gauges.
6. Section 13736 – Pressure and Differential Pressure Switches.
7. Section 13739 – Diaphragm Seals.
8. Section 13766 – Suspended Solids-Sludge Density Analyzers.
9. Section 13789 – Position, Speed, and Motion Measurement Devices.
10. Section 13798 – Relays.
11. Section 13799 – Isolators, Intrinsically Safe Barriers, and Surge Suppressors.
12. Section 13801 – Power Supplies.

C. Furnish training as specified herein.

D. This Section covers the training requirements for all devices and systems furnished and installed as detailed on the Drawings.

E. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Preliminary Training Plan Submittal:

1. Prior to the preparation of the Final Training Plans, submit outlines of each training course including course objectives and target audience, resumes of instructors, prerequisite requirements for each class, and samples of handouts for review.

B. Final Training Plan Submittal:

1. Upon receipt of the Engineer's comments on the preliminary training plan, submit the specific proposed training plan with the following:

a. Definitions, objectives, and target audience of each course.
b. Schedule of training courses including proposed dates, duration and locations of each class.
c. Complete copy of all proposed handouts and training materials bound and logically arranged with all materials reduced to a maximum size of 11 inch by 17 inch, then folded to 8.5 inch by 11 inch for inclusion into the binder.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. The training and instruction shall be directly related to the system being supplied. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance of the system.

B. Coordinate all training schedules with and at the convenience of the Owner, including shift training required to correspond to the Owner's working schedule.

C. All onsite instructors must be intimately familiar with the operation and control of the Owner's facilities.

D. Provide detailed training manuals to supplement the training courses including specific details of equipment supplied and operations specific to the project. The manuals shall be provided in hardcopy for each student. Provide electronic copy of each training manual in PDF format for Owner's future use.

E. The trainer shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, all training materials shall be delivered to Owner.

F. Videotape all training sessions. All training tapes become the sole property of the Owner.

G. Cost of Travel for off-site training:

1. Cost of Travel for off-site training is paid directly by the entity employing the staff doing the traveling.

3.2 TRAINING SUMMARY

A. Provide the following training courses listed in the summary table below:

Description	Minimum Course Duration (hours)	Number of Times Course to be Given
Onsite Training		
Control System Overview Seminar	Covered in AESS Scope of work	
Operator Control System Training	Covered in AESS Scope of work	
Installed Control System	2	3
PLC Hardware/Software	2	3
Instrument manufacturer training - Magnetic Flow Meters	4	3
Instrument manufacturer training – Radar Level Meters	4	3
Instrument manufacturer training – Sludge Blanket Analyzers	4	3
Instruments	8	3
Instruments - Operator familiarity	4	3

3.3 ONSITE TRAINING

A. Training personnel are required to be intimately familiar with the control system equipment, its manipulation, and configuration. Training personnel are required to command knowledge of system debugging, program modification, troubleshooting, maintenance procedure, system operation, and programming, and capable of transferring this knowledge in an orderly fashion to technically oriented personnel.

B. Installed Control System Training:

1. Provide training for the Owner's personnel in the functionality, maintenance, and troubleshooting, of the installed Control System. The training shall be held before the Functional Demonstrator Test (FDT), but not more than one month before.
2. Provide training and instruction specific to the system that is being supplied.
3. Provide training consisting of classroom instructions and hands-on instruction utilizing the Owner's system.
4. Provide detailed training on the actual configuration and implementation for this Contract covering all aspects of the system that will allow the Owner's personnel to maintain, modify, troubleshoot, and develop future additions/deletions to the system. Provide training covering the following subjects:

    a. System overview.
    b. System hardware components and specific equipment arrangements.
    c. Periodic maintenance.
    d. Troubleshooting and diagnosis.
    e. Network configuration, communications, and operation.
    f. TCP/IP addressing procedures for all Ethernet devices.

C. Programmable Logic Controller (PLC) Hardware and Software:

1. Provide training for the Owner's personnel in the operation, maintenance, troubleshooting, etc. with the PLC hardware and software system. The training shall be held before the FDT, but not more than one month before.
2. Provide training and instruction specific to the system that is being supplied.
3. Provide training consisting of classroom instructions and hands-on instruction utilizing the Owner's system. Provide detailed training on the actual configuration and implementation for this Contract covering all aspects of the PLC system that will allow the Owner's personnel to maintain, modify, troubleshoot, and develop future additions/deletions to the PLC system. Provide training covering the following subjects:

    a. PLC system overview.
    b. PLC system architecture.
    c. PLC system hardware components and specific equipment arrangements.
    d. PLC system startup, shut down, load, backup, and PLC failure recovery.
    e. Periodic maintenance.
    f. Troubleshooting and diagnosis down to the I/O card level.
    g. PLC configuration, communications, and operation.

D. Instrument Manufacturer Training:

1. Provide manufacturer instrument training for those instruments where specifically indicated in the Instruments section. This is on-site training provided by an authorized representative of the manufacturer. The manufacturer's representative is required to be fully knowledgeable in the operation and maintenance of the equipment.

E. Instrument Training:

1. Provide instruction on the maintenance of the field and panel instrumentation for the Owner's instrumentation technicians. Conduct this training before the FDT, but no more than1 month before and at a time suitable to the Owner. This training shall take place at the Owner's facility. Training program is required to include the following elements:

    a. Training in standard hardware maintenance for the instruments provided.
    b. Specific training for the actual instrumentation configuration to provide a detailed understanding of how the equipment and components are arranged, connected, and set up for this Contract.
    c. Testing, adjustment, and calibration procedures.
    d. Troubleshooting and diagnosis.
    e. Maintenance and frequency.

F. Instruments - Operator familiarity:

1. Provide operator level instruction on the use of the field and panel instrumentation for the Owner's operations staff. Conduct training at a time suitable to the Owner. This training shall take place at the Owner's facility. Include hands on demonstration of the information each transmitter indicates, and the method used to retrieve any operator information from the transmitter, including use of pushbuttons and interpretation of international graphic symbols used on the instruments.

END OF SECTION 13613

SECTION 13614 - PROCESS CONTROL DESCRIPTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Refer to Section 406113.

1.2 SUMMARY

A. This Section is provided to clarify the control strategies to be used to program the system.

B. All SCADA System PLC controller programming and SCADA Operator Interface Terminal (OIT) or Operator Workstation Station (OWS) graphics and programming shall be performed as defined in Section 13622 – Operator Workstation Computers and Section 13631 - Operator Interface Terminals.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. The control descriptions are broken into areas. The following is a list of areas and the loop numbers associated with each area.

1.	Influent Pump Station	100-199
	Dry Weather Primary Pumps, Clarifiers, & Soda Ash System	300-399
	Final Clarifiers & Return Sludge Pumps	500-599
	UV System	600-629
	Dry Weather Effluent Pump Station	630-656
	Flood Pump Station	658-679
	UPS and Miscellaneous SCADA Devices Monitoring	1920-1999
	Electrical Manhole Alarms	2701-2740
	Electrical and Power Monitoring	2000-2699, 2800-3098, 3201-3218

B. The control descriptions are sorted by loop number for each area. The loop index has three columns associated with it; Loop Number, Loop Description, and Page. Each loop is associated with a specific SCADA I/O cabinet location to which it shall communicate.

C. The control descriptions are broken into a hierarchical layer concept. There may be one layer or multiple layers per loop, depending upon that loop. An example of multiple layered loop is as follows. The lowest layer of control, local control, is at that piece of equipment or that piece of equipment's panel or drive. The second layer of control is at an intermediate control panel between the equipment and the SCADA I/O or vendor's PLC I/O. The third layer would be at the vendor's PLC or microprocessor touchscreen station. The highest layer of control is by the SCADA PLC System with its associated operator workstations (OWS) in the main control room, remote office locations, and satellite locations operator interface terminals (OITs). The SCADA PLC/ OWS refers to both the SCADA PLC, which does the actual monitoring and control logic for the process equipment and the SCADA operator workstation (OWS), which are computers that have graphical software that interface to the PLC software for monitoring and implementing all operator-required tasks to control that process equipment. Any functions done in the operator workstations also take place at all the SCADA OITs.

3.2 CONTROL FUNCTION DEFINITIONS AND GENERAL CRITERIA

A. The hardware and/or software functions noted by this paragraph reference are to be implemented by the SCADA PLC/OWS control system specified herein.

B. The following list of ISA abbreviations is typical of those utilized. The description, following the abbreviation, summarizes the basic function to be implemented in the SCADA PLC/OWS software.

1. HS: Represent selector switches or pushbuttons, which shall be implemented by keyboard entry. Function shall be similar to their hardware counterparts. Examples are as follows:

    a. HSH-Open Command.
    b. HSL-Close Command.
    c. HSS-Start/Stop Command.

2. YI: Represents equipment status (i.e., availability, running, in remote, etc.) implemented by a change of color on the OWS symbol for this equipment. For motor driven equipment such as pumps, blowers, compressors, etc., availability contact represents remote operation and no alarm conditions. Examples are as follows:

    a. YCI-Selector switch in auto or remote position.
    b. YRI-Motor running status.
    c. YFI-Motor failure or overload status.
    d. YMI-Selector switch in maintenance position.

3. PAL, AAH, UA, etc.: Represent high or low alarms implemented on the OWS.
4. FIC, PIC, AIC, etc.: Represent PID process controllers implemented in a controller logic algorithm incorporating proportional, integral, and/or derivative modes. Local/remote and manual/auto capabilities shall be provided.
5. FIK, PIK, AIK, etc.: Represent control stations implemented in logic (via keyboard entry and CRT display) to allow downloading of a set point to a FIC, PIC, AIC, etc., and display of the process variable or controller output.

6. FI, PI, AI, etc.: Represent digital output display on the CRT of a process variable in engineering units and/or a dynamic representation of the variable by symbol or graphical means.
7. FIR, PIR, AIR: Represent values stored on the hard disk to provide the data for historical trend graphics of process variables against time (or other selected variables).
8. ZSH, ZSL etc.: Represent high or low, open or close limit positions implemented on the OWS

C. All interlocks that are represented, before the local operational descriptions, or are stated as hardwired interlocks, shall interlock all the controls locally and at the SCADA PLC/OWS or at the vendor PLCs. The SCADA PLC shall be programmed to shut down that equipment if that hardwired interlock is also wired to the SCADA PLC.

D. All interlocks that are represented in a particular layer of the operational descriptions, shall interlock all the controls in that layer and the layer after it. However, the interlock shall not interlock the commands in the layer before it.

E. The SCADA system shall stop a motor or drive in its program if it does not receive the auto or remote status or one of its software interlocks trip. If the drive or motor is in hand or remote it will continue to run but the SCADA start/stop output will be open.

F. All motors that are requested to start by an operator or an automatic program shall alarm if the run confirm status for that motor does not activate within two seconds. If a motor stops by an interlock or stops without any operator or SCADA intervention, then that motor shall go into alarm. All motors that are stopped by a program or the operator shall not go into an alarm.

G. All valves that are requested to open by an operator or an automatic program shall alarm if the open feedback status for that valve does not activate within ten seconds. All valves that are requested to close by an operator or an automatic program shall alarm if the close feedback status for that valve does not activate within ten seconds.

H. Motors that have an H/O/A (or L/O/R) switch shall indicate to the operator that the pump is being run in the "Hand" (or “Local”) position. A motor is being run in "Hand" when the "Auto" (or “Remote) position is not true and the run confirm status is true. If not in "Auto" the SCADA PLC shall open up its output contact to stop (shutdown) the pump from SCADA.

I. All motors shall be programmed so if a motor stops for an alarm or fault condition (except a loss of power), it shall not be re-started automatically once the problem with the motor has been resolved. The start command on the OWS shall not be a maintained contact but a momentary command to the PLC. The run confirms of all motors shall seal in the control output to the motor once the momentary start command drops out. The run confirms shall be on a five second timer delay in that if the run confirm is not present after five seconds, the contact output to the motor from the PLC shall drop out. Thus, the only way a motor can be restarted after five seconds by the SCADA system is if the operator reinitiates the start command for that motor on the OWS or when that motor control at the OWS is placed in complete automatic mode and the PLC through logic/interlocks requests the motor to run.

J. Terminology associated with interlocks is as follows:

1. When a contact or status is true, the PLC will receive power to its input channel. The PLC registers this as a binary bit of one.

2. When a contact or status is false, the PLC will receive no power (open circuit) to its input channel. The PLC registers this as a binary bit of zero.

K. When an analog signal goes outside the 4-20 mA range due to a failure at the instrument or PLC card, the following SCADA programming shall take place:

1. Alarm the signal at any local OITs and in the HMI system.
2. If the analog signal is associated with a control loop or ratio control loop that loop shall go into manual.
3. If the analog signal is used in a calculation, that calculation shall use the last good analog signal. The PLC shall place the control loop in manual if using the calculation.

L. Disable all alarms on analog inputs unless specifically called for in the drawings or specifications.

M. All interlocks that shutdown (Stop a piece of equipment and prevent it from being restarted or moved) shall be shown on the faceplate pop-up graphic for that piece of equipment.

N. The run confirms or on status of all motors and lamps shall be accumulated to calculate a run time status of the equipment on the HMI graphic.

O. Select flow indications shall be totalized (as determined during the draft graphic review meeting, refer to section 13684 “Configuration of HMI Software”). Do not totalize if the analog signal is outside the 4-20 mA range. Do not totalize if the value of the flow input is less than 2% of the full range of the input.

3.3 INDIVIDUAL CONTROL DESCRIPTIONS AND CONTROL SEQUENCES

LOOP INDEX

LOOP 103 TOTAL FLOW INTO PLANT

General:

The combined calculated flow of Blackstone Valley Interceptor Flume Flow and the East Providence Interceptor Flume Flow shall be used in calculating the total flow into the Wet Weather System, and in triggering the auto-sequences for the influent pumps, vortex grit collectors and grit equipment. The monitoring and control described in this loop is existing, however the flow setpoints will be updated as described below.

Control:

Local:

None

SCADA PLC/OWS:

Flow measurement shall be used in a following formula to determine the flow into the wet weather system.

(FIT100B + FIT101B) = Total Flow Into Plant (FY103)
FY103- FIT303 = Total Flow into Wet Weather System (FY700)

FY700 shall be used in pacing sodium hypochlorite and bisulfite pumps.

When the **PRIMARY** auto-sequence mode is selected the total flow (FY-103) shall be used to trigger the two auto sequences.

Activation:

At a certain flow (operator adjustable between 5.76-14.4 MGD, initially set at 7.2 MGD) the Influent Pump Lead Sequence shall be activated. Once the flow increases to a second flow setpoint (operator adjustable between 36-47.52 MGD, initially set at 37.44 MGD), the Influent Pump Lag 1 Sequence shall be activated. If the flow continues to increase and reaches the third and final flow setpoint (operator adjustable between 72-79.2 MGD, initially set at 76.32 MGD) the Influent Pump Lag 2 Sequence shall be activated.

De-Activation:

If three row of the sequences are running and the flow decreases to flow setpoint (operator adjustable between 67.68-76.32 MGD, initially set at 72 MGD) the Influent Pump Lag 2 Sequence shall be deactivated. As the flow continues to decrease to flow setpoint (operator adjustable between 31.68-37.44 MGD, initially set at 36 MGD), the Influent Pump Lag 1 Sequence shall be deactivated.

The auto-sequence program shall always leave one pump running. To stop all the pumps the operator must manually stop it.

LOOP 105 RAW WATER INFLUENT WETWELL LEVEL

General:

Level measurement monitored by existing continuous level monitoring system. The level measurement shall be used in loops 110-1 thru 110-4 (and associated loops) for speed control of VFD pumps and in a **BACKUP** mode to determine the automatic sequencing of the Influent Pumps. When in automatic mode, the lead influent pump shall always be running. In the backup level control mode, influent wetwell level will be used to activate lag pumps. The programming described below existing, but the level setpoints shall updated as described. When in backup mode, these setpoints also trigger operation of the vortex grit collectors and grit equipment. Triggering of the systems based on these setpoints will remain as currently programmed.

Control:

Local:

None

SCADA PLC/OWS:

BACKUP Influent Pump System Activation and Deactivation

The level measurement of the existing LIT-105 shall be updated to 6.5 feet.

When the backup level control mode is selected, pump activation and deactivation shall operate as follows.

When the raw water influent wetwell level reaches an Influent Pump Lead Start Setpoint (2.59 feet, operator adjustable), the Influent Pump Lead Sequence shall be activated. When the raw water influent wetwell level reaches an Influent Pump Lag 1 Start Setpoint (5.4 feet, operator adjustable), the Influent Pump Lag 1 Sequence shall be activated. When the raw water influent wetwell level reaches an Influent Pump Lag 2 Start Setpoint (5.97 feet, operator adjustable), the Influent Pump Lag 2 Sequence shall be activated.

If the Influent Pump Lag 2 Sequence is active and the raw water influent wetwell level falls below an Influent Pump Lag 2 Stop Setpoint (4.71 feet), the Influent Pump Lag 2 Sequence shall be deactivated. If the Influent Pump Lag 1 Sequence is active and the raw water influent wetwell level falls below an Influent Pump Lag 1 Stop Setpoint (4.08 feet), the Influent Pump Lag 1 Sequence shall be deactivated.

In automatic mode, one pump shall always remain running. To stop all the pumps the operator must manually stop it.

Variable Speed Influent Pump Level Controller

The raw water influent wetwell level shall be used as the process variable for software PID controller, LIC-105, whose output shall control the speed any running variable speed Influent Pumps (see Loops 111-1 and 111-4).

The operator shall be able to enter a level set point (operator adjustable between 4.75 feet and 5.90 feet) to the level controller and the output of the controller (LIC-105) shall control the speed of any running influent screw pumps (Loops 111-1 and 111-4). When the operator enters a level set point, the controller shall adjust the output to maintain a level measurement that is equal or very close to the actual set point entered by the operator.

Alarms / Monitoring:

SCADA PLC/OWS:

Level (LI) (existing).
High Level (LAH) (existing).
High High Level (LAHH) (existing).

LOOPS 110-1 TO 4 INFLUENT PUMP SYSTEMS

General:

On/Off Operation of the Influent Screw Pump Systems. Operation shall be either at the pumps or from an OWS/SCADA PLC.

Control:

Hardwired Interlocks:

Influent Pump Systems 110-2 and 110-3 (Existing):

An influent pump system Start command, either locally or from the SCADA PLC/OWS, first activates the associated grease pump. Once the grease pump's run confirm has been energized and the flow switch (FSL-112-*X*) on the grease line is no longer low the screw pump shall be energized.

The grease pump flow switch shall be hardwired to the screw pump starter. If the flow switch is low the screw pump shall not be able to be started or shall stop if running.

Influent Pump Systems 110-1 and 110-4 (New):

An influent pump system Start command, either locally or from the SCADA PLC/OWS, first activates the associated grease pump. Once the grease pump's run confirm has been energized and the flow switch (FSL-112-*X*) on the grease line is no longer low the screw pump shall be energized.

The grease pump run status and flow switch shall be hardwired to the screw pump VFD. If the grease pump run status is off or the flow switch is low after the screw pump has been running for 10 seconds (adjustable by a time delay relay in the VFD), the screw pump shall stop.

If the screw pump's gear box oil low flow switch (FSL-113-*X*) or low-pressure switch (PSL-113-*X*) is in alarm after the screw pump has been running for 10 seconds (adjustable by a time delay relay in the VFD), the screw pumps shall stop.

If the screw pump's gear box oil low level switch (LSL-113-*X*) is in alarm for 30 seconds (adjustable by a time delay relay in the VFD), the screw pump shall be prevented from running or stopped if it is running.

If the screw pump's gear box oil high temperature switch (TSH-113-*X*) is in alarm, the screw pump shall be prevented from running or stopped if it is running.

If the screw pump's low speed switch (SSL-111-*X*) is in alarm after the screw pump has been running for 10 seconds (adjustable by a time delay relay in the VFD), the screw pumps shall stop.

If the screw pump's motor winding high temperature switch (TSH-111-*X*) is in alarm, the screw pump shall be prevented from running or stopped if it is running.

Local:

Local Start/Stop Control:

Influent Pump Systems 110-2 and 110-3 (Existing):

Local Start/Stop control is performed by the system Hand/Off/Auto (HOA) selector switch.

Hand: When the HOA selector switch is in the "Hand" position, the grease pump will start, which will in turn start the screw pump as described above (See "Hardwired Interlocks").

Off: When the HOA selector switch is in the "Off" position, the system will be stopped if running or prevented from starting.

Auto: When the HOA selector switch is in the "Auto" position, pump system Start/Stop control is transferred to the SCADA PLC/OWS.

Influent Pump Systems 110-1 and 110-4 (New):

Local Start/Stop control is performed by the Local/Off/Remote (LOR) selector Switch and Start and Stop pushbuttons at the Screw Pump VFD Panels.

Local: When the LOR selector switch is in “Local” the screw pump can be started by the Start and Stop pushbuttons. A momentary press of the Start pushbutton shall start the grease pump, which will in turn start the screw pump as described above (See “Hardwired Interlocks”). A momentary press of the Stop pushbutton shall stop the grease pump and the screw pump.

Off: When the LOR selector switch is in the "Off” position, the system will be stopped if running or prevented from starting.

Remote: When the LOR selector is in the “Remote” position, influent pump system Start/Stop control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlocks:

Influent Pump Systems 110-2 and 110-3 (Existing):

Software interlocks to the system that occur when control is at the SCADA PLC/OWS are as follows:

If the zero-speed switch (SSL-111-*X*), the flow switch (FSL-113-*X*) or the pressure switch (PSL-113-*X*) is in alarm after the screw pump has been running for 10 seconds, the system shall shutdown.

If the lube oil level switch is low (LSL-113-*X*) for more than 30 seconds the system shall shutdown or cannot be started.

If the associated influent gate is not open (ZSH-107-*X*) then the system cannot be started at the OWS.

Influent Pump Systems 110-1 and 110-4 (New):

Software interlocks to the system that occur when control is at the SCADA PLC/OWS are as follows:

If the associated influent gate is not open (ZSH-107-*X*) then the system cannot be started at the OWS.

If the associated grease pump is not running or in “Auto” at the grease pump LCS (see Loop 112-1 or 112-4), the system cannot be started at the OWS.

Manual:

All Influent Pump Systems:

If the screw pump system is in manual mode at the SCADA PLC/OWS, the system can be manually started or stopped by the operator at the OWS.

Auto:

If the screw pump is in automatic mode at the SCADA PLC/OWS, the screw pump shall be started and stopped according to the following:

Influent Pump Automatic Sequence

If no Influent Pumps are running in automatic mode, the operator shall be able to set an Influent Pump Order by assigning each of the four Influent Pumps to one of the following: Influent Pump Lead, Influent Pump Lag 1, Influent Pump Lag 2, Influent Pump Standby. If an Influent Pump Order is already set, the operator must first clear the current Influent Pump Order. If an Influent Pump Order has not been selected, an alarm will be generated.

The operator shall be able to change the Influent Pump Order when up to two influent pumps are running. When changing the Pump Order when one influent pump is on, the Lead pump from the last order shall remain on until the Lead pump of the new order starts, and then the Lead pump from the old order shall stop. Thus, during a change from order A to order G, Influent Pump 1 shall remain running until Influent Pump 2 is running, and then Influent Pump 1 shall shutdown.

When changing Pump Order when two influent pumps are one, and the new order shares both pumps with the last order, both pumps shall remain running while order is changed.

When changing the Pump Order when two influent pumps are on, and the new order shares one pump with last order, there will be two pumps whose run command will change:

- Last Pump: Pump that is part of the last order, but not part of the new order.
- New Pump: Pump that is part of the new order, but not part of the last order.

The Last Pump will remain on until the New Pump starts, and then the Last pump shall stop. Thus, during a change from order A to order C, Influent Pump 2 will remain running until Influent Pump 3 is running, and then Influent Pump 2 shall shutdown.

When changing the Pump Order when two influent pumps are on, and the new order does not share any pumps with the last order, the last Lead pump will remain on until the new Lead pump starts, and then the last Lead pump shall stop. After the Lead pump has been switched to the new order and a subsequent time delay (initially set at 10 seconds), the Lag 1 pumps may then change. The last Lag 1 pump will remain on until the new Lag 1 pump starts, and then the last Lag 1 pump may stop. Thus, during a change from Order A to Order Q, both Influent Pumps 1 and 2 will continue to run until Influent Pump 3 is running, then Influent Pump 1 will stop. Once Influent Pump 1 stops and the subsequent time delay expires, Influent Pump 4 will start while Influent Pumps 2 and 3 are running. Once Influent Pump 4 is running, Influent Pump 2 will stop.

If a change in Pump Order is attempted while three pumps are running, the operator will be limited to selecting the three pumps that are already running. The pumps will remain running until the new order is selected.

The following is the list of possible Influent Pump Orders, with the Influent Pump System listed by its Loop Suffix:

ORDER	LEAD	LAG 1	LAG 2	STANDYBY
A	1	2	3	4
B	1	2	4	3
C	1	3	2	4
D	1	3	4	2
E	1	4	2	3
F	1	4	3	2
G	2	1	3	4
H	2	1	4	3
I	2	3	1	4
J	2	3	4	1
K	2	4	1	3
L	2	4	3	1
M	3	1	2	4
N	3	1	4	2
O	3	2	1	4
P	3	2	4	1
Q	3	4	1	2
R	3	4	2	1
S	4	1	2	3
T	4	1	3	2
U	4	2	1	3
V	4	2	3	1
W	4	3	1	2
X	4	3	2	1

If an influent pump is not available for automatic start, fails, or does not start the Standby Pump shall be started.

If no pumps are running, an Influent Pump Order has been selected, an influent pump is available for automatic start, and the Influent Pump Lead Start Setpoint (Loop 105) the lead influent pump system shall be started.

If the Lead Influent Pump is running and the Influent Pump Lag 1 Start Setpoint (Loop 105) is reached, the Lag 1 Influent Pump system shall be started.

If the Lead and Lag 1 Influent Pumps are running and the Influent Pump Lag 2 Setpoint (Loop 105) is reached, the Lag 2 Influent Pump System Shall be started.

If the Lead, Lag 1, and Lag 2 Influent Pumps are running and the Influent Pump Lag 2 Stop Setpoint (Loop 105) is reached, the Lag 2 Influent Pump System Shall be stopped.

If the Lead and Lag 1 Influent Pumps are running and the Influent Pump Lag 1 Stop Setpoint (Loop 105) is reached, the Lag 1 Influent Pump System Shall be stopped.

If the Lead Influent Pump is running and the Influent Pump Lead Off Setpoint (Loop 105) is reached, the Lead Influent Pump System shall be stopped.

Alarms / Monitoring:

Local:

Influent Pumps Systems 110-2 and 110-3 (Existing):

None

Influent Pump Systems 110-1 and 110-4 (New):

None

SCADA PLC/OWS:

Influent Pumps Systems 110-2 and 110-3 (Existing):

HOA selector switch in “Auto” (YCI)

LOOP 111-1 INFLUENT SCREW PUMP NO. 1

General:

Speed operation of the pump (see Loops 110-1 thru 110-4 for Start/Stop Operation). The Operation of the pump is either at pump's VFD or at the SCADA PLC/OWS.

Control:

Hardwired Interlocks:

If the screw pump VFD in a fault state, the pump shall be stopped if it is running or prevented from starting.

See Loops 110-1 to 4 for other screw pump hardwired interlocks.

Local:

On/Off Operation

See Loops 110-1 to 4 for screw pump Local Start/Stop operation.

Speed Control

When the VFD LOR selector switch is in “Local” the pump speed may be set by the VFD keypad.

SCADA PLC/OWS:

Software Interlock:

See Loops 110-1 to 4 for software interlocks.

On/Off Operation

See Loops 110-1 to 4 for Start/Stop control.

Speed Control:

Manual:
In manual mode, the operator can enter a speed setpoint (0-100%) to command the pump to run at a percentage speed.

Automatic:
Once the first Variable Speed Influent Pump System (110-1 or 110-4) in the Automatic Influent Pump Sequence begins running, the pump speed shall be ramped up to the minimum speed setpoint (initially set at 50% speed). Once at the minimum speed setpoint, the level controller output (LIC-105) shall be used and converted to a speed set point between 0-100% and this pump shall control the level. The speed can be controlled between the minimum speed setpoint and the maximum speed setpoint (100% speed).

If the second Variable Speed Influent Pump system in the Automatic Influent Pump Sequence is started, the second variable speed influent pump shall be ramped up to the minimum speed setpoint and the first variable speed pump shall be ramped down to the minimum speed setpoint. Once both pumps are at the minimum speed setpoint, the level controller output (LIC-105) shall be used and converted to a speed setpoint between 0-100%. The same level controller output will used for both pumps. The speed of the two pumps can be controlled between the minimum speed setpoint and the maximum speed setpoint. The minimum and maximum speed setpoints shall be the same for both variable speed influent pumps

If more than two influent pumps are running, the maximum speed setpoint of the variable speed influent pumps shall be lowered to a Max-Flow maximum speed setpoint (70%).

Alarms / Monitoring:

Local:

VFD Speed (SI) at VFD keypad
Pump Running Light (YRI) at VFD panel
Pump Stopped Light (YRI) at VFD panel
Low Speed Switch Light (SAL) at VFD panel
High Motor Temperature Light (TAH) at VFD panel
VFD Fault Light (XA) at VFD panel
Grease Pump Fault Light (XA) at VFD Panel.

SCADA PLC/OWS:

LOR selector switch (HS) is in "Remote" (YCI)
Motor Run Confirm Status (YRI)
Low Speed (SAL)

High Motor Temperature (TAH)
VFD Fault (XA)
VFD Speed (SI)

LOOP 111-2 INFLUENT SCREW PUMP NO. 2 (EXISTING)

General:

On/off operation of the pump. The Operation of the pump is either at pump's LCS or at the SCADA PLC/OWS.

Control:

Hardwired Interlocks:

If the screw pump motor is in an overload state, the pump shall be stopped if it is running or prevented from starting.

See Loops 110-1 to 4 for other screw pump hardwired interlocks.

Local:

On/Off Operation

See Loops 110-1 to 4 for screw pump Local Start/Stop operation.

SCADA PLC/OWS:

Software Interlock:

See Loops 110-1 to 4 for software interlocks.

On/Off Operation

See Loops 110-1 to 4 for Start/Stop control.

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

Motor Run Confirm Status (YRI)
Low Speed (SAL)
Motor Overload (XA)

LOOP 111-3 INFLUENT SCREW PUMP NO. 3 (EXISTING)

Functionally identical to Loop 111-2.

LOOP 111-4 INFLUENT SCREW PUMP NO. 4

Functionally identical to Loop 111-1.

LOOP 112-1 INFLUENT SCREW PUMP SYSTEM NO. 1 GREASE PUMP

General:

On/off operation of the grease pump. Operation can be either locally at the grease pump LCS or automatically via hardwired interlock with associated screw pump VFD.

Control:

Hardwired Interlocks:

If the grease pump motor is in an overload state, the pump shall be stopped if it is running or prevented from starting.

See Loops 110-1 to 4 for other screw pump hardwired interlocks.

Local:

On/Off Operation

Local Start/Stop control is performed by the Local/Off/Auto (LOA) selector switch and start and stop pushbuttons located at the Grease Pump Local Control Station.

Local: When the LOA selector switch is in the "Local" position, the pump can be started by the Start and Stop pushbuttons. A momentary press of the Start pushbutton shall start the grease pump. A momentary press of the Stop pushbutton shall stop the grease pump.

Off: When the LOA selector switch is in the "Off" position, the grease pump will be stopped if running or prevented from starting.

Auto: When the LOA selector switch in the "Auto" position, the grease will be started by interlock with the associated screw pump VFD. See Loops 110-1to 4.

SCADA PLC/OWS:

Software Interlock:

None

On/Off Operation

None

Alarms / Monitoring:

Local:

Motor Run Confirm Light (YRI) at the grease pump's MCC-SG cubicle.
Grease Low Flow Light (FAL) at the grease pump's MCC-SG cubicle.
Motor Overload Light (XA) at the grease pump's MCC-SG cubicle.

SCADA PLC/OWS:

Motor Run Confirm Status (YRI)
Grease Low Flow (FAL)
Motor Overload (XA)

LOOP 112-2 INFLUENT SCREW PUMP SYSTEM NO. 2 GREASE PUMP (EXISTING)

General:

On/off operation of the grease pump. The operation of the system is either at pump or at the OWS.

Control:

Hardwired Interlocks:

See Loops 110-1 to 4 for other screw pump hardwired interlocks.

Local:

None

SCADA PLC/OWS:

Software Interlock:

None

On/Off Operation

None

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

Motor Run Confirm Status (YRI)
Grease Low Flow (FAL)
Motor Overload (XA)

LOOP 112-3 INFLUENT SCREW PUMP SYSTEM NO. 3 GREASE PUMP (EXISTING)

Functionally identical to Loop 112-2.

LOOP 112-4 INFLUENT SCREW PUMP SYSTEM NO. 4 GREASE PUMP

Functionally identical to Loop 112-1.

LOOP 113-1 INFLUENT SCREW PUMP SYSTEM NO. 1 OIL SYSTEM

General:

Lubrication of the influent screw pump gearbox. Lubrication system is driven by the screw pump's motor, so it runs when the screw pump operates.

Control:

Hardwired Interlocks:

See Loops 110-1 to 4 for other screw pump hardwired interlocks.

Local:

None

SCADA PLC/OWS:

Software Interlock:

See Loops 110-1 to 4 for other screw pump software interlocks.

Alarms / Monitoring:

Local:

Oil High Temp Light (TAH) at the associated screw pump VFD.
Oil Low Flow Light (FAL) at the associated screw pump VFD.
Oil Low Pressure Light (PAL) at the associated screw pump VFD.
Oil Low Level Light (LAL) at the associated screw pump VFD.

SCADA PLC/OWS:

Oil High Temp (TAH)
Oil Low Flow (FAL)
Oil Low Pressure (PAL)
Oil Low Level (LAL)

LOOP 113-2 INFLUENT SCREW PUMP SYSTEM NO. 2 OIL SYSTEM (EXISTING)

General:

Lubrication of the influent screw pump gearbox. Lubrication system is driven by the screw pump's motor, so it runs when the screw pump operates.

Control:

Hardwired Interlocks:

See Loops 110-1 to 4 for other screw pump hardwired interlocks.

Local:

None

SCADA PLC/OWS:

Software Interlock:

See Loops 110-1 to 4 for other screw pump software interlocks.

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

Oil High Temp (TAH)
Oil Low Flow (FAL)
Oil Low Pressure (PAL)
Oil Low Level (LAL)

LOOP 113-3 INFLUENT SCREW PUMP SYSTEM NO. 3 OIL SYSTEM (EXISTING)

Functionally Identical to Loop 113-2

LOOP 113-4 INFLUENT SCREW PUMP SYSTEM NO. 4 OIL SYSTEM

Functionally Identical to Loop 113-1

LOOP 355 RETURN SLUDGE FLOW TO DRY WEATHER PRIMARY EFFLUENT FLOW SPLITTER BOX NO. 1

General:

Continuous flow measurement by an existing magnetic flow meter. (Monitoring of this point was previously programmed into the existing CPP-4 PNL 2 PLC processor. However, the use of this point for calculating the flow rate from Return Sludge Pump Station No. 1 will be updated).

Control:

Local:

None.

SCADA PLC/OWS:

The flow signal shall be used to calculate the flow from Return Sludge Pump Station 1. See Loop 546.

Alarms / Monitoring:

Local:

Flow (FIT).

SCADA PLC/OWS:

Flow (FI).

LOOP 357-1 RETURN SLUDGE FLOW CONTROL TO AERATION TANK NO. 1

General:

Return sludge from the three return sludge pump stations can be supplied directly to the four aeration tanks when not supplied to the Dry Weather Primary Effluent Flow Splitter box (through Magnetic Flow Meter FIT/FE-355, see Loop 355). Return sludge flow sent directly to the Aeration Tanks will be balanced equally between the aeration tanks with continuous flow monitoring by magnetic flow meters and flow control by modulating pinch valves on the return sludge distribution lines to each of the four Aeration Tanks. Operation of the modulating valve is either at the valve via its integral Local Control Station (LCS) or at the SCADA PLC/OWS.

Control:

Local:

Flow control valve operation can be locally controlled by the LCS integral to the valve actuator. The valve LCS shall have a Local/Off/Remote (LOR) selector switch and "Open" and "Close" pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the valve can be opened stopped in mid-travel, or closed by the Open and Close pushbuttons. Local operation of the valve shall be inching such that the "Open" or "Close" pushbuttons must be continuously depressed for the valve to continue to open or close, respectively.

Off: When the LOR selector switch is in the "Off" position, the valve cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, valve control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

When a motor overload condition is detected, the SCADA PLC/OWS open or close command will be disabled.

Manual Mode:

When the valve is placed into "Manual" from the OWS, the operator can enter a valve position setpoint to command the valve to a position.

Automatic Mode:

When any of the return sludge flow control valves (PCHV-357-1, 2, 3, or 4) are placed in automatic mode, all return sludge flow control valves in automatic mode will open to a Maximum Open Position (initially set at 90%) for a period of time (initially set at 5 minutes). At the end of this time period, the valve whose associated flow meter (FIT/FE-357-1, 2, 3, or 4) has the lowest flow will be set as the Most-Open-Valve (MOV). Once a MOV has been selected, the MOV will be maintained at the Maximum Open Position. The real-time flow value from the MOV's associated flow meter will be used as a setpoint for the other return sludge flow control valves that are in automatic mode.

For each flowmeter not associated with the MOV, the flow measurement shall be used as the process variable to a software PID controller. The setpoint to the PID controller will be the real-time flow associated with the MOV. The output from the PID controller shall control the return sludge flow control valve. The output from the controller is reverse-acting, in that the valve will close as the flow upstream increases in order to maintain the flow set point.

If the output from one of the flow PID controllers (in percent of valve position) exceeds the Maximum Open Position for a period of time (initially set a 20 seconds), the valve controlled by this controller will be selected as the MOV and operate as described above. The previous MOV will be controlled by a flow PID controller as described above.

Should any individual flow PID controllers fail (for example due to a loss of the flow signal, loss of valve feedback, or loss of valve position output) the valve control will be placed into Manual Mode, with the valve position setpoint set as the last know output from the PID controller.

Should the MOV flow control fail (for example due to a loss of the flow signal, valve feedback, or valve position output), the return flow control valve that is in automatic mode that has the greatest flow PID controller output (in percent of valve position), will be selected as the MOV. The previous MOV will be placed into Manual Mode, with the valve position setpoint maintained at the last know valve setpoint.

The flow signals shall be used to calculate the flow from Return Sludge Pump Station 1. See Loop 546.

Alarms / Monitoring:

Local:

Flow Indication (FIT)
Valve Position (ZIT)
Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)

SCADA PLC/OWS:

Flow Indication (FI)
High Flow Alarm (FAH) – Programmed for Flow 10% Higher than Setpoint
Low Flow Alarm (FAL) – Programmed for Flow 10% Lower than Setpoint
Valve Position (ZT)
Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)
Valve LOR Selector Switch Position (YCI)

LOOP 357-2 RETURN SLUDGE FLOW CONTROL TO AERATION TANK NO. 2

Functionally identical to Loop 357-1.

LOOP 357-3 RETURN SLUDGE FLOW CONTROL TO AERATION TANK NO. 3

Functionally identical to Loop 357-1.

LOOP 357-4 RETURN SLUDGE FLOW CONTROL TO AERATION TANK NO. 4

Functionally identical to Loop 357-1.

LOOPS 505, 506, 507 FINAL CLARIFIER NO. 1 THRU 6 FLOW CONTROL (UPDATED)

General:

Flow to Final Clarifiers 1 through 6 is controlled by existing doppler flow meters and existing butterfly valves. Flow is controlled in pairs of clarifiers: Clarifiers 1 and 2; Clarifiers 3 and 4; and Clarifiers 5 and 6. Each pair of clarifiers has one doppler flow meter and one butterfly valve. A flow controller (FIC) controls flow to each pair of clarifiers. In the existing programming, flow to each pair is set by as an operator adjustable percentage of total flow to the clarifiers. Based on the entered percentages and the total dry weather flow a flow setpoint is calculated for each pair of clarifiers. For example, flow to Final Clarifiers No. 1 and 2 would be calculated as:

$$FC\ No.1\ and\ 2\ Flow = (Total\ Flow\ to\ FC's) \times (\frac{\%\ Setpoint\ to\ FC\ No.1\ and\ 2}{100})$$

The total flow to the Final Clarifiers is calculated as the sum of the Dry Weather Flow (existing FI-303 measured at CPP-4) and the total RAS Flow. Under this contract the total RAS flow calculation will be updated as below:

Total RAS Flow = (FI-355) + [(FI-357-1) + (FI-357-2) + (FI-357-3) + (FI-357-4)]

As a result, the total final clarifier flow will be updated to:

Flow to FC's = FI-303 + (FI-355) + [(FI-357-1) + (FI-357-2) + (FI-357-3) + (FI-357-4)]

The existing flow splitting controls to the final clarifiers will remain but be updated to also include individual percentage flow setpoints to Final Clarifiers No. 7 and No. 8. This percentage setpoint will be used to set a flow setpoint for clarifiers No. 7 and No. 8 (see Loops 509-7 and 509-8). The sum of all the % flow setpoints to the clarifiers must equal 100% to be accepted.

LOOP 509-7 FINAL CLARIFIER NO. 7 FLOW CONTROL

General:

Continuous flow measurement into the Final Clarifier by means of a Magnetic Flow Meter. The flow measurement shall be used to control the operation of its associated flow control butterfly valve. Operation of the modulating valve is either at the valve via its integral Local Control Station (LCS) or at the SCADA PLC/OWS.

Control:

Hardwired Interlocks:

None.

Local:

Flow control valve operation can be locally controlled by the LCS integral to the valve actuator. The valve LCS shall have a Local/Off/Remote (LOR) selector switch and "Open" and "Close" pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the valve can be opened, stopped in mid-travel, or closed by the Open and Close pushbuttons. Local operation of the valve shall be inching such that the "Open" or "Close" pushbuttons must be continuously depressed for the valve to continue to open or close, respectively.

Off: When the LOR selector switch is in the "Off" position, the valve cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, valve control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

When a motor overload condition is detected, the SCADA PLC/OWS open or close command will be disabled.

Manual Mode:

When the valve is placed into "Manual" from the OWS, the operator can enter a valve position setpoint to command the valve to a position.

Automatic Flow Control:

An influent flow setpoint will be calculated based on the total flow to the final clarifiers (see Loops 505, 506, 507). An operator adjustable % flow setpoint will be used with the total Final Clarifier flow to set the Final Clarifier No. 7 Influent Flow Setpoint according to the below formula:

$$FC\ No.7\ Influent\ Flow = (Total\ Flow\ to\ FC's) \times (\frac{\%\ Setpoint\ to\ FC\ No.7}{100})$$

The flow measurement FI-509-7 shall be used as the process variable to a software PID controller (FIC-509-7). The above Final Clarifier No. 7 flow set point will be used as an input to the flow controller. The output from the controller shall control the control valve. The output from the controller is reverse-acting, in that the valve will close as the flow upstream increases to maintain the flow set point.

Alarms / Monitoring:

Local:

Flow Indication (FIT)
Valve Position (ZIT)
Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)

SCADA PLC/OWS:

Flow Indication (FI)
High Flow Alarm (FAH) – Programmed for Flow 10% Higher than Setpoint
Low Flow Alarm (FAL) – Programmed for Flow 10% Lower than Setpoint
Valve Position (ZT)
Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)
Valve LOR Selector Switch Position (YCI)

LOOP 509-8 FINAL CLARIFIER NO. 8 FLOW CONTROL

Functionally identical to Loop 509-7.

LOOP 510-1 FINAL CLARIFIER NO. 1 CONTROL AND MONITORING

General:

Control and on/off operation of the clarifier drive. Operation of the rake is either at the drive or at the SCADA. Clarifier effluent flow is monitored by a radar level meter monitoring a Palmer-Bowlus flume installed in the effluent launder. Clarifier effluent flow rate is calculated at the radar level meter's transmitter. Flow through the flume will be calculated using standard empirical relationships for Palmer-Bowlus flumes. Flow for the overall clarifier effluent flow rate will be calculated by multiplying the flume flow rate by two. Sludge level is monitored by an ultrasonic sludge blanket analyzer. (Control and monitoring of this equipment as described below is currently programmed in the existing CPP-6 processor with the exception of effluent flowrate monitoring and the sludge blanket level monitoring. All other Final Clarifier No. 1 control and monitoring will remain).

Control:

Hardwired Interlocks:

The high torque switch (WSH) shall be wired to the drive's motor starter. If the switch is tripped the motor shall stop.

Local:

The clarifier drive is controlled through a HOA switch and its starter. The HOA is located at the drive's motor.

Hand: When the HOA selector switch is in the "Hand" position, the clarifier drive will run.

Off: When the HOA selector switch is in the "Off" position, the clarifier drive will not run.

Auto: When the HOA selector switch is in the "Auto" position, control of the clarifier drive is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

If the SCADA system gets a high torque signal from the starter, the SCADA system shall open its start/stop command to the drive.

If the HOA switch is not in auto, the SCADA system shall open its start/stop command to the drive.

On/Off Features

Manual: The drive can be manually started or stopped (HSS) by the operator at the SCADA. When a drive is running, the Final Clarifier will be considered "Online".

Auto: None.

Alarms / Monitoring:

Local:

Effluent Flow Rate (FIT/LIT)
Sludge Blanket Level (LIT)

SCADA PLC/OWS:

Effluent Flow Rate (FI)
Sludge Blanket Level (LI)
H/O/A selector switch (HS) is in "Auto" (YCI)
Motor Run Confirm Status (YRI)
High Torque Status (WSH)
Motor Overload (YFI)

LOOP 510-2 FINAL CLARIFIER NO. 2 CONTROL AND MONITORING

Functionally identical to Loop 510-1. (Control and monitoring of this equipment was previously programmed in the existing CPP-6 processor with the exception of effluent flowrate monitoring).

LOOP 510-3 FINAL CLARIFIER NO. 3 CONTROL AND MONITORING

Functionally identical to Loop 510-1. (Control and monitoring of this equipment was previously programmed in the existing CPP-6 processor with the exception of effluent flowrate monitoring and the sludge blanket level monitoring).

LOOP 510-4 FINAL CLARIFIER NO. 4 CONTROL AND MONITORING

Functionally identical to Loop 510-1. (Control and monitoring of this equipment was previously programmed in the existing CPP-6 processor with the exception of effluent flowrate monitoring).

LOOP 510-5 FINAL CLARIFIER NO. 5 CONTROL AND MONITORING

Functionally identical to Loop 510-1. (Control and monitoring of this equipment was previously programmed in the existing CPP-6 processor with the exception of effluent flowrate monitoring and the sludge blanket level monitoring).

LOOP 510-6 FINAL CLARIFIER NO. 6 CONTROL AND MONITORING

Functionally identical to Loop 510-1. (Control and monitoring of this equipment was previously programmed in the existing CPP-6 processor with the exception of effluent flowrate monitoring).

LOOP 510-7 FINAL CLARIFIER NO. 7 CONTROL AND MONITORING

General:

Control and On/Off operation of the clarifier drive. Operation of the clarifier rake is either at the drive Local Control Station or at the SCADA PLC/OWS. Clarifier effluent flow is monitored by a radar level meter monitoring a Palmer-Bowlus flume installed in the effluent launder. Clarifier effluent flow rate is calculated at the radar level meter's transmitter. Flow through the flume will be calculated using standard empirical relationships for Palmer-Bowlus flumes. Flow for the overall clarifier effluent flow rate will be calculated by multiplying the flume flow rate by two. Sludge level is monitored by an ultrasonic sludge blanket analyzer.

Control:

Hardwired Interlocks:

The high-high torque switch (WSHH) shall be wired to the drive's motor starter. If the switch is tripped the motor shall stop.

Local:

Local Start/Stop control of the final clarifier can be performed from the Clarifier Local Control Station (LCS). The LCS includes a Local/Off/Remote (LOR) selector switch and Start and Stop pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the clarifier can be started and stopped by the Start and Stop pushbuttons. The Start and Stop pushbuttons shall only require a momentary push to start and stop the clarifier drive.

Off: When the LOR selector switch is in the "Off" position, the clarifier drive cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

If the SCADA system receives a high torque signal from the starter, the SCADA system shall open its start/stop command to the drive.

When a motor overload condition is detected, the SCADA PLC/OWS start command will be disabled.

Manual Mode:

The clarifier drive can be manually started or stopped by the operator from the OWS. When a drive is running, the Final Clarifier will be considered "Online".

Automatic Control:

None.

Alarms / Monitoring:

Local:

Effluent Flow Rate (FIT/LIT)
Sludge Blanket Level (LIT)
Running Status Light (YRI) at the LCS and associated MCC cubicle.
Stopped Status Light (YRI) at the LCS and associated MCC cubicle.
High-High Torque Light (WAHH) at the associated MCC cubicle.
Overload Light (XA) at the associated MCC cubicle.

SCADA PLC/OWS:

Effluent Flow Rate (FI)
Sludge Blanket Level (LI)
LCS In Remote Status (YCI)
Running Status (YRI)
High Torque (WAH)
High-High Torque (WAHH)
Overload Light (XA)

LOOP 510-8 FINAL CLARIFIER NO. 8 CONTROL AND MONITORING

Functionally identical to Loop 510-7.

LOOP 516-7 FINAL CLARIFIER NO. 7 SCUM WELL LEVEL

General:

Clarifier scum well level is monitored by a High-High Level (LSHH) and a radar level meter. The radar level meter is used to control the scum pump. See mechanical drawings for level control points.

Control:

Hardwired Interlocks:

See Loop 520-7 for interlocks with associated scum pump.

Local:

When the well level falls below the Low-Low level, the level transmitter (LIT-516-7) relay outputs shall open. Refer to Loop 520-7.

The High-High Level Switch (LSHH-516-7) dry contacts shall open when the well scum level rises to or above the high-high level**.**

SCADA PLC/OWS:

Software Interlocks:

See Loop 520-7 for interlocks with associated scum pump.

Alarms / Monitoring:

Local:

Low Low-Level Alarm Light (LALL) at the associated scum pump MCC cubicle.
Well Level (LI) at local LIT.

SCADA PLC/OWS:

Low Low-Level Alarm (LALL)
High High-Level Alarm (LAHH)
Well Level (LI)

LOOP 516-8 FINAL CLARIFIER NO. 8 SCUM WELL LEVEL

Functionally identical to Loop 516-7.

LOOP 520-7 FINAL CLARIFIER NO. 7 SCUM PUMP

General:

Control and On/Off operation of the clarifier scum pump. Operation of the scum pump is either at the Local Control Station or at the SCADA PLC/OWS. Scum well level is monitored by a radar level sensor (see Loop 516-7).

Control:

Hardwired Interlocks:

The high moisture switch (MSH) shall be wired to the pump's motor starter. If the switch is tripped the motor shall stop.

The motor high temperature switch (TSH) shall be wired to the pump's motor starter. If the switch is tripped the motor shall stop.

The associated radar level transmitter (LIT) relay output shall be wired to the pump's motor starter (see Loop 516-7). If the scum level falls to or below the low level, the pump shall stop.

Local:

Local Start/Stop control of the scum pump can be performed from the Scum Pump Local Control Station (LCS). The LCS includes a Local/Off/Remote (LOR) selector switch and Start and Stop pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the scum pump can be started and stopped by the Start and Stop pushbuttons. The Start and Stop pushbuttons shall only require a momentary push to start and stop the scum pump.

Off: When the LOR selector switch is in the "Off" position, the scum pump cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

If the SCADA system receives a high moisture signal from the starter, the SCADA PLC/OWS start command will be disabled.

If the SCADA system receives a high temperature signal from the starter, the SCADA PLC/OWS start command will be disabled.

If the SCADA system receives a low low-level signal from the starter, the SCADA PLC/OWS start command will be disabled.

When a motor overload condition is detected, the SCADA PLC/OWS start command will be disabled.

Manual Mode:

The scum pump can be manually started or stopped by the operator from the OWS.

Automatic Control:

When in automatic mode, the pump shall be started and stopped by the scum well level LI-516-7. See the Mechanical Drawing for pump control setpoints.

When the scum well level rises to or above either of the Pump On Elevation or the High High-Level, the pump shall start.

When the well level falls below the Pump Off Elevation or the Low Low Alarm Elevation the pump shall stop.

Alarms / Monitoring:

Local:

Running Status Light (YRI) at the LCS and associated MCC cubicle.
Stopped Status Light (YRI) at the LCS.
High Moisture Light (MAH) at the associated MCC cubicle.
High Temperature Light (TAH) at the associated MCC cubicle.
Overload Light (XA) at the LCS and associated MCC cubicle.

SCADA PLC/OWS:

LOR Selector Switch Position (YCI)
Running Status (YRI)

High Moisture (MAH)
High Temperature (TAH)
Overload (XA) at the LCS

LOOP 520-8 FINAL CLARIFIER NO. 8 SCUM PUMP

Functionally identical to Loop 520-7.

LOOP 530-3 WASTE SLUDGE PUMP NO. 3

General:

Control and On/Off and speed operation of the waste sludge pump. Operation of the waste sludge pump is either at the Waste Sludge Pump VFD or at the SCADA PLC/OWS.

Control:

Hardwired Interlocks:

The motor high temperature switch (TSH) shall be wired to the pump's motor starter. If the switch is tripped the motor shall stop.

The pump low pressure switch (PSL) shall be wired to the pump's motor starter. If the switch is tripped the motor shall stop.

The Emergency Stop (E-stop) pushbutton located at the pump shall be wired to the pump's motor starter. When the E-stop pushbutton is depressed, the motor shall start and be prevented from running. The E-stop pushbutton shall be pull or twist to reset type.

Local:

Local Start/Stop control of the waste sludge pump can be performed from the waste sludge pump VFD. The VFD includes a Local/Off/Remote (LOR) selector switch and Start and Stop pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the waste sludge pump can be started and stopped by the Start and Stop pushbuttons. The Start and Stop pushbuttons shall only require a momentary push to start and stop the pump. When the pump is running speed can be controlled from the VFD keypad.

Off: When the LOR selector switch is in the "Off" position, the waste sludge pump cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

If the SCADA system receives a high temperature signal from the starter, the SCADA PLC/OWS start command will be disabled and the pump will be prevented from starting.

If the SCADA system receives a low-pressure signal from the starter, the SCADA PLC/OWS start command will be disabled and the pump will be prevented from starting.

If the SCADA system receives a E-stop signal from the starter, the SCADA PLC/OWS start command will be disabled and the pump will be prevented from starting.

If the SCADA system receives a VFD Faults signal from the starter, the SCADA PLC/OWS start command will be disabled and the pump will be prevented from starting.

Manual Mode:

The waste sludge pump can be manually started or stopped by the operator from the OWS. In manual mode, the operator can enter a speed setpoint (0-100%) to command the pump to run at a percentage speed.

Automatic Control:

On/Off Control:

The operator shall choose which pump of Waste Sludge Pump 3 and Waste Sludge Pump 4 is duty and which pump is standby (Loops 530-3 & 530-4). The one not chosen as duty will revert to the standby pump.

Duty: The pump shall start when the either the operator initiates a start command or by a timer.

Standby: When the pump is chosen as the standby pump, it shall automatically start when duty pump fails or is stopped by an interlock but is not stopped by the operator.

The operator shall select whether the alternation between duty and standby shall be manual or by SCADA timer mode. If the operator selects the SCADA timer mode the operator shall enter the length of time between alternations.

When the duty pump is running and the operator or SCADA timer mode selects the standby pump as duty, the PLC shall start the new duty pump and then stop the new standby pump (old duty) once the new duty pump is running.

Speed Control:

The flow measurement of FIT-539 shall be used as the process variable to software PID controller (FIC). Refer to Loop 539. The operator shall be able to enter the flow set point to the flow controller. The output from the controller shall control the speed of the duty WAS Pump.

Alarms / Monitoring:

Local:

Running Status Light (YRI) at the VFD.
Stopped Status Light (YRI) at the VFD.
High Temperature Light (TAH) at the VFD.
Low Pressure Light (PAL) at the VFD.
VFD Fault Light (XA) at the VFD.
E-stop Light at the VFD (HSA) at the VFD.
Speed Indication from the VFD Keypad.

SCADA PLC/OWS:

LOR Selector Switch Position (YCI)
Running Status (YRI)
High Temperature (TAH)
Low Pressure (PAL)
E-stop Pushbutton Position (ES)
VFD Fault (XA)
VFD Speed Feedback (SI)

LOOP 530-4 WASTE SLUDGE PUMP NO. 4

Functionally identical to Loop 530-3.

LOOP 539 RETURN SLUDGE PUMP STATION NO. 3 WASTE SLUDGE PUMP FLOW

General:

Continuous flow measurement of the RSPS 3 waste sludge flow by means of a magnetic flow meter. The flow measurement shall be used to control Waste Sludge Pumps No. 3 and 4.

Control:

Local:

None

SCADA PLC/OWS:

The measurement of FIT-539 shall be used as the process variable for a PID flow controller (FIC-539).

The operator shall be able to enter a flow set point to the flow controller. The output of the controller (FIC-539) shall control the speed of the duty Return Sludge Pump Station No. 3 waste sludge pump (see Loops 530-3 and 530-4). When the operator enters a flow set point, the controller shall adjust the output to maintain a flow measurement that is equal or very close to the actual set point entered by the operator.

Alarms / Monitoring:

Local:

Flow Indication (FIT)

SCADA PLC/OWS:

High flow alarm (FAH) – Programmed for 10% greater than the flow setpoint.
Low flow alarm (FAL) – Programmed for 10% lower than the flow setpoint.
No flow alarm (FALL) if either Waste Sludge Pump No. 3 or No. 4 (see Loops 530-3 and 530-4) is running for a set period of time (20 seconds) with no flow detected by FIT.

LOOP 540 RETURN ACTIVATED SLUDGE FLOW SETPOINTS

General:

Calculations to determine RAS flow setpoints for RSPS No. 1, RSPS No. 2 and the the RSPS No. 3 Sludge Pumps assigned to each of Final Clarifier No. 5, Final Clarifier No. 6, Final Clarifier No. 7, and Final Clarifier No. 8.

Control:

SCADA PLC/OWS:

Total Return Activated Sludge (RAS) Setpoint

Overall control of the three RSPS's will be based on a Total RAS Setpoint. An operator may enter a Percentage of Dry Weather Flow Setpoint. The Total RAS Setpoint will then be calculated based on the Dry Weather Flow (FI-303, measured at CPP-4) as follows:

$$Total\ RAS\ Setpoint\ = \left[\frac{(\%\ of\ Dry\ Weather\ Flow\ Setpoint)}{100}\right] \times (FI - 303)$$

RAS Flow Split Setpoints

Based on the Total RAS Setpoint, Individual RAS flow setpoints will be calculated for: RSPS No. 1 (Final Clarifiers 1 through 3), RSPS No. 2 (Final Clarifier 4), and the RSPS No. 3 Sludge Pumps assigned to each of Final Clarifier No. 5, Final Clarifier No. 6, Final Clarifier No. 7, and Final Clarifier No. 8 (see Loops 540-8 thru 540-12). Individual RAS Flow Setpoints will be based on the Total RAS setpoint and a "% of Total RAS" setpoint according to the below formula:

$$Individual\ Flow\ Setpoint\ = \left[\frac{(\%\ of\ Total\ RAS\ Setpoint)}{100}\right] \times (Total\ RAS\ Setpoint)$$

Based on the combination of Online Final Clarifiers (see Loops 520-1 thru 8) the % of Total RAS Setpoints will set by reference to a table of setpoints. Different tables will be used depending on the number of Final Clarifiers Online. Each table will include: Final Clarifier Combination, RSPS No. 1 Flow Setpoint; RSPS No. 2 Flow Setpoint, and % of Total RAS Setpoints for the RSPS No. 3 Sludge Pumps assigned to each of Final Clarifier No. 5, Final Clarifier No. 6, Final Clarifier No. 7, and Final Clarifier No. 8. The sum of the % of Total RAS Setpoints for a single FC Combination must equal 100%. The different tables will be for:

- 8 Final Clarifiers Online (1 FC Combination)
- 7 Final Clarifiers Online (8 FC Combinations)
- 6 Final Clarifiers Online (28 FC Combinations)
- 5 Final Clarifiers Online (56 FC Combinations)
- 4 Final Clarifiers Online (70 FC Combinations)
- 3 Final Clarifiers Online (56 FC Combinations)
- 2 Final Clarifiers Online (28 FC Combinations)
- 1 Final Clarifier Online (8 FC Combinations)

Each % of Total RAS setpoint shall be operator adjustable. The setpoints shall initially be set based on the number of final clarifiers Online in the Final Clarifier Combination, and the number of Final Clarifiers associated with the RSPS or RAS Pump according to the below formula:

$$\%\ of\ Total\ RAS\ Setpoint\ = \left[\frac{Number\ of\ Associated\ FC's\ Online}{Total\ Number\ of\ FC's\ Online}\right] \times 100$$

For the purposes of providing an example, Tables are provided below for 8 Clarifiers Online, 7 Clarifiers Online, and 6 Clarifiers Online (cells with RSPS's or Final Clarifiers not online are highlighted in grey for the purposes of clarity).

8 Final Clarifiers Online

FC Combination	RSPS No. 1 RAS %	RSPS No. 2 RAS %	FC No. 5 RAS %	FC No. 6 RAS %	FC No. 7 RAS %	FC No. 8 RAS %
1, 2, 3, 4, 5, 6, 7, 8	37.5%	12.5%	12.5%	12.5%	12.5%	12.5%

7 Final Clarifiers Online

FC Combination	RSPS No. 1 RAS %	RSPS No. 2 RAS %	FC No. 5 RAS %	FC No. 6 RAS %	FC No. 7 RAS %	FC No. 8 RAS %
1, 2, 3, 4, 5, 6, 7	42.8%	14.3%	14.3%	14.3%	14.3%	0%
1, 2, 3, 4, 5, 6, 8	42.8%	14.3%	14.3%	14.3%	0%	14.3%
1, 2, 3, 4, 5, 7, 8	42.8%	14.3%	14.3%	0%	14.3%	14.3%
1, 2, 3, 4, 6, 7, 8	42.8%	14.3%	0%	14.3%	14.3%	14.3%
1, 2, 3, 5, 6, 7, 8	42.8%	0%	14.3%	14.3%	14.3%	14.3%
1, 2, 4, 5, 6, 7, 8	28.5%	14.3%	14.3%	14.3%	14.3%	14.3%
1, 3, 4, 5, 6, 7, 8	28.5%	14.3%	14.3%	14.3%	14.3%	14.3%
2, 3, 4, 5, 6, 7, 8	28.5%	14.3%	14.3%	14.3%	14.3%	14.3%

6 Final Clarifiers Online

FC Combination	RSPS No. 1 RAS %	RSPS No. 2 RAS %	FC No. 5 RAS %	FC No. 6 RAS %	FC No. 7 RAS %	FC No. 8 RAS %
1, 2, 3, 4, 5, 6	50%	16.6%	16.6%	16.7%	0%	0%
1, 2, 3, 4, 5, 7	50%	16.6%	16.6%	0%	16.7%	0%
1, 2, 3, 4, 5, 8	50%	16.6%	16.6%	0%	0%	16.7%
1, 2, 3, 4, 6, 7	50%	16.6%	0%	16.6%	16.7%	0%
1, 2, 3, 4, 6, 8	50%	16.6%	0%	16.6%	0%	16.7%
1, 2, 3, 4, 7, 8	50%	16.6%	0%	0%	16.6%	16.7%
1, 2, 3, 5, 6, 7	50%	0%	16.6%	16.6%	16.7%	0%
1, 2, 3, 5, 6, 8	50%	0%	16.6%	16.6%	0%	16.7%
1, 2, 3, 5, 7, 8	50%	0%	16.6%	0%	16.6%	16.7%
1, 2, 3, 6, 7, 8	50%	0%	0%	16.6%	16.6%	16.7%
1, 2, 4, 5, 6, 7	33.3%	16.6%	16.7%	16.7%	16.7%	0%
1, 2, 4, 5, 6, 8	33.3%	16.6%	16.7%	16.7%	0%	16.7%
1, 2, 4, 5, 7, 8	33.3%	16.6%	16.7%	0%	16.7%	16.7%
1, 2, 4, 6, 7, 8	33.3%	16.6%	0%	16.7%	16.7%	16.7%
1, 2, 5, 6, 7, 8	33.3%	0%	16.6%	16.7%	16.7%	16.7%
1, 3, 4, 5, 6, 7	33.3%	16.6%	16.7%	16.7%	16.7%	0%
1, 3, 4, 5, 6, 8	33.3%	16.6%	16.7%	16.7%	0%	16.7%
1, 3, 4, 5, 7, 8	33.3%	16.6%	16.7%	0%	16.7%	16.7%
1, 3, 4, 6, 7, 8	33.3%	16.6%	0%	16.7%	16.7%	16.7%
1, 3, 5, 6, 7, 8	33.3%	0%	16.6%	16.7%	16.7%	16.7%
1, 4, 5, 6, 7, 8	16.6%	16.6%	16.7%	16.7%	16.7%	16.7%
2, 3, 4, 5, 6, 7	33.3%	16.6%	16.7%	16.7%	16.7%	0%
2, 3, 4, 5, 6, 8	33.3%	16.6%	16.7%	16.7%	0%	16.7%
2, 3, 4, 5, 7, 8	33.3%	16.6%	16.7%	0%	16.7%	16.7%
2, 3, 4, 6, 7, 8	33.3%	16.6%	0%	16.7%	16.7%	16.7%
2, 3, 5, 6, 7, 8	33.3%	0%	16.6%	16.7%	16.7%	16.7%
2, 4, 5, 6, 7, 8	16.6%	16.6%	16.7%	16.7%	16.7%	16.7%
3, 4, 5, 6, 7, 8	16.6%	16.6%	16.7%	16.7%	16.7%	16.7%

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

None

LOOP 540-8 RETURN SLUDGE PUMP NO. 8

General:

Control and On/Off and speed operation of the return sludge pump. Operation of the return sludge pump is either at the Return Sludge Pump VFD or at the SCADA PLC/OWS.

Control:

Hardwired Interlocks:

The motor high temperature switch (TSH) shall be wired to the pump's motor starter. If the switch is tripped the motor shall stop.

The pump low pressure switch (PSL) shall be wired to the pump's motor starter. If the switch is tripped the motor shall stop.

The Emergency Stop (E-stop) pushbutton located at the pump shall be wired to the pump's motor starter. When the E-stop pushbutton is depressed, the motor shall stop and be prevented from running. The E-stop pushbutton shall be pull or twist to reset type.

Local:

Local Start/Stop control of the return sludge pump can be performed from the waste sludge pump VFD. The VFD includes a Local/Off/Remote (LOR) selector switch and Start and Stop pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the return sludge pump can be started and stopped by the Start and Stop pushbuttons. The Start and Stop pushbuttons shall only require a momentary push to start and stop the pump. When the pump is running speed can be controlled from the VFD keypad.

Off: When the LOR selector switch is in the "Off" position, the return sludge pump cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Manual Control:

When in manual mode, the operator can start and stop the pump from the OWS. The operator can enter a speed setpoint to command the VFD to a speed.

Automatic On/Off and Speed Control

When none of the RSPS No. 3 Return Sludge Pumps are running, the operator can assign each of sludge pumps 540-8 thru 540-12 to pump sludge from one of Final Clarifiers 5 thru 8. The possible valid combinations of Final Clarifier (FC) - Sludge Pump (RSP) combinations will depend on Final Clarifiers that are in operation. Valid combinations are listed below with a sequence ID:

One Final Clarifier of FC-540-5 thru 8 in Operation

SEQUENCE	FC	RSP
1-A	5	8
1-B	5	9
1-C	5	10
1-D	5	11
1-E	5	12
1-F	6	8
1-G	6	9
1-H	6	10
1-I	6	11
1-J	6	12
1-K	7	8
1-L	7	9
1-M	7	10
1-N	7	11
1-O	7	12
1-P	8	8
1-Q	8	9
1-R	8	10
1-S	8	11
1-T	8	12

Two Final Clarifiers of FC-540-5 thru 8 in Operation

SEQUENCE	FC I	RSP I	FC II	RSP II
2-A	5	9	6	8
2-B	5	10	6	8
2-C	5	11	6	8
2-D	5	12	6	8
2-E	5	10	6	9
2-F	5	11	6	9
2-G	5	12	6	9
2-H	5	8	7	10
2-I	5	8	7	11
2-J	5	8	7	12
2-K	5	9	7	10
2-L	5	9	7	11
2-M	5	9	7	12
2-N	5	10	7	11
2-O	5	10	7	12
2-P	5	8	8	10
2-Q	5	8	8	11
2-R	5	8	8	12
2-S	5	9	8	10
2-T	5	9	8	11
2-U	5	9	8	12
2-V	5	10	8	11
2-W	5	10	8	12
2-X	5	11	8	12

2-Y	6	8	7	9
2-Z	6	8	7	10
2-AA	6	8	7	11
2-AB	6	8	7	12
2-AC	6	9	7	10
2-AD	6	9	7	11
2-AE	6	9	7	12
2-AF	6	10	7	11
2-AG	6	10	7	12
2-AH	6	8	8	9
2-AI	6	8	8	10
2-AJ	6	8	8	11
2-AK	6	8	8	12
2-AL	6	9	8	10
2-AM	6	9	8	11
2-AN	6	9	8	12
2-AO	6	10	8	11
2-AP	6	10	8	12
2-AQ	6	11	8	12
2-AR	7	8	8	11
2-AS	7	8	8	12
2-AT	7	9	8	11
2-AU	7	9	8	12
2-AV	7	10	8	11
2-AW	7	10	8	12
2-AX	7	11	8	12

Three Final Clarifiers of FC-540-5 thru 8 in Operation

SEQUENCE	FC I	RSP I	FC II	RSP II	FC III	RSP III
3-A	5	9	6	8	7	10
3-B	5	9	6	8	7	11
3-C	5	9	6	8	7	12
3-D	5	10	6	8	7	11
3-E	5	10	6	8	7	12
3-F	5	10	6	9	7	11
3-G	5	10	6	9	7	12
3-H	5	8	7	10	8	11
3-I	5	8	7	10	8	12
3-J	5	9	7	10	8	11
3-K	5	9	7	10	8	12
3-L	5	8	7	11	8	12
3-M	5	9	7	11	8	12
3-N	5	10	7	11	8	12
3-0	6	8	7	9	8	11
3-P	6	8	7	9	8	12
3-Q	6	8	7	10	8	11
3-R	6	8	7	10	8	12
3-S	6	8	7	11	8	12

3-T	6	9	7	10	8	11
3-U	6	9	7	10	8	12
3-V	6	9	7	11	8	12
3-W	6	10	7	11	8	12

All of Final Clarifiers of FC-540-5 thru 8 in Operation

SEQUENCE	FC I	RSP I	FC II	RSP II	FC III	RSP III	FC IV	RSP IV
4-A	5	9	6	8	7	10	8	11
4-B	5	9	6	8	7	10	8	12
4-C	5	10	6	8	7	11	8	12
4-D	5	10	6	9	7	11	8	12

Once the sludge pump has been assigned to a Final Clarifier, a flow setpoint for the sludge pump shall be set as described in Loop 540.

The flow measurement FI-540-8 shall be used as the process variable to a software PID controller (FIC-540-8). The above calculated sludge pump set point shall be entered to the flow controller. The output from the controller shall be converted to a sludge pump speed setpoint between 0-100%.

Alarms / Monitoring:

Local:

Flow indication (FIT)
Running Status Light (YRI) at the VFD.
Stopped Status Light (YRI) at the VFD.
High Temperature Light (TAH) at the VFD.
Low Pressure Light (PAL) at the VFD.
VFD Fault Light (XA) at the VFD.
E-stop Light at the VFD (HSA) at the VFD.
Speed Indication from the VFD Keypad.

SCADA PLC/OWS:

Flow indication (FI)
LOR Selector Switch Position (YCI)
Running Status (YRI)
High Temperature (TAH)
Low Pressure (PAL)
E-stop Pushbutton Position (ES)
VFD Fault (XA)
VFD Speed Feedback (SI)
High flow alarm (FAH) – Programmed for 10% greater than the flow setpoint.
Low flow alarm (FAL) – Programmed for 10% lower than the flow setpoint.
No Flow Alarm (FALL) if the pump has been running for a period of time without flow detected from the associated FIT.

LOOP 540-9 RETURN SLUDGE PUMP NO. 9

Functionally identical to Loop 540-8.

LOOP 540-10 RETURN SLUDGE PUMP NO. 10

Functionally identical to Loop 540-8.

LOOP 540-11 RETURN SLUDGE PUMP NO. 11

Functionally identical to Loop 540-8.

LOOP 540-12 RETURN SLUDGE PUMP NO. 12

Functionally identical to Loop 540-8.

LOOP 545 RETURN SLUDGE PUMP STATION NO. 2 DISCHARGE FLOW

General:

Continuous flow measurement by means of an existing magnetic flow meter. The flow measurement shall be used to control the Return Sludge Pump Station (RSPS) No. 2 Return Sludge Pumps. As a result of the site piping modifications, of this project, RSPS No. 2 serves Final Clarifier No. 4. (Monitoring described below was previously programmed into existing PLC processor in CPP-6. However, pump controls will be updated to use the flow setpoint calculated in Loop 540 as the setpoint for the flow controller and the use of the measured for calculating the flow rate from Return Sludge Pump Station No. 1 will be updated).

Control:

Local:

None

SCADA PLC/OWS:

The flow measurement shall be used as the process variable for software PID flow controller, FIC-545, whose output shall control the speed of the Return Sludge Pumps 5-7 (Loops 540-5, 540-6 and 540-7). (Loops 540-5, 540-6, and 540-7 were previously programmed into the existing CPP-6 PLC processor. The programming of these loops will not be modified).

The RSPS No. 2 RAS flow setpoint calculated in loop 540 will be used by the flow controller and the output of the controller (FIC-545) shall control the speed of the three Return Sludge Pump Station No. 2 Sludge pumps (Loops 540-5, 540-6 and 540-7). The controller shall adjust the output to maintain a flow measurement that is equal or very close to the actual set point entered by the operator.

The flow measurement shall also be used to calculate flow from Return Sludge Pump Station No. 1. See Loop 546.

Alarms / Monitoring:

Local:

Flow indication (FIT)

SCADA PLC/OWS:

Flow indication (FI)
No flow alarm (FAL) if one Return Sludge Pump Station No. 2 return sludge pump (Loops 540-5, 540-6 & 540-7) is running for a set period of time.

LOOP 546 CALCULATED RETURN SLUDGE PUMP STATION NO. 1 DISCHARGE FLOW

General:

Calculated flow measurement from two flow measurements. The calculated flow measurement shall be used to control the Return Sludge Pump Station No. 1 Sludge Pumps based on the RSPS No. 1 RAS Flow Setpoint calculated in Loop 540. (The flow calculation was previously programmed in the CPP-6 PLC Processor, but it updated here to accommodate for the added flows of Return Sludge Pump Station 3. Additionally, the flow PID controller will be updated to use the RSPS No. 1 flow setpoint calculated in Loop 540).

Control:

Local:

None

SCADA PLC/OWS:

The flow measurement from Return Sludge Pump Station No. 2 and the total return sludge flow measurements FI-355, FI-357-1, FI-357-2, FI-357-3, and FI-357-4 shall be used to calculate flow measurement FY-546 as shown below:

FY-546 = (FI-355) + [(FI-357-1) + (FI-357-2) + (FI-357-3) + (FI-357-4)] – (FI-545) – (FY-547)

The calculated flow measurement (FY-546) shall be used as the process variable for software PID flow controller, FIC-546, whose output shall control the speed of the Return Sludge Pumps 1-4 (Loops 540-1, 540-2, 540-3 and 540-4). (Loops 540-1, 540-2, 540-3, and 540-4 were previously programmed into the existing CPP-6 PLC processor. The programming of these loops will not be modified).

The RSPS No. 1 RAS flow setpoint calculated in loop 540 will be used by the flow controller and the output of the controller (FIC-546) shall control the speed of the four Return Sludge Pump Station No. 1 Return Sludge Pumps (Loops 540-1,540-2, 540-3 and 540-4). The controller shall adjust the output to maintain a calculated flow measurement that is equal or very close to the actual set point entered by the operator.

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

Flow indication (FI)
No flow alarm (FAL) if one Return Sludge Pump Station No. 1 Return Sludge pump (Loops 540-1, 540-2, 540-3 & 540-4) is running for a set period of time.

LOOP 547 CALCULATED RETURN SLUDGE PUMP STATION NO. 3 DISCHARGE FLOW

General:

Calculated flow measurement from Return Sludge Pump Station No. 3 flow measurements. The calculated flow measurement shall be used to calculated the Return Sludge Pump Station No. 1 discharge flow.

Control:

Local:

None

SCADA PLC/OWS:

The flow of any Running Return Sludge Pump Station No. 3 return sludge pumps (see Loops 540-8, 540-9, 540-10, 540-11, and 540-12) shall be added together. This sum shall be flow measurement FY-547.

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

Flow indication (FI)

LOOP 600 UV INFLUENT UV TRANSMITTANCE MONITORING

General:

UV transmittance is monitored by a UV transmittance analyzer. UV transmittance is used for automatic control of the UV system by the UV System Control Center (SCC). UV transmittance is available for monitoring at the SCADA OWS by connection of the SCC to the SCADA

network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Local:

None

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

UV Transmittance (AI) at SCC OIT.

SCADA PLC/OWS:

UV Transmittance (AI)

LOOP 601-1 UV CHANNEL 1 INFLUENT GATE

General:

A two position (Open/Closed) slide gate allows influent flow into the UV channel. The influent gate position is controlled by the SCC according to the UV system's controls. Control and monitoring of the gate at the SCADA OWS is achieved by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Hardwired Interlocks:

None.

Local:

Slide gate operation can be locally controlled by the LCS integral to the valve actuator. The valve LCS shall have a Local/Off/Remote (LOR) selector switch and "Open" and "Close" pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the valve can be opened, stopped in mid-travel, or closed by the Open and Close pushbuttons. Local operation of the valve shall be maintained such that the "Open" or "Close" pushbuttons may only need to be depressed a single time for the valve to completely to open or close, respectively.

Off: When the LOR selector switch is in the "Off" position, the valve cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, valve control is transferred to the SCC.

SCADA PLC/OWS:

Software Interlock:

When a motor overload condition is detected, the SCADA PLC/OWS open or close command will be disabled.

Remote Manual Mode:

When the valve is placed into "Remote Manual" either from the OWS or SCC OIT, the operator can command the slide gate to open or close either from the OWS or SCC OIT.

Remote Auto Mode:

When the valve is placed into "Remote Auto" either from the OWS or SCC OIT, the SCC will automatically control the slide gate according to the UV's System's automatic control sequence.

Alarms / Monitoring:

Local:

Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)

SCADA PLC/OWS:

Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)
Valve LOR Selector Switch Position (YCI)

LOOP 601-2 UV CHANNEL 2 INFLUENT GATE

General: Functionally identical to Loop 601-1.

LOOP 601-3 UV CHANNEL 3 INFLUENT GATE

General: Functionally identical to Loop 601-1.

LOOP 606 UV SYSTEM CONTROL CENTER (SCC) PLC HEARTBEAT

General:

Heartbeat signals between the UV SCC and SCADA to check network communication between SCADA and the SCC PLC. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Local:

None

SCADA PLC/OWS:

The UV System Control Center (SCC) PLC generates a Boolean signal that is On for 2 seconds and then Off for two seconds. Programming in CPP-5 validates this heartbeat signal to check that the SCC is communicating with the SCADA network.

Additionally, CPP-5 will create a Boolean signal that is on for 2 seconds and then off for two second. Programming in the UV System SCC validates this heartbeat signal to check that the SCADA network is communicating with the SCC PLC.

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

SCADA Heartbeat Signal (YJN-606A)
SCC PLC Heartbeat Signal (YJN-606B)

LOOP 607 UV SYSTEM CONTROL CENTER (UV-SCC) ENCLOSURE HIGH TEMPERATURE

General: Alarm status from a thermostat mounted in the SCC enclosure. Alarm monitoring at the SCADA OWS is achieved by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

High Temperature (TAH)

LOOP 608 UV SYSTEM CONTROL CENTER (UV-SCC) REDUNDANT 24VDC POWER SUPPLY FAULTS

General: Alarm status from UV SCC 24VDC Power Supplies. Alarm monitoring at the SCADA OWS is achieved by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

Power Supply 1 Fault (XA-608A)
Power Supply 2 Fault (XA-608B)

LOOP 609 SCC-UPS ALARM AND STATUS

General: Alarm and status information from SCC-UPS to the SCADA system. Alarm and status monitoring at the SCADA OWS is achieved by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

On UPS Power (XS)
UPS Fault (YFI)
UPS Low Battery (XA)

LOOP 610 OVERALL UV SYSTEM MONITORING

General:

I/O and alarms for monitoring the overall UV system. Overall UV System monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 “Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment” for greater detail on the UV Disinfection System controls.

Control:

Local:

Control of UV system through UV System SCC.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

Low Number of Channels (NAL) at SCC OIT
Calculated UV Dose (ACI) at SCC OIT
Low UV Dose (AAL) at SCC OIT
System Power On (JIN) at SCC OIT

SCADA PLC/OWS:

Low Number of Channels (NAL)
Calculated UV Dose (ACI)
Low UV Dose (AAL)
System Power On (JIN)

LOOP 611-1 UV CHANNEL 1 MONITORING

General:

I/O and alarms for monitoring the channel 1 of the UV system. UV channel 1 monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 “Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment” for greater detail on the UV Disinfection System controls.

Control:

Local:

Control of UV system through UV System SCC.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

Channel Online (YIN) at SCC OIT
Maintenance Mode (YIF) at SCC OIT
Low Number of Banks (NAL) at SCC OIT
Channel High Flow (FAH) at SCC OIT
Wiper High Flow (XAH) at SCC OIT
High Level (LAH) at SCC OIT
Low Level (LAL) at SCC OIT

SCADA PLC/OWS:

Channel Online (YIN)
Maintenance Mode (YIF)
Low Number of Banks (NAL)
Channel High Flow (FAH)
Wiper High Flow (XAH)
High Level (LAH)
Low Level (LAL)

LOOP 611-2 UV CHANNEL 2 MONITORING

General: Functionally identical to Loop 611-1.

LOOP 611-3 UV CHANNEL 3 MONITORING

General: Functionally identical to Loop 611-1.

LOOP 612-1 UV CHANNEL 1 POWER DISTRIBUTION CENTER (PDC) MONITORING

General:

I/O and alarms for monitoring the UV channel 1 power distribution system (PDC). UV channel 1 power distribution system (PDC) monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 “Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment” for greater detail on the UV Disinfection System controls.

Control:

Local:

None.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

PDC High Temperature (TAH) at SCC OIT
PDC High High Temperature (TAHH) at SCC OIT
PDC Fan Failure (XA) at SCC OIT
PDC Disconnect Open (JZO), Banks A, B, C, & D at SCC OIT
PDC to SCC Communications Failure (XJ), Banks A, B, C, & D at SCC OIT

SCADA PLC/OWS:

PDC High Temperature (TAH)
PDC High High Temperature (TAHH)
PDC Fan Failure (XA)
PDC Disconnect Open (JZO), Banks A, B, C, & D
PDC to SCC Communications Failure (XJ), Banks A, B, C, & D

LOOP 612-2 UV CHANNEL 2 POWER DISTRIBUTION CENTER (PDC) MONITORING

General: Functionally identical to Loop 612-1.

LOOP 612-3 UV CHANNEL 3 POWER DISTRIBUTION CENTER (PDC) MONITORING

General: Functionally identical to Loop 613-1.

LOOP 613-1 UV CHANNEL 1 HYDRAULIC SYSTEM CENTER (HSC) MONITORING

General:

I/O and alarms for monitoring the UV channel 1 hydraulic system center (HSC). UV channel 1 hydraulic system center (HSC) monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 “Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment” for greater detail on the UV Disinfection System controls.

Control:

Local:

The HSC provides UV bank lifting and cleaning wiper operation in from the console installed at the HSC.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

HSC Tank Low Level (LAL) at SCC OIT
HSC Pump Fault (XA) at SCC OIT
HSC to SCC Communication Failure (XJ) at SCC OIT
Wiper Inhibited (YCF) at SCC OIT

SCADA PLC/OWS:

HSC Tank Low Level (LAL)
HSC Pump Fault (XA)
HSC to SCC Communication Failure (XJ)
Wiper Inhibited (YCF)

LOOP 613-2 UV CHANNEL 2 HYDRAULIC SYSTEM CENTER (HSC) MONITORING

General: Functionally identical to Loop 613-1.

LOOP 613-3 UV CHANNEL 3 HYDRAULIC SYSTEM CENTER (HSC) MONITORING

General: Functionally identical to Loop 613-1.

LOOPS 614-1A, B, C, & D UV CHANNEL 1 UV BANK MONITORING

General:

I/O and alarms for monitoring the channel 1 UV banks. The narrative below is typical for banks A, B, C, and D. Overall UV channel 1 UV lamp bank monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 “Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment” for greater detail on the UV Disinfection System controls.

Control:

Local:

None.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

Bank in Remote (YCI) at SCC OIT
Bank Online (YRI) at SCC OIT
Bank Not in Place (ZIH) at SCC OIT
Improper Lift (ZCA) at SCC OIT

Bank Configuration Fault (YDA) at SCC OIT
BCB Dip Switch Fault (XA) at SCC OIT

SCADA PLC/OWS:

Bank in Remote (YCI)
Bank Online (YRI)
Bank Not in Place (ZIH)
Improper Lift (ZCA)
Bank Configuration Fault (YDA)
BCB Dip Switch Fault (XA)

LOOPS 614-2A, B, C, & D UV CHANNEL 2 UV BANK MONITORING

General: Functionally identical to Loops 614-1 A, B, C, & D.

LOOPS 614-3A, B, C, & D UV CHANNEL 3 UV BANK MONITORING

General: Functionally identical to Loops 614-1 A, B, C, & D.

LOOPS 615-1A, B, C, & D UV CHANNEL 1 WIPER MONITORING

General:

I/O and alarms for monitoring the channel 1 UV bank wipers. The narrative below is typical for banks A, B, C, and D. UV channel 1 bank wiper monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Local:

Wiper control at the UV Channel HSC.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

Wiper Not in Remote (YCI) at SCC OIT
Wiper Jammed (XA) at SCC OIT
Wiper Travel Time High (ZKH) at SCC OIT
Wiper Position Unknown (ZA) at SCC OIT

SCADA PLC/OWS:

Wiper Not in Remote (YCI)
Wiper Jammed (XA)
Wiper Travel Time High (ZKH)
Wiper Position Unknown (ZA)

LOOPS 615-2A, B, C, & D UV CHANNEL 2 WIPER MONITORING

General: Functionally identical to Loops 615-1 A, B, C, & D.

LOOPS 615-3A, B, C, & D UV CHANNEL 3 WIPER MONITORING

General: Functionally identical to Loops 615-1A, B, C, & D.

LOOPS 616-1A, B, C, & D UV CHANNEL 1 LAMP MONITORING

General:

I/O and alarms for monitoring the channel 1 UV bank lamps. The narrative below is typical for banks A, B, C, and D. UV channel 1 bank lamp monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Local:

None.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

Multiple Lamp Failures (NXA) at SCC OIT
Low Number of Lamps (NAL) at SCC OIT
Lamp Failure (XA) at SCC OIT
Lamp Life Exceeded (KQH) at SCC OIT
Lamp Driver Failure (XJ) at SCC OIT
Lamp Driver Communication Failure (XJ) at SCC OIT
Lamp Disabled (YIF) at SCC OIT
Lamp Power (JI) at SCC OIT
Lamp Hours (KQ) at SCC OIT

SCADA PLC/OWS:

Multiple Lamp Failures (NXA)
Low Number of Lamps (NAL)

Lamp Failure (XA)
Lamp Life Exceeded (KQH)
Lamp Driver Failure (XJ)
Lamp Driver Communication Failure (XJ)
Lamp Disabled (YIF)
Lamp Power (JI)
Lamp Hours (KQ)

LOOPS 616-2A, B, C, & D UV CHANNEL 2 LAMP MONITORING

General: Functionally identical to Loops 616-1A, B, C, & D.

LOOPS 616-3A, B, C, & D UV CHANNEL 3 LAMP MONITORING

General: Functionally identical to Loops 616-1A, B, C, & D.

LOOPS 617-1A, B, C, & D UV CHANNEL 1 UV INTENSITY

General:

Monitoring of the UV intensity in each UV bank by means of a UV intensity sensor. The narrative below is typical for banks A, B, C, and D. UV bank intensity monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Local:

None.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

UV Intensity (AI) at SCC OIT

SCADA PLC/OWS:

UV Intensity (AI)

LOOPS 617-1A, B, C, & D UV CHANNEL 2 UV INTENSITY

General: Functionally identical to Loops 617-1A, B, C, & D.

LOOPS 617-3A, B, C, & D UV CHANNEL 3 UV INTENSITY

General: Functionally identical to Loops 617-1A, B, C, & D.

LOOP 618-1 UV CHANNEL 1 WATER LEVEL

General:

Monitoring of the water level in each UV channel downstream of the UV banks by means of a radar level element. This level is used by the SCC to control the UV channel weir gate position according the UV systems automatic controls (see Loop 620-1). UV channel level monitoring at the SCADA OWS by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Local:

None.

SCADA PLC/OWS:

None

Alarms / Monitoring:

Local:

UV Channel Level (LI) at SCC OIT

SCADA PLC/OWS:

UV Channel Level (LI)

LOOP 618-2 UV CHANNEL 2 WATER LEVEL

General: Functionally identical to Loop 618-1.

LOOP 618-3 UV CHANNEL 3 WATER LEVEL

General: Functionally identical to Loop 618-1.

LOOP 619-1 UV EFFLUENT FLOW SAMPLER NO. 1

General:

UV system effluent is sampled by three refrigerated automatic samplers. Each sampler can pull from one of two sampling locations in the UV System Effluent Channel. Sampling location is controlled by a three-way solenoid valve. In automatic operation, the sampling location is based

on the operation of the Effluent Flood Pump Station. Automatic samplers are flow paced based on the effluent flow.

Control:

Local:

A local control station (LCS-619-1) is located adjacent to the automatic sampler. The LCS provides separately fused power sources for the automatic sampler and the associated solenoid valve. In addition to providing power to the solenoid valve an automatic sampler, the LCS provides local control by means of a Local-Off-Remote (LOR) hand switch and a Position 1-Position 2 hand switch.

Local: When the LOR switch is in "Local", control of the solenoid valve is based on the position of the Position 1-Position 2 switch. When the Position 1-Position 2 switch is in "Position 1", the solenoid valve position will have an open flow path to Sample Location No. 1 (deenergized state of the solenoid valve). When the Position 1-Position 2 switch is in "Position 2" the solenoid valve position will have an open flow path to Sample Location No. 2 (energized sate of the solenoid valve).

Off: When the LOR switch is in "Off", there will be no control of the solenoid valve and the solenoid will be in the deenergized state, with an open flow path to Sample Location No. 1.

Remote: When the LOR switch is in "Remote", control of the solenoid is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

In all operating modes, SCADA will send an effluent flow signal (see Loop 630) to the automatic sampler for sample flow pacing.

Manual Mode:

When the solenoid valve is in "Remote Manual" mode, an operator may manually set the sampling location for the automatic sampler as either "Effluent Sample Location 1" or "Effluent Sample Location 2".

Automatic Mode:

The sample location (and associated solenoid valve position) will be based on the operation of the Flood Pump Station. If the Flood Pump Station is either in "Automatic Flood Mode" (see Loop 680) or "Flood Pump Station Exercise Mode" (see Loops 665-1 thru 4) and a flood pump is running (see Loop 665-1 thru 4), the solenoid valve will open a flow path to "Effluent Sample Location 2" (valve Position 2 – energized state). In any other condition, the solenoid valve will open a flow path to "Effluent Sample Location 1" (valve Position 1 – deenergized state).

Alarms / Monitoring:

Local:

None

SCADA PLC/OWS:

The autosampler will provide a Common Alarm to indicate a fault in the equipment.

LOOP 619-2 UV EFFLUENT FLOW SAMPLER NO. 2

General: Functionally identical to Loop 619-1.

LOOP 619-3 UV EFFLUENT FLOW SAMPLER NO. 3

General: Functionally identical to Loop 619-1.

LOOP 620-1 UV CHANNEL 1 WEIR GATE

General:

A modulating weir gate is used to maintain effluent water level through the UV channel according to the UV system's automatic controls. Control and monitoring of the gate at the SCADA OWS is achieved by connection of the SCC to the SCADA network. Refer to Specification Section 11656 "Open-Channel Low-Pressure/High-Output Ultraviolet Treatment Equipment" for greater detail on the UV Disinfection System controls.

Control:

Hardwired Interlocks:

None.

Local:

Weir gate operation can be locally controlled by the LCS integral to the valve actuator. The valve LCS shall have a Local/Off/Remote (LOR) selector switch and "Open" and "Close" pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the valve can be opened, stopped in mid-travel, or closed by the Open and Close pushbuttons. Local operation of the valve shall be inching such that the "Open" or "Close" pushbuttons must be continuously depressed for the valve to continue to open or close, respectively.

Off: When the LOR selector switch is in the "Off" position, the valve cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, valve control is transferred to the SCC.

SCADA PLC/OWS:

Software Interlock:

When a motor overload condition is detected, the SCADA PLC/OWS open or close command will be disabled.

Remote Manual Mode:

When the valve is placed into "Remote Manual" either from the OWS or SCC OIT, the operator can enter the gate's position setpoint to command the weir gate to a position either from the OWS or SCC OIT.

Remote Auto Mode:

When the valve is placed into "Remote Auto" either from the OWS or SCC OIT, the SCC will automatically control the weir gate according to the UV's System's automatic control sequence.

Alarms / Monitoring:

Local:

Valve Position (ZIT)
Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)

SCADA PLC/OWS:

Valve Position (ZT)
Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)
Valve LOR Selector Switch Position (YCI)

LOOP 620-2 UV CHANNEL 2 WEIR GATE

General: Functionally identical to Loop 620-1.

LOOP 620-3 UV CHANNEL 3 WEIR GATE

General: Functionally identical to Loop 620-1.

LOOP 630 UV INFLUENT FLOW MEASUREMENT AND CALCULATION

General:

Influent flow to the UV System is calculated using an existing weir (FE-630A) installed in the Dry Weather Effluent Pump Station, a new radar level element and transmitter installed upstream of the weir (LIT/FIT-630) and a new radar level element installed in the dry weather effluent

pump station wetwell (LE-651). The upstream level element and transmitter calculates the flow using standard weir flow calculations. The weir (FE-630A) is a suppressed rectangular weir and flow will be calculated by the transmitter (LIT/FIT-630) using the Francis weir equation. The downstream level element is used to adjust this flow measurement based on the operation of the Dry Weather Effluent Pumps. This flow measurement is output to the UV System Control Center (SCC) PLC via peer-to-peer network communication between CPP-5 and the SCC PLC. This flow value is used by the UV System according to its automatic control sequence.

Control:

Local:

LE-630 measures the level upstream of weir FE-630A. LIT/FIT-630 uses this level measurement to calculate, using standard weir flow calculations, the flow over the weir. LIT/FIT-630 will also output a level signal to replace the existing level signal interfaced with CPP-5 (LI-630).

SCADA PLC/OWS:

The flow measurement from LIT/FIT-630 will be corrected using the level measurement of the Dry Weather Effluent Wetwell (LI-651) according to the following equation:

$$Individual\ Flow\ Setpoint\ = \left[7.4805 \times \left(\left(\frac{FI_{630}}{7.4805}\right) - \left(A \times \left(\frac{\Delta LI_{651}}{\Delta t}\right)\right)\right)\right] \times \left[1 + \left(\frac{f}{100}\right)\right]$$

where,

- UV Influent Flow is the calculated flow in cubic feet per second.
- FI_{630} is the flow signal from LIT/FIT-630 in GPM.
- A is the cross-sectional area of the Dry Weather Effluent Wetwell, which is approximately constant across the normal operating levels. A is equal to 863 ft^2.
- ΔLI_{651} is a time difference of the Dry Weather Effluent Wetwell level (LI-651) in feet at a specified rate (Operator adjustable with password protection, initially set at one second). A negative value indicates a decreasing level, while a positive value indicates an increasing level.
- Δt is the time difference in seconds that the level time difference ΔLI_{651} is calculated.
- 7.4805 is a constant to convert from cubic feet per section to gallons per minute (GPM).
- f is an Operator adjustable biasing factor, adjustable between 0 and 10 that is representative of percentage adjustment of flow from what is calculated.

Alarms / Monitoring:

Local:

Flow over DWEPS Weir (FI) at LIT
DWEPS Weir Level (LI) at LIT

SCADA PLC/OWS:

Flow over DWEPS Weir (FI)

DWEPS Weir Level (LI)

LOOP 651 DRY WEATHER EFFLUENT PUMP STATION WETWELL LEVEL

General:

Monitoring of the Dry Weather Effluent Pump Station (DWEPS) wetwell level by means of a radar level element. This level is used in the calculation of the UV influent flow (see Loop 630).

Control:

Local:

None.

SCADA PLC/OWS:

LI-651 is used in the calculation of the UV System influent flow. See Loop 630.

Alarms / Monitoring:

Local:

DWEPS Wetwell Level (LI) at LIT

SCADA PLC/OWS:

DWEPS Wetwell Level (LI)

LOOP 660 FLOOD PUMP STATION WETWELL LEVEL

General:

Both continuous and point level monitoring of the flood pump station wetwell. Continuous monitoring is by a radar level element (LE-660). Point level monitoring is provided be a High-High Level ball float level switch (LSHH-660), installed at 7.67 ft (above tank floor) ft above the bottom of the wetwell. The radar level element is used to control the operation of the flood pumps (see Loop 665-1).

Control:

Local:

None

SCADA PLC/OWS:

Flood Pump Station Start and Stop Control

If the Flood Pump Station is either in "Automatic Flood Mode" (see Loop 680) or "Flood Pump Station Exercise Mode" (see Loop 665), and the flood pump station wetwell level

rises above a Flood Pump Start Setpoint (4.6 feet (above tank floor), operator adjustable), the Flood Pump Sequence shall be activated (see Loop 665-1). If any flood pumps are running and the flood pump station wetwell level falls below a Flood Pump Stop Setpoint (4.5 feet (above tank floor), operator adjustable) for a period of time (initially set at 10 seconds), the Flood Pump Sequence shall be deactivated (see Loops 665-1 through 665-4).

Variable Speed Flood Pump Level Controller

The flood pump station wetwell level shall be used as the process variable for software PID controller, LIC-660, whose output shall control the speed any running variable speed Flood Pumps (see Loops 665-1 through 665-4).

The operator shall be able to enter a level set point (initially set at 6.5 feet above floor of the wetwell) to the level controller and the output of the controller (LIC-660) shall control the speed of any running flood pumps (Loops 665-1 through 665-4). When the operator enters a level set point, the controller shall adjust the output to maintain a level measurement that is equal or very close to the actual set point entered by the operator.

Alarms / Monitoring:

SCADA PLC/OWS:

Level (LI)
High High Level (LAHH) either from activation of LSHH-660 or a level above 7.67 ft above the bottom of the wetwell as detected by the radar level element.

LOOPS 661 AND 662 UV EFFLUENT DIVERSION GATES DIVERSION GATES

General:

Two motor actuated slide gates installed in the UV Effluent channel control diversion of UV effluent flow to either directly to the outfall or to the Flood Pump station based on the Outfall Level (Loop 680).

Control:

Hardwired Interlocks:

None.

Local (typical for both gates):

Two position (Open or Closed) gate operation can be locally controlled by the LCS integral to the gate actuator. The gate LCS shall have a Local/Off/Remote (LOR) selector switch and “Open” and “Close” pushbuttons.

Local: When the LOR selector switch is in the “Local” position, the gate can be opened, stopped in mid-travel, or closed by the Open and Close pushbuttons. Local operation of the gate shall be maintained such that the “Open” or “Close”

pushbuttons only need to be depressed a single time for the gate to completely to open or close, respectively.

Off: When the LOR selector switch is in the "Off" position, the gate cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, gate control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlock:

When a motor overload condition is detected, the SCADA PLC/OWS open or close command will be disabled.

Manual Mode:

When the valve is placed into "Manual" from the OWS, the operator can command the gate fully open or fully closed.

Automatic Control:

Normal Operation:

If the Flood Pump Station is not in "Automatic Flood Mode" (see Loop 680) or "Flood Pump Station Exercise Mode" (see Loop 665), slide gate SG-661 will be commanded to be fully closed and slide gate SG-662 will be commanded to be fully open, directing UV effluent flow directly to the outfall.

Operation if the Flood Pump Station is in Operation:

If the Flood Pump Station is set to either "Automatic Flood Mode" (see Loop 680) or "Flood Pump Station Exercise Mode" (see Loop 665), slide gate SG-661 will be commanded to be fully open. Once slide gate SG-661 is fully open and after an operator adjustable time delay (initially set at 1 minute), slide gate SG-662 will be commanded to be fully closed, directing UV effluent flow to the flood pump station.

Alarms / Monitoring:

Local:

Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)

SCADA PLC/OWS:

Open Limit Switch (ZLH)
Close Limit Switch (ZLL)
Valve Motor Overload (YFI)

Valve LOR Selector Switch Position (YCI)

LOOPS 665-1 TO 4 FLOOD PUMPS

General:

On/Off Operation and speed control of the Flood Pump Systems. Operation shall be either at the pump VFDs (in UV-MCC) or from the SCADA OWS/PLC.

Control:

Hardwired Interlocks:

If the flood pump's motor high temperature switch (TSH-665-*X*) is in alarm, the flood pump shall be prevented from running or stopped if it is running.

If the flood pump's motor high moisture switch (MSH-665-*X*) is in alarm, the flood pump shall be prevented from running or stopped if it is running.

Local:

Local Start/Stop control of the return sludge pump can be performed from the waste sludge pump VFD. The VFD includes a Local/Off/Remote (LOR) selector switch and Start and Stop pushbuttons.

Local: When the LOR selector switch is in the "Local" position, the return sludge pump can be started and stopped by the Start and Stop pushbuttons. The Start and Stop pushbuttons shall only require a momentary push to start and stop the pump. When the pump is running speed can be controlled from the VFD keypad.

Off: When the LOR selector switch is in the "Off" position, the return sludge pump cannot be operated locally or remotely.

Remote: When the LOR selector switch is in the "remote" position, control is transferred to the SCADA PLC/OWS.

SCADA PLC/OWS:

Software Interlocks:

If the flood pump's motor high temperature switch (TSH-665-*X*) is in alarm, the flood pump shall be prevented from running or stopped if it is running.

If the flood pump's motor high moisture switch (MSH-665-*X*) is in alarm, the flood pump shall be prevented from running or stopped if it is running.

If the flood pump's VFD has a fault, the flood pump shall be prevented from running or stopped if it is running.

If the flood pump station wetwell level (LI-660) is below 4.5 feet above bottom of wetwell the flood pump shall stop or be prevented from running.

Manual Control:

When in manual mode, the operator can start and stop the pump from the OWS. The operator can enter a speed setpoint to command the VFD to a speed.

Automatic On/Off and Speed Control

If the flood pump is in automatic mode at the SCADA PLC/OWS, the flood pump shall be started and stopped according to the following:

Flood Pump Sequence

Flood pumps may be allowed to operate under only if the Flood Pump Station is either in "Automatic Flood Mode" (see Loop 680) or "Flood Pump Station Exercise Mode". "Flood Pump Station Exercise Mode" is an Operator selectable mode at the SCADA OWS. If the UV Influent Flow (Loop 630) is below 10.37 MGD "Flood Pump Station Exercise Mode" shall not be selectable.

If no Flood Pumps are running in automatic mode, the operator shall be able to set an Flood Pump Sequence order by assigning each of the four Flood Pumps to one of the following: Flood Pump Lead, Flood Pump Lag 1, Flood Pump Lag 2, Flood Pump Standby. If a Flood Pump Sequence is already set, the operator must first clear the current Flood Pump Sequence. If a Flood Pump Order has not been selected, an alarm will be generated.

The operator shall be able to change the Flood Pump Sequence when up to two pumps are running. When changing the Flood Pump Sequence when one pump is on, the Lead pump from the last sequence shall remain on until the Lead pump of the new sequence starts, and then the Lead pump from the old sequence shall stop. Thus, during a change from order A to order G, Flood Pump 1 shall remain running until Flood Pump 2 is running, and then Flood Pump 1 shall shutdown.

When changing the Flood Pump Sequence when two pumps are one, and the new order shares both pumps with the last order, both pumps shall remain running while order is changed.

When changing the Flood Pump Sequence when two pumps are on, and the new order shares one pump with last order, there will be two pumps whose run command will change:

- Last Pump: Pump that is part of the last sequence, but not part of the new sequence.
- New Pump: Pump that is part of the new sequence, but not part of the last sequence.

The Last Pump will remain on until the New Pump starts, and then the Last pump shall stop. Thus, during a change from sequence A to sequence C, Pump 2 will remain running until Pump 3 is running, and then Pump 2 shall shutdown.

When changing the Pump Sequence when two pumps are on, and the new order does not share any pumps with the last sequence, the last Lead pump will remain on until the new Lead pump starts, and then the last Lead pump shall stop. After the Lead pump has been switched to the new sequence and a subsequent time delay (initially set at 10 seconds), the Lag 1 pumps may then change. The last Lag 1 pump will remain on until the new Lag 1 pump starts, and then the last Lag 1 pump may stop. Thus, during a change from Order A to Order Q, both Pumps 1 and 2 will continue to run until Pump 3 is running, then Pump 1 will stop. Once Pump 1 stops and the subsequent time delay expires, Pump 4 will start while Pumps 2 and 3 are running. Once Pump 4 is running, Pump 2 will stop.

If a change in Pump Order is attempted while three pumps are running, the operator will be limited to selecting the three pumps that are already running. The pumps will remain running until the new order is selected.

The following is the list of possible Flood Pump Sequences, with the Flood Pump System listed by its Loop Suffix:

SEQUENCE	LEAD	LAG 1	LAG 2	STANDYBY
A	1	2	3	4
B	1	2	4	3
C	1	3	2	4
D	1	3	4	2
E	1	4	2	3
F	1	4	3	2
G	2	1	3	4
H	2	1	4	3
I	2	3	1	4
J	2	3	4	1
K	2	4	1	3
L	2	4	3	1
M	3	1	2	4
N	3	1	4	2
O	3	2	1	4
P	3	2	4	1
Q	3	4	1	2
R	3	4	2	1
S	4	1	2	3
T	4	1	3	2
U	4	2	1	3
V	4	2	3	1
W	4	3	1	2
X	4	3	2	1

If a flood pump is not available for automatic start, fails, or does not start the standby pump shall be started.

If no pumps are running, a Flood Pump Sequence has been selected, a flood pump is available for automatic start, and Flood Pump Station wetwell is above the Flood Pump Lead Start Setpoint (Loop 660) the lead flood pump shall be started.

When the Flood Pump Station is either in "Automatic Flood Mode" (see Loop 680) or "Flood Pump Station Exercise Mode" (see Loop 665), and the Flood Pump Station wetwell level is above the Flood Pump Start Setpoint (Loop 660) the flood pumps will be started.

The number of flood pumps initially started and starting speed will be determined by the amount of influent flow to the UV Facility (Loop 630) according to the following table (note that "(" or ")" indicates non-inclusiveness of a minimum of maximum of a range while "[" or "]" indicates inclusiveness of a minimum or maximum of range):

Start Sequence	UV Influent Flow (MGD)	Number of Pumps	Pump Speed
1	[10.37-13.68]	1	Minimum Load (67%)
2	(13.68-18.29]	1	75%
3	(18.29-20.59]	1	100%
4	(20.59-27.36]	2	Minimum Load (67%)
5	(27.36-36.72]	2	75%
6	(36.72-41.76]	3	Minimum Load (67%)
7	>41.76	3	75%

The Flood pumps will operate according to this table until the Flood Pump Station wetwell level rises above a Level Based Control Setpoint (6.6 feet above the tank floor) or until an operator adjustable time delay expires (initially set at 1 minute), at which point speed control and On-Off operation of the pumps will switch to Level Based Control as described in subsequent paragraphs. When multiple pumps are called to run, there shall be a time delay between pump starts (initially set at 10 seconds). If the UV influent flow changes before switching to Level Based Control such that the start sequence would change, the start sequence will change after an operator adjustable time delay (initially set at 15 seconds).

The level controller output (LIC-660) shall be used and converted to a speed setpoint between 0-100%. While pumps are in level control, output to the pumps shall be the same regardless of the number of pumps running. As the Lead Flood Pump turns on, it shall control the wetwell level by itself until the speed command signal for the pump reaches 95% or higher. Once this speed or higher is reached for a period of time (initially set at 10 seconds), the Lag 1 pump shall come on and ramp up to its minimum load condition (initially set at 67%).

After the Lag 1 pump is at its minimum load condition, the Lead pump shall ramp down and the Lag 1 pump shall start to ramp up from its minimum load position until both pumps are running at the same speed. After both pumps are running at the same speed, pump speeds will be based on level control as described above. If the speed

command signal for both pumps reaches 95% or higher for a period of time (initially set at 10 seconds), the Lag 2 pump shall come on and ramp up to its minimum load condition (initially set at 67%).

After the Lag 2 pump is at its minimum load condition, the Lead and Lag 1 Pump shall ramp down and the Lag 2 pump shall ramp up from its minimum load condition until all three pumps are running at the same speed.

After three pumps are running at the same speed, pump speeds will be based on level control as described above. All three pumps shall remain running until the speed command of all three pumps is less than 5% above the minimum load condition of the Lag 2 pump. At this point, and after a period of time (initially set at 10 seconds), the Lag 2 pump shall stop.

Once two pumps are running, both pumps will continue to run until the speed command of both pumps is less than 5% above the minimum load condition of the Lag 1 pump. At this point, and after a period of time (initially set at 10 seconds), the Lag 1 pump will stop. The lead pump will continue to run until the level in the Flood Pump Station falls below the Flood Pump Stop Setpoint, at which point the Lead Pump will stop.

Should the Flood Pumps start in automatic operation and then neither "Automatic Flood Mode" (see Loop 680) nor "Flood Pump Station Exercise Mode" are no longer active, then the Flood Pumps shall continue to operate according to the above description until all of the pumps stop.

Alarms / Monitoring:

Local:

Running (YRI-A)
Stopped (YRI-B)
VFD Fault (XA)
High Motor Temperature (TAH)
Leak (MAH)
Power On (JN)
Speed (SI, At VFD Keypad)

SCADA PLC/OWS:

Running (YRI-A)
Stopped (YRI-B)
VFD Fault (XA)
High Motor Temperature (TAH)
Leak (MAH)
Power On (JN)
In Remote (YCI)
Speed (SI)

LOOP 675 FLOOD STATION DRAIN PUMP

General:

On/Off control of the Flood Station Drain Pump, which serves to drain both the flood pump station and UV Channels. The Flood Drain Pump can only be locally at the motor starter installed in the UV-MCC.

Control:

Hardwired Interlocks:

If the flood drain pump's motor high temperature switch (TSH-675-1) is in alarm, the flood drain pump shall be prevented from running or stopped if it is running. The pump shall not be able to run again until the Reset push button is depressed.

If the flood drain pump's motor high moisture switch (MSH-675-1) is in alarm, the flood drain pump shall be prevented from running or stopped if it is running. The pump shall not be able to run again until the Reset push button is depressed.

If the flood drain pump overloads, the flood drain pump shall be prevented from running or stopped if it is running. The pump shall not be able to run again until the Reset pushbutton is depressed.

If the Flood Drain pump Low-Low level 1 ft. (above the bottom of the drain wetwell floor) switch is activated, the flood drain pump shall be prevented from running or stopped if it is running. This interlock shall be non-latching, so the Reset pushbutton does not need to be pressed to resume operation.

Local:

Local Start/Stop control of the flood drain pump can be performed from the pump's motor starter. The motor starter includes start and stop pushbuttons to start and stop the pump. The start and stop push buttons shall only require a momentary push to start and stop the pump.

SCADA PLC/OWS:

Software Interlock:

None

Manual Mode:

None

Automatic Control:

None.

Alarms / Monitoring:

Local:

Running Status Light (YRI) at the associated MCC cubicle.
Stopped Status Light (YRI) at the associated MCC cubicle.
Motor High Temperature Light (TAH) at the associated MCC cubicle.
Leak Light (MAH) at the associated MCC cubicle.
Low-Low Leve Light (LALL) at the associated MCC cubicle.
Overload Light (XA) at the associated MCC cubicle.
Power On Light (JN) at the associated MCC cubicle.

SCADA PLC/OWS:

Running Status (YRI)
Stopped Status (YRI)
Motor High Temperature (TAH)
Leak (MAH)
Level (LI)
Low-Low Level (LALL)
Overload (XA)

LOOP 680 OUTFALL LEVEL

General:

The water level at the outfall (and by extension the Seekonk River) is measured by a radar level element (LE-680) installed in a dedicated measurement well that is in hydraulic communication with the outfall culvert. This level is used to activate and deactivate "Automatic Flood Mode", which is allows the Flood Pump Station Pumps to run (see Loops 675-1 through 675-4).

Control:

Local:

None

SCADA PLC/OWS:

If the outfall level (LI-680) rises above an Automatic Flood Mode Enable Setpoint, 10.24 feet (elevation) for a period of time (initially set at 5 minutes), Automatic Flood Mode shall be initiated. If the outfall level falls below an Automatic Flood Mode Disable Setpoint, 10.24, for a period of time (initially set at 5 minutes), Automatic Flood Mode shall be disabled.

Alarms / Monitoring:

SCADA PLC/OWS:

Level (LI)

LOOP 1925 RSPS3-UPS ALARM AND STATUS

General: Alarm and status information from RSPS3-UPS to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

Status on UPS HMI screen.

SCADA:

UPS fault (YFI)
UPS On Battery Power (XS)
UPS On Static Bypass (ZS-A)
UPS Low Battery Power (XA)
UPS On Maintenance Bypass (ZS-B)

LOOP 1926 UV-UPS ALARM AND STATUS

General: Functionally identical to Loop 1925.

LOOP 1956 RIOP-6B OSM TROUBLE ALARM

General: Alarm status from optical switch module (ethernet switch) to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

Trouble Alarm (XA)

LOOP 1957 RIOP-5C MANAGED ETHERNET SWITCH TROUBLE ALARM

General: Functionally identical to Loop 1956.

LOOP 1958-1 RIOP-5C OLM 1 TROUBLE ALARM

General: Alarm status from optical link module to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

Trouble Alarm (XA)

LOOP 1958-2 RIOP-5C OLM 2 TROUBLE ALARM

General: Functionally identical to Loop 1958-1.

LOOP 1959-1 CPP-5 PANEL 1 FIBER OPTIC CONVERTER 1 TROUBLE ALARM

General: Alarm status from the ethernet to fiber optic media converter to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

Trouble Alarm (XA)

LOOP 1959-2 CPP-5 PANEL 1 FIBER OPTIC CONVERTER 2 TROUBLE ALARM

General: Functionally identical to Loop 1959-1.

LOOP 1960 RIOP-6B MANAGED ETHERNET SWITCH TROUBLE ALARM

General: Functionally identical to Loop 1956.

LOOP 1961-1 RIOP-6B OLM 1 TROUBLE ALARM

General: Functionally identical to Loop 1958-1.

LOOP 1961-2 RIOP-6B OLM 2 TROUBLE ALARM

General: Functionally identical to Loop 1958-1.

LOOP 1978-1 RIOP-6B 24 VDC POWER SUPPLY 1 TROUBLE ALARM

General: Alarm status from 24 VDC power supply to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

Trouble Alarm (XA)

LOOP 1978-2 RIOP-6B 24 VDC POWER SUPPLY 1 TROUBLE ALARM

General: Functionally identical to Loop 1978-1.

LOOP 1979-1 RIOP-5C 24 VDC POWER SUPPLY 1 TROUBLE ALARM

General: Functionally identical to Loop 1978-1.

LOOP 1979-2 RIOP-5C 24 VDC POWER SUPPLY 2 TROUBLE ALARM

General: Functionally identical to Loop 1978-1.

LOOP 1988 RIOP-6B COMMON SURGE PROTECTION DEVICE TROUBLE ALARM

General: Common Alarm status to the SCADA system from the surge protection devices. All surge protection device contacts shall be wired in series. If one trips the SCADA system will get this common alarm.

Control:

None.

Alarms / Monitoring:

Local:

None.

SCADA:

Trouble Alarm (XA)

LOOP 1989 RIOP-5C COMMON SURGE PROTECTION DEVICE TROUBLE ALARM

General: Functionally identical to Loop 1988.

LOOP 2749-5 MANHOLE EMH-P100A HIGH HIGH LEVEL ALARM

General: High high level alarm status from sump control panel to the SCADA system.

Control:

Local:

None.

Alarms / Monitoring:

Local:

High High Level Alarm (LAHH).

SCADA:

High High Level Alarm (LAHH).

LOOP 2749-6 MANHOLE EMH-P100B HIGH HIGH LEVEL ALARM

General: Functionally identical to Loop 2749-5.

LOOP 2749-7 MANHOLE EMH-C102 HIGH HIGH LEVEL ALARM

General: Functionally identical to Loop 2749-5.

LOOP 2763 RETURN SLUDGE PUMP STATION NO. 3 SUMP CONTROL PANEL HIGH HIGH LEVEL ALARM

General: High high level alarm status alarm from sump control panel to the SCADA system.

Control:

Local:

All level control on sump pump is performed locally by sump control panel.

Alarms / Monitoring:

Local:

High High Level Alarm (LAHH).

SCADA:

High High Level Alarm (LAHH).

LOOP 2774 RETURN SLUDGE PUMP STATION NO. 3 HEAT TRACING PANEL TROUBLE ALARM

General: Trouble alarm status from Heat Tracing Panel to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

Trouble Alarm (XA).

SCADA:

Trouble Alarm (XA).

LOOP 2786 HVAC CONTROL PANEL ATC-1 COMMON ALARM

General: Common alarm status from HVAC Control Panel ATC-1 (in RSPS No. 3) to the SCADA system.

Control:

None.

Alarms / Monitoring:

Local:

Common Alarm (XA).

SCADA:

Common Alarm (XA).

LOOP 2787 HVAC CONTROL PANEL UV-ATC-1 COMMON ALARM

General: Common alarm status from HVAC Control Panel UV-ATC-1 (in UV Facility) to the SCADA system. This common alarm will indicate status for both UV-ATC-1 and UV-ATC-2 control panels. Refer to HVAC drawings.

Control:

None.

Alarms / Monitoring:

Local:

Common Alarm (XA).

SCADA:

Common Alarm (XA).

LOOP 3081 to 3088 MCC-RSL BUS-A POWER MONITORING STATUS

The following points are transfer over an Ethernet connection to the SCADA servers from the power monitoring Ethernet switches

- II-3081A - Phase A Amperes
- II-3081B - Phase B Amperes
- II-3081C - Phase C Amperes
- JI-3082A - Phase A Kilovolts
- JI-3082B - Phase B Kilovolts
- JI-3082C - Phase C Kilovolts
- JI-3083 - Kilovolt Amperes
- JI-3084 - Kilowatts
- JI-3085 - KVAR
- IY-3086 - Power factor
- JY-3087 - Kilowatt-Hours
- JI-3088 - Voltage to Neutral

LOOP 3091 to 3098 MCC-RSL BUS-B POWER MONITORING STATUS

The following points are transfer over an Ethernet connection to the SCADA servers from the power monitoring Ethernet switches

- II-3091A - Phase A Amperes
- II-3091B - Phase B Amperes
- II-3091C - Phase C Amperes
- JI-3092A - Phase A Kilovolts
- JI-3092B - Phase B Kilovolts
- JI-3092C - Phase C Kilovolts
- JI-3093 - Kilovolt Amperes
- JI-3094 - Kilowatts
- JI-3095 - KVAR
- IY-3096 - Power factor
- JY-3097 - Kilowatt-Hours
- JI-3098 - Voltage to Neutral

LOOP 3201 to 3208 MCC-UV BUS-A POWER MONITORING STATUS

The following points are transfer over an Ethernet connection to the SCADA servers from the power monitoring Ethernet switches

- II-3201A - Phase A Amperes
- II-3201B - Phase B Amperes
- II-3201C - Phase C Amperes
- JI-3202A - Phase A Kilovolts
- JI-3202B - Phase B Kilovolts
- JI-3202C - Phase C Kilovolts
- JI-3203 - Kilovolt Amperes
- JI-3204 - Kilowatts
- JI-3205 - KVAR
- IY-3206 - Power factor
- JY-3207 - Kilowatt-Hours
- JI-3208 - Voltage to Neutral

LOOP 3091 to 3098 MCC-UV BUS-B POWER MONITORING STATUS

The following points are transfer over an Ethernet connection to the SCADA servers from the power monitoring Ethernet switches

- II-3211A - Phase A Amperes
- II-3211B - Phase B Amperes
- II-3211C - Phase C Amperes
- JI-3212A - Phase A Kilovolts
- JI-3212B - Phase B Kilovolts
- JI-3212C - Phase C Kilovolts
- JI-3213 - Kilovolt Amperes
- JI-3214 - Kilowatts
- JI-3215 - KVAR
- IY-3216 - Power factor
- JY-3217 - Kilowatt-Hours
- JI-3218 - Voltage to Neutral

END OF SECTION 13614

SECTION 13631 - PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

1. Section includes programmable logic controllers.
2. Provide the new RIOP-6B with S7-300 Series ET 200M I/O racks for interfacing with all hardwired I/O. The number of I/O racks, power supplies, interface modules, and I/O modules will be based on number of I/O shown on the P&ID plus the specified number of spare I/O. See “IO Rack Components” below for further details. At a minimum each I/O rack shall have 2 redundant interface modules to separately connect the I/O rack to each redundant processor rack in CPP-6.
3. Provide the new RIOP-5C with S7-300 Series ET 200M I/O racks for interfacing with all hardwired I/O. The number of I/O racks, power supplies, interface modules, and I/O modules will be based on number of I/O shown on the P&ID plus the specified number of spare I/O. See “IO Rack Components” below for further details. At a minimum each I/O rack shall have 2 redundant interface modules to separately connect the I/O rack to each redundant processor rack in CPP-5 Panel 1.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions” for submittal requirements.
2. Section 13614 “Process Control Descriptions”.

1.3 DEFINITIONS

A. AO – Analog Output

B. AI – Analog Input

C. DI - Digital Input

D. DO - Digital Ouput

E. I/O – Input/Output

F. IO – Input/Output

G. PLC - Programmable Logic Controller

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions” for preinstallation meetings.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

B. Shop Drawings:

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.6 INFORMATIONAL SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.7 CLOSEOUT SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Processors: 1 Spare Processor
2. Memory Cards: 1 Spare Memory Card
3. I/O Cards: 2 Spare I/O cards of each type provided
4. Network interface, remote I/O, and communication modules: 2 Spare Cards of each type provided
5. Specialty modules: 1 Spare modules of each type provided
6. PLC Power Supplies: 1 Spare power supply of each size provided.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.10 TECHNOLOGY OBSOLESCENCE MITIGATION

A. Not applicable to this Section.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.12 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.13 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Configuration: Networked programmable controller for controlling the Final Clarifier system and the Ultraviolet Disinfection Facility.

B. Spare I/O, Slots and Future Expansion:

1. Spare PLC I/O:

a. Provide 20 percent points per type AI AO, DI, and DO for future use.
b. Provide spare I/O points of same type of I/O modules supplied.

2. Future PLC Expansion (Non-Chassis-Based I/O Racks):

a. Provide adequate space to the right of the last I/O card per row of I/O cards for 2 future I/O cards.
b. Card width based on the widest I/O card provided in panel.

3. Provide external relay for spare output points that require their use.
4. Wire all unused points on all I/O to terminal blocks in the order that they occur on the I/O modules.

2.2 PLC SYSTEM

A. Manufacturers:

1. Provide all PLCs from a single manufacturer. If the PLC manufacturer has authorized third party vendors to provide modules that are compatible with their platforms, then products manufactured by these authorized third-party vendors will be acceptable.
2. Manufacturers and their products are subject to compliance with requirements. Provide the following:

    a. Siemens – S7 Series
    b. Substitutions: Not Permitted.

B. General:

1. Provide Programmable Logic Controller equipment with the required memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points.
2. Provide processor, power supply, communication modules, redundancy modules, and remote interface modules as required to meet system requirements.
3. Provide products listed and classified by UL, CSA, or FM approval as suitable for purpose specified and indicated.
4. Provide products designed for continuous industrial service.
5. Provide products of a single manufacturer, insofar as possible
6. Provide equipment models that are currently in production.
7. Provide only equipment designed and constructed so that in the event of power interruption the systems go through an orderly shutdown with no loss of memory and resume normal operation without manual intervention when power is restored.
8. Provide PLCs that communicate between workstations, servers, instruments, switches, controllers, process actuators, etc. as shown on the Drawings and specified herein.
9. Provide products such that communication protocols shall be transparent from any HMIs or OITs.
10. Provide a PLC capable of stand-alone operation in the event of failure of the communication link to the HMI subsystem.
11. Provide I/O modules, interface modules, communication modules, and power supply to meet system I/O requirements.

C. Identify all major assemblies and sub-assemblies, circuit boards, and devices using permanent labels or markings indicating:

1. Module product type such as analog or digital.
2. Module catalog number.
3. Module major revision number.
4. Module minor revision number.
5. Module manufacturer vendor.
6. Module serial number.

D. Include all necessary cables as specified by the manufacturer. Assemble and install cables per manufacturer recommendations.

E. IO Rack Components:

1. Power Supply: S7-300 PS307. Rated for 120/230 VAC Input and 24 VDC Output.
2. Interface Modules: S7-300 IM 153-2. Profibus DP Slave Module (Part No. 6ES71532BA100XB0).

3. Discrete Input Modules: S7-300 SM 321. 16 DI, 120/230 VAC, isolated discrete input modules (Part No. 6ES73211FH000AA0).
4. Discrete Output Modules: S7-300 SM 322. 16 DO, 24-230V relay discrete output modules (Part No. 6ES73221HH010AA0).
5. Analog Input Modules: S7-300 SM 331. 8 AI, isolated analog input module (Part No. 6ES73317NF000AB0).
6. Analog Output Modules: S7-300 SM 332. 4 AI, isolated analog output module (Part No. 6ES73327ND020AB0).

2.3 SOURCE QUALITY CONTROL

A. Testing: Test programmable controller according to NEMA IA 2.2.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and rooms for suitable conditions where programmable logic controllers will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Arrange I/O points such that I/O for equipment that operates in parallel, as shown on the Drawings or specified in section 13614 “Process Control Descriptions”, are installed on separate I/O modules (e.g. similar points for pumps in a Lead-Lag-Standby configuration installed on separate modules).

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports in accordance with the following:

1. Section 13610 “Process Control and Enterprise Management General Provisions.”
2. Section 13612 “Process Control System Testing.”

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 SOFTWARE SERVICE AGREEMENT

A. Not Required

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13631

SECTION 13661 - SWITCHES AND ROUTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

1. Section includes switches and routers.
2. RIOP-6B:

    a. Install one new Managed Ethernet Switch (MES) in the new RIOP-6B. Provide MES with SFP compatible with existing SFPs installed in MES located in CPP-6.
    b. Use one SFP slot (with appropriate SFP) in MES to connect to existing MES in CPP-6 via fiber optic patch panels.
    c. Install one new Optical Switch Module (OSM) in the new RIOP-6B.
    d. Use two fiber ports to connect the new OSM to Plant Profinet SCADA network via a fiber optic patch panel.
    e. Install two new Optical Link Modules (OLM) in the new RIOP-6B. Connect the RS485 Profibus port of each OLM to one interface module on each IO Rack. Connect one fiber port of each OLM to the unused fiber ports of the existing OLM of CPP-6.

3. RIOP-5C:

    a. Install one new Ethernet switch in the new RIOP-5C to support communication between the UV System PLC (UV-SCC) and the CPP-5 processors and SCADA network.
    b. Use two fiber ports to connect to newly installed media converters in CPP-5 Panel 1.
    c. Two ethernet port will be used for connection to UV System PLC.
    d. Install two new Optical Link Modules (OLM) in the new RIOP-5C. Connect the RS485 Profibus port of each OLM to one interface module on each IO Rack. Connect one fiber port of each OLM to the unused fiber ports of the existing OLM of CPP-5.

4. CPP-5 PNL 1

    a. Install two new Copper (ethernet) to Fiber Media Converters in the existing CPP-5 PNL 1. Provide the media convers with 24VDC power from CPP-5 PNL 1. Connect RJ45 ports of the media converters to the existing OSM in CPP-5 PNL1. Connect the fiber port of each media converters to the new MES installed in the new RIOP-5C.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions” for submittal requirements.
2. Section 13612 “Process Control System Testing.”
3. Section 13631 “Programmable Logic Controllers.”

1.3 DEFINITIONS

A. F/E MC –Copper (Ethernet) to Fiber Media Converter

B. MES – Managed Ethernet Switch

C. OLM – Optical Link Module

D. OSM – Optical Switch Module

E. SFP – Small Form-Factor Pluggable Transceiver

F. UV-SCC: Ultraviolet System Control Center

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions” for preinstallation meetings

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

B. Shop Drawings:

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.6 INFORMATIONAL SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.7 CLOSEOUT SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Industrial Managed Ethernet Switch: 1 Spare Managed Ethernet Switch

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.10 TECHNOLOGY OBSOLESCENCE MITIGATION

A. Not applicable to this Section.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.12 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.13 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions/”

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 OPTICAL SWITCH MODULES (OSM)

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide the following:

    a. Siemens SCALANCE X-300 Series
    b. Substitutions: Not Permitted.

B. General:

1. Furnish a DIN rail mountable industrial managed Ethernet switch for connection to the network as shown in the Drawings and specified herein.
2. Furnish ethernet switches by the same manufacturer for the project, regardless of type.

C. Physical Features:

1. Minimum Fiber Optic ports: 2 x 100 Mbs ST/BFOC ports.
2. Minimum copper ports: 6 x 10/100 Mbs ports.
3. Operating temperature: 0 to 130 °F.
4. Power: redundant 24VDC power input
5. Enclosure: Metal case.

D. Network Features:

1. Layer 2 switching
2. Spanning Tree Protocol (STP)
3. Rapid Spanning Tree Protocol (RSTP) (IEEE 802.1w)
4. Full duplex on all port.
5. Auto negotiation and manual configurable speed and duplex.
6. IGMP snooping.
7. IGMP filtering.
8. Configuration password protected.
9. Configuration backup capability required.
10. SNMP V3.
11. Lock port function for blocking unauthorized access based on MAC address.

E. Additional Features:

1. Provide a dry contact rated for 120 VAC 5A to be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.

2.3 INDUSTRIAL MANAGED ETHERNET SWITCH (MES)

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide the following:

    a. Siemens Cisco Catalyst IE3300 Rugged Series
    b. Substitutions: Not Permitted.

B. General:

1. Furnish a DIN rail mountable industrial managed Ethernet switch for connection to the network as shown in the Drawings and specified herein.
2. Furnish ethernet switches by the same manufacturer for the project, regardless of type.

C. Physical Features:

1. Minimum SFP Slots: 2 x 100/1000 Mbs SFP ports. Provide SFPs as necessary to communicate with new or existing networking equipment as shown on the drawings.
2. Minimum copper ports: 6 x 10/100 Mbs ports.
3. Operating temperature: 0 to 130 °F.
4. Power: redundant 24VDC power input
5. Enclosure: Metal case.

D. Network Features:

1. Layer 2 switching
2. Spanning Tree Protocol (STP)
3. Rapid Spanning Tree Protocol (RSTP) (IEEE 802.1w)
4. Full duplex on all port.
5. Auto negotiation and manual configurable speed and duplex.
6. IGMP snooping.
7. IGMP filtering.
8. Configuration password protected.
9. Configuration backup capability required.
10. SNMP V3.
11. Lock port function for blocking unauthorized access based on MAC address.

E. Additional Features:

1. Provide a dry contact rated for 120 VAC 5A to be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.

2.4 OPTICAL LINK MODULE (OLM)

A. Manufacturers

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

   a. Siemens OLM/G12
   b. Substitutions: Not Permitted.

B. General:

1. Provide a copper to fiber media converter as shown in the Drawings and specified herein.

C. Physical Features:

1. RS485 port: One 9 pin port compatible with electrical Profibus interfaces.
2. Fiber port: 10/100MB/1GB (LC/ST/SC connectors).
3. Fiber optics: Multi- or single-mode capability as shown in the Drawings.
4. Operating temperature: 0 to 130 °F.
5. Power: 24 VDC.
6. Enclosure: DIN-rail mountable.

D. Additional Features:

1. The converter shall come equipped with a dry contact rated for 120 VAC 5A that shall be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.

2.5 COPPER (ETHERNET) TO FIBER MEDIA CONVERTER (F/E MC)

A. Manufacturers

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Moxa.
b. Phoenix Contact.
c. Red Lion.
d. Substitutions: Or equal.

B. General:

1. Provide a copper to fiber media converter as shown in the Drawings and specified herein.

C. Physical Features:

1. RJ45 port: 10/100MB/1GB.
2. Fiber port: 10/100MB/1GB (LC/ST/SC connectors as required).
3. Fiber optics: Multi- or single-mode capability as shown in the Drawings.
4. Operating temperature: 0 to 130 °F.
5. Power: 24 VDC.
6. Enclosure: DIN-rail mountable.

D. Additional Features:

1. The converter shall come equipped with a dry contact rated for 120 VAC 5A that shall be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and rooms for suitable conditions where switches will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings and specifications for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports in accordance with the following:

1. Section 13610 “Process Control and Enterprise Management General Provisions.”
2. Section 13612 “Process Control System Testing.”

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. For Managed Ethernet Switches:

    a. Enable the lock port function to block unauthorized access based on MAC address for each switch and router. All devices connecting to switch shall have static IP addresses assigned.
    b. Lock down all spare switch and router ports.

3.6 SOFTWARE SERVICE AGREEMENT

A. Refer to Section 13610 “Process Control and Enterprise Management Systems - General Provisions.”

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13661

SECTION 13675 – INDUSTRIAL ENCLOSURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes Industrial Enclosures.

B. Related Requirements:

1. Section 13340 “Instrumentation for Process Systems”.
2. Section 13610 “Process Control and Enterprise Management Systems General Provisions”.
3. Section 13631 “Programmable Logic Controllers.”
4. Section 13661 “Switches and Routers.”
5. Section 13678 “Panel Wiring”.
6. Section 13679 “Uninterruptible Power Supplies”.
7. Section 13798 “Relays”.
8. Section 13799 “Isolators, Intrinsically Safe Barriers, and Surge Suppressors.”
9. Section 13801 “Power Supplies.”

C. Match all new panels and panel components to existing equipment and models wherever possible, so that system additions can be most easily integrated with respect to operation and maintenance training, spare parts inventory, and service contracts. Even when exact matches are not possible, equipment furnished must be fully compatible with the existing system. Provide color, size, and materials of new panels as required to conform to that of existing panels.

D. Provide the following panels. Supply each panel with full sub-panels and side panels as required.

PANEL SCHEDULE

Panel Designation	Minimum Panel Size	Maximum Panel Size	Enclosure Rating and Type
RIOP-6B	72” High x 48” Wide x 24” Deep	90” High x 60” Wide x 24” Deep	NEMA Type 4, 2-door, painted steel construction, free standing. Front Access Only.
RIOP-5C	72” High x 36” Wide x 24” Deep	90” High x 48” Wide x 24” Deep	NEMA Type 4, 1 or 2-door, painted steel construction, free standing. Front Access Only.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

PART 2 - PRODUCTS

2.1 INDUSTRIAL ENCLOSURES

A. Manufacturers

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. nVent: Hoffman.
b. Rittal.
c. Signinaw.
d. Substitutions: Or equal.

B. Freestanding and Floor-Mounted Vertical Panels:

1. Furnish freestanding and floor-mounted vertical panels that meet the NEMA classification as shown on the drawings or specified herein. Construct panels of 12 gauge sheet steel, suitably braced internally for structural rigidity and strength. Construct all NEMA 4X rated panels of Type 316 stainless steel, unless FRP is specifically indicated to be provided. For front panels or panels containing instruments, provide not less than 10 gauge stretcher-leveled sheet steel, reinforced to prevent warping or distortion.

C. Wall and Unistrut Mounted Panels:

1. Furnish wall- and Unistrut- mounted panels that meet the NEMA classification as shown on the Drawings or specified herein. Construct panels of not less than USS 14 gauge steel, suitably braced internally for structural rigidity and strength. Construct NEMA 4X rated wall mounted panels of Type 316 stainless steel, unless FRP is specifically indicated. For chlorine areas, use FRP panels. Provide a protective coating and sun shield to prevent discoloration and cracking for FRP panels located in direct sunlight.

2.2 ACCESSORIES

A. Environmental Controls:

1. Provide louvers, sun shields, heat sinks, forced air ventilation, and / or air conditioning units as required to prevent temperature buildup inside of panel. Regulate internal temperature of all panels to a range of 45 Deg F to 104 Deg F under all conditions. Do not compromise the NEMA rating of the panel under any circumstances.

2. Except for panels mounted with their backs directly adjacent to a wall, louvers shall be in the rear of the panels, top and bottom, and shall be stamped sheet metal construction.
3. For panels mounted with their backs directly adjacent to a wall, louvers shall be on the sides.
4. Forced air ventilation fans, where used, shall provide a positive internal pressure within the panel, and shall be provided with washable or replaceable filters. Fan motors shall operate on 120-volt, 60-Hz power.
5. For panels with internal heat that cannot be adequately dissipated with natural convection and heat sinks, or forced air ventilation, an air conditioner shall be provided.
6. Provide custom fabricated sun shields for all outdoor panels in accordance with the following requirements:

    a. Fabricate sun shields from minimum 12 gauge Type 316 stainless steel. Design, fabricate, install, and support shields to fully cover and shade the top, sides and back of the enclosure, and to partially shade the front panel of the enclosure, from direct exposure to sunlight from sunrise to sunset.
    b. Depending on overall size, fabricate sun shields in single or multiple segments for attachment to the enclosure support framing or to separate free standing framing around the enclosure.
    c. Do not attach sun shields directly to the enclosure by drilling holes through, or welding studs to, the enclosure surfaces. Design and mount shields to provide a minimum 3-inch air gap all around the enclosure for air circulation and heat dissipation.
    d. Slope the top section of all sun shields at a minimum angle of 5 degrees from horizontal. For wall mounted enclosures, slope the top section downward away from the wall and towards the front of the enclosure. For free standing, floor mounted and frame mounted enclosures, slope the top section downward towards the back side of the enclosure.
    e. Incorporate a narrow and more steeply sloped drip shield segment at the front edge of the top section of all sun shields that sheds water away from the front of the enclosure and prevents it from dripping or running directly onto the front panel of the enclosure.
    f. Use continuous seam welds in sun shield fabrication and grind smooth.
    g. Smooth round or chamfer exposed corners, edges, and projections to prevent injury.

7. Provide an integral heater, fan, and adjustable thermostat for outdoor enclosures and enclosures located in unheated areas indoors or in areas subject to humidity and moisture to reduce condensation and maintain the minimum internal panel temperature. Mount unit near bottom of the enclosure with discharge away from heat-sensitive equipment. Heater shall be Hoffman DAH, 120 Volt, 50/60 HZ or equal.

B. Nameplates:

1. Equip panels and panel devices with suitable nameplates to identify the panel and individual devices as required. Unless otherwise indicated, include up to three lines with the first line containing the device tag number as shown on the drawings, the second line containing a functional description (e.g., Recirculation Pump No. 1), and the third line containing a functional control description (e.g., Start).
2. Unless escutcheon plates are specified or unless otherwise noted on the Drawings, furnish nameplates as 3/32-inch thick, black and white, Lamicoid with engraved inscriptions. Use

black against a white background unless otherwise noted. Bevel and smooth edges of the. Nameplates with chipped or rough edges are not acceptable.

3. Mount or fasten cabinet mounted nameplates with epoxy adhesive or stainless steel screws.
4. For every panel, provide a panel nameplate with a minimum of 1-in high letters. Provide legend plates or 1-in by 3-in engraved nameplates with 1/4-in lettering for identification of door mounted control devices, pilot lights, and meters.
5. Use single lamicoid nameplates with multiple legends for grouping of devices such as selector switches and pilot lights that relate to one function.

C. Corrosion Control:

1. Protect panels from internal corrosion by the use of corrosion-inhibiting vapor capsules. Size and quantity as necessary per manufacturer recommendations.
2. Manufacturer:

   a. Zerust VC.
   b. Hoffman Model AHCI.
   c. Or equal.

2.3 GENERAL FINISH REQUIREMENTS

A. Descale, degrease, fill, grind and finish sections. Finish steel-fabricated enclosures with two rust resistant phosphate prime coats and two coats of enamel, polyurethane, or lacquer finish which are applied by either the hot air spray or conventional cold spray methods. Brushed anodized aluminum, stainless steel, and FRP panels do not require a paint finish.

B. Grind smooth, sandblast and then clean with a solvent. Fill surface voids and grind smooth.

C. Immediately after cleaning, apply one coat of a rust-inhibiting primer inside and outside, followed by an exterior intermediate and top coat of a two-component type epoxy enamel. Apply final sanding to the intermediate exterior coat before top coating.

D. Apply a minimum of two coats of manufacturer’s standard, flat light-colored lacquer, on the panel interior after priming.

E. Unless otherwise noted, finish exterior colors as ANSI 61 gray with a textured finish.

F. Finish products after assembly.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 16061 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 16058 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 ADJUSTING

A. Adjust hardware and moving parts to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION 13675

SECTION 13678 - PANEL WIRING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes requirements for internal wiring of control panels and consoles.

B. Related Requirements:

1. Section 13340 “Instrumentation for Process Systems”.
2. Section 13610 “Process Control and Enterprise Management Systems General Provisions”.
3. Section 13631 “Programmable Logic Controllers.”
4. Section 13661 “Switches and Routers.”
5. Section 13675 “Industrial Enclosures”.
6. Section 13679 “Uninterruptible Power Supplies”.
7. Section 13798 “Relays”.
8. Section 13799 “Isolators, Intrinsically Safe Barriers, and Surge Suppressors.”
9. Section 13801 “Power Supplies.”

1.3 ACTION SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 CONTROL PANEL - INTERNAL CONSTRUCTION

A. Internal Electrical Wiring:

1. Provide stranded, type THHN or THWN interconnecting wiring with 600 volt insulation rated for not less than 90 degrees Celsius. Segregate wiring for systems operating at voltages in excess of 120 VAC from other panel wiring either in a separate section of a multi-section panel or behind a removable Plexiglas or similar dielectric barrier. Develop panel layout such that technicians shall have complete access to 120 VAC and lower voltage wiring systems without direct exposure to higher voltages.
2. For power distribution wiring on the line side of fuses or breakers, use 12 AWG minimum. For control wiring on the secondary side of fuses, use 16 AWG minimum.

Utilize 18 AWG shielded, twisted pair cable insulated for not less than 600 volts for electronic analog circuits.

3. Cover power distribution blocks with protective guards to meet "finger-safe" requirements of IP20.
4. Route power and low voltage DC wiring systems in separate wireways. Cross different system wires at right angles. Separate different system wires routed parallel to each other by at least 6-inches. Terminate different wiring systems on separate terminal blocks. Do not fill wiring troughs to more than 60 percent visible fill.
5. Terminations:

    a. Terminate wiring onto single tier terminal blocks, where each terminal is uniquely and sequentially numbered. Direct wiring between field equipment and panel components is not acceptable.

        1) Multi-level terminal blocks or strips are not acceptable.

    b. Arrange terminal blocks in vertical rows and separated into groups (power, AC control, DC signal). Provide each group of terminal blocks with a minimum of 25 percent spares.
    c. Use compression type, fused, unfused, or switched terminal blocks. Use two terminals per point for discrete inputs and outputs (DI and DO) with adjacent terminal assignments. Wire all active and spare PLC and controller points to terminal blocks.
    d. Use three terminals per point for analog inputs and outputs (AI and AO) per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the PLC cabinet. Wire all active and spare PLC and controller points to terminal blocks.
    e. Use sleeve-type wire and tube markers with heat impressed letters and numbers.
    f. Use only one side of a terminal block row for internal wiring. Field wiring side of the terminal shall not be within 6-inches of the side panel or adjacent terminal or within 8-inches of the bottom of free standing panels, or within 3-inches of stanchion mounted panels, or 3-inches of adjacent wireway.
    g. Isolate circuit power from the SCADA cabinet out to field devices (switches, dry contacts etc.) that are used as discrete inputs to the PLC input cards with an isolating switch terminal block with flip cover that is supplied with a dummy fuse. Use an Allen Bradley Model 1492-H7 or equal. One isolating switch terminal block per loop numbered piece of equipment and one per spare I/O point is acceptable.
    h. Isolate all PLC discrete outputs to the field with an isolating fuse switch terminal block with a flip cover and a neon blown fuse indicator. Use an Allen Bradley 1492-H4 or equal.

6. Clearly identify wiring to hand switches and other devices, which are live circuits independent of the panel's normal circuit breaker protection as such.
7. Wiring shall be clearly tagged and color coded. Tag numbers and color coding shall correspond to panel wiring diagrams and loop drawings prepared by the PCSS. Power wiring, control wiring, grounding, and DC wiring shall utilize different color insulation for each wiring system used. Color coding scheme shall be in accordance with UL 508a.

8. Provide surge protectors on all incoming power supply lines at each panel per requirements of Section 13799 – Isolators, Intrinsic Safety Barriers, and Surge Suppressors.
9. Each field instrument furnished under Division 13 and shown on the Drawings as deriving input power from the control panel(s) shall have a separate power distribution circuit with a circuit breaker or fuse and blown fuse indication. Instruments requiring 120VAC power shall be powered as shown on the drawings.
10. Wiring trough for supporting internal wiring shall be plastic type with snap-on covers. Side walls shall be open top type to permit wire changing without disconnecting. Trough shall be supported to the subpanel by stainless steel screws. Trough shall not be bonded to the panel with glue or adhesives.
11. Each panel shall have a single tube, LED light fixture, 20 Watt in size (minimum), mounted internally to the ceiling of the panel. Light fixture shall be switched and shall be complete with the lamp.
12. Each panel shall have a specification grade duplex convenience receptacle with ground fault interrupter, mounted internally within a stamped steel device box with appropriate cover. Convenience receptacle shall not be powered from a UPS and shall be protected by a dedicated fuse or circuit breaker.
13. Each panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturer's recommendations.
14. Each panel shall be provided with a separate copper power grounding bus (safety) in accordance with the requirements of the National Electrical Code.
15. Each panel shall have control, signal, and communication line surge suppression in accordance with Section 13799.
16. Microprocessor-based electronic devices in the panel that are powered by 120VAC shall be powered by the UPS, refer to Section 13679.
17. Each panel shall be provided with a circuit breaker to interrupt incoming power.
18. Additional electrical components including transformers, motor starters, switches, circuit breakers, etc. shall be in compliance with the requirements of Division 16.
19. For panels provided with 2 separate power feeds (as shown on the electrical drawings), panel lights, convenience receptacles, and environmental conditioning (heating or cooling) equipment shall be powered from a separate power feed from other process control equipment.

B. Relays not provided under Division 16 and required for properly completing the control function specified in Division 13, Division 16 or shown on the Drawings shall be provided under this Section.

C. Orientation of devices including PLC and I/O when installed shall be per the manufacturer's recommendations. No vertical orientation of PLC racks shall be allowed unless specifically indicated by the manufacturer as an acceptable mounting alternative and also approved by the Engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

END OF SECTION 13678

SECTION 13679 – UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

1. Section includes control panel mounted uninterruptible power supply.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions” for submittal requirements.

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions” for preinstallation meetings

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

B. Shop Drawings:

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.5 INFORMATIONAL SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.6 CLOSEOUT SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Batteries: 1 spare external battery.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 TECHNOLOGY OBSOLESCENCE MITIGATION

A. Not applicable to this Section.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.11 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.12 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 SINGLE-PHASE UPS - EXTERNAL TO CONTROL PANEL

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Schneider Electric APC Smart-UPS.
b. Vertiv Liebert GXT5 Series.
c. Tripp Lite.
d. Substitutions: Or equal.

B. System Description:

1. Provide a continuous-duty, on-line, solid state, dual conversion, single-phase input (using input voltage as shown on the Drawings), single-phase 120VAC true sinewave output uninterruptible power system.
2. UPS shall provide power conditioning and power backup for computer, communication, and other critical electronic loads as indicated on Drawings.
3. UPS system shall consist of the following major components:

    a. Rectifier and battery charger.
    b. Inverter.
    c. Batteries and battery disconnect switch.
    d. Automatic static bypass switch.
    e. External maintenance bypass switch.
    f. Integral control and monitoring panel.
    g. Other features as described in this Section and as indicated on Drawings.

C. General Requirements:

1. External Battery Enclosure: A separate enclosure shall be provided for housing additional batteries if required to provide minimum run time as specified herein. Battery enclosure shall match main UPS enclosure in style and color.
2. Cabling required to interconnect all components of UPS system shall be provided by UPS manufacturer.
3. Battery protection shall be provided an internal circuit breaker disconnect. Battery cabinets shall be protected by an internal circuit breaker.
4. Current limiting circuitry shall protect inverter output under any load condition. High speed semiconductor fusing shall protect static bypass in event of an output short circuit.
5. AC output neutral shall be electrically isolated from UPS chassis. UPS chassis shall have an equipment ground terminal. Provisions for installation of a bonding connector shall be provided.
6. UPS shall be a tower style suitable for installation at the location as shown on Drawings.

D. Performance Requirements - Ratings:

1. Battery runtime: Provide batteries to support 125% of calculated load for 30 minutes. Provide additional batteries in separate enclosure as required to meet runtime requirement.
2. Output power: Provide minimum recommended kVA ratings for the following UPSs in order to supply control panels and ancillary equipment shown on Control System Architecture Diagram and P&IDs. Confirm UPS ratings below per UPS submitted load calculations, spare capacity, and runtime requirements as specified herein.

    a. UPS-RSPS3: 3 kVA, 120 VAC single-phase input, 120 VAC single phase output.
    b. UPS-UV: 3kVA, 120 VAC single-phase input, 120 VAC single phase output.

E. Performance Requirements - Environment:

1. Ambient temperature: 0 to 40 degrees C.
2. Elevation: Project site elevation.
3. Relative humidity: 0 to 95 percent non-condensing.

F. Electrical Requirements:

1. System Input - Primary source:

   a. Single input: Nominal Input Voltage: 120 VAC.
   b. Frequency: 60 Hertz plus or minus five percent.
   c. Input Power Factor: 0.96 lag minimum, 50 to 100 percent load.
   d. Input Current Total Harmonic Distortion (THD): <33 percent.
   e. Input Surge Withstandability: Per IEEE 587/ANSI C62.41. Category A and B, (6 kV).
   f. Input Connection: Coordinate with electrical contractor.

2. System Output:

   a. Nominal Output Voltage: As indicated herein and as shown on Drawings.
   b. Frequency: 60 Hertz plus or minus 3 Hertz.
   c. 100 percent load with 3:1 Crest Ratio.
   d. Frequency Slew Rate: 1 Hz/second. (Adjustable at startup).
   e. Output Connections: (six) NEMA 5-15R receptacles.

3. AC to AC Efficiency: (100 percent load @ rated PF): 91 percent.
4. Acoustical Noise: Noise generated by UPS under normal operation shall not exceed 65 dBA (60 dBA typical) at one meter from any surface, measured at 25 degrees C (77 degrees F) and full load.
5. EMI Suppression: UPS shall meet FCC Rules and Regulation 47, Part 15, Subpart B, for Class A devices.

G. Modes of Operation:

1. Normal Mode: UPS shall be a continuous online unit. Power to critical loads shall be continuously generated by inverter during normal AC line power. In event of AC line power failure, power to inverter is supplied by batteries. Under normal operation, batteries shall be charged in a manner that optimizes battery life. Simple "trickle charge" of batteries shall not be acceptable.
2. Bypass Mode: Automatic bypass shall transfer critical load to commercial AC source, bypassing UPS' inverter/rectifier, in case of an overload, load fault, or internal failure.
3. Maintenance Mode: If a Maintenance Bypass switch is provided, external manual bypass switch shall be operated to transfer load to alternate source when UPS is taken out of service for maintenance or repair. This transfer shall occur without interruption.

H. Controls:

1. Microprocessor-controlled circuitry: Fully automatic operation of UPS shall be provided through use of a microprocessor-based controller. All operating and protection parameters shall be firmware-controlled. Logic shall include system test capability to facilitate maintenance and troubleshooting. Startup, battery charging, and transfers shall be automatic functions.
2. Graphical Display: UPS control panel shall utilize an LED graphical display for all UPS control, monitoring, alarming, configuration and diagnostic functions. Following operational controls and indicators shall be provided on UPS control panel per following KVA ranges:

I. To 3 KVA Controls:

1. UPS On/Alarm Silence/Manual Battery Test control.
2. Standby/Manual Bypass control.

J. To 3 KVA Indicators:

1. LED Battery Meter.
2. Battery in operation status.
3. Load on Inverter status.
4. Load on By-Pass status.
5. AC input status.
6. UPS malfunction alarm.

K. Remote alarm and status indication: Isolated SPDT Form C dry contacts shall be provided to indicate UPS status for remote monitoring. Contacts shall be rated for 250VAC @ 5A or 30VDC @ 5A. If contacts are not rated for at least 120 VAC 5 A provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel. Individual contacts shall be provided for separate annunciation of the following alarm and status conditions:

1. UPS Normal (UPS is using utility power to power the load and detects no faults).
2. UPS in Static bypass mode.
3. UPS using battery to power the load.
4. UPS on battery and battery low.

L. Rectifier/Charger:

1. Term rectifier/charger shall denote solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to inverter and for battery charging. Rectifier/charger shall be a solid-state SCR/IGBT power transistor type with constant voltage/current limiting control circuitry.

M. Inverter:

1. Inverter shall include all solid-state equipment and controls to convert DC power from rectifier/charger or battery to a regulated AC power for powering the critical load. Inverter shall use Insulated Gate Bipolar Transistors (IGBTs) in a phase-controlled, pulse width modulated (PWM) design capable of providing specified AC output.
2. Inverter shall be capable of supplying current and voltage for overloads exceeding 100 percent. Inverter is to provide 150 percent of full load for 30 seconds and 125 percent of full load for 2 minutes. A status indicator and audible alarm shall indicate overload operation. UPS shall transfer the load to bypass when overload capacity is exceeded.
3. Output voltage shall be maintained to within plus or minus 4 percent.
4. Output voltage total harmonic distortion (THD) shall not be greater than 5 percent for all loads. For 100 percent rated load of 3:1 crest factor nonlinear loads, output voltage total harmonic distortion shall not be greater than 4 percent. Output rating shall not be derated in kVA or kW due to the 100 percent nonlinear load with 3:1 crest factor.
5. Inverter shall use software control to adjust output voltage from plus or minus 5 percent of nominal value.

N. Batteries:

1. Batteries shall be VRLA (valve-regulated lead-acid), sealed, maintenance-free, high-rate discharge, lead-acid cells suitable for use indoors with no off-gassing or water addition requirements. Batteries shall not require special ventilation. Battery shall consist of one or more battery banks with number of cells required to meet requirements of the rest of these specifications.
2. Battery Design Life: five years.
3. Run time operation of UPS shall be accomplished using batteries mounted within UPS enclosure and supplemented as required with an external battery enclosure to provide battery runtime specified.

O. External Maintenance Bypass:

1. Each UPS shall be provided with a "two-position" external bypass switch system to permit UPS to be removed for repair or maintenance without causing power disruption to connected power loads. External bypass switch shall be snap-action type with switching speed approximately 10ms or less independent of operator action. External bypass switch positions shall be labeled UPS and UTILITY.
2. For UPS units up to and including 3KVA, furnish an Electroswitch series 103 snap action switch or equivalent, along with custom plugs, receptacles, and appropriate wiring to achieve the specified functionality. For UPS units above 3 KVA, furnish standard manufacturer's maintenance bypass switch unless a dry contact for remote monitoring is specified herein to monitor the switch and it is not offered by the manufacturer. Otherwise, provide an Electroswitch series 103 switch or equivalent along with custom plugs, receptacles, and appropriate wiring to achieve the specified functionality.
3. Provide a dry contact to indicate when bypass switch is in "Maintenance" position. Contact shall be rated for 250VAC @ 5A or 30VDC @ 5A. If contacts are not rated for at least 120 VAC 5 A provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.
4. External bypass switch shall be housed in a NEMA 4 enclosure. Equip enclosure with name plated in accordance with Section 13675 "Industrial Enclosures".

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and rooms for suitable conditions where uninterruptible power supplies will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Prepare test and inspection reports in accordance with the following:

1. Section 13610 “Process Control and Enterprise Management General Provisions.”
2. Section 13612 “Process Control System Testing.”

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 SOFTWARE SERVICE AGREEMENT

A. Refer to Section 13610 “Process Control and Enterprise Management Systems - General Provisions.”

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13679

SECTION 13684 - CONFIGURATION OF HMI SOFTWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. If referred to anywhere else in the project manual, AE or AESS services are those services specified in this Section.

B. Provide all programming, configuration, and related services required to achieve a fully integrated and operational system as specified herein. All equipment shall be controlled in full conformity with the Contract Drawings, process control descriptions, specifications, engineering data, instructions, and recommendations of the equipment manufacturer. Coordinate the control system for proper operation with related equipment and materials furnished by other suppliers under other Sections of these specifications and with related existing equipment.

1. Provide configuration/modification of the existing HMI System Software, for all new equipment or existing equipment impacted by new work shown on the drawings, including equipment provided by vendor package systems. The final number of graphics and graphic modifications will be confirmed with the Owner and Engineer during the draft graphics review meeting. The following graphics and graphic modifications are expected as a minimum:

    a. Modification of Plant Overall Graphic to include new areas.
    b. Modification of SCADA equipment status graphic to include new SCADA equipment installed in new RIOP-6B.
    c. Modification of SCADA equipment status graphic to include new SCADA equipment installed in new RIOP-5C.
    d. Modification of existing Influent Pump Station graphics to include new instrumentation and speed controls for replacement influent screw pumps.
    e. Modification of existing Final Clarifier graphics to include newly added instrumentation and process flow modifications.
    f. Modification of RSPS 1 & 2 graphics to include process flow modifications.
    g. New graphic for Final Clarifiers 7 & 8 and associated process equipment, process flow, instrumentation, and controls.
    h. New graphic for RSPS No. 3 and associated process equipment, process flow, instrumentation, and controls.
    i. New graphic for RSPS No. 3 MCC power monitoring.
    j. Modification of existing Dry Weather Primary Effluent Flow Splitter graphics to include process flow modifications.

k. Replacement of existing UV graphic screens with new graphics screens for the new UV system.
l. Modification of the existing Dry Weather Effluent Pump Station graphics to accommodate new points and loops.
m. New graphic for UV-MCC power monitoring.
n. New graphics for the Flood Pump Station and associated process equipment, process flow, instrumentation and controls.

2. Provide configuration/modification of the existing SCADA Historian Software to add new points to the Historian. Proposed points to be added to the Historian shall be submitted as below.
3. Provide for and test communications and functionality between all connected devices (such as PLCs) and the HMI software packages, including devices supplied by others, as depicted on the system architecture drawings in order to provide a comprehensive working system of data collection, storage and reporting.

C. All work shall be coordinated with plant operating personnel to minimize impacts on daily operation. Delays caused for any reason shall be noted and formally submitted to the Engineer and the Owner in the form of a letter.

D. Related Requirements:

1. Section 13684 “Configuration of Controller Software.”

1.3 DEFINITIONS

A. AE – Applications Engineering

B. AESS – Applications Engineering System Supplier

1.4 COORDINATION MEETINGS AND WORKSHOPS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.” The meetings below are in addition to the meetings specified in that section.

B. Schedule and conduct a draft graphics review meeting. The purpose of this meeting shall be to present draft graphics for the Owner's and Engineer's review and feedback prior to creating the full set of graphics for review. For repetitive graphics such as graphics for multiple process trains, include an example of the first graphic only for discussion. Include discussion of process and overview displays, examples of pop-ups, trends, and system navigation tools. Expect major comments and incorporate any changes resulting from those comments.

C. Schedule and conduct a historical data management and reports workshop. The purpose of this workshop shall be to discuss and solicit Engineer/Owner input for storage and management of historical data.

D. Schedule and conduct a factory testing coordination meeting, two weeks prior to factory testing. The purpose of this meeting is to discuss the specifics of the proposed tests and to provide a forum for coordinating the required factory testing.

E. Schedule and conduct a field-testing coordination meeting, two weeks prior to field testing. The purpose of this meeting is to discuss the specifics of the proposed tests and to provide a forum for coordinating the required field-testing.

1.5 ACTION SUBMITTALS

A. Provide all required submittals in accordance with Section 01300 “Submittals.” The submittals listed below shall be provided as a minimum;

1. System Standards and Conventions
2. Operator Interface
3. Controller Program
4. Historical Data Management

B. System Standards and Conventions Submittal

1. Following the standards and conventions workshop, submit the standards and conventions that will be used on this project. The submittal shall define, at a minimum:

   a. Graphic display standards, including color conventions, equipment symbols, display format, equipment control pop-up displays, trend displays, and display navigation. Include samples of each proposed type of graphic display (i.e., overview, detail, diagnostic, tabular, etc.)
   b. System naming conventions, such as graphic displays naming, database naming, tag names, and computer naming.
   c. System configuration, including network addressing and PLC/RTU addressing
   d. Alarm configuration standards, including priorities and logging
   e. Security configuration standards, including user groups and privileges
   f. PLC/RTU standard programming modules, including analog input scaling, flow totalization, equipment runtime, motor start/stop, valve open/close, and any other standard logic planned to be used.

2. To facilitate the Owner's future operation and maintenance, the submitted standards and conventions shall be used as the basis for programming and configuration of the system. System programming and configuration shall not begin prior to the System Standards and Conventions Submittal.

C. Operator Interface

1. Following the approval of the standards and conventions submittal, submit a draft of all proposed graphic displays, examples of each type of pop-up (faceplate) displays, and examples of trends. For those graphics which will be duplicated more than once for similar type of equipment, submit the graphics for the first equipment only.
2. Following the draft graphics review meeting and prior to the factory test, submit a ready-for testing version of all graphic displays. These graphics should be completely finished other than the incorporation of comments and changes resulting from testing.
3. Submitted graphic displays and trends shall be no less than 8.5 inches by 11 inches and in full color.

D. Historical Data Management

1. Following the Historical Workshop, submit all aspects of the historical data management system and shall include as a minimum the following:

    a. A complete listing of all new signals to be collected and stored. This listing shall include data sampling rate and duration for which the data will be immediately accessible. Up to all analog inputs and outputs, all discrete outputs, and up to 75% of discrete inputs as shown on the drawings will be collected and stored in the historian.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. The system specified herein shall perform the following generalized functions:

1. The system shall allow the operator to control equipment such as pumps and valves as shown on the Drawings and as defined in Section 13614 - Control Descriptions.
2. Perform real-time process control, including proportional integral derivative control action, sequencing, process calculations, etc.
3. Collect, calculate, and store accurate, reliable operating information for present and future uses.
4. Assist remote site operating personnel by noting and communicating off normal operating conditions and equipment failures.
5. Accumulate and store equipment running times for use in preventative maintenance.
6. Provide color graphic displays and reports for use by the system operating and supervisory personnel.
7. Provide trending for all analog values.
8. Provide control system diagnostics.
9. All process control functions including PID, calculations, sequencing, timing, etc., shall be done in the process controller. The HMI software shall perform the real-time database, report generation, graphic screens, program development, set point modification, data archiving, etc.
10. The system shall allow the operator to manually control (by keyboard entry and mouse type pointing device) the status of pumps, valves, etc. (i.e., on off, open close, setpoint value, etc.) when viewing the appropriate graphic screen on the HMI.

3.2 GRAPHIC DISPLAYS - GENERAL

A. All displays shall contain and continuously update the displayed process variables, date and time of day. All process values shall be displayed in engineering units. All displays shall incorporate references to both instrumentation tag numbers and plant equipment numbers. All process variables shall be displayed on their associated display(s) with correct engineering units. Process variables shall display their associated data quality flags.

B. All operator commands related to controlling field devices or system attributes shall require multiple keystrokes or mouse actions to protect against inadvertent operations. The operator shall receive confirmation of the selected point to be controlled, at which time a cancellation of the control can be affected.

C. Process graphic displays, shall be based on the P&ID's, site plan drawings, mechanical drawings and electrical drawings included in these Contract Documents. The graphic displays shall depict process flow streams, process structures, and all major items of process equipment and control devices in a schematic format.

D. All main graphical screens shall include a title bar, main graphic area, navigational buttons, and alarm summary bar. Title bar shall be displayed on the top of each screen and include display name, description and time/date. The main graphical area shall contain primary screen data in graphical format. Navigational buttons shall include a minimum of main menu, trends, main alarm summary, and security log in. The alarm summary bar shall display the last three valid alarms on the bottom of each screen.

E. Animation shall be provided to mimic level changes in tanks or vessels, and to mimic rotation of rotating equipment when running. Valve colors shall change when opened and closed.

F. Unless specifically noted, all timers, setpoints, alarm actuation levels, etc., shall be adjustable from the operator interface.

G. The system shall show field conditions with text that can alternate (i.e., OPEN/CLOSE, START/STOP, HIGH/LOW) and change color correspondingly. Field devices that are tri-state must be represented in three conditions.

H. Conditions in the field designated as alarm conditions shall report to the operator workstation, actuate an audible alarm, and provide a visual blinking image on the associated graphic page. All alarms and events shall be displayed on the screen and archived.

I. All interlocks that affect equipment operation shall be identified both by alarm and by HMI indication.

J. All analog inputs shall be checked for out of range (via high and low limit checks) and alarmed.

K. All process flow streams shall be labeled and color coded using the project color schedule in Division 09. All structures and equipment shall be identified by name and appropriate equipment and loop tags.

L. Color coding for equipment status and alarms shall be as follows:

1. Red for on or open.
2. Green for off or closed.
3. Active, unacknowledged alarms are indicated by flashing amber.
4. Active, acknowledged alarms are indicated solid amber.

M. Automatically record all alarm and events should any of the following sequences or events occur:

1. Date/Time entry.

2. Limit changes.
3. Any commanded or uncommanded change of any point.
4. Alarm conditions.
5. PLC activation or deactivation.
6. Operator login or logout activity.

N. There may be additional general programming requirements listed in Part 1 of the Section 13614 - Control Descriptions that impact the HMI configuration.

3.3 SPECIFIC GRAPHIC SCREENS

A. At a minimum, provide the following types of graphic screen indicated below.

1. Modification of the existing Plant Overview screen shall include a site plan representation, indicating the geographic location of each process, and each building.
2. Main menu screen shall be developed to link to all screens and process areas. The screen shall be a complete and logical listing of the names and number of all screens.
3. Modification of the existing Overall plant process block flow diagram screen shall show all major processes in block form with flow arrows. Each block shall include a text description of key individual treatment processes. Navigational buttons to the individual treatment processes shall be performed by pressing on the text description.
4. Individual treatment process screens shall graphically screen key process variables and equipment. No operator entries shall be done from these screens. Individual process flow screens for each process shall include all process components, including tanks, pumps, blowers, mixers, drives, flow meters, valves, mechanical devices, as well as manual shutoff and isolation valves. These diagrams shall be generally depicted from the P&ID's and there shall be at least 1 screen per P&ID on average.
5. Individual unit process screens depicted from the P&ID's are used for control and screen of each major item of process equipment, process variables, and control devices, including pumps, blowers, valves, gates, mixers, drives etc. Navigational buttons shall consist of the P&ID's flow arrows to other individual unit processes. The unit process screens shall provide the ability for the operator to go to individual equipment popup screens. These diagrams shall be generally depicted from the P&ID's and there shall be at least 2 screens per P&ID on average.
6. Popup screens shall be provided for each piece of equipment to start/stop equipment, open / close valves, implement automatic control, adjust set points, establish and adjust tuning parameters, set alarm limits and initiate a sequence.
7. Modification of PLC system diagnostic screens, showing the operational status, and fault conditions of all PLC components, including processors, I/O modules, OIT's, power supplies and UPS units.
8. Modification of communications diagnostic screens, showing the details of network status, communications status of all major components including Operator Work Stations, peripheral devices and network components.
9. Maintenance screens shall screen the raw value for each analog and digital I/O point in the system. They shall also allow the operators/maintenance personnel to enter an override value for an analog point that is then used by the system instead of the value read from the input card / communications link.
10. Trend screens with the capability to screen up to eight, operator assigned, analog and/or digital process variables. Each analog value will be shown on a trend screen.

11. Main alarm summary screen shall screen the following information on each alarm: Time, tag name, description, alarm type, current value and status. An acknowledge alarm button shall acknowledge all new unacknowledged alarms. The acknowledged and unacknowledged alarms shall be different colors. Acknowledged alarms shall clear automatically after the condition is corrected.
12. Analog variable screens showing a tabular summary of all plant process variables, in operator assigned groupings.

3.4 ALARM/EQUIPMENT STATUS REPORTING

A. The alarm log shall display all alarms as they occur. The alarm message shall include the time of occurrence, tag name, tag number, and whether it is a low, high, or failure alarm. When the point in alarm returns to normal, the time, point identification number, and return to normal shall be displayed. All reports shall include the plant equipment number of the associated device.

B. The equipment status shall be logged whenever a change in status occurs (i.e., start, stop). The equipment status log shall include the time, equipment name, tag number, and the particular change in status.

3.5 HISTORICAL DATA MANAGEMENT

A. The following features shall be provided for processing and storage of system historical data:
1. All process analogs and all flow totals and run time indications of all primary process equipment motors shall be sampled and stored in the historical data management system.

3.6 TESTING

A. Refer to Section 13612.

B. Supplement to Field Testing requirements

1. Prior to leaving the site, use the Owner's programming computer to monitor all PLC processors online, make on-line changes, upload and download the processor to ensure programming software version compatibility.
2. Loop Tuning - All PID control loops (single or cascade) shall be tuned following device installation but prior to commencement of the Functional Demonstration Test.

    a. Optimal loop tuning shall be achieved either by auto-tuning software or manually by trial and error, Ziegler-Nichols step-response method, or other documented process tuning method.
    b. Determine and configure optimal tuning parameters to assure stable, steady state operation of final control elements running under the control PID. Each control loop that includes anti-reset windup features shall be adjusted to provide optimum response following startup from an integral action saturation condition.
    c. Tune all PID control loops to eliminate excessive oscillating final control elements. Loop parameters shall be adjusted to achieve a decay ratio of 1/4 or better. In

addition, loop steady state shall be achieved at least as fast as the loop response time associated with critical damping.

d. Loop performance and stability shall be verified by step changes to setpoint in the field.

e. Submit loop tuning documentation as specified in Part 1 of this Section.

3.7 TRAINING

A. Refer to Section 13613 for general training requirements

B. Furnish training as shown in the table below.

Description	Minimum Course Duration (hours)	Number of Times Course to be Given
Onsite Training		
Control System Overview Seminar	2	3
Operator Training (Post start-up)	4	3

C. Control System Overview Seminar:

1. Provide Control System Overview seminar for the Owner's personnel at the Owner's facility. The objective of this seminar is to provide personnel with an overview understanding of the Control System. The seminar material shall be targeted to the Owner's management, engineering, and other non-operations personnel. The seminar shall include, but not limited to, the following:

   a. An overview of the Control system explaining how the hardware and software supplied under this Contract is used for the operation and control of the facilities.
   b. A block diagram presentation of the Control system showing how and what information flow within the system and what each functional unit does.
   c. An explanation of the operator interfaces including a demonstration of how to use an operator's workstation to monitor, control, navigate, display trends, and all other operational features of the system. Discussion of process control of individual processes shall be addressed outside of this course.
   d. A walkthrough of the installed system explaining each of the items covered in the functional units' discussion. The features and functions of operator controls and interfaces shall be discussed.

D. Operator Control System Training (post start-up):

1. Operator training shall cover plant operation with the control system and use of the HMI display screens, including at a minimum all the following items:

   a. Basics of HMI control and navigation.
   b. Alarming and Interlocks.
   c. Auto functionality of automated processes and HMI control.
   d. Failure modes of equipment and operator responses.

2. One or two operator training session (Post-Startup) for operators shall be held one week after system startup.

3. Operator training shall be held at the convenience of the Owner. This training may be held during the day, late at night, or very early in the morning to accommodate the Owner's shift schedule.
4. Operator training shall be introductory in nature during pre-startup training and more in-depth and detailed during post-startup training.
5. At a minimum, the following teaching aids shall be available for distribution during Operator training sessions:

    a. Preliminary O&M Manuals (pre-startup); Final O&M Manuals (post-startup).
    b. P&IDs.
    c. Daily syllabus.

6. Fifty percent of all Operator training shall be "hands on" utilizing the installed Control System to the fullest extent possible. Confirm the operability of the Control System before commencing training. Training performed using a non-functioning Control System shall be rejected and repeated.

3.8 APPENDIX A – GRAPHIC STANDARDS

END OF SECTION 13684

NARRAGANSETT BAY COMMISSION

CONTROL SYSTEM HUMAN MACHINE INTERFACE (HMI)

CONFIGURATION STANDARDS DOCUMENT

CONFIGURATION STANDARDS - REVISION LIST

REVISION #	DESCRIPTION	BY	PROPOSED DATE	APPROVED DATE	COMPLETED DATE

TABLE OF CONTENTS:

1. Overview

1.1 Purpose of Document

The NBC owns the two largest municipal wastewater treatment facilities in Rhode Island: the Field's Point WWTF, located on Ernest Street in Providence and the Bucklin Point WWTF on Campbell Avenue in East Providence. The NBC also maintains several sewage pumping stations and interceptors that convey wastewater to each treatment facility for processing.

Both facilities have distributed control systems (DCS) as primary systems for monitoring and automatic control of instrumentation and equipment for continuous treatment processes. The Field's Point WWTF primary control system is an ABB-Bailey Infi 90 DCS, along with a newer ABB Process Portal B system operating the Combined Sewer Overflow (CSO) System Field's Point Tunnel Pump Station and Screening Facility. The Bucklin Point WWTF utilizes a Siemens system with Simatic PCS-7 V5.2 consoles running on a Windows NT platform as the primary process control system.

The purpose of this document is to convey the standard elements required by NBC to give the HMI graphics and operator interaction and experience at both facilities the same "look and feel".

1.2 Document Updates

Updates to this document will be made on an as-needed basis. A proposed revision should be forwarded to the Standards Contact. The Standards Contact is ***Art Sheridan, asheridan@narrabay.com.*** If the Standards Contact authorizes the change, the revision will be made. When a revision is made, a new Revision note will be added to the Revision List.

1.3 HMI Project Revision Control

After any work is performed, downloaded or modified on-site, all changes to the HMI Project must be logged through the Revision Control Manager.

2. HMI Configuration Standards

2.1 General

2.1.1 Abbreviations

The following abbreviations are used throughout this document:

Table 2-1.
Abbreviations Table

CLD – Control Logic Diagram	RIOP – Remote I/O Panel
COB – Corporate Office Building	BP – Bucklin Point WWTP
FCP – Facility Control Panel	RIO – Remote I/O
FP – Field's Point WWTP	RTU – Remote Telemetry Unit
FPTPS – Field's Point Tunnel Pump Station	PPB – Process Portal B
GTW – Gateway Communication Point	PCU – Process Control Unit
I/O – System Inputs & Outputs	OWS – Operator Workstation
NBC – Narragansett Bay Commission	MTU – Master Telemetry Unit
P&ID – Process & Instrumentation Diagram	

2.1.2 Tag Names

2.1.2.1. Input and Output Tag Names

For all the existing tags in both systems, the original tag names will remain unchanged

The naming convention for new I/O tags will be as follows:

"Facility Code" _ "ISA Tag" _ "Loop Number" "Suffix" (i.e. TS_PSH_2260

The Facility code will be selected from table 2-2 through 2-4 below.

The ISA Tag will be an approved ISA identifier as defined by ISA Standard S5.2 and shown on the associated P&ID.

The Loop number suffix will match the P&ID loop designation.

2.1.2.2. Facility Codes

The following Facility Codes will be used:

Table 2-2.
Facility Codes – PHASE I TUNNEL SYSTEM

G1 – 067 G&S Structure	TS – FPTPS Screening Facility
G2 – 004/061 G&S Structure	TP – FPTPS
G3 – 016 (Moshassuck) G&S Structure	X1 – Corporate Office Building
G4 – 006/007 G&S Structure	X2 – Dept. of Transportation Building
G5 – 009 G&S Structure	SCR – FPTPS Screening Facility
G6 – 032 G&S Structure	CA – Central Avenue Pump Station
G7 – Woonasquatucket G&S Structure	FP – Field's Point WWTP
D1 – 032 Diversion Structure	D1 – 032 Diversion Structure
FS – Foundry Shaft	IR – 012/013 Regulator Structures
S1 – S-1 Shaft/Screening Facility	

Table 2-3.
Facility Codes – FIELD'S POINT TREATMENT PLANT

GR – Grit Removal Facility	MP – Main Pumping Station(Ernest St)
GG – Grit Generator	HC – Hypochlorite Facility
WW – Wet Weather Facility	DC – Dechlorination Facility
PS – Primary Sludge	AD – Aeration Dewatering
BL – Aeration Blowers	B1 – Butterfly #1
AT – Aeration Tanks	B2 – Butterfly #2
R1 – Return Sludge PS #1	FP – Field's Point WWTP
R2 – Return Sludge PS #2	CA – Central Ave PS
SL – Screw Lift	TV – TopView Alarms
GT – Gravity Thickeners	FA – Fire Alarms
OP – Operations Bldg	PCU – Process Controller
PW – Plant Water	TL – Telog System
CSO – Combined Sewer Overflow	FC – Final Clarifiers
FP – Fields Point	WP – Washington Park PS
V1 – Venturi #1	V2 – Venturi #2
FP – Fields Point	V3 – Venturi #3
RA – Reservoir Ave PS	

Table 2-4.
Facility Codes – BUCKLIN POINT TREATMENT PLANT

CPP1 – Floatation Thickening	RIOP1A– Wet Weather
CPP2 – New Switchgear Bldg	RIOP1B– Sludge Dewatering
RIOP2A– Digestion Control	RIOP2B– Gas Complex
CPP3 – Screening & Grit Bldg	RIOP3A– Influent Pump Station
CPP4 – Dry Weather Primary	RIOP4A– Chlorine Control Bldg
CPP5 – Dry Weather Effluent Pumping	RIOP5A– Blower Bldg
CPP6 – Electrical Substation #2	RIOP6A– Sludge Distribution Chamber

2.2 Network Conventions

2.2.1 Workstation & Server Naming Conventions

Unless otherwise defined in the project plan, all workstation names will follow the format below.

Format: ***LLLLLL_T_NNN***

Where:

LLLLLL = Workstation Location. Minimum 3 characters and Maximum 6 characters (e.g. FPTPS, FP)

T = One character, Type (“S” for Server / “C” for Client)

NNN = Three characters; For Servers, this will indicate the Node number, e.g. N02, N12, etc. For clients, this will indicate a distinct designation number, e.g. 001, 002, etc.

2.2.2 Network Settings

Each Server and Workstation will follow the NBC IT standard addressing standards. The IP addresses will be available after the first meeting with the successful firm for the HMI conversion project

2.3 Graphic Conventions

2.3.1 Screen Layout

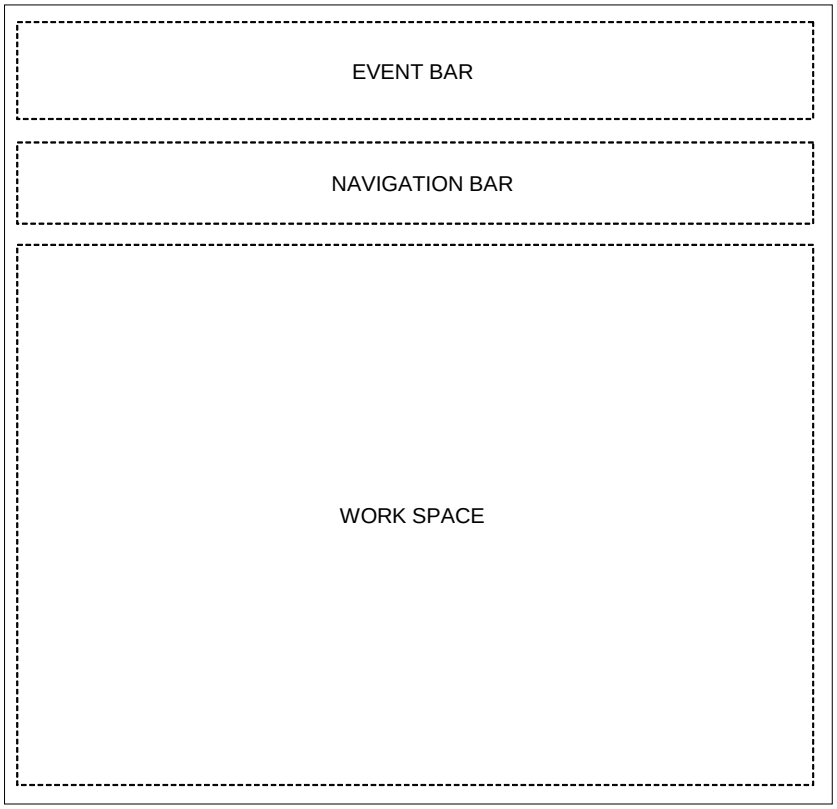
Screens will be configured in the system to show graphical representation of the process in an organized way that it is clear to the user. The process will always flow from left to right. Process lines that come or continue out of the scope of the screen will be label with the origin or destination respectably. Its label will be placed above the respective process line.

The entire area available for viewing is designated as the "Interface Area"

The Interface area is divided into three (3) parts. (See Figure 2-3) The event bar and the navigation bar will always be visible to the user. The workspace area is equal to a full size screen.

If a screen is identified as a "full screen" size, it will cover the entire workspace area, but not the event and navigation bars.

Figure 2-3: Layout Screen



2.3.2 Screen Hierarchy

A hierarchy of screens will be created to simplify navigation of the project. At the top of the hierarchy is an ***Overview Screen***. This is the first screen that appears when the workstation is powered up. The startup Overview Screen chosen for a particular workstation should be consistent with the location and operational intent of the workstation.

Opening a new ***Overview Screen*** or ***Process Screen*** will replace the current screen. For all other types of screens, only a screen defined as a full-size screen will replace the current screen. All other screens will appear as "pop-ups"; that is, they will superimpose themselves over the current screen, not replace it.

A maximum four screens will be allowed to be open at a given time. If a fifth pop-up screen is opened, the first pop-up screen that was opened will be closed, keeping open only four screens.

The alarm/event bar will be visible at all times and on top of the screen.

2.3.3 Screen Names

All graphical screen names will be displayed in the center top area of the screen.

The existing naming format will be used for all existing graphics.

The process or sub-process name, sites or facility name, or equipment names will be represented on the screen.

The full screen name will be no more than 15 characters.

2.3.4 Screen Types

2.3.4.1. Overview Screen:

Overview screen(s) will graphically provide an overview of various system processes grouped together in a logical fashion. An overview screen should provide at minimum an overall depiction of two or more processes. The screen will be developed to depict status of equipment, the location of major alarms or events, and the important process values considered necessary to be displayed on the overview screen for immediate access.

2.3.4.2. Menu Screen or Screen List

The Menu screen or Screen List will list all main process areas graphics as well as trend screens and access to system diagnostic information. The intent is to provide a tool that will allow the operator to easily locate and view any configured graphic with proper security. The menu or screen list should be organized logically by screen type and subdivided by process area. Multiple menu or screen lists are acceptable on approval by the NBC.

2.3.4.3. Process Screen

Process screen(s) will graphically display equipment related to a particular sub-process or site. If used to depict a site, the site should be small enough that all pertinent information can be easily displayed on a single screen. If the site requires more than one screen, screens should be developed by process. This screen will mimic the layout of the actual process in the field. The information indicated is more specific than the overview and is intended to be the primary location for monitoring and control of a particular process.

2.3.4.4. Control Screen:

Control screen(s) will display pushbuttons, hand switches, keypads and all information needed to control process equipment.

2.3.4.5. Event Page:

Event page(s) will display alarms or events from digital and/or analog triggers within the system. Hardware and software information is also available to the user through this screen.

2.3.4.6. Trend Screen:

Trend screen(s) will display historical data collected or real time data in a graphic way.

1. **Real Time**

   Real-time trends screens will be developed for diagnostics and pens can be added or deleted by the user.

2. **Historical Time**

   Historical trends will be developed for select groups of data. These trends utilize historical data collected and stored on the historian server. These screens are mainly

predefined. However, a user with proper security rights can add or delete pens.

2.3.4.7. Equipment Screen:

Equipment screen(s) will graphically display single process equipment and only make available to the user data pertinent to that equipment (i.e. status, faults, runtimes, maintenance schedules, etc).

2.3.4.8. Information and Help Screens:

Information screen(s) will display procedures, prompts to operators, manual, catalogs, drawings, control strategy flow charts, etc. as desired and configured. Operator prompt Information Screens will be automatically generated and created by the system for display. Auxiliary Information Screens, such as manuals, catalogs, etc will be accessed via a pre-defined aspect. All auxiliary information screens will be stored on the Configuration Server and will be of a format accessible by the software on the Operator Workstations (e.g. Microsoft Office, Adobe Acrobat, etc).

2.3.4.9. Faceplates:

Faceplate(s) for the unit or devices are accessed from an aspect or interactive spot in a process screen. Faceplates include information related to a signal, control system network, node or equipment and are normally used for diagnostics. Control may be performed from the faceplate as well.

2.3.4.10. System Diagnostic or Architectures Screens:

The system diagnostic display indicates the state of the control network and operational network, showing all active nodes, server and clients, and their communication status.

2.3.4.11. System Administrative Screen:

The system administrative screen is accessible only to a System Administrator and is used for performing configuration duties related to the HMI system. The following are typical functions available:

- Access to System configuration tools and browser.
- Access to Windows Explorer or Operating system.
- Access to System Utilities.
- Access to Graphic Editor

2.3.5 Screen Navigation

From the Overview Screen, the User will be able to go to all Process Screens, Control screens, Event Page and trend screens.

From the Process Screen, the user will be able to go to the Equipment Screens related to any sub-process that appears in the process screen.

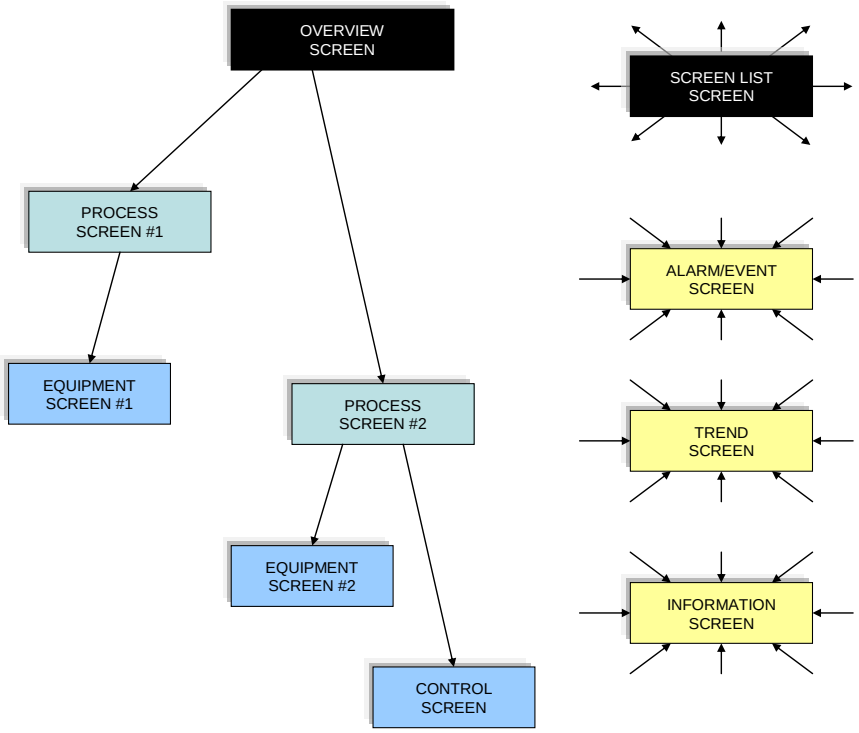
From the Process Screen, the user will be able to go to related Control Screens to any sub-process or equipment that appears in the Process Screen.

Users will be able to get to any screen in the project with no more than three clicks.

Navigation to Control Screens, Event Page and Trend Screens will be available from all overview and process screens. See Figure 2-4 below.

A Screen List or Menu screen displaying the names of all of the screens will be provided. All screen descriptions will be hot spots that will direct the user to the selected screen when clicked.

Figure 2-4: Screen Navigation by Clicks



Navigation can be accomplished by any or all the following ways:

1. Clicking on a hot spot (e.g. Pump, building, facility, text)
2. Pushbuttons with arrows that indicate “go forward” or “go backward” in the process flow. See Figure 2-5.
3. Pushbuttons that open specific screens. See Figure 2-5.
4. A “BACK” or “Previous” button should be provided on all screens to allow operators to return to the screen opened immediately prior to the current.

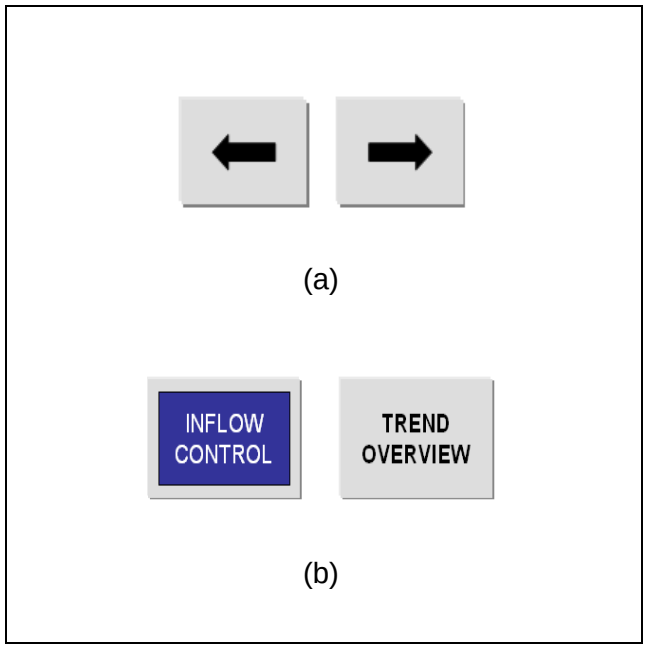


Figure 2-5: Navigation Pushbuttons

Information, Equipment and Control Screens can show up anywhere in the screen (preferable next to the equipment related) so the main information of the Process Screen behind it can be seen as well.

> Note: All type of screens, except Information Screens, will not be resizable and will not allow access to the system menu. Avoid using scroll bars if possible.

2.3.6 Screen Sizes

All Overview and Process Screens will be full screen, no exception.

Trend Screens and Event Pages can be either full screen or pop-up screen not smaller than 80% of the full size. If the screens has been created as a pop-up, it should be always placed in the center and not movable.

Information, Equipment and Control Screens are pop-up screens of any size, including full size. These pop-ups screen can be fixed on the screen or have their title bar enabled to allow the user to move the pop-up around the screen if necessary.

2.3.7 Text Font and Format

Text font will be Arial. Do not use italic attributes. Point sizes will vary depending on the application

Screen Titles: Min 18 pt

Process Data: Min 12 pt. For key values, font size should be coordinated.

Equipment Tags: Min 12 pt.

Descriptors: Min 12 pt.

Units: Min 12 pt.

Alarm or event banner text: Min 10 pt though 12 pt preferred.

Other text, misc: min 12 pt.

Text will contrast with the background and be easily visible and distinguishable. Any customized text should be submitted for review.

2.3.8 Screen Depiction

2.3.8.1. Numeric Values:

Standard Numeric Value Windows (color, text) will be used for indication of similar types of information. (i.e. Process variables and user adjustable setpoints). See the Color Standards and Text Formatting Sections for details regarding color and text depiction.

All numeric values and their associated engineering units will be located inside the window. The window will be of a different background color than the picture graphic.

If required, a text descriptor can be placed next to the Numeric Value Window. This will be placed as close as possible to the Window.

As a general rule, numeric values will be displayed with different decimal points based on the range of the variable. For values whose range is 0-100, 2 decimals shall be displayed. From 100-999, 1 decimal is sufficient. For value above 1000, no decimal points are needed.

Animation tools will be used to make the Numeric Value Windows interactive. For example, the value color will change when the value reaches significant thresholds (ex. Alarm limit)

Where possible, fill bars will be utilized to visually display values. These will be used in conjunction with Numeric Value Windows, which are required for all analog value indications.

2.3.8.2. Status:

Status indication will be shown in one of the following ways:

1. Indicating light (e.g. solid light red or green).
2. Textual indication (e.g. “Hand”, “Auto”, “Lead”, “Lag”, “Open”, “Closed” etc)
3. Equipment animation (e.g. pump symbol changes colors based on its status)
4. In or Out of Service indication: For key process vessels, tanks, facilities and/or areas, “On/Off” or “In

Service/Out of Service" selection buttons will be provided. Toggling these buttons will display the status of the process area or vessel and inhibit or enable associated process alarms.

2.3.8.3. Alarms and events:

Alarms and events indications will be configured to be viewed in the following ways:

1. Indicating lights: Indicating lights are mainly used on Overview Screens to exhibit a problem pertaining to a specific process or piece of equipment.

2. Text Boxes with the alarm descriptions: Boxes with alarm descriptions are mainly used on Process and Equipment Screens to provide the user with an actual event or alarm description.

3. Line item on the alarm page.

4. Event bar based on priority.

5. Tank, facility and/or process areas "out of service" or "disabled" status will inhibit process alarms for that tank, facility or process area.

All alarms and events will be listed in the respective Event Page based on its priority.

2.3.8.4. Non-process related alarms and events:

Typically, information from non-process systems will consist of alarms and events. In the event that an actual non-process system screen is required, this screen should mimic standard screen types.

Non-process related alarms and events will be shown as:

1. Text Boxes with the non-process alarm descriptions: Boxes with Non-process alarm descriptions can be used in screens that summarize all alarms of a specific sub-process.

2. Line item on the alarm page.

3. Event bar based on priority.

All Non-process alarms and events will be listed in the respective Event Page based on its priority.

2.3.9 Process Equipment Symbols

Use process equipment symbols from standard NBC Symbols Library (*) or create to match real equipment to the extent possible. All process equipment symbols must be 3D. Create or use existing 3D symbols for all equipment, including but not limited to: Valves, gates, pumps, critical instruments, tanks/vessels. Submit all new symbols for review. On approval, include in NBC Symbols Library.

Prior to performing any project work, submit Project Symbols Library that will be used identifying all new equipment symbols created that are not in the existing NBC Symbols Library.

2.3.10 Process Piping

Depict process piping on the screens in a clear, organized fashion. Where possible, process flow should move from left to right. All process piping 2" and larger shall be in 3D. Pipe colors shall fill the 3D pipe and match process lines and colors. Animation shall be provided for pipes carrying flows in excess of 10 MGD. In the absence of flow, animated pipes shall be the standard "empty pipe" color. In the presence of flow, the 3D pipe will the appropriate process color. For piping smaller than 2", where possible, use 3D. Otherwise, lines matching process line color shall be permitted.

2.3.11 Process Structures

Process Structures include buildings, large in-ground tanks and other structures for which it will be important to provide an accurate depiction on the screen(s). Prior to performing any project work, submit approach to Project Process Structures that will be used on the project for review and approval by the NBC.

2.3.12 Buttons and Switches

Utilize standard 3D buttons and switches. Utilize standard symbols from the NBC Standard Library.

2.3.13 Faceplates

2.3.13.1. Faceplates

Utilize Faceplates from the NBC standard Library [1] or create new ones subject to approval. Examples of faceplates include the following:

- Controllers (Level, Pressure, Temperature, Flow): At minimum, controllers shall show in bar graph and numeric format the Setpoint (SP), Manipulated Variable (MV) and Process Variable (PV). Provide control buttons/entry/display for (as needed): Manual mode, Auto mode, Cascade mode, ratio control, bias, overrides, manual output, setpoint entry, manual or auto track & hold, controller alarms, etc.
- On/off control of valves/pumps/gates (run-time example shown): At minimum, display gate status and provide on/off control buttons. If stop or pause control is possible, provide this capability on the faceplate.

- Mode selection controls
- In / Out-Of-Service Display (configuration mode example shown)
- Modulating/throttling control of valves/gates: At minimum, display gate status and provide on/off control buttons. If stop or pause control is possible, provide this capability on the faceplate.

2.3.14 Bitmaps

Bitmaps shall be permitted for use only on approval by the NBC. Bitmaps can be used for creation of non-standard symbols or structures, as process

[1] The NBC does not currently have a Wonderware Standard Symbols Library. It is expected that the successful bidder for the HMI Integration RFQ/P (released in July 2009) setup and compile the project Symbols Library for use throughout the NBC's facilities.

piping and equipment backgrounds for screens, or as photographic backgrounds for screens, portions of screens or overlays. Where possible, 3D CADD conversions of process piping/equipment into bitmaps for use in screen backgrounds are preferred. All process piping shall match requirements listed herein. Equipment symbols used in bitmaps deviating from the NBC Standards Library are subject to review and approval by the NBC.

2.3.15 Engineering units

Engineering units will be included all numeric values. Common abbreviations are provided below.

Table 2-6.
Engineering Units abbreviation

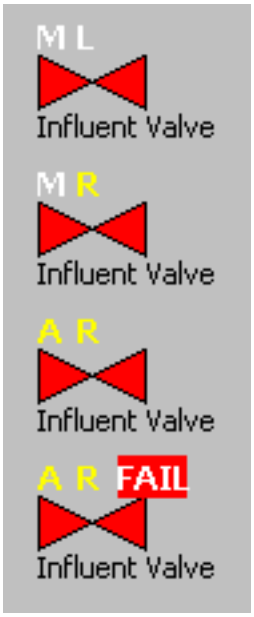
DESCRIPTION	ABBREVIATION
Degrees Centigrade	C
Degrees Fahrenheit	F
Feet	FT
Gallons	GAL
Millions of Gallons	MG
Gallons per Minute	GPM
Inch	INCH
Inches of water column	IN WC
Liters	L
Millions of Gallons per Day	MGD
Percent	%
Pounds	LBS
Pounds per square inch (Gauge)	PSIG
Pounds per square inch (Atmospheric)	PSIA
Pounds per square inch (Differential)	PSID
Standard Cubic Feet per Hour	SCFH
Standard Cubic Feet per Minute	SCFM
pH	pH

Revolution per Minute	RPM
Parts per Million	PPM
Parts per Billion	PPB
Pounds per Day	PPD
Pounds per Hour	PPH
Kilowatts	KW
Kilo Volt Amps	KVA
Hertz	HZ
Millivolt	mV
Milliamps	mA
Milligrams per Liter	Mg/L
Lower Explosive Limit	LEL

2.3.16 HMI Animation

2.3.16.1. Valves

(a) Symbols
  (i) General
    1. Shapes: based on P&ID symbols or NBC standard symbol library
    2. Standard text
      a. Status character(s) above symbol
        i. AUTO/MANUAL indicator – yellow “A” for AUTO, white “M” for MANUAL
        ii. LOCAL/REMOTE indicator – yellow “R” for REMOTE, white “L” for LOCAL
        iii. FAIL indicator – “FAIL” for FAIL, flashing red/white to white/red when active
        iv. Example:



2.3.16.2. Gates

For modulating gates, the gate body and actuator color will reflect the value of the position of the gate, not the commanded output. If the actual position is greater than or equal to 100 % open or on limit switch make, the gate will be considered open. If less than or equal to 0 % open or on limit switch make, the gate will be considered closed. If the actual position is greater than or equal to 1 % open and less than or equal to 99 % open, the gate will be considered in travel. See Color section for open, close and travel color standards.

For values without position feedback, the position will be based on the commanded output of the gate.

The value of the open position will be displayed in close proximity to the gate indicating the percentage the gate is open. This field is not part of the gate symbol.

A field adjacent to the gate will indicate, with a single upper-case character, the mode of operation: yellow “A” for auto and white “M” for manual.

2.3.16.3. Motors and Pumps

Pumps will be represented by an appropriate graphic symbol with an imbedded text field. The symbol will be color filled to represent the status of the device. The text field indicates the

mode of operation: HAND, OFF or AUTO based on a software 3-position switch.

When the switch is in "Auto" position, the control logic will determine when it will run, when the switch is in "Hand" position, it is started and stopped only by the user via the workstation. Proper access will be necessary for this operation and all actions will be logged as an event.

The pump will be defined as a hot spot in the screen. When selected by the operator, a pop-up screen will be displayed providing the option to start or stop the pump, or place the pump in auto or manual mode. The user must have security access to perform this operation.

A field adjacent to the pump will indicate if the control is available at the workstation (Ready Indication) or at the local panel(Local). This state is based on the LOCAL/REMOTE switch located at the local panel.

Alarm conditions for the motor shall be indicated by a change of color in the pump. Refer to color standard section for alarm colors.

2.3.16.4. Level indication

Level indication of tanks will be displayed in both numeric and bar/animated form. Both items shall be displayed along with the tank symbol. Level animation shall be displayed on the vessel itself. If not possible, a bar will span one side of the tank. Tick marks corresponding to the alarm levels for the process variables will be indicated on the bar. This span will indicate the minimum and maximum value, or 0-100 percent, of the transmitted signal. The numeric value will be displayed as described in numeric values section of this document. Fill colors shall match the respective Process Line or Service color.

2.3.16.5. In or Out of Service animation:

For key process vessels, tanks, facilities and/or areas, "On/Off" or "In Service/Out of Service" selection buttons will be provided. Toggling these buttons will display the status of the process area or vessel and inhibit or enable associated process alarms. No animation effect shall be provided for tanks,

facilities or process areas taken out of service except for indication of status.

2.3.16.6. Special:

Some instruments or equipment warrant special animation. Submit for review and approval by the NBC.

2.4 Color Standards

2.4.1 General

Background	
Static Text	
Dynamic Text	

2.4.2 Status Indication

On, Run, Open	
Off, Stop, Closed	
State Transition	
Bad Quality	

2.4.3 Numeric Values

Static	**100 PSI**
Dynamic	**100 PSI**
Dynamic in Alarm	**100 PSI**

2.4.4 Alarm

Unacknowledged alarms will blink in active color.

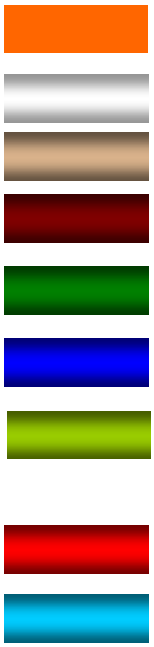
Unacknowledged alarms that return to normal will stop blinking and become static in active color. After acknowledgement, alarms will turn to normal color.

Acknowledged alarms will remain static in active color until return to normal.

Priority	Active	Normal
1	100 PSI	100 PSI
2	100 PSI	100 PSI
3	100 PSI	100 PSI
4	100 PSI	100 PSI
5	100 PSI	100 PSI
6	100 PSI	100 PSI
7	100 PSI	100 PSI

2.4.5 Process Lines and Colors

Typical process lines and fill colors are shown below. For any service not listed below, use of colors are subject to approval by the NBC.



Thickened Sludge	
Sodium Hypochlorite	
Sodium Bisulfite	

2.5 Alarm Handling

Typically, information from non-process systems will consist of alarms and events. In the event that an actual non-process system screen is required, this screen should mimic standard screen types.

2.5.1 Alarm Priorities

2.5.1.1. Priority 1:

Dire / risk to personnel / permit

2.5.1.2. Priority 2:

Immediate field check required (pump mismatch, loss communication, etc)

2.5.1.3. Priority 3:

Field check required when possible

2.5.1.4. Priority 4:

Event / status (pump on/off, etc)

2.5.1.5. Priority 5:

Related systems alarms (PI, Telog, etc)

2.5.1.6. Priority 6:

Network / Communications

2.5.1.7. Priority 7:

Preventive maintenance issues

2.5.1.8. Priority 8:

System Hardware Alarms

2.6 HMI Drivers

2.6.1 Siemens PCS-7 Processor Communications

The Siemens communications drivers are redundant Kepware for Wonderware OPC Drivers.

2.6.2 ABB Process Communications

The ABB communications drivers are redundant Rovisys ABB-Bailey OPC90 Unlimited Drivers.

2.7 Trending Conventions

A trend screen is divided in two main parts. The top part will display the chart and the lower part will display the trend reference.

The chart will have the following characteristics:

1. Black background
2. Show maximum 10 lines in the horizontal grid.
3. Show maximum 10 lines in the vertical grid.
4. Use color No. 13 (Light Gray) for grid lines.
5. Show 4 or 5 labels and ticks on the Y-axis.
6. Show only 4 labels and ticks on the X-axis.
7. X and Y-axis will have a title.

The trend reference will disclose the following information:

1. Pen color
2. Tag name
3. Tag description
4. Status
5. Ruler time
6. Ruler value

Trends will be configurable online to allow the following:

1. Move forward or backward, Large and small steps.
2. Zoom in and out.
3. Expand
4. Turn pens on/off
5. Selectable time/Value scales

2.8 Historical Data Archiving Conventions

The following data types will be historized:

1. Raw data.
2. Event data.
3. System and process alarms.
4. Files.

Selected user actions will be logged electronically. These events messages are included in the alarm history file and are purged from the disk at the same time the data collected is purged.

2.8.1.1. Store rate

Create files of 8 hours long

2.8.1.2. Free space

The minimum free space, in megabytes, on the hard disk that will be maintained for hard disk archive is 20 Mb. If the limit is exceeded a system event is generated.

2.9 Security

The security system is based on Windows security, which takes advantage of the available features.

The definition of users and user groups will be completed with Windows tools.

HMI security profile will be setup per user. At a minimum, the following user groups will be configured:

1. Engineers: Administration rights

2. Operators: no configuration rights and limited control capabilities.

3. Read only user.

Each user will have a unique login name and password. Once logged into the system, the user will have access to applications, areas, screens and controls as assigned to him or her by the system administrator.

Users will be logged out automatically after a pre-determined period of time or inactivity. Login and logout activity will be logged as an event.

Once logged out, the screen will switch to the overview screen to ensure that another operator does not gain access to a not authorized screen.

2.10 Applications

2.10.1 Plant Historian

The NBC has standardized on the use of the OSI-Soft PI Historian.

All tags requiring historical archiving will be sent to the PI Historian for system trending and population of reports. This includes, but is not limited to, all points sent to the local HMI historian.

The PI system collects information from other sources outside of the ABB & Siemens Control Systems All points associated with these systems and required by the HMI for indication, trending or other will be obtained from the PI system.

Any point sent by the HMI to the PI system shall be configured per the existing PI tagging standards.

Any point obtained by the HMI system from the PI system shall be tagged and configured per this standards document.

2.10.2 System Historian

A Wonderware Historian will be utilized for collection of data required by the system. The historian will reside on the servers. Data stored in this historian will be utilized to populate historical trends and reports.

SECTION 13685 - CONFIGURATION OF CONTROLLER SOFTWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. If referred to anywhere else in the project manual, AE or AESS services are those services specified in this Section.

B. Provide all programming, configuration, and related services required to achieve a fully integrated and operational system. All equipment shall be controlled in full conformity with the Contract Drawings, process control descriptions, specifications, engineering data, instructions, and recommendations of the equipment manufacturer. Coordinate the control system for proper operation with related equipment and materials furnished by other suppliers under other Sections of these specifications and with related existing equipment.

1. Provide configuration of the PLC provided for all equipment shown on the drawings, except for controls equipment shown being provided as part of a vendor package system.

C. All work shall be coordinated with plant operating personnel to minimize impacts on daily operation. Delays caused for any reason shall be noted and formally submitted to the Engineer and the Owner in the form of a letter.

D. Related Requirements:

1. Section 13684 “Configuration of HMI Software.”

1.3 DEFINITIONS

A. AE – Applications Engineering

B. AESS – Applications Engineering System Supplier

1.4 COORDINATION MEETINGS AND WORKSHOPS

A. Refer to meeting requirements of section 13684 “Configuration of HMI Software.”

1.5 ACTION SUBMITTALS

A. Controller Program Submittal

1. For each controller, submit the following using the controller manufacturer's built in printing functions. Electronic submission of Adobe Portable Document Format ("pdf") files in lieu of paper submittals is acceptable. Review will be for general program organization, level of documentation, and overall programming standards (basic pump and valve control, for example). The review will not attempt to confirm the logic works correctly for every loop.

    a. PLC programs showing function block language used. Include individual block, network, and/or command descriptions with abundant comments to clearly identify function and intent of each code segment. Each logic segment shall be clearly presented, the function of each timer described, the purpose of each subroutine call labeled and defined, etc. Program documentation shall be sufficiently clear to allow determination of compliance with the process control requirements included in the control descriptions and with the Drawings. The submittal shall demonstrate that all logic provided under this project follows the same structure and format and reflects a common programming approach.
    b. Submit a memory usage report for the controller. This report shall indicate total memory capacity and unused memory capacity.
    c. Submit cross reference index of I/O allocation and controller memory address. Every physical I/O point as well calculated or virtual I/O required for the implementation of the process scheme shall be included.

2. Submit details of control system communication. Submit a "memory map" or other means showing which signals are exchanged between PLCs. Also submit a HMI tag database showing all signals exchanged between the PLCs and HMI. Any specific communication block memory addresses shall be defined.

B. Submit all electronic files associated with the controller such that the Owner and Engineer can open a complete copy of the controller program using the controllers native programming package.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONTROLLER PROGRAMS

A. All applications programs shall be developed in a structured manner and shall follow an intuitive arrangement so that an instrumentation technician with basic programming knowledge will be able to understand. Programs shall utilize standard program templates or subroutines for repetitive logic such as equipment control, flow total calculations, equipment runtime calculations.

B. Make changes to the application programs and software configuration, based on comments during the submittals, the factory tests, the field tests, and during the commissioning process to meet the design intent, at no additional cost to the Owner.

END OF SECTION 13685

SECTION 13701 - MAGNETIC FLOW METERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes magnetic flow meters.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”
3. Section 13612 “Process Control System Testing.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Magnetic Flow Meter Transmitters: 1 Spare Transmitter

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Furnish sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, transmitters, control devices, interconnecting cables, and unit conversions and algorithms as required for application.

2.2 MAGNETIC FLOW METERS

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Siemens;
b. Substitutions: Not Permitted.

B. Description: Low-frequency, electromagnetic induction-type flow meter, producing a linear signal directly proportional to flow rate, consisting of flow tube, signal cable, and transmitter.

C. Performance and Design Criteria:

1. Design: According to AWWA M33.

D. Flow Rate Range: As indicated on the Instrument Device Schedule.

E. Size: As indicated on Drawings.

F. Flow Tubes:

1. Body Material: Type 304 stainless steel
2. Liner: Hard Rubber.
3. Length: As indicated on Drawings.
4. End Connections: Meter sizes up to 24 inch: Flanged, ANSI 150lb or DIN PN 16 stainless steel. Meter Sizes greater than 24 inch: Flanged, AWWA Class D.
5. Environment: For meters with remote mounted transmitters, meters below grade shall be suitable for submergence for up to 48 hours to a depth of 30 ft (9m). Meters above grade shall be NEMA 4X (IP65).

G. Electrodes:

1. Type 316L stainless steel or Hastelloy C.
2. Self-cleaning bullet-nose shape.

H. Accuracy: Plus or minus 0.25 percent of actual flow rate over a 30:1 range, within velocity limits of 0.1-10.0 ft/sec.

I. Provide adjustment for zero and span.

J. Accessories:

1. Option: If installed in a hazardous location as noted on the electrical drawings, flowmeters shall be rated for the hazardous area.
2. Furnish cable between transmitter and receiver.
3. Furnish grounding rings, wires, and gaskets as recommended by the manufacturer. All materials must be suitable for the process and surrounding pipe.

2.3 TRANSMITTERS

A. Manufacturer: Same manufacturer as meter.

B. Transmitter Output:

1. 4- to 20-mA dc analog signal.

C. Housing: NEMA 4X (IP65), suitable for surface or pipe stand mounting.

D. Control Power:

1. 120-V ac, single phase, 60 Hz.
2. Furnish local transformers as required.

E. HMI:

1. Touch-screen programming, functioning through enclosure window without opening enclosure.
2. Display:

    a. Size: Four lines by 16 characters.
    b. Type: Backlit digital display.
    c. User-selectable engineering units.
    d. Readout of diagnostic error messages.

F. Mounting:

1. Mounting: Remote, as shown on the electrical drawings.
2. Remote Mounting Locations Less Than 4 Feetabove Grade: Provide stainless-steel mounting posts.

G. Accessories:

1. Current signal output simulation.
2. Empty pipe detection.
3. Self-diagnostics.
4. Automatic zero adjustment.
5. For outdoor installations, provide a sunshield of sturdy, corrosion- and UV-resistant material.
6. Signal Cable: Provided by flow meter manufacturer.

2.4 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of meters according to AWWA M6.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process connections for suitable conditions where magnetic flow meters and transmitters will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. All manufacturer recommended tests and procedures.

C. Magnetic flow meters will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. The start-up services include calibration, oversight of installations of the sensor, and start-up of the sensor/transmitter in order to provide reliable measurement at the instrument. The factory-authorized service representative or manufacturer shall work with the PCSS and AESS to verify the transmitter sends correct information to the control system (i.e., that the scaling and units are the same at the instrument and on the control system's operator interface/PLC). Submit an instrument calibration report in order to document the calibration procedure of the instruments in accordance with Section 13612.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 – Process Control and Enterprise Management Systems General Provisions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13701

SECTION 13722 - RADAR LEVEL METERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes radar level meters.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”

1.3 DEFINITIONS

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.6 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.7 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Radar Level Element: 1 Spare Transducer.
2. Radar Level Transmitter: 1 Spare Transmitter.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.12 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 NON- CONTACT RADAR-LEVEL MEASUREMENT DEVICE

A. Level Element

1. Manufacturers:

a. Manufacturers and their products are subject to compliance with requirements. Provide the following:

1) VEGA Americas, Inc. VEGAPULS 64

2) Substitutions: Not Permitted.

2. Type:

a. Non-contact, microwave type level meter.
b. High 80 GHZ radar frequency for continuous level measurement of slurry, corrosive liquids, low dielectric liquids and bulk solids in storage vessels.
c. Antenna: Rod, Horn, Parabolic, or Encapsulated.

3. Function/Performance:

a. Measuring Range: Range suitable for the installation indicated,
b. Accuracy: Plus or minus 0.04 inches (1 mm).
c. Operating Temperature: -40 to 149 degrees F (-40 to 65 degrees C).
d. Output: Isolated 4-20 mA output.
e. Beam Angle: 3°.

4. Physical:

a. Antenna: Type 316 stainless steel, Hastelloy C or other material depending upon its compatibility to the process in which it is measuring.
b. NEMA 4X (IP66) housing. Where the instrument is installed in a hazardous area, provide explosion-proof housing, approved for Class I, Division 1, Groups C and D installation and certified for installation of the antenna in a Class I, Division 1, Groups C and D (Zone 0) environment.
c. Power Requirements: 24 VDC Loop powered
d. Remote Display: Digital indicator displaying level or volume in engineering units or percent, as indicated on the Drawings or in the Instrument List. Display unit used to remotely program the transmitter.

5. Accessories Required:

a. Where required for calibration/programming, provide a hand-held programmer

B. Transmitter/Controller:

1. Manufacturers: Match Level Element
2. Type:

a. Microprocessor based compatible with the transducer(s) provided.
b. Transmitter: Remotely mounted from transducer.

3. Functional/Performance:

a. Capable of performing Palmer-Bowlus and v-notch weir open channel flow calculations. Analog output from the transmitter/controller will be flume flow. Level to flow calculation shall not be programmed in the PLC.
b. Resolution (including transducer): Plus or minus 0.1 percent of range whichever is greater.
c. Accuracy (including level element): Plus or minus 0.25 percent of range.
d. Range: As required by the installation indicated on the Drawings and Instrument Device Schedule.

e. Temperature Range: -22 to 122 degrees F.
f. Output: Minimum two isolated 4-20 mA outputs and minimum two alarm contacts (number of contacts above 4 required of each device to be determined by signals required as shown on the drawings adjustable to trip at any point in the instrument range. Output contacts shall be rated 5 A at 230 VAC.
g. Display: Digital indicator displaying flow in engineering units or percent as indicated on the Drawings or in the Instrument Device Schedule.
h. Diagnostics: On-screen instructions and display of self- diagnostics.
i. Configuration Protection: Protected programmable parameters using E2PROM. Battery backup protection is not acceptable.

4. Physical

a. Transmitter: Suitable for surface or pipe stand mounting.
b. Enclosure: NEMA 4X (IP66).
c. Input A/C Power: 120vac.

5. Accessories Required

a. Hand-held programmer where required for configuration and calibration of the instrument.
b. Provided with manufacturer’s supplied sun shield.

2.2 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process areas for suitable conditions where radar level meters will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. All manufacturer recommended start-up tests and procedures.

C. Radar level meters will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. The start-up services include calibration, oversight of installations of the sensor, and start-up of the sensor/transmitter in order to provide reliable measurement at the instrument. The factory-authorized service representative or manufacturer shall work with the PCSS and AESS to verify the transmitter sends correct information to the control system (i.e., that the scaling and units are the same at the instrument and on the control system's operator interface/PLC). Submit an instrument calibration report in order to document the calibration procedure of the instruments.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 "Process Control and Enterprise Management Systems General Provisions."

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

B. While starting up the instruments, the manufacturer shall provide training to the Owner's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.

END OF SECTION 13722

SECTION 13729 - LEVEL SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes level switches.

1.3 Related Requirements:

A. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

B. Section 13340 “Instrumentation for Process Systems.”

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.6 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Float Switches: 2 Float Switches.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 FLOAT SWITCHES

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

    a. Contegra FS 90.
    b. Siemens Water Technologies Model 9G-EF.
    c. Substitutions: Or equal.

B. Type:

1. Mercury free ball float switch.

C. Function/Performance:

1. Differential: Less than 8 inch.
2. Type of Switch: SPDT snap switch
3. Switch Rating: 1 amps at 120 VAC or 100 VA @ 120 VAC.

D. Physical:

1. Float: Type 316 stainless steel, Teflon or non-stick coating, minimum 5 in diameter.
2. Totally encapsulated switch.
3. Cable shall be heavy-duty, PVC or equivalent jacketed integral to float.

E. Options/Accessories Required:

1. Provide stainless steel hardware.
2. Lead wire shall be a waterproof cable of sufficient length so that no splice or junction box is required in the vault.
3. Provide 316 stainless steel NEMA 4X junction box outside the sump pit with terminals for all floats and tapped as required for conduit connections.
4. Provide mounting equipment as shown on the drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process locations for suitable conditions where float switches will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 – Process Control and Enterprise Management Systems General Provisions.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13729

SECTION 13731 - PRESSURE AND DIFFERENTIAL PRESSURE GAUGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pressure and differential pressure gauges.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”
3. Section 13612 “Process Control System Testing.”
4. Section 13739 “Diaphragm Seals.”
5. Section 11217 “Screw Centrifugal Pumps.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Refer to Specification Section 13739 “Diaphragm Seals.”

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 PRESSURE GAGES

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Ametek US Gauge.
b. Ashcroft.
c. Weksler.
d. Substitutions: Or equal.

B. Type: Differential or Gauge - Bourdon tube actuated dial face pressure gauge.

C. Dials:

1. Nominal Diameter: Minimum 4 inches.
2. Face: White, laminated plastic dials with black graduations.
3. Scale: Extend over arc not less than 200 and not more than 270 degrees.
4. Ranges: As indicated on Instrument Device Schedule.

D. Cases:

1. Liquid filled.
2. Material: Phenolic or Type 316 stainless steel.
3. Provide removable rear plate.
4. For gauge pressure, vented case for temperature/atmospheric compensation
5. Windows:

    a. Material: Clear acrylic or shatterproof glass.
    b. Thickness: 1/8 inch.
    c. Provide gasket.

E. Connection:

1. Location: Bottom.
2. Socket:

    a. 1/4-inch NPT male thread.
    b. Material: Brass forging.
    c. Extend minimum 1-1/4 inches below gage cases.
    d. Provide wrench flats.

3. Mounting: Stem or surface.

F. Measuring Element:

1. Bourdon Tubes:

    a. Material: Stainless steel, to brass socket.
    b. Provide welded, stress-relieved joints.

2. Movement:
    a. Material: Stainless steel.

3. Accuracy:

    a. Comply with ASME B40.100.
    b. Plus and minus 1.0 percent of full-scale range.

G. Adjustment:

1. Provide for zero-reading adjustment.
2. Adjusting Screws: Accessible from rear of case without need for disassembly.

H. Options:

1. Provide pressure gauges with NIST traceable certificate of calibration. Submit this certificate as part of the instrument calibration form under Section 13612.

I. Accessories:

1. Pressure Snubber:

a. Material: Type 316 stainless steel.

2. Gauges shall be liquid filled at the factory.

2.2 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process connections for suitable conditions where pressure gauges will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 – Process Control and Enterprise Management Systems General Provisions.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13731

SECTION 13736 - PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pressure and differential pressure switches.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”
3. Section 13612 “Process Control System Testing.”
4. Section 13739 “Diaphragm Seals.”
5. Section 11217 “Screw Centrifugal Pumps.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Refer to Specification Section 13739 “Diaphragm Seals.”

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 PRESSURE SWITCHES

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Ashcroft.
b. Mercoid.
c. Static-O-Ring (SOR).
d. Substitutions: Or equal.

B. Type:

1. Pressure: Diaphragm actuated.

C. Materials:

1. Diaphragm: Stainless steel.
2. Wetted parts: 316L Stainless Steel.
3. Seals: Viton.
4. Connection port: 316 Stainless Steel.

D. Accuracy

1. Plus or minus 5 percent of operating range.

E. Repeatability: Better than 1 percent of full scale.
F. Dead Band: Adjustable to 60 percent of full scale.
G. Set Points: Adjustable between 20 and 80 percent of adjustable range.
H. Reset: Unit shall be of the automatic reset type.
I. Over Range Protection: Over range protection to 150 percent of the maximum process line pressure,
J. Hermetically-sealed switches
K. Connection:

1. Location: Bottom.
2. Size: 1/4 inch.
3. Furnish taps for sensing lines.

L. Electrical:

1. Contacts:

a. SPDT.
b. Type: Snap action, according to NEMA ICS 1.

2. Ampacity: 10 A at 230 V AC.

M. Enclosures: NEMA 250 Type 4X

N. Operation:

1. Where pressure switches are installed on the suction piping of a pump, pressure switches shall open upon falling below setpoint. Where pressure switches are installed on the discharge piping of a pump, pressure switches shall open upon rising above setpoint.

O. Accessories

1. Where pressure switches are installed on the discharge piping of a pump, provide a Type 316 stainless steel snubber for pulsation dampening.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process connections for suitable conditions where pressure switches will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Refer to Section 13739 – Diaphragm Seals.Pressure switches will be considered defective if it does not pass tests and inspections.

B. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify pressure switch setpoint and dead band settings by applying external pressure onto the pressure tree assembly (by use of a hand pump with a bleed valve or other means). Record final pressure switch trip (at setpoint) and reset pressures. Pressures shall be measured by a pressure gauge with an active NIST traceable calibration certificate verifying that the test gauge is at least as accurate as the manufacturer listed accuracy of the pressure switch. Submit pressure switch verification as well as the NIST calibration certificate of the test gauge used as part of the instrument calibration form under Section 13612.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 – Process Control and Enterprise Management Systems General Provisions.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13736

SECTION 13739 - DIAPHRAGM SEALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes diaphragm seals.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”
3. Section 13612 “Process Control System Testing.”
4. Section 13731 “Pressure and Differential Pressure Gauges.”
5. Section 13736 “Pressure and Differential Pressure Switches.”
6. Section 11217 “Screw Centrifugal Pumps.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Pressure Assemblies: 1 complete pressure assemblies including diaphragm seal, pressure instruments, and sealed interconnecting piping for each type and size installed.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 DIAPHRAGM SEALS – ANNULAR FLANGE MOUNTED

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Ashcroft
b. Wika
c. Winters

d. Substitutions: Or equal.

B. Type:

1. Line mounted, between two flanges.

C. Function/Performance:

1. Pressure Limit: Correspond to flange ratings.
2. Inside diameter shall conform to the dimensions of the pipe where the seal is installed.
3. ANSI or DIN flange class shall be equivalent to the flange class of the piping where the seal is installed. Bolting dimensions shall conform to ANSI or DIN drilling specifications as required by the installation.

D. Physical:

1. Body material and Flange: 316SS and compatible with process connection.
2. Pressure instrument connection: 1/4-inch NPT.
3. Wetted Parts and Bolt Materials: Corrosion resistant to process fluid.
4. Sensing Liquid: Silicone Oil.

E. Pressure Instrument Mounting:

1. Single Pressure Instrument Assembly: Directly to pressure gage socket.
2. Multiple Pressure Instrument Assembly: 316 Stainless Steel pipe tree connecting seal to pressure instruments. Tree piping design should minimize the number of fittings while allowing pressure to be easily read.
3. Pressure Instrument Assemblies shall be factory assembled, filled, and sealed. See Specification Sections 13731 “Pressure and Differential Pressure Gauges” and 13736 “Pressure and Differential Pressure Switches”.

2.2 SOURCE QUALITY CONTROL

A. Section 01400 - Quality Requirements: Requirements for testing, inspection, and analysis.
B. Diaphragm Seals:

1. Factory-assemble, fill, and calibrate entire assembly, including gage switch and transmitter, prior to shipment.
2. Field filling is not acceptable.

C. Provide shop inspection and testing of completed assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process connections for suitable conditions where pressure instrument assemblies will be installed.
B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.
B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Inspect all pressure assemblies for hydraulic fluid leaks before and after installation.

B. Diaphragm seals will be considered defective if it does not pass tests and inspections.
C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup procedures according to manufacturer's written instructions.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13739

SECTION 13766 - SUSPENDED SOLIDS/SLUDGE DENSITY ANALYZERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes suspended solids-sludge density analyzers.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sludge Blanket Level Monitor Transducer: 1 Spare Transducer.
2. Sludge Blanket Level Monitor Transmitter: 1 Spare Transmitter.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 ULTRASONIC SLUDGE BLANKET LEVEL MONITOR

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Hach Sonatax sc
b. Substitutions: Not permitted.

B. Description: Continuous monitoring system consisting of a microprocessor controller, a sonic transducer/transceiver assembly with a hinged mounting arm, and all interconnecting cables. System shall monitor sludge level as well as provide a process upset warning, which measures the change in percent solids in a selected zone above the sludge level.

C. Function/Performance:

1. Range: 0 to 40 Feet

2. Resolution: .1 feet
3. Accuracy: ± 0.33 feet

D. Transducer:

1. Probe Housing: Stainless Steel
2. Operating Temperature Range: 35 to 122 F degrees
3. Protection: IP68 submersible
4. Cable: Submersible rated cable. Coordinate cable length with transmitter installation location. Cable length shall be sufficient to connect transducer to transmitter and allow for complete removal to perform maintenance of the transducer while the transducer is connected to the transmitter.
5. Transducer shall have surface wiper to perform automatic self-cleaning of the measuring face.

2.2 Transmitter:

A. Manufacturer:

1. Provide a transmitter from the same manufacturer as the transducer that is compatible with the transmitter.

B. Housing: NEMA 4X

C. Power: 120 VAC, 60 Hz

1. Furnish local transformers as required

D. Output: 4-20 mA DC analog signal.

E. Touch-screen programming, functioning through enclosure window without opening enclosure.

F. Display:

1. Backlit digital display
2. User-selectable engineering units
3. Readout of diagnostic error messages.

G. Provide Stainless Steel Sunshield

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process area for suitable conditions where Ultrasonic Sludge Blanket Level Monitors will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. The start-up services include calibration, oversight of installations of the sensor, and start-up of the sensor/transmitter in order to provide reliable measurement at the instrument. The factory-authorized service representative or manufacturer shall work with the PCSS and AESS to verify the transmitter sends correct information to the control system (i.e., that the scaling and units are the same at the instrument and on the control system's operator interface/PLC). Submit an instrument calibration report in order to document the calibration procedure of the instruments.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 – Process Control and Enterprise Management Systems General Provisions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13766

SECTION 13789 - POSITION, SPEED, AND MOTION MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes position, speed, and motion measurement devices.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions.”
2. Section 13340 “Instrumentation for Process Systems.”
3. Section 11258 “Circular Secondary Clarifier Equipment.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13340 “Instrumentation for Process Systems.”

B. Shop Drawings:

1. Refer to Section 13340 “Instrumentation for Process Systems.”

1.5 INFORMATIONAL SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions” for any PCSS requirements regarding informational submittals for instruments.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Inductive Proximity Switch: Full-size units equal to 25 percent of quantity installed, but no fewer than 1 unit.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.10 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.11 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 INDUCTIVE PROXIMITY SWITCH

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Telemecanique Sensors.
b. Pepperl+Fuchs.
c. Eaton.
d. Substitutions: Or equal**.**

B. Type:

1. Two wire inductive type.

C. Function/Performance:

1. Normally Closed (NC) output contacts.
2. Minimum 40 mm sensing distance.
3. Rated for 24 VDC or 120 VAC 60 Hz. If switch is only compatible with DC voltage, provide power supply with 120VAC input and output matched to proximity switch operating voltage. Power supply shall be in accordance with Section 13801 – Power Supplies. Power supply shall be installed in respective clarifier spray control panel.
4. Switching capacity: Rated for 200 mA on DC power or 300 mA on AC power.
5. Switch shall have an integral output status indicating LED.

D. Physical:

1. Sensor housing shall be cylindrical and made of 316 stainless steel. Sensor shall be IP68.
2. Sensor cable shall be of sufficient length to connect to respective clarifier spray control panel. Sensor shall be submersible.

E. Accessories/Options Required:

1. If a sealed pre-wired switch is used, a separate connection or junction box of equal environmental protection rated shall be supplied and installed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and process area for suitable conditions where inductive proximity switches will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 MAINTENANCE SERVICE

A. PCSS Maintenance Service required for this instrument: Refer to Section 13610 – Process Control and Enterprise Management Systems General Provisions.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13789

SECTION 13798 - RELAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes relays.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions” for submittal requirements.
2. Section 13675 “Industrial Enclosures.”
3. Section 13678 “Panel Wiring.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions” for preinstallation meetings

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

B. Shop Drawings:

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.5 INFORMATIONAL SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.6 CLOSEOUT SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. General Purpose Relays and Time Delays: Full-size units including relays and associated relay socket equal to 25 percent of quantity installed for each model installed, but no fewer than 2 units of each model installed.
2. Current Trips: Full-size units equal to 25 percent of quantity installed for each model installed, but no fewer than 2 units of each model installed.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 TECHNOLOGY OBSOLESCENCE MITIGATION

A. Not applicable to this Section.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.11 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.12 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE RELAYS AND TIME DELAYS

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

    a. Allen Bradley.
    b. IDEC
    c. Omron
    d. Schneider Electric.
    e. Substitutions: Or equal.

B. Type:

1. General purpose plug-in type.

C. Functional:

1. Contact arrangement/function shall be as required to meet the specified control function; Mechanical life expectancy shall be in excess of 10 million.
2. Duty cycle shall be rated for continuous operation; Units shall be provided with integral indicating light to indicate if relay is energized.
3. Solid state time delays shall be provided with polarity protection (DC units) and transient protection.
4. Time delay units shall be adjustable and available in ranges from .1 second to 4.5 hours.

D. Physical:

1. For 120 VAC service provide contacts rated 10 amps at 120 VAC, for 24 VDC service provide contacts rated 5 amps at 28 VDC, for electronic (milliamp/millivolt) switching applicator provide gold plated contacts rated for electronic service; relays shall be provided with dust and moisture resistant covers.
2. All relays shall be provided with number of poles required to meet the design intent but no fewer than 2 poles.
3. All relay poles shall be double throw.

E. Options/Accessories Required:

1. Provide blade terminal din rail mounting sockets with pressure type terminal blocks rated 300 volt and 10 amps.
2. Provide mounting rails/holders as required.
3. Provide LED/neon lamp indicator and manual check button.

2.2 SIGNAL RELAY SWITCHES (CURRENT TRIPS)

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

    a. Acromag.
    b. Eurotherm Ultra Slim Pak II.
    c. Substitutions: Or equal.

B. Type:

1. Solid state, ASIC technology, electronic type.

C. Functional:

1. Input: 4-20 mA.
2. Output: Isolated contact output, double pole double throw, rated 5 amps at 120 VAC.
3. Accuracy: 0.1 percent.
4. Protection: Provide RFI protection.
5. Deadband: Adjustable between 0.1 and 5.0 percent of span.
6. Set point Adjustment: Single Point alarms shall be adjustable to trip on rising or falling input signal, dual point alarms shall be adjustable to trip on rising and falling input signals.
7. Repeatability: Trip point repeatability shall be at least 0.1 percent of span.

D. Physical:

1. Mounting: DIN rail.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, rooms and panels for suitable conditions where general purpose relays, time delays, and current trips will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports in accordance with the following:

1. Section 13610 “Process Control and Enterprise Management General Provisions.”
2. Section 13612 “Process Control System Testing.”

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13798

SECTION 13799 - ISOLATORS, INTRINSICALLY SAFE BARRIERS, AND SURGE SUPPRESSORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes isolators, intrinsically safe barriers, and surge suppressors.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions” for submittal requirements.
2. Section 13675 “Industrial Enclosures.”
3. Section 13678 “Panel Wiring.”

1.3 DEFINITIONS

A. ISB: Intrinsically Safe Barrier

B. ISR: Intrinsically Safe Relay

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions” for preinstallation meetings

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

B. Shop Drawings:

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.6 INFORMATIONAL SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.7 CLOSEOUT SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Signal Isolators/Boosters/Converters: Full-size units equal to 25 percent of quantity installed for each model installed, but no fewer than 2 units of each model installed.
2. Intrinsically Safe Barriers: Full-size units equal to 25 percent of quantity installed for each model installed, but no fewer than 2 units of each model installed.
3. Surge Suppressors: Full-size units equal to 25 percent of quantity installed for each model installed, but no fewer than 1 unit of each model installed.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.10 TECHNOLOGY OBSOLESCENCE MITIGATION

A. Not applicable to this Section.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.12 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.13 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 SIGNAL ISOLATORS/BOOSTERS/CONVERTERS

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Acromag.
b. Eurotherm Ultra Slim Pak II.
c. Substitutions: Or equal.

B. Type:

1. Solid state, ASIC technology; electronic type.

C. Functional:

1. Accuracy: 0.15 percent.

2. Inputs: Current, voltage, frequency, temperature, or resistance as required.

3. Outputs: Current or voltage as required.

4. Isolation: There shall be complete isolation between input circuitry, output circuitry, and the power supply.

5. Adjustments: Zero and span adjustment shall be provided.

6. Protection: Provide RFI protection.

D. Physical:

1. Mounting: DIN Rail.

2.2 INTRINSIC SAFETY BARRIERS

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Gems – 54800 (4-20mA) and 65800 (dry contacts).
b. R. Stahl - Intrinspak
c. Substitutions: Or equal.

B. Type:

1. Barriers shall be of the solid state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe usage in hazardous areas.
2. Provide a barrier for instrumentation and equipment transmitting analog or digital signals that originate in a hazardous areas.

C. Options Required:

1. Barriers shall match power supply provided.

2. Barriers shall be located in non-hazardous areas.

2.3 INTRINSIC SAFETY BARRIERS (FOR 2-WIRE TRANSMITTER SYSTEMS)

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Gems.
b. P&F.
c. Substitutions: Or equal.

B. Intrinsic safety barriers shall be passive devices requiring no external voltage supply and supplied with series resistors, series fuse and shunt zener diodes to limit the transfer of energy to levels required by intrinsically safe protection between safe and hazardous locations.

C. Unit shall be Factory Mutual approved and certified for use in accordance with National Fire Protection Association (NFPA 493).

2.4 SURGE PROTECTION FOR CONTROL SYSTEMS

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Citel DLA series
b. Citel CAT series,
c. MTL Surge Technologies,
d. Phoenix Contact PlugTrab Series,
e. Transtector FSP Series,
f. Substitutions: Or equal.

B. General - Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines from lightning, utility, or the plant electrical system. The protection systems shall be such that the protective level shall not interfere with normal operation but shall be lower than the instrument surge withstand level. Protection shall be maintenance free and self-restoring. Devices shall have a response time of less than 50 nanoseconds and be capable of handling a discharge surge current (at an 8x20µs impulse waveform) of at least 8 kA. Ground wires for all instrumentation device surge

protectors shall be connected to a low resistance ground in accordance with Section 16660 - Grounding and Bonding For Electrical Systems. Provide surge protection devices with relay alarm contacts rated for 5A at 120VAC. Provide surge protection devices with alarm indication light to locally indicate a fault.

C. Provide protection of all analog signal (4-20 mA) circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at the control system end of the circuit. Protection devices in control panels shall be MTL Surge TechnologiesSD Series, Phoenix Contact PT Series, Citel DLA series, Citel CAT series or equal.

D. Provide protection of all 120 VAC power feeds into control panels. Surge protective devices shall be Transtector, Phoenix Contact "Mains-PlugTrab", MCG Surge Protection 400 Series, Citel DS40 series, or equal.

E. Inductive Loads: Provide coil surge suppression devices, such as varistors or interposing relays, on all process controller outputs or switches rated 120 VA or less that drive solenoid, coil, or motor loads.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, rooms, and panels for suitable conditions where signal isolators/boosters/converters, intrinsically safe barriers, and surge suppressors will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. NFPA 70: Comply with Article 504 of NFPA 70 for installation of intrinsically safe barriers.

B. Comply with NECA 1.

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 IELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Prepare test and inspection reports in accordance with the following:

1. Section 13610 “Process Control and Enterprise Management General Provisions.”
2. Section 13612 “Process Control System Testing.”

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 SOFTWARE SERVICE AGREEMENT

A. Refer to Section 13610 “Process Control and Enterprise Management Systems - General Provisions.”

3.7 EMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13799

SECTION 13801 - POWER SUPPLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes power supplies.

B. Related Requirements:

1. Section 13610 “Process Control and Enterprise Management Systems General Provisions” for submittal requirements.
2. Section 13675 “Industrial Enclosures.”
3. Section 13678 “Panel Wiring.”

1.3 PREINSTALLATION MEETINGS

A. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions” for preinstallation meetings

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

B. Shop Drawings:

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.5 INFORMATIONAL SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.6 CLOSEOUT SUBMITTALS

1. Refer to Section 13610 “Process Control and Enterprise Management System General Provisions.”

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. 24 VDC Power supplies: 1 Spare Redundant Power Supply

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.9 TECHNOLOGY OBSOLESCENCE MITIGATION

A. Not applicable to this Section.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.11 FIELD CONDITIONS

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

1.12 WARRANTY

A. Refer to Section 13610 “Process Control and Enterprise Management Systems General Provisions.”

PART 2 - PRODUCTS

2.1 24 VDC POWER SUPPLIES

A. Manufacturers:

1. Manufacturers and their products are subject to compliance with requirements. Provide one of the following:

a. Phoenix Contact Quint Model 2938581.

b. Substitutions: Not Permitted.

B. Provide a 24 VDC power supply in the control panel to power field instruments, panel devices, etc., as required. Equip the power supply with a power on/off circuit breaker.

C. Provide redundant power supplies that operate in parallel to power field instruments and panel devices as shown on the drawings.

D. The 24 VDC power supply shall meet the following requirements:

1. Input power: 115 VAC, plus or minus 10 percent, 60 Hz.

2. Output voltage: 24 VDC.

3. Output voltage adjustment: 5 percent.

4. Line regulation: 0.05 percent for 10 volt line change.

5. Load regulation: 0.15 percent no load to full load.

6. Ripple: 3 mV RMS.

7. Operating temperature: 32 to 140 degrees Fahrenheit.

E. Size the 24 VDC power supply to accommodate the design load plus a minimum 25 percent spare capacity.

F. If power supply on/off status signal is shown on drawings, provide a relay contact (internal to the power supply or external if the power supply is not so equipped) to indicate on/off status of the power supply.

G. Provide output overvoltage and overcurrent protective devices with the power supply to protect instruments from damage due to power supply failure and to protect the power supply from damage due to external failure.

H. Mount the 24 VDC power supply such that dissipated heat does not adversely affect other panel components.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, roofs, and panels for suitable conditions where power supplies will be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

3.3 IDENTIFICATION

A. Refer to drawings for tagging designations

3.4 FIELD QUALITY CONTROL

A. Prepare test and inspection reports in accordance with the following:

1. Section 13610 “Process Control and Enterprise Management General Provisions.”
2. Section 13612 “Process Control System Testing.”

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup procedures according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 13801

SECTION 14625 - MONORAIL HOISTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Electric-powered monorail hoists and components, with wire rope.
2. Monorail system; including monorail runway beam, supplementary framing, support members and anchorage to building.
3. Delegated-design.

B. Related Requirements:

1. Section 09910 “Painting” for exposed piping and repair of damaged coatings.
2. Section 05502 “Metal Fabrications” for connections to building structure
3. Section 15100 “Low-Voltage Motor Requirements for Process Equipment” for electric motors and accessories normally supplied as part of equipment assemblies.

1.3 DEFINITIONS

A. Pendant: A hand-operated controller that hangs from the crane by a cable.

B. Trolley-Mounted Hoist: An assembly consisting of a wheeled trolley that moves along the runway beam rail and a hoist that is suspended from the trolley and provides for the raising and lowering of a freely suspended load.

1.4 ACTION SUBMITTALS

A. Product Data: Submit manufacturer catalog information for each hoist, trolley, runway beam, and support system, including materials, weights, dimensions, and capacities.

B. Shop Drawings:

1. Indicate monorail and runway beam capacities, hook envelope, equipment dimensions, and hoist limits.
2. Indicate runway beam, trolley, hoist, motors, controls, power cabling and mounting details.
3. Indicate arrangement of runway beam, including curves and switches, clearances, principal dimensions, details of structural connections, and components.

4. Indicate control panel layout, including wiring diagrams, system schematics.
5. Details for connection of the monorail and runway beam supports to the building, and vertical and horizontal reactions imposed on the building system.
6. Supplementary framing as required to stabilize and support the monorail runway beam for longitudinal, transverse lateral and vertical forces, including impact.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

B. Welder Certificates: Certify welders and welding procedures employed on Work, verifying AWS qualification within previous 12 months.

C. Test and Evaluation Reports: Indicate crane certification documentation.

D. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

E. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statements:

1. Submit qualifications for manufacturer, installer, and licensed professional.
2. Submit manufacturer's approval of installer.
3. Welders: Qualify procedures and personnel according to AWS D14.1/D14.1M.

1.6 DELEGATED DESIGN SUBMITTALS

A. Delegated Design Certification: As required by Division 00 and Division 01.

B. Delegated Design Submittals: Submit signed and sealed Shop Drawings with design calculations and assumptions for sizing of runway beams, connections and supports. Provide all runway beam reactions to support framing and clarify if it includes load factors and all impact loading. Sign and seal shall be by a professional engineer registered in the State of Rhode Island.

C. After the monorail systems have been installed and accepted, submit structural design calculations for the monorail system for record purposes only. Calculations shall demonstrate compliance with the performance criteria specified herein. Calculations shall be prepared, stamped, and signed by a professional engineer registered in the State of Rhode Island. The calculations will not be reviewed by the Engineer.

1.7 CLOSEOUT SUBMITTALS

A. Section 01770 “Closeout Procedures” for requirements for submittals.

B. Project Record Documents: Record actual locations of monorail hoists.

C. Operation and Maintenance Data:

1. Submit assembly views.
2. Submit replacement part numbers and availability.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Section 01770 “Closeout Procedures” for requirements for maintenance materials.

B. Spare Parts:

1. Furnish following spare parts for each monorail hoist:

a. One complete set of linings for each type and size of brake.
b. One set of collector shoes.
c. One wire rope of specified length, with end fittings.
d. 10 percent spare wires for each cable in festoon system.

1.9 QUALITY ASSURANCE

A. Design and Fabrication: Comply with ASME B30.11, ASME HST-1, AWS D14.1/14.1M, MH27.1, and OSHA 1910.179.

B. Construction: Comply with ASME NUM-1.

C. Welding: Comply with AWS D14.1/D14.1M.

1.10 QUALIFICATIONS

A. Manufacturer Qualifications:

1. Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.
2. Member of the Hoist Manufacturers Institute and the Monorail Manufacturers Association.

B. Installer Qualifications: Company specializing in performing Work of this Section with minimum three years' documented experience.

C. Welders: AWS qualified within previous 12 months for employed weld types.

D. Licensed Professional: Professional engineer experienced in design of specified Work and licensed at Project location.

E. Single Source: Monorail, runway beam and carrier equipment shall be products of a single, experienced, reputable and qualified manufacturer who is a member of the MMA.

F. Structural design shall be performed by a qualified Professional Engineer registered in the State of Rhode Island.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Section 01600 “Product Requirements”: Requirements for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Store materials according to manufacturer instructions.

D. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.12 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.13 WARRANTY

A. Section 01770 “Closeout Procedures” for requirements for warranties.

B. Furnish five-year manufacturer's warranty for monorail hoists.

PART 2 - PRODUCTS

2.1 PERFORMANCE AND DESIGN CRITERIA

A. Comply with CMAA 74 and AISC Steel Construction Manual.

B. Service: Indoor.

C. Capacity: 3 tons.

D. Provide manufacturer installed identification plates of non-corrosive metal showing the manufacturer’s name, model number, capacity, power supply, and other essential information. Label the monorail with capacity, legible from the floor on both sides of the beam.

E. Runway Beam:

1. Fabricate of a high carbon manganese or vanadium alloy steel "T" bottom section with a Brinell hardness of 225 minimum, a carbon steel web plate and a top flange plate. The

bottom "T" shall be 3.33-inch wide. Join the components by high-penetration machine welding.

2. Size for maximum loads anticipated on spans with deflection not to exceed 1/600 of span.
3. Hardware including splices, end stops or other items necessary to furnish a complete system shall be provided as required for the systems.

F. Structural Supports: Add the following to the live-load capacity:

1. Add 15 percent for hoist and trolley weight (or actual hoist and trolley weight).
2. Add 25 percent for vertical impact.
3. Add 20 percent for lateral force.
4. Add 10 percent for longitudinal force.

G. Bearings:

1. Type: Antifriction ball, ABMA 9.
2. L-10 Life: 5,000 hours.

H. Motor: As specified in Section 15100 “Low-Voltage Motor Requirements” for Process Equipment.

I. Control Panel:

1. Factory mounted.
2. NEMA 250 Type 4X, 316SS.
3. Single-point power connection and grounding lug.

J. Controls:

1. Pendant Push-Button Station:

   a. Hanging from crane structure to minimum 4 feet above lower level floor.
   b. Comply with NEMA ICS 8.
   c. Furnish mounting bracket on crane to stow pendant when not in use.
   d. Push Buttons: RAISE; LOWER; FORWARD, REVERSE.
   e. NEMA 250 Type 4X, fiberglass reinforced plastic.

2. Limit Switches:

   a. Wire Rope Hoists: Adjustable upper, lower, and secondary, independently wired, upper switch.

3. Overload Cutoff:

   a. Prevent hoist from applying pull that would exceed rated hoist load.
   b. De-energize raising circuit to hoist motor and reset automatically when overload is removed.

4. Operation Sequences: Adjustable, mechanical stops to limit lift height.

K. Disconnect Switch: Readily accessible from operating floor.

L. Safety Signs: Comply with NEMA 535.

2.2 MOTOR-OPERATED MONORAIL HOISTS

A. Manufacturers:

1. Capco Crane & Hoist, Inc., Harrington Hoists, Inc., Ingersoll-Rand, Spanco Inc., Coffing Hoists.
2. Substitutions: As specified in Section 01600 “Product Requirements”.

B. Runway Beam:

1. Description:

a. Straight patented style and constructed of high-carbon steel with raised tread.
b. Curved sections shall have radii as shown on drawings with 5” tangent sections
c. Sections: Continuously welded.
d. Ends: Factory prepared.

2. Comply with MH27.1.
3. Stops:

a. Furnish trolley stops at every open end.
b. Description:

1) Bolted and moveable.
2) Establish contact with trolley frame.

4. Splice Holes: Factory drilled.
5. Limit Switch Tripping Bars and Fasteners: Type 316 stainless steel.

C. Trolleys:

1. Drive: Single speed.
2. Wheels:

a. Description:

1) Removable without removing trolley from beam.
2) Treads: Hardened.

b. Number of Wheels:

1) Capacity of Two Tons or Less: Four.
2) Capacity Greater than Two Tons: Six.

c. Bearings: Permanently grease lubricated.

3. Brakes:

a. Magnetic-release disc type.

b. Integrally mounted to motor.

4. Furnish rubber bumper devices to maintain separation if two or more hoists are located on same monorail beam.

5. Electrical Characteristics:

a. Dual 0.5 Hp motors
b. Voltage: 460 V, three phase, 60 Hz.
c. Minimum Power Factor: 0.8 percent at rated load.

D. Hoists:

1. Comply with ASME HST-4, Class H3.
2. Drive: Direct-coupled motor.
3. Brakes: Solenoid type.
4. Lift: For clearance as indicated on Drawings.
5. Drum:

a. Material: Steel.
b. Construction:

1) Machined grooves for wire rope, with flanges on each end to prevent binding.
2) Minimum Pitch Diameter: 18 times wire rope diameter.
3) Minimum two wraps of hoisting rope to remain on each anchorage when hook is in its lowest position.

6. Sheaves: Steel.

7. Wire Rope:

a. Material: Type 316 stainless steel.
b. Comply with ASTM A1023/A1023M.
c. Length: Sufficient to maintain minimum two full wraps of rope at dead end of drum.

8. Hook:

a. Material: Forged steel.
b. Bearing: Anti-friction type, allowing 360-degree rotation of load.
c. Furnish spring-loaded safety latch.
d. Furnish nuts keyed to hook shanks by setscrew.
e. Sheaves:

1) Material: Forged steel.
2) Bearings: Permanently lubricated roller type; ABMA 11.
3) Minimum Diameter: 20 times rope diameter.

9. Electrical Characteristics:

a. Lift speed – Two, 16 (high)/5(low) (feet per minute)
4.0 hp.
b. Voltage: 460 V, three phase, 60 Hz.
c. Minimum Power Factor: 0.8 percent at rated load.

E. Festoon System:

1. Description:

a. Neoprene-jacketed, multi-conductor flat cables with separate control and power conductors.
b. Suspend cables from trolleys mounted on heavy-duty C-track parallel to hoist monorail.
c. Construction: Nonsparking.

2. Cables:

a. Description: UL-listed flat cables.
b. Minimum Rating: 85 A at 40 degrees C.
c. Length: 110 percent of required length.
d. Minimum Size: No. 12.
e. Type: Stranded.

3. Trolleys:

a. Furnish towing and manufacturer's standard trolleys.
b. Tow Cables:

1) Material: Stainless steel.
2) Furnish strain-relief cable between first trolley and adjacent wall.

4. C-Track:

a. Material: Type 316 stainless steel.
b. Furnish polyamide tow rope assembly for trolley spacing.
c. End Clamps: Furnish fixed end clamps with outrigger arms.

5. Cable Reels:

a. Maintain consistent pull on cable to prevent sagging.
b. Construction: Weather-resistant, self-winding, and spring operated.
c. Furnish swivel bases and roller outlets.

F. Accessories:

1. Assembly and Mounting Hardware: Type 316 stainless steel.

2.3 MATERIALS

A. Mounting Hardware: Type 316 stainless steel.

2.4 SOURCE QUALITY CONTROL

A. Section 01400 “Quality Requirements” for requirements for testing, inspection, and analysis.

B. Testing:

1. Proof-test load chains with load equivalent to at least 150 percent of rated load of hoist, divided by number of chain parts supporting load.
2. Comply with OSHA 1919.71.

C. Provide shop inspection and testing of completed assembly.

D. Owner Inspection:

1. Make completed hoist assembly available for inspection at manufacturer's factory prior to packaging for shipment.
2. Notify Owner at least seven days before inspection is allowed.

E. Owner Witnessing:

1. Allow witnessing of factory inspections and test at manufacturer's test facility.
2. Notify Owner at least seven days before inspections and tests are scheduled.

F. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Shop Drawings.

B. Verify that items provided by other Sections of Work are ready to receive Work of this Section.

3.2 INSTALLATION

A. According to manufacturer instructions and as indicated on Drawings.

B. Comply with ASME B30.11, MH27.2, and OSHA 1910.179.

3.3 FIELD QUALITY CONTROL

A. Section 01700 “Startup and Demonstration Testing” for requirements for inspecting and testing.

B. Inspection: Check hoist and motors for excessive vibration and noise.

C. Testing:

1. Operate crane through complete lift and lowering cycle.
2. Verify that hoist, trolley, and controls operate as required.
3. Verify that limit switches operate as required.
4. Verify that pendant cable length is sufficient to permit operation from desired floor levels.
5. Test Load Certification:

    a. Comply with OSHA 1919.71.
    b. Test in presence of Engineer.

D. Manufacturer Services: Furnish services of manufacturer's representative experienced in installation of products furnished under this Section for not less than one day on Site for installation, inspection, startup, field testing, and instructing Owner's personnel in operation and maintenance of equipment.

E. Equipment Acceptance:

1. Adjust, repair, modify, or replace components failing to perform as specified and rerun tests.
2. Make final adjustments to equipment under direction of manufacturer's representative.

F. Repair damaged coatings with material equal to the original coating as specified in Section 09910 “Painting”.

3.4 ADJUSTING

A. Field-calibrate local controls and indicators.

3.5 DEMONSTRATION

A. Demonstrate hoist operation, routine maintenance, and emergency repair procedures to Owner's personnel.

3.6 ATTACHMENTS

A. Monorail Hoist Schedule:

1. Location: Return Sludge Pump Station No. 3
2. Use: To lift and handle pump components, pipe segments, fittings, meters and valves.
3. Type: Electric.
4. Hoist: Wire rope.
5. Capacity: 4 tons.
6. Lift: Maximum hook lift of 30.0’
7. Motor Hp: 5.0 (total)
8. Voltage: 460.

END OF SECTION 14625

SECTION 14651 – DAVIT CRANES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install, test, paint and place in satisfactory operation davit cranes and pedestal bases, as shown on the Drawings and as specified herein.

B. Design and furnish anchor bolts with layout templates for installation under Division 03. Furnish and install nuts and washers for anchor bolts.

1.2 RELATED WORK

A. Concrete work is included in Division 03.

B. Field painting is included in Section 09910.

1.3 ACTION SUBMITTALS

A. Shop drawings showing all important dimensions and details of construction, dimensions, erection and anchorage details.

B. Descriptive literature, bulletins, and/or catalogs of the equipment.

C. The total weight of the equipment.

D. A complete total bill of materials for all equipment.

E. A list of the manufacturer's recommended spare parts with the manufacturer's current price for each item. Include replacement wire rope, load hook, hand winch, etc., on the list. List bearings by the bearing manufacturer's numbers only.

F. Complete description of surface preparation and shop prime painting for ferrous metals.

G. Provide anchorage details, including locations, quantity, type, material, size, embedment depth, and edge distance requirements for anchor bolts. Provide a summary of reactions and moments imposed on structure at each davit base considering all applicable loads and load combinations. Submit structural design calculations for the anchorages of the davit systems for record purposes only. Calculations shall demonstrate compliance with the performance criteria specified herein. Calculations shall be prepared, stamped, and signed by a professional engineer registered in the State of Rhode Island. The calculations will not be reviewed by the Engineer.

H. Operation and Maintenance Data.

I. Operating and maintenance instructions.

1.4 MAINTENANCE MATERIALS SUBMITTALS

A. Tools and Spare Parts.

B. Provide special tools required for normal operation and proper servicing of the equipment.

1.5 QUALITY ASSURANCE

A. Provide products of a single manufacturer experienced in production of similar equipment.

B. Design all structural steel members of the davit cranes in accordance with AISC, current edition. Provide welded construction in accordance with AWS and comply with Sections 05120 "Structural Steel Framing," and 05502 "Metal Fabrications."

C. Design the davit crane anchorage and pedestal base to transfer all anticipated loads into the concrete structure, in accordance with AISC and ACI 318.

D. Castings, Forgings, Stampings and Other Structural Elements Safety Factor: 5.

E. Provide equipment that meets or exceeds the requirements of OSHA.

F. Manufacturer: L.K. Goodwin Co., 5PT20 Commander Series, or equal.

1.6 SYSTEM DESCRIPTION

A. One portable davit crane and three pedestal bases shall be installed in the locations shown on the Drawings. The crane shall be freestanding with a pivoting and extendable horizontal boom. Each pedestal base shall be a permanently mounted, pedestal type or socket base mounted flush as indicated on the Drawings. Each crane system shall have a net load capacity of 2000 lbs (plus minimum 15 percent total allowance for hoist and trolley).

B. Crane shall be Thern Commander Model 5PT10S-M3 or approved equal.

C. Crane shall have a variable lift capacity depending on boom position. Lift capacity range shall be 550 lbs to 1,000 lbs. With the boom in the horizontal position, the maximum hook reach shall be 66" (measured from the mast center to the hook center) and the hook height shall be 43" minimum. The book angle shall be adjustable with a ratchet jack anywhere from horizontal to 45 degrees. Wire rope shall pass over a sheave at the end of the boom. Sheave shall have a bronze bearing.

D. All components specified herein shall be spark resistant and comprised of brass and/or stainless steel components.

E. The supplied winch shall be hand operated with option for operation by drill.

F. The mast, boom, boom extension, screw jack, handle and pedestals shall all be Type 316 stainless steel.

G. Three (3) pedestal mount base shall be provided, Thern Model 5BP10S or equal. Base shall be Stainless Steel.

H. The wire rope shall be Type 304 stainless steel, minimum ¼-inch diameter.

1.7 WARRANTY

A. The equipment manufacturer shall provide warranty. Warranty period and warranty requirements shall be in accordance with Section 01740. The warranty must be submitted during the shop drawing phase. Approval of the shop drawings will be contingent on the receipt of the warranty. If any part of the equipment should fail during the warranty period, it shall be replaced at no expense to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. This Section calls attention to certain features, but does not purport to cover all details of construction of the units.

2.2 DAVIT CRANE

A. The davit crane shall be freestanding, baseplate pedestal mounted, anchored to its foundation, 1-ton (2000-lb) capacity. The davit crane shall consist of a swiveling horizontal boom mounted on a heavy wall structural steel pipe, with wall thickness sized for minimum deflection. The mast shall have a large diameter baseplate reinforced with heavy steel gussets for continuous alignment and stiffness. The head section shall provide a weather protected enclosure for the bearings and rollers supporting the wire rope. The boom shall have the ability to rotate a full 360 degrees, providing full capacity vertical and radial thrust loading. All bearings shall be easily accessible for lubrication. Mast swivel shall be manually operated. Mast height shall place the top of the boom when set horizontal at approximately 54 inches above the deck. The entire unit shall be designed to meet or exceed the requirements of AISC and for outdoor installation.

B. Design and furnish the anchorage of the davit crane to the concrete structure in accordance with AISC and ACI 318.

C. Any ferrous davit crane or component shall be primed and finish painted in the manufacturer's shop. Surface preparation and painting shall be as specified in Sections 09910 shall be suitable for outdoor installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in strict accordance with the respective instructions of the manufacturer and in the locations shown on the Drawings. Installation shall include furnishing the required oil and/or grease for initial operation. The grades of oil and grease shall be in accordance with the manufacturer's recommendations.

3.2 INSPECTION AND TESTING

A. The Contractor shall require the manufacturer to furnish the services of a factory representative for 1 day who has complete knowledge of proper operation and maintenance to inspect the final installation and supervise a test run of the equipment. These services may be combined with those provided under PART 1.

B. Working under the direction of the manufacturer, and in the presence of the Engineer, perform field tests as follows:

C. Full load operating tests on all davit cranes.

D. Furnish the labor and weights for testing capacity of cranes.

E. In the event the equipment fails to meet the above test, the necessary changes shall be made and the equipment retested. If the equipment remains unable to meet the test requirements to the satisfaction of the Engineer, it shall be removed and replaced with satisfactory equipment at the expense of the Contractor.

F. All defects recorded during the above field tests and all defects and failures occurring within the first year of operation shall be corrected by the Contractor.

END OF SECTION 14651

SECTION 15011 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers:

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

END OF SECTION 15011

SECTION 15013 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Grout.
5. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inchminimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Jay R. Smith Mfg Co; a division of Morris Group International.
2. Zurn Industries, LLC.

B. Description: Manufactured, galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advance Products & Systems, Inc.
2. Airex Manufacturing.
3. CALPICO, Inc.
4. GPT; an EnPro Industries company.
5. Metraflex Company (The).
6. Proco Products, Inc.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Composite plastic.
5.

2.4 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Pecora Corporation.
c. Permathane®/Acryl-R®; ITW Polymers Sealants North America.
d. Polymeric Systems, Inc.
e. Sherwin-Williams Company (The).
f. The Dow Chemical Company.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. May National Associates, Inc.; a subsidiary of Sika Corporation.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07620 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.

2. Exterior Concrete Walls Below Grade:

   a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

   b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

   a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

   b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs Above Grade:

   a. Piping Smaller Than NPS 6: Stack-sleeve fittings.
   b. Piping NPS 6and Larger: Stack-sleeve fittings.

5. Interior Partitions:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 15013

SECTION 15014 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, Inc.
6. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
   b. Chrome-Plated Piping: One-piece steel or split-casting brass with polished, chrome-plated finish.
   c. Insulated Piping: One-piece steel with polished, chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
   g. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

   a. Chrome-Plated Piping: Split-casting, stamped steel with concealed hinge with polished, chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: One-piece, floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 15014

SECTION 15015 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Filled-system thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.
6. Test plugs.
7. Test-plug kits.
8. Sight flow indicators.

B. Related Requirements:

1. Section 15131 "Facility Water Distribution Piping" for domestic water meters and combined domestic and fire-protection water-service meters outside the building.
2. Section 15135 "Domestic Water Piping Specialties" for water meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Miljoco Corporation.
    b. Trerice, H. O. Co.
    c. Weiss Instruments, Inc.
    d. Weksler Glass Thermometer Corp

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch 6-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Stainless steel.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device rigid, back and rigid, bottom; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Miljoco Corporation.
    b. Trerice, H. O. Co.
    c. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.

4. Case Form: Adjustable angle, Back angle or Straight unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Ametek U.S. Gauge.
    b. Miljoco Corporation.
    c. Trerice, H. O. Co.
    d. Weiss Instruments, Inc.
    e. Weksler Glass Thermometer Corp.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

5. Pressure Connection: Brass, with NPS 1/4 (DN 8), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Ametek U.S. Gauge.
   b. Miljoco Corporation.
   c. Trerice, H. O. Co.
   d. Weiss Instruments, Inc.

2. Standard: ASME B40.100.
3. Case: Sealed type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball Brass or stainless-steel needle, with NPS 1/4, ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

A. Description: Test-station fitting made for insertion into piping tee fitting.

B. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

C. Thread Size: NPS 1/4, ASME B1.20.1 pipe thread.

D. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

E. Core Inserts: EPDM self-sealing rubber.

2.7 TEST-PLUG KITS

A. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

B. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

C. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

D. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least 0 to 200 psig.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.8 SIGHT FLOW INDICATORS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:

1. ARCHON Industries, Inc.
2. Dwyer Instruments, Inc.
3. Emerson Process Management; Rosemount Division.
4. Ernst Flow Industries.
5. John C. Ernst Co., Inc.
6. KOBOLD Instruments, Inc. - USA.
7. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
8. Pentair Valves & Controls; Penberthy Brand.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 125 psig.

E. Minimum Temperature Rating: 200 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install remote-mounted pressure gages on panel.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install test plugs in piping tees.

K. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.
2. Inlets and outlets of each domestic water heat exchanger.
3. Inlet and outlet of each domestic hot-water storage tank.
4. Inlet and outlet of each remote domestic water chiller.

L. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be the following:
   1. Metal case, industrial-style, liquid-in-glass type.

B. Thermometers at inlets and outlets of each domestic water heat exchanger shall be the following:
   1. Metal case, industrial-style, liquid-in-glass type.

C. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be the following:

D. Metal case, industrial-style, liquid-in-glass type. Thermometers at inlet and outlet of each remote domestic water chiller shall be the following:

   1. Metal case, industrial-style, liquid-in-glass type.

E. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.

B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F.

C. Scale Range for Domestic Cooled-Water Piping: 0 to 100 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be the following:

   1. Solid-front, pressure-relief, direct or remote -mounted, metal case.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:

C. Solid-front, pressure-relief, direct or remote -mounted, metal case. Pressure gages at suction and discharge of each domestic water pump shall be the following:

   1. Solid-front, pressure-relief, direct or remote -mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 200 psi.

B. Scale Range for Domestic Water Piping: 0 to 100 psi.

END OF SECTION 15015

SECTION 15022 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Steel ball valves.
3. Iron ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and soldered ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for solder-joint connections.
6. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
2. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. WATTS.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded or soldered.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.

B. Bronze Ball Valves, Two-Piece, Safety-Exhaust:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. FNW; Ferguson Enterprises, Inc.
c. Jamesbury; Metso.
d. NIBCO INC.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze, ASTM B584, Alloy C844.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Chrome-plated brass, with exhaust vent opening for pneumatic applications.
i. Port: Full.

2.3 STEEL BALL VALVES

A. Steel Ball Valves with Full Port, Class 150:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. FNW; Ferguson Enterprises, Inc.
c. Jamesbury; Metso.
d. NIBCO INC.

2. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 285 psig.
c. Body Design: Split body.
d. Body Material: Carbon steel, ASTM A216, Type WCB.
e. Ends: Flanged or threaded.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.

2.4 IRON BALL VALVES

A. Iron Ball Valves, Class 125:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. WATTS.
c. Zurn Industries, LLC.

2. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 200 psig.
c. Body Design: Split body.
d. Body Material: ASTM A126, gray iron.
e. Ends: Flanged or threaded.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 15035 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Brass ball valves, two-piece with full port and stainless-steel trim.

B. Pipe NPS 2-1/2 and Larger:

1. Steel and Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Steel ball valves, Class 150 with full port.

3. Iron ball valves, Class 150.

3.5 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Brass ball valves, two-piece with full port and stainless-steel trim.

B. Pipe NPS 2-1/2 and Larger:

1. Steel and Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Steel ball valves, Class 150 with full port.
3. Iron ball valves, Class 150.

3.6 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze ball valves, two-piece with full port and stainless-steel trim.

B. Pipe NPS 2-1/2 and Larger:

1. Steel and Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

C. Iron ball valves, Class 150.

END OF SECTION 15022

SECTION 15024 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bronze swing check valves.
2. Iron swing check valves.
3. Iron swing check valves with closure control.
4. Iron, grooved-end swing check valves.
5. Iron, center-guided check valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

E. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

G. Valve Sizes: Same as upstream piping unless otherwise indicated.

H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. WATTS.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

2.3 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. WATTS.

2. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. WATTS.

2. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.

f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed exterior lever and weight.

2.5 IRON, GROOVED-END SWING CHECK VALVES

A. Iron, Grooved-End Swing Check Valves, 300 CWP:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Anvil International.
b. Tyco by Johnson Controls Company.
c. Victaulic Company.

2. Description:

a. CWP Rating: 300 psig.
b. Body Material: ASTM A536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.6 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

A. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. NIBCO INC.

2. Description:

a. Standard: MSS SP-125.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron.
d. Style: Compact wafer, spring loaded.
e. Seat: EPDM.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

F. Install valve tags. Comply with requirements in Section 15035 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
    b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; or iron, center-guided, resilient-seat check valves.
    c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded.
3. For Copper Tubing, NPS 5 and Larger: Flanged.
4. For Steel Piping, NPS 2 and Smaller: Threaded.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged or threaded.
6. For Steel Piping, NPS 5 and Larger: Flanged.
7. For Grooved-End Copper Tubing and Steel Piping: Grooved.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125, with soldered or threaded end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves with metal seats, Class 125, with threaded or flanged end connections.
2. Iron, grooved-end swing check valves, 300 CWP.

END OF SECTION 15024

SECTION 15031 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal hanger-shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Pipe-positioning systems.
8. Equipment supports.
9. Delegated-design.

B. Related Requirements:

1. Section 05502 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.3 ACTION SUBMITTALS

A. Shop Drawings: Signed and sealed by a qualified professional engineer registered in the State of Rhode Island. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

1.4 DELEGATED-DESIGN SUBMITTALS

A. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in the State of Rhode Island responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.

2. Include design calculations for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer registered in the State of Rhode Island, as defined in Section 01400 "Quality Requirements," to design trapeze pipe hangers, metal framing systems, pipe stands, and equipment supports for loads in excess of 200 lb.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems for indoor general service applications.:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Thomas & Betts Corporation; A Member of the ABB Group.
    b. Atkore International (Unistrut).
    c. Eaton (B-line).

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
8. Metallic Coating: Pregalvanized G90.

B. MFMA Manufacturer Metal Framing Systems for Hostile Environment Applications:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. B-line, an Eaton business.
    b. Thomas & Betts Corporation; A Member of the ABB Group.
    c. Unistrut; Part of Atkore International.

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted stainless-steel, Type 316 channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
8. Metallic Coating: No coating.

2.5 THERMAL HANGER-SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Buckaroos, Inc.
2. Pipe Shields Inc.
3. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psi or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psi or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors

1. Fastening to Concrete Substrate: Zinc plated carbon steel wedge type anchors, complete with zinc plated nuts and washers, unless otherwise noted.
2. Submerged or Weather Exposed Substrates: ASTM A276 Type 316 stainless steel wedge type anchors, complete with Type 316 stainless steel nuts and washers, unless otherwise noted.
3. Meet ICC ES AC01 or ICC ES AC193.
4. Length: When length or anchor embedment is not indicated, provide length sufficient to place the wedge and expansion cone portion of the anchor at least 1 inchbehind concrete reinforcing steel.
5. Basis-of-Design:

a. Anchorage designs indicated are based on Hilti, Kwik-Bolt TZ, unless otherwise noted.
b. Acceptable Anchors: Hilti Kwik-Bolt TZ; Simpson Strong-Tie Strong Bolt 2 Wedge Anchor; DeWalt Power-Stud+ SD1; DeWalt Power-Stud+ SD6 for stainless steel; or equal.

B. Adhesive Anchoring System

1. Fastening to Concrete Substrate: Manufactured system consisting of post installed threaded rods, nuts, washers, other anchoring hardware, and chemical dispenser for installation in hammer drilled holes.

a. Anchors: Meet ICC ES AC308.
b. Injection Adhesive: Two-component epoxy system consisting of a hardener and a resin, furnished in pre-measured side-by-side cartridges which keep both components separate.
c. Adhesive Cartridge: Side-by-side design to accept a static mixing nozzle which thoroughly blends both components and allows injection directly into a drilled hole.
d. Anchor: Type 316 stainless steel as indicated consisting of an all-thread anchor rod with nut and washer, of matching material to anchor rod.

1) Basis-of-Design:

a) Anchorage designs indicated are based on Hilti HIT- RE 500 V3, unless otherwise noted.
b) Acceptable Manufacturers: Hilti HIT- RE 500 V3; Simpson Strong Tie SET-3G; ITW Ramset Red Head Epcon G5+; or equal.

e. Reinforcing Bar Dowels: Reinforcing bar, per Section 03300a “Cast-in-Place Concrete.”

1) Basis-of-Design:

a) Anchorage designs indicated are based on Hilti HIT- RE 500 V3, unless otherwise noted.
b) Acceptable Manufacturers: Hilti HIT- RE 500 V3; Simpson Strong Tie SET-3G; ITW Ramset Red Head Epcon G5; or equal.

2. Fastening to Hollow Concrete Block: Three-part threaded rod, screen tube, and chemical dispenser anchoring system.

a. Anchors: Meet ICC ES AC58.
b. Adhesive Cartridges: Contain pre-measured amounts of resin and hardener which are mixed and deposited in a screen tube by a dispenser.
c. Anchor: Type 316 stainless steel as indicated consisting of an all-thread anchor rod with nut and washer, of matching material to anchor rod.
d. Reinforcing Bar Dowel: Reinforcing bar, per Section 03300a “Cast-in-Place Concrete.”
e. Basis-of-Design:

1) Anchorage designs indicated are based on Hilti HIT HY-70 System, unless otherwise noted; or equal.

2.7 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two, stainless-steel, continuous-thread 1/2-inch rods.
4. Horizontal Member: Adjustable horizontal, stainless-steel pipe support channels.
5. Pipe Supports: Roller, strut clamps, clevis hanger or swivel hanger.
6. Hardware: Stainless-steel.
7. Accessories: Protection pads.
8. Height: 12 inches above roof.

D. High-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Single vulcanized rubber or molded polypropylene.
3. Vertical Members: Two, stainless-steel, continuous-thread 1/2-inch rods.
4. Horizontal Member: One, adjustable height, galvanized- orstainless-steel pipe support slotted channel or plate.
5. Pipe Supports: Roller, clevis hanger or swivel hanger.
6. Hardware: Stainless-steel.
7. Accessories: Protection pads, 1/2-inch continuous-thread stainless-steel rod.
8. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber.

3. Vertical Members: Two or more, stainless-steel channels.
4. Horizontal Members: One or more, adjustable height, stainless-steel pipe support.
5. Pipe Supports: Strut clamps.

6. Hardware: Stainlesssteel.
7. Height: 36 inches above roof.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.8 PIPE-POSITIONING SYSTEMS

A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

2.10 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
2. Install adhesive-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07720 "Roof Accessories" for curbs.

G. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

M. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 09910 "Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers andmetal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal hanger-shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion or adhesive anchors instead of building attachments where required in concrete construction .

S. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 15031

SECTION 15035 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Carlton Industries, LP.

d. Champion America.
e. Craftmark Pipe Markers.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: White and orange..

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater

viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 09910 "Painting."

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Domestic Water Piping:

   a. Background: Safety green.
   b. Letter Colors: White.

2. Sanitary Waste and Storm Drainage Piping:

   a. Background Color: Safety black.
   b. Letter Color: White.

3. Protected Water Piping:

   a. Background: Safety green.
   b. Letter Colors: White.

4. Natural Gas Piping:

   a. Background: Safety yellow.
   b. Letter Colors: Black

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15035

SECTION 15042 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers:

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Provide grounding rings or straps on motors with variable frequency controller.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

END OF SECTION 15042

SECTION 15044 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 07841 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advance Products & Systems, Inc.
2. Airex Manufacturing.
3. CALPICO, Inc.
4. GPT; an EnPro Industries company.
5. Metraflex Company (The).
6. Proco Products, Inc.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Composite plastic.
5. Connecting Bolts and Nuts: Stainless steel, Type 316, of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Pecora Corporation.
c. Permathane®/Acryl-R®; ITW Polymers Sealants North America.
d. Polymeric Systems, Inc.
e. Sherwin-Williams Company (The).
f. The Dow Chemical Company.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. May National Associates, Inc.; a subsidiary of Sika Corporation.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07620 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout or silicone sealant, seal space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Steel pipe sleeves.

2. Exterior Concrete Walls Below Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch Insert dimension annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch Insert dimension annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs Above Grade:

a. Piping Smaller Than NPS 6: Stack-sleeve fittings.
b. Piping NPS 6 and Larger: Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 15044

SECTION 15061 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Fastener systems.
3. Equipment supports.
4. Delegated-design.

B. Related Requirements:

1. Section 01882 "Seismic Performance Requirements" for anchorage submittal requirements.
2. Section 05502 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
3. Section 15064 "Vibration Controls for HVAC" for vibration isolation devices.
4. Section 15712 "Metal Ducts" for duct hangers and supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 DELEGATED-DESIGN SUBMITTAL:

A. Shop Drawings: Signed and sealed by a qualified professional engineer registered in the State of Rhode Island. Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Equipment supports.

B. For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in the State of Rhode Island responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

C. Qualification Data: For professional engineer registered in the State of Rhode Island.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer registered in the State of Rhode Island, as defined in Section 01400 "Quality Requirements," to design trapeze pipe hangers, metal framing systems, pipe stands, and equipment supports for loads in excess of 200 lb.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.3 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors

1. Fastening to Concrete Substrate: Zinc plated carbon steel wedge type anchors, complete with zinc plated nuts and washers, unless otherwise noted.

2. Submerged or Weather Exposed Substrates: ASTM A276 Type 316 stainless steel wedge type anchors, complete with Type 316 stainless steel nuts and washers, unless otherwise noted.
3. Meet ICC ES AC01 or ICC ES AC193.
4. Length: When length or anchor embedment is not indicated, provide length sufficient to place the wedge and expansion cone portion of the anchor at least 1 inchbehind concrete reinforcing steel.
5. Basis-of-Design:

    a. Anchorage designs indicated are based on Hilti, Kwik-Bolt TZ, unless otherwise noted.
    b. Acceptable Anchors: Hilti Kwik-Bolt TZ; Simpson Strong-Tie Strong Bolt 2 Wedge Anchor; DeWalt Power-Stud+ SD1; DeWalt Power-Stud+ SD6 for stainless steel; or equal.

B. Adhesive Anchoring System

1. Fastening to Concrete Substrate: Manufactured system consisting of post installed threaded rods, nuts, washers, other anchoring hardware, and chemical dispenser for installation in hammer drilled holes.

    a. Anchors: Meet ICC ES AC308.
    b. Injection Adhesive: Two-component epoxy system consisting of a hardener and a resin, furnished in pre-measured side-by-side cartridges which keep both components separate.
    c. Adhesive Cartridge: Side-by-side design to accept a static mixing nozzle which thoroughly blends both components and allows injection directly into a drilled hole.
    d. Anchor: Type 316 stainless steel as indicated consisting of an all-thread anchor rod with nut and washer, of matching material to anchor rod.

        1) Basis-of-Design:

            a) Anchorage designs indicated are based on Hilti HIT- RE 500 V3, unless otherwise noted.
            b) Acceptable Manufacturers: Hilti HIT- RE 500 V3; Simpson Strong Tie SET-3G; ITW Ramset Red Head Epcon G5+; or equal.

    e. Reinforcing Bar Dowels: Reinforcing bar, per Section 03300A.

        1) Basis-of-Design:

            a) Anchorage designs indicated are based on Hilti HIT- RE 500 V3, unless otherwise noted.
            b) Acceptable Manufacturers: Hilti HIT- RE 500 V3; Simpson Strong Tie SET-3G; ITW Ramset Red Head Epcon G5; or equal.

2. Fastening to Hollow Concrete Block: Three-part threaded rod, screen tube, and chemical dispenser anchoring system.

    a. Anchors: Meet ICC ES AC58.

b. Adhesive Cartridges: Contain pre-measured amounts of resin and hardener which are mixed and deposited in a screen tube by a dispenser.
c. Anchor: Type 316 stainless steel as indicated consisting of an all-thread anchor rod with nut and washer, of matching material to anchor rod.
d. Reinforcing Bar Dowel: Reinforcing bar, per Section 03300A.
e. Basis-of-Design:

1) Anchorage designs indicated are based on Hilti HIT HY-70 System, unless otherwise noted; or equal.

2.4 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.5 MATERIALS

A. Aluminum: ASTM B 221.

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
2. Install adhesive-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

D. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

F. Install lateral bracing with pipe hangers and supports to prevent swaying.

G. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

H. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

J. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers andequipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches Insert dimension.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers andmetal framing systems and attachments for indoor general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for outdoor and indoor hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion or adhesive anchors instead of building attachments where required in concrete construction.

END OF SECTION 15061

SECTION 15062 - COUPLINGS, ADAPTERS, AND SPECIALS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipe penetrations
2. Restrained joints
3. Flexible connections
4. Expansion joints
5. Expansion loops
6. Sleeve-type couplings.
7. Quick connect couplings.
8. Service clamps.
9. Wash hose stations (WHS) for plant water.

B. Related Requirements:

1. Section 05502 “Metal Fabrications” for miscellaneous metalwork and fasteners as required by this Section
2. Section 07920 “Joint Sealants” for sleeve sealant for pipe penetrations
3. Section 09910 “Painting” for product and execution requirements for painting specified by this Section
4. Section 02561 “Ductile Iron Utility Pipe for Water Service” for pipe restraints
5. Section 15140 “Hangers and Supports for Process Piping” for hangers, anchors, sleeves, and sealing of piping to adjacent structures
6. Section 15103 “Ductile Iron Process Pipe” for ductile-iron piping materials and appurtenances
7. Section 15108 “Common Requirements for Process Valves” for common product requirements for valves for placement by this Section

1.3 COORDINATION

A. Coordinate Work of this Section with installation of piping, valves and equipment connections specified in other Sections and as indicated on Drawings.

1.4 SUBMITTALS

A. Product Data:

1. Submit manufacturer catalog information for each specified product, including installation instructions.
2. Firestopping: Submit data on product characteristics, performance, and limitation criteria.
3. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
4. Expansion Joints: Indicate maximum temperature, pressure rating, and expansion compensation.

B. Shop Drawings:

1. Identification:

   a. Submit list of wording, symbols, letter size, and color coding for pipe identification.
   b. Comply with ASME A13.1.

2. Indicate restrained joint details and materials.
3. Submit layout drawings showing piece numbers and location, indicating restrained joint locations.
4. Indicate layout of piping systems, including flexible connectors, expansion joints and compensators, loops, offsets, and swing joints.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

D. Welder Certificates: Certify welders and welding procedures employed on Work, verifying ASME qualification within previous 12 months.

E. Delegated Design Submittals: Submit signed and sealed Shop Drawings with design calculations and assumptions for:

1. Flexible connectors
2. Expansion joints
3. Pipe Restraints:

   a. Determine restrained lengths and submit joint restraint details.
   b. Use joint restraint devices specifically designed for applications as described in manufacturer data.

F. Manufacturer Instructions: Submit special procedures and setting dimensions.

G. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

H. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

I. Qualifications Statements:

1. Submit qualifications for manufacturer, installer, and licensed professional.
2. Submit manufacturer's approval of installer.

3. Welders: Qualify procedures and personnel according to ASME BPVC-IX or AWS D1.1/D1.1M.
4. American Iron and Steel (AIS): Submit certification indicating compliance with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of piping appurtenances.

B. Identify and describe unexpected variations to pipe routing or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Materials in Contact with Potable Water: Certified to NSF Standards 61 and 372.

B. Perform Work according to ASME B31.9 for installation of piping systems and according to ASME BPVC-IX or AWS D1.1/D1.1M for welding materials and procedures.

C. Perform Work according to ASME B31.3, ASME B31.9 and applicable code for installation of piping systems.

D. Surface-Burning Characteristics: Maximum 25/450 flame-spread/smoke-developed index when tested according to ASTM E84.

E. Perform Work according to industry standards.

F. Maintain copy of each standard affecting Work of this Section on Site.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum five years' experience.

B. Welders: AWS qualified within previous 12 months for employed weld types.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 01600 “Material and Equipment”

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Store materials according to manufacturer instructions.

D. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.

2. Furnish temporary end caps and closures on piping and fittings and maintain in place until installation.
3. Provide additional protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.10 WARRANTY

A. Section 01740 “Warranties” for requirements for warranties.

PART 2 - PRODUCTS

2.1 PIPE PENETRATIONS

A. Performance and Design Criteria:

1. Firestopping Materials: As specified in Section 078400 - Firestopping.
2. Firestop interruptions to fire-rated assemblies, materials, and components.
3. Firestopping: Provide certificate of compliance from authority having jurisdiction, indicating approval of materials used.

2.2 PIPE SLEEVES

A. All construction except new concrete walls:

1. Material: Schedule 40 galvanized steel conforming to ASTM A53.
2. 2-inch minimum circumference water stop welded to exterior sleeve at midpoint
3. Ends cut and ground to be:

    a. Flush with ground
    b. Flush with ceiling
    c. 2 inches above finished floors
    d. Sealed with caulking
    e. Sized as required.

B. New concrete walls with pipes up to 20 inches in diameter:

1. Material: non-metallic High-Density Polyethylene Sleeves (HDPE)
2. Integral hollow molded water stops

    a. 4 inches larger than the outside diameter of the sleeve.

3. End caps for forming and reinforcing ribs.
4. Domestically manufactured by:

    a. Century-Line as manufactured by Pipeline Seal & Insulator, Inc., Houston, TX, or equal.

C. New concrete with pipes 20 to 60 inches in diameter:

1. Material: molded HDPE modular interlocking discs to make the width of the wall

    a. Corrugated
    b. Cell-Cast as manufactured by Pipeline Seal & Insulator, Inc., Houston, TX, or equal.

D. External wall penetrations:

1. 36-in diameter and less may be made by means of a ductile iron sleeve capable of being bolted directly to the formwork:
2. Seal of the annular space between the carrier pipe and the sleeve made by means of a confined rubber gasket and be capable of withstanding 350 psi.:
3. Sleeve to have an integrally cast waterstop of 1/2-in minimum thickness, 2-1/2-in minimum height.
4. Manufacturers: Omni-Sleeve, Malden, MA or equal.

2.3 WALL CASTINGS

A. Ductile iron conforming to ANSI/AWWA A21.51/C151, thickness Class 53.

B. Diameter as required.

C. Flanges and/or mechanical joint bells drilled and tapped for studs where flush with the wall.

D. Castings provided with a 2-in minimum circumferential flange/waterstop integrally cast with or welded to the casting.

E. Located as follows:

1. for castings set flush with walls: located at the center of the overall length of the casting,
2. for castings which extend through wall: located within the middle third of the wall.

2.4 SEALING MATERIALS

A. Mechanical seals:

1. Of rubber links shaped to continuously fill the annular space between the pipe and the wall opening or sleeve.
2. Link pressure plates molded of glass reinforced nylon:

    a. colored throughout elastomer,

b. permanent identification of the size and manufacturer's name molded into the pressure plate and sealing element.

3. Hardware:

a. Mild steel with a 60,000 psi minimum tensile strength
b. 2-part Zinc Dichromate coating per ASTM B-633
c. Organic Coating, tested in accordance with ASTM B-117 to pass a 1,500-hour salt spray test.
d. Use Type 316 Stainless Steel hardware:

1) in chemical areas
2) for submerged service
3) for penetrations in tanks containing sludge or wastewater.

4. Completed sealing system:

a. Duty pressure rated for 20 psig differential pressure.
b. EPDM for all services except fire rated assemblies

1) fire rated seals use silicone link material.

c. Manufacturer: PSI-Thunderline/ Link-Seal as manufactured by Pipeline Seal & Insulator, Inc., Houston, TX, or equal.

B. Sealant:

1. A two-part foamed silicone elastomer manufactured by:

a. Dow Corning Co., Product No. 3-6548 silicone R.T.V.
b. 3M brand fire barrier products caulk C.P. 25 and 3M brand moldable putty MP+;
c. Flame-Safe fire stop systems FS-900 by Rectorseal.

2. Sealant bead configuration, depth and width in accordance with manufacturer's recommendations.

2.5 MISCELLANEOUS MATERIALS

A. Bonding compound:

1. Sikadur Hi-Mod epoxy by Sika Corp.;
2. Euco 452 by Euclid Chemical Corp.; Master Builders Company
3. or equal.

B. Non-shrink grout:

1. Masterflow 713 by Master Builders Co.;
2. Euco NS by Euclid Chemical Co.;
3. Five Star Grout by U.S. Grout Corp.
4. or equal.

2.6 RESTRAINED JOINTS

A. Manufacturers:

1. For applications with steel piping: Victaulic Company, Easton, PA or equal.
2. Substitutions: As specified in Section 01600 - Product Requirements.

2.7 FLEXIBLE CONNECTIONS

A. Manufacturers:

1. For pressure pipe applications and applications with steel and copper piping: Flexicraft Industries, Chicago, IL; Hyspan Precision Products, Inc.; Metraflex Company, Chicago, IL; Victaulic Company, Easton, PA or equal.
2. For non-pressurized applications involving plastic, clay, asbestos cement, or cast iron applications: Fernco or equal.
3. Substitutions: As specified in Section 01600 - Product Requirements

B. Steel Piping:

1. Inner Hose: Stainless steel.
2. Exterior Sleeve: Braided stainless steel.
3. Pressure Rating: 200 psig WOG at 250 degrees F.
4. Joints: Flanged.
5. Size: Use pipe-sized units.
6. Maximum Offset: **1** inch on each side of installed center line.

C. Copper Piping:

1. Inner Hose: Bronze.
2. Exterior Sleeve: Braided bronze.
3. Pressure Rating: 200 psig WOG at 250 degrees F.
4. Joints: Flanged.
5. Size: Use pipe-sized units.
6. Maximum Offset: **1** inch on each side of installed center line.

D. Non-Pressurized Piping (Plastic, Clay, Asbestos Cement, Cast Iron utilized under 4.3 psig)

1. Flexible couplings: in accordance with ASTM D 5926, C1173 and CSA B602.
2. Couplings: rubberized PVC and be attached with the use of adjustable stainless steel clamps.

2.8 EXPANSION JOINTS

A. Manufacturers:

1. Flexicraft Industries, Chicago, IL; Hyspan Precision Products, Inc.; Metraflex Company, Chicago, IL; Red Valve, Pittsburgh. PA; Proco Products, Stockton.CA; Victaulic Company, Easton, PA or equal.

B. Performance and Design Criteria:

1. Bellow Design: According to Section C of EJMA Standards.
2. Rubber Spool Design

C. Stainless-Steel Bellows Type:

1. Pressure Rating: 200 psig WOG at 250 degrees F.
2. Maximum Compression: 1-3/4 inches.
3. Maximum Extension: 1/4 inch.
4. Joint: Flanged.
5. Application: Stainless steel piping 3 inches and smaller.

D. External Ring-Controlled Stainless-Steel Bellows Type:

1. Pressure Rating: 200 psig WOG at 250 degrees F.
2. Maximum Compression: 1-1/4 inches .
3. Maximum Extension: 3/8 inch.
4. Maximum Offset: 1/8 inch.
5. Joint: Flanged.
6. Accessories: Internal flow liner.
7. Application: Steel piping 3 inches and larger.

E. Single- and Multiple-Arch Rubber Spool Type:

1. Spool: EPDM or Neoprene.
2. Backing Rings: Galvanized Steel.
3. Working Pressure: 200 psig.
4. Maximum Temperature: 120 degrees F.
5. Maximum Compression: 3/4 inch.
6. Maximum Elongation: 1/2 inch.
7. Maximum Lateral Offset: 5/8 inch.
8. Maximum Angular Movement: 15 degrees.
9. Joint: Full-faced, Drilled to 150 # Standard, integral to body, with Backing Rings.
10. Accessories: Stainless Steel Control rods,.
11. Application: Piping 1 inch and larger.

2.9 SLEEVE-TYPE COUPLINGS

A. Manufacturers:

1. GE Oil & Gas (Dresser); Xylem (Smith-Blair) or equal.
2. Substitutions: As specified in Section 01600 - Product Requirements.

B. Description:

1. Comply with AWWA C213, C219.
2. Middle Ring: Ductile iron.
3. Followers: Ductile iron.
4. Gaskets:

a. Material: EPDM.
b. Comply with ASTM D2000.

5. Bolts: ASTM A307 Galvanized Steel.
6. Maximum-working pressure: 250 psi.

C. Finishes:

1. Factory fusion bonded epoxy coated.

2.10 QUICK CONNECT COUPLINGS

A. Couplings to be constructed of aluminum, with EPDM seal material for chemical resistance. Male adapter to connect to the ductile iron pipe with a 125 lb flange connection and designed to receive a female coupler without requiring threading, bolting and tools. Connection to remain tight and leakproof under pressure up to 100 psig. Each adapter to be furnished with a dust cap complete with 18-in long security chain of stainless steel.

2.11 SERVICE CLAMPS

A. Manufacturers:

1. Dresser Industries.
2. Smith-Blair.
3. Mueller.
4. Or equal.

B. Service clamps on ductile iron piping systems with outlet sizes up to 2-in to have malleable or ductile iron bodies that extend at least 160 degree around the circumference of the pipe and have EPDM gaskets cemented to the saddle body. Bodies to be tapped for IPS. Clamps to have double straps.

2.12 YARD HYDRANTS

A. Yard hydrants shall be non-freezing type Eclipse #2 Post Hydrant by Kupferle of St. Louis, MO or equal. Yard hydrants shall have two 1-1/2-in hose nozzles with a 2-in mechanical joint inlet connection. Each hydrant shall have one of the two 1-1/2-in hose nozzles fitted with a special adapter fitting to reduce to a ¾-in male hose connection.

B. Hose rack and hose as included in Paragraph ”Wash Hose Stations (WHS) for Plant Water” shall be provided adjacent to the yard hydrant.

C. Caution sign for plant water hose station as included in Paragraph 2.13 shall be provided for the yard hydrant.

2.13 WASH HOSE STATIONS (WHS) FOR PLANT WATER

A. Wash hose stations as shown on the Drawings to be 1 1/2-in, single supply, wall mounted hose stations. Brass hose nozzle to be straight, twist type with wall holder by Dixon Valve, Part No. BFN150NST or equal. Hose to be 1 1/2-in, 50 ft long, rated for a working pressure of 250 psi, with chlorobutyl tube, hypalon cover, yellow, and double jacketed, complete with expansion ring couplings at each end and bronze swivel protector. Hose rack to be fabricated from 1/4-in stainless steel. The pipe hanger to be copper plated malleable iron split ring type with malleable iron wall plate to receive 3/8-in diameter threaded rod. The wall anchors for hose rack shall be 5/16-in threaded stainless-steel anchors with 5/16-in stainless steel bolts. Assembly to be by Leonard Valve Company, Model No. SW-50-1572-HDHR-50HDH (1 1/2-in).

2.14 CAUTION SIGNS FOR PLANT WATER HOSE STATIONS

A. Furnish and install s sign adjacent to each plant water hose station with the following text:

1. “WATER IS UNSAFE AND IS NOT TO BE USED FOR DRINKING, WASHING OR COOKING PURPOSES”

B. Sign to conform to the latest OSHA Regulation as to size, color, exact wording, type and height of letters.

2.15 FINISHES

A. Prepare piping appurtenances for field finishes as specified in Section 09910 - Painting and Coating.

2.16 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assemblies.

B. Certificate of Compliance:

1. Submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Drawings.

B. Inspect existing flanges for nonstandard bolt hole configurations or design and verify that new pipe and flanges mate properly.

C. Verify that openings are ready to receive sleeves and firestopping.

D. Verify that pipe plain ends to receive sleeve-type couplings are smooth and round for 12 inches from pipe ends.

E. Verify that pipe outside diameter conforms to sleeve manufacturer's requirements.

3.2 PREPARATION

A. Cleaning: Thoroughly clean end connections before installation.

B. Close pipe and equipment openings with caps or plugs during installation.

C. Surface Preparation: Clean surfaces to remove foreign substances.

3.3 INSTALLATION

A. According to ASME B31.3 or ASME B31.9.

B. Coating: Finish piping appurtenances as specified in Section 09910 - Painting and Coating for service conditions.

C. Pipe Penetrations:

1. Flashing:

   a. Provide flexible flashing and metal counterflashing where piping penetrates weatherproofed or waterproofed walls, floors, and roofs.
   b. Flash floor drains with topping over finished areas with lead, 10 inches clear on sides, with minimum 36-by-36-inch sheet size.
   c. Fasten flashing to drain clamp device.

2. Sleeves:

   a. Exterior Watertight Entries: Seal with mechanical sleeve seals.
   b. Set sleeves in position in forms and provide reinforcement around sleeves.
   c. Size sleeves large enough to allow for movement due to expansion and contraction and provide for continuous insulation wrapping.
   d. Extend sleeves through floors 2 inches above finished floor level and calk sleeves.
   e. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent Work with firestopping insulation and calk airtight.
   f. Provide close-fitting metal collar or escutcheon covers at both sides of penetration.
   g. Install stainless-steel escutcheons at finished surfaces.

D. Flexible Connections: Install flexible couplings at connections to equipment and where indicated on Drawings.

E. Expansion Joints:

1. Install flexible couplings and expansion joints at connections to equipment and where indicated on Drawings.

2. If expansion joint is supplied with internal sleeve, indicate flow direction on outside of joint.

3.4 FIELD QUALITY CONTROL

A. After installation, inspect for proper supports and interferences.

B. Repair damaged coatings with material equal to original coating.

3.5 CLEANING

A. Keep equipment interior clean as installation progresses.

END OF SECTION 15062

SECTION 15064 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Open-spring isolators.
4. Housed-spring isolators.
5. Restrained-spring isolators.
6. Housed-restrained-spring isolators.
7. Elastomeric hangers.
8. Spring hangers.
9. Vibration isolation equipment bases.
10. Delegated-design.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 DELEGATED-DESIGN SUBMITTAL

A. For each vibration isolation device:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads: Type 1.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Ribbed or Waffle pattern.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts: Type 2.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.

2. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded.

b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: Type 2.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. California Dynamics Corporation.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.4 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: Type 2.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. California Dynamics Corporation.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt.

2.5 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: Type 4.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top plate with threaded mounting holes.
    c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.6 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: Type 4.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: Type 2.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.8 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: Type 3.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.9 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. California Dynamics Corporation.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03300A "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.3 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03300A "Cast-in-Place Concrete."

END OF SECTION 15064

SECTION 15065 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Stencils.
4. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Carlton Industries, LP.

d. Champion America.
e. Craftmark Pipe Markers.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: White and orange..

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater

viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 STENCILS

A. Stencils for Ducts:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Brimar Industries, Inc.
    b. Carlton Industries, LP.
    c. Champion America.
    d. Craftmark Pipe Markers.

2. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
3. Stencil Material: Fiberboard or metal.
4. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.
5. Identification Paint: Exterior, acrylic enamel. Paint may be in pressurized spray-can form.

B. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Brimar Industries, Inc.
    b. Carlton Industries, LP.
    c. Champion America.
    d. Craftmark Pipe Markers.

2. Lettering Size: Minimum letter height of 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
3. Stencil Material: Fiberboard or metal.
4. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.
5. Identification Paint: Exterior, acrylic enamel. Paint may be in pressurized spray-can form.

2.4 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 09912 "Interior Painting."

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Chilled-Water Piping: White letters on a safety-green background.
2. Condenser-Water Piping: White letters on a safety-green background.
3. Heating Water Piping: White letters on a safety-green background.
4. Refrigerant Piping: White letters on a safety-purple background.
5. Condensate Drain: White letters on a safety-green background.
6. Low-Pressure Steam Piping: Black letters on a safety-white background.
7. High-Pressure Steam Piping: White letters on a safety-gray background.
8. Low Pressure Steam Condensate Piping: Black letters on a safety-white background.
9. High Pressure Steam Condensate Piping: White letters on a safety-gray background .

3.5 DUCT LABEL INSTALLATION

A. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

B. Locate stenciled labels showing service and flow direction near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15065

SECTION 15091 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, exposed supply and outdoor air.
2. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 15061 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General" article for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

2.3 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Vimasco Corporation.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.4 SEALANTS

A. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Childers Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2.6 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Avery Dennison Corporation, Specialty Tapes Division.
b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
e. Venture Tape.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.7 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

        1) AGM Industries, Inc.
        2) Gemco.
        3) Hardcast; a Carlisle Company.
        4) Midwest Fasteners, Inc.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

        1) AGM Industries, Inc.
        2) CL WARD & Family Inc.
        3) Gemco.
        4) Hardcast; a Carlisle Company.
        5) Midwest Fasteners, Inc.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

        1) AGM Industries, Inc.
        2) Gemco.
        3) Midwest Fasteners, Inc.

    b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    c. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely

in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1) Gemco.
2) Midwest Fasteners, Inc.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast; a Carlisle Company.
4) Midwest Fasteners, Inc.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast; a Carlisle Company.
4) Midwest Fasteners, Inc.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

        1) Gemco.
        2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

2.8 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A167 or ASTM A240/A240M, Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies.

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09911 "Exterior Painting" and Section 09912 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

    a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. See schedule on Drawings for type and thickness of insulation to be provided.

B. Plenums and Ducts Requiring Insulation:

1. Indoor, exposed supply and outdoor air.
2. Indoor, exposed return located in unconditioned space.
3. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

C. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.
8. Exposed ductwork located in the area it serves.
9. Return air ductwork located in return air ceiling spaces above the area it serves, except where the return ductwork is installed in ceiling spaces with a roof above.

END OF SECTION 15091

SECTION 15100 – LOW-VOLTAGE MOTOR REQUIREMENTS FOR PROCESS EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single- and three-phase motors for application on process equipment provided under other Sections.

B. The manufacturer of the driven equipment shall provide the associated motor.

C. Related Requirements:

1. Section 16056 “Grounding and Bonding for Electrical Systems”.
2. Section 16070 “Identification for Electrical Systems”.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

B. VFC: Variable-frequency motor controller. See VFD.

C. VFD: Variable-frequency drive. Used interchangeably with the term VFC.

1.4 SUBMITTALS

A. Product Data: For each type and rating of motor indicated.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include nameplate data, compliance with specified standards, electrical ratings and characteristics, physical dimensions, frame size, weights, mechanical performance data, support points and the following:

a. Descriptive bulletins, including full description of insulation system.
b. Bearing design data.
c. Efficiency at ½, ¾ and full load.
d. Power factor at ½, ¾ and full load.
e. Conduit entry points and sizes.
f. Special features and accessories (i.e. space heaters, temperature detectors, etc.).

g. Power factor correction capacitor rating and type (when required).

B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

C. Qualifications Statements:

1. Submit qualifications for manufacturer and testing agency.

1.5 QUALITY ASSURANCE

A. Electric motors driving identical equipment shall be identical

B. Motors shall be listed under UL recognized component file as applicable.

C. Motor manufacturer to maintain a documented ISO 9001 quality assurance program implementing suitable procedures and controls to monitor all aspects of production and testing.

D. When electrically driven equipment differs from that indicated, adjust the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed.

E. Testing Agency Qualifications: Member company of NETA.

1.6 DELIVERY, STORAGE AND HANDLING

A. Ship motor fully assembled, capable of being lifted in one piece. Comply with Section 01600, "Product Requirements" for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on site in manufacturer's original packaging and inspect for damage.

C. Storage:

1. Store materials according to manufacturer instructions.
2. Energize motors furnished with space heaters to prevent condensation throughout the storage and construction period. Perform periodic motor insulation resistance tests per manufacturer’s storage recommendations.
3. For extended outdoor storage, remove motors from equipment and store separately.
4. Maintain bearings during storage and construction period, and periodically rotate the motor shaft per manufacturer’s storage recommendations.
5. Lubricate per manufacturer’s recommendations and inspect purged grease for water, rust, or other contaminants.

D. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of motors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion for inverter duty motors.
2. Warranty Period: Five years from date of Substantial Completion for constant speed severe-duty motors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Nidec (US Motors)
2. ABB (Baldor-Reliance)
3. TECO-Westinghouse
4. Toshiba
5. WEG
6. General Electric
7. Or equal

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.

B. Comply with the latest revision of the following as applicable:

1. NEMA MG 1, “Motors and Generators”.
2. IEEE 841 for TEFC motors where driven equipment specification indicates equipment requires motors to be severe-duty, chemical duty, or mill duty.

C. Unless otherwise noted, all motors ½ through 100 horsepower shall be rated 230/460 Volt, three-phase, 60 Hertz A.C.; motors 125 horsepower and above shall be rated 460 Volt, three-phase, 60 Hertz; and motors below ½ horsepower shall be rated 115/230 Volt, single phase, 60 Hertz A.C.

D. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

E. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

F. Horsepower rating: Size for operation within the full load nameplate rating without applying the service factor, throughout the full range of mechanical or hydraulic operating condition.

G. Specific motor application data such as Hp, rpm, enclosure type, accessories, etc., are specified under the detailed driven mechanical equipment specification.

H. Nameplates: Engrave or emboss on 316 stainless steel fastened to the motor frame with stainless steel screws or drive pins with information per NEMA MG 1.

I. Space heater: Include 120-volt space heater for moisture control on all motors rated 50 horsepower and larger.

J. Service Factor: 1.15 service factor on sine wave power and 1.0 service factor on VFD power in a 40 degrees C ambient, unless otherwise noted.

K. Motors and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

L. Enclosures: Conform to one of the NEMA standard enclosure designs as specified under the detailed driven mechanical equipment specification. If no enclosure type is specified, provide TEFC (Totally Enclosed Fan Cooled) enclosures.

M. Motors connected to VFCs: Inverter duty rated and comply with NEMA MG 1, Part 31. First or second torsional critical speed shall be outside the operating speed range for all VFC controlled motors.

N. Three-phase motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Service Factor: 1.15.
3. Multispeed Motors: Variable torque.

    a. For motors with 2:1 speed ratio, consequent pole, single winding.
    b. For motors with other than 2:1 speed ratio, separate winding for each speed.

4. Rotor: Random-wound, squirrel cage.
5. Code Letter Designation:

    a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
    b. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

6. Accessories: Where specified herein, or under process mechanical specification.

2.3 THREE PHASE MOTOR CONSTRUCTION

A. Enclosure and Frame:

1. NEMA enclosure type as specified in the process equipment specification.
2. NEMA frame for the associated horsepower.
3. Motor frames: Cast iron or welded heavy plate steel construction, stiff enough to withstand the rotating forces and torques generated and designed to limit or avoid any undesirable harmonic resonances.
4. Provide a threaded, forged steel, shouldered eyebolt blind tapped into the motor frame for lifting on all frames 254T and larger.

5. Condensate drain openings: Locate drain holes at the low points in the end brackets to allow removal of accumulated moisture from enclosures. Provide corrosion resistant, breather drain plugs for severe-duty motors.
6. Hardware: Hex head, SAE Grade 5 or better, plated for corrosion protection.
7. Nameplates: Engraved or embossed stainless steel plates fastened to the motor frame with stainless steel screws or drive pins. Clearly indicate all items of information listed in the applicable part of NEMA MG 1.
8. Main terminal box: Fabricated steel or cast iron, sized per the NEC for number and size of conduit connections and conductor bending and terminations as indicated on the Drawings. Split box top to bottom with capability to rotate entry point to any quadrant. Provide gaskets between the box and motor frame and between box and its cover. Include ground lug for equipment grounding conductor termination.
9. Bearing housings: Provide machined surfaces for attaching a magnet mounted accelerometer to monitor the motor vibration in the vertical, horizontal, and axial directions at each bearing housing.
10. Frame grounding: provide motor frame grounding pad or threaded stud where supplemental grounding to frame is indicated on the drawings.
11. Corrosion resistant mill and chemical duty paint.

B. Windings:

1. Copper
2. Insulation rating: Class F.
3. Temperature rise: Class B at 1.0 SF, Class F at 1.15 SF.
4. Insulation: Non-hygroscopic, epoxy encapsulated windings for enclosure types WP I and WP II. Provide upgraded insulation by additional dips and bakes to increase moisture resistance for totally enclosed designs. Provide vacuum pressure impregnated (VPI) epoxy insulation for moisture resistance for outdoor motors.
5. Provide chemical and humidity resistance insulation system when IEEE 841 motors are specified.
6. Provide winding surge withstand capability per NEMA 1, Part 31 for VFC driven motors.
7. Provide specified temperature sensing devices for VFC driven equipment. If not specified, provide a winding temperature detector per the accessories paragraph.

C. Motor leads: Non-wicking type, minimum Class F temperature rating and permanently numbered for identification.

D. Stator: Built up core using high grade, low loss silicon steel laminations keyed or dovetailed to the stator frame and securely held in place at each end.

E. Rotor:

1. Forged or rolled steel shaft, machined, smooth finished, with sufficient strength for operation including 25 percent overspeed condition.
2. Shaft end coordinated with driven equipment coupling.
3. Entire assembly coated with protective coating.
4. Inpro seals on both ends of the shaft to prevent grease leakage and entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest. Severe duty motors to have improved sealing per IEEE 841.
5. Vertical Motor Shafts:

a. Provide hollow shaft and P flange mounting to allow driven shaft to extend through provide for vertical pump applications.
b. Coupling for connecting the motor shaft to the driven shaft is located in the top of the motor.
c. Where solid shaft is provided couple the driven shaft below the P flange face.

6. Rotor Core:

a. Solid, built-up stack of fully processed and coated, high-grade, low-loss silicon steel laminations.
b. Die cast aluminum or fabricated copper bars or their respective alloys.
c. Rotors on frames 213T and above to be keyed to shaft and rotating assembly dynamically balanced.

7. Rotor Assembly:

a. Coated with corrosion resistant epoxy insulating varnish or other protective coating, thermally stable, statically and dynamically balanced.
b. Balance weights securely attached to the rotor resistance ring by welding or similar permanent method.

F. Horizontal Bearings: roller type, grease lubricated.

1. Bearings: Anti-friction open or single-shield, vacuum-degassed steel ball or roller bearings, electric motor quality, designed for 45 degrees C maximum temperature rise. Metric size bearings are not acceptable.
2. Life: L 10 life of 100,000 hours for direct coupled applications and 26,000 hours for belted applications based. IEEE 841 motors, L 10 life increased to 150,000 and 50,000 hours respectively.
3. Shaft seals: Provide to prevent grease leakage and the entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest.
4. Shaft currents: Provide mitigation per process equipment specification.
5. Comply with ABMA and refer to process equipment specification for stricter or additional requirements.

G. Vertical Bearings: per manufacturer, thrust type.

1. Bearings: Manufacturer's standard design, constructed with thrust bearings on top to allow inspection and/or replacement without requiring complete disassembly of motor, of type and size to satisfy thrust loading requirements.
2. Life: Rated for an in-service L 10 life of 8800 hours, designed to support the weight of the rotor plus, if required, the weight of the rotating driven equipment parts and the hydraulic thrust created by the driven equipment, with a 40 degrees C maximum temperature rise. Metric bearings are not acceptable.
3. Shaft seals: Provide to prevent grease leakage and the entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest.
4. Shaft currents: Provide mitigation per process equipment specification.
5. Comply with ABMA and refer to process equipment specification for stricter or additional requirements.

2.4 THREE PHASE MOTOR ACCESSORIES

A. Space heaters: Silicone rubber strip type, accessible for inspection, rated 120 Volt, single phase, designed to prevent condensation inside the enclosure when the motor is idle, with leads brought out to a separate terminal box. Emboss the heater wattage and voltage on the motor nameplate.

B. Winding temperature switch: Three embedded bi-metallic temperature thermostat switches with normally open or normally closed as shown on the Drawings and leads terminating in the main conduit box.

C. Bearing temperature sensing: Number, type, and location for motor and driven equipment per process equipment specification.

1. RTD: Replaceable 100 Ohm platinum (PT 100) three-wire RTD's, with spring loaded tip. Mount RTD as close as possible to outer surface of each bearing. RTD includes conduit connection head, terminal block, and cabling brought out to a common terminal box.

D. Motor shaft currents: insulate the ODE bearing and provide a shaft grounding strap. Insulate bearing probes to prevent shorting out bearing insulation.

E. Shaft grounding rings: maintenance free, circumferential micro fiber type, AEGIS™ SGR by electro Static Technology or equal to discharge shaft currents to ground.

F. Anti-Backspin Device: Provide shaft mounted, mechanical non-reverse ratchet rated at 100 percent of motor full load torque for immediate protection against reversing due to phase reversals or from backspin at shutdown.

2.5 SOURCE QUALITY CONTROL

A. Factory Testing: Prior to shipment perform manufacturer’s standard tests in accordance with NEMA MG 1 and IEEE 112.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of motor and prior to unloading, inspect equipment for damage.

B. Comply with DELIVERY, STORAGE, AND HANDLING article within this specification.

3.2 INSTALLATION

A. Prepare rigid foundation or mounting surface to minimize vibration and maintain alignment between motor and load shaft.

B. Install the motors per manufacturer's installation instructions.

C. Anchor motor base to load bearing surface with grade 5 steel bolts or better.

D. Align the motor shaft with driven equipment according to manufacturer's written instructions. Adjust axial position of motor frame with respect to load shaft.

E. Accurately adjust flexible couplings for direct drive according to machine manufacturer's guidelines. Check alignment to minimize vibrations. Coupling spacing shall be according to coupling manufacturer guidelines.

F. Install motor branch circuit conduits and conductors in accordance with NEC and local code requirements. Connect motors to rigid conduit system by a short section of liquid-tight flexible conduit to isolate the conduit system from motor vibration. Where motors are installed outdoors, bring conduit into bottom of motor terminal box to avoid standing water at connection point.

G. Terminate the motor leads as shown on the connection diagrams using products intended for vibration applications.

H. Ground equipment according to Section 26056, "Grounding and Bonding for Electrical Systems."

I. Tighten electrical connections and terminals according to manufacturers' published torque values.

J. Install conduit and wiring between motor auxiliary devices and associated indicators, controllers and protective devices in accordance to installation drawings.

K. Connect devices sensitive to electromagnetic interferes such as RTD's, thermistors, thermal protector switches, vibration sensors with shielded instrumentation wiring per installation drawings.

L. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements for identification specified in Section 16070, "Identification for Electrical Systems." Identify field-installed conductors, interconnecting wiring, and components.

3.4 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until motors are ready to be energized and placed into service.

B. Lubrication and Shaft Rotation: Lubricate parts and rotate shaft periodically according to manufacturer's written instructions until motors are ready to be energized and placed into service.

3.5 FIELD QUALITY CONTROL

A. Perform inspections and tests Inspect and test according to the Inspection and Test Procedures for Rotating Machinery state in NETA Acceptance Testing Specification paragraph 7.15.1. Options tests are not required unless called for within the process equipment specification.

B. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Motors will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies the motor and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP AND ADJUSTMENT

A. Complete installation and startup checks according to manufacturer's written instructions. Confirm motor is structurally, mechanically, and electrically ready for start-up. Checks include support system, vibration isolation, alignment, lubrication system, and cleanliness.

B. Start-up motor in accordance with process equipment specification.

C. Verify correct phase rotation at motor with driven equipment uncoupled. Correction for phase rotation to be made in the motor terminal box.

D. Prepare inspection and test reports.

3.7 DEMONSTRATION / SYSTEM FUNCTION TESTS

A. Run motor for system testing as required in motor controller and driven equipment specifications.

B. Confirm correct operation of all protective and metering devices.

C. Measure voltage and motor running current and evaluate relative to load conditions and nameplate full load amperes. Corrective action is required for any current imbalance 10 percent or greater.

D. Prepare driven equipment system testing report. Include results of all tests and check made, meter readings and recordings, and summary adjustments made. Clearly identify any discrepancies and concerns.

END OF SECTION 15100

SECTION 15103 - DUCTILE IRON PROCESS PIPE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Ductile-iron pipe.
2. Ductile-iron, malleable-iron, and cast-iron fittings.
3. Accessories.

B. Related Requirements:

1. Section 09910 “Painting” for product and execution requirements for painting specified by this Section.
2. Section 15062 “Couplings, Adapters, and Specials” for Process Piping: Piping appurtenances.
3. Section 15140 “Hangers and Supports for Process Piping” for hangers, anchors, sleeves, and sealing of piping to adjacent structures.
4. Section 15108 “Common Requirements for Process Valves” for common product requirements for valves for placement by this Section.

1.3 COORDINATION

A. Coordinate Work of this Section with piping and equipment connections specified in other Sections and indicated on Drawings.

1.4 ACTION SUBMITTALS

A. Product Data: Submit manufacturer information regarding pipe and fittings.

B. Shop Drawings: Indicate layout of piping systems, including equipment, critical dimensions, sizes, and materials lists.

C. Manufacturer's Certificate: Prior to shipment of pipe, submit a certified affidavit of compliance from the pipe manufacturer stating that the pipe fittings, gaskets, linings and exterior coating for this project have been manufactured and tested in accordance with AWWA and ASTM standards and requirements specified herein.

D. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

F. Qualifications Statements:

1. Submit qualifications for manufacturer, installer, and licensed professional.
2. Submit manufacturer's approval of installer.

G. American Iron and Steel (AIS): Submit certification indicating compliance with AIS requirements.

1.5 CLOSEOUT SUBMITTALS

A. Section 01650 “Contract Closeout” for requirements for submittals.

B. Project Record Documents: Record actual locations of piping, valves and other appurtenances, connections, and centerline elevations or invert elevations for gravity-flow lines.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Materials (including linings) in Contact with Potable Water: Certified according to NSF 61 and NSF 372.

B. Hydrostatically test each length of ductile iron pipe at the point of manufacture to 500 psi for a duration of 10 seconds per AWWA C151. Furnish certified test results in duplicate to the Engineer prior to time of shipment.

C. Inspect and test by Manufacturer the ductile-iron pipe and fittings at the foundry as required by the AWWA C600, Hydrostatic Testing. Furnish in duplicate to the Engineer sworn certificates of such tests and their results prior to the shipment of the pipe.

D. Engineer will inspect the pipe and fittings after delivery. Products are subject to rejection at any time on account of failure to meet any of the specified requirements, even though accepted as satisfactory at the place of manufacture. Immediately mark pipe rejected after delivery and remove from the job site.

E. Permanently mark pipe and fittings with the following information:

1. Manufacturer name and trademark
2. Manufacturing date.
3. Size, type, class, or wall thickness.
4. Production Standard (AWWA, ASTM, etc.).

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum five years' documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage. Photograph and provide written documentation of damaged materials.

B. Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Coverall openings to prevent entrance of dirt, water, and debris.
3. Protect piping and appurtenances by storing off ground
4. Limit stacking height to manufacturers specified maximum
5. Provide additional protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS

A. Piping:

1. Comply with AWWA C115, C150 and C151.
2. Thickness Class:53.
3. Ductile Iron pipe as manufactured by U.S. Pipe and Foundry Company, Inc.; American Cast Iron Pipe Company; all divisions of the McWane Company or an approved equal who is a member of the Ductile Iron Pipe Research Association (DIPRA).

B. Fittings:

1. Material: AWWA C110, ductile iron.
2. Class: Same as that of connected piping.
3. Mechanical Joints:

    a. Comply with AWWA C110 and AWWA C111.
    b. Glands: Ductile iron with asphaltic coating.
    c. Push-on Joints: Comply with AWWA C111.

4. Restrained Joints: Comply with AWWA C111.
5. Flanged joints: Comply with AWWA C110.

a. Assembly bolts: square headed carbon steel machine bolts with hexagon nuts per ANSI B18.2. Threads conform to ANSI B1.1. Bolt length: 1/8" to 5/8" protrusion from nut after torquing.

6. Grooved joints: Comply with AWWA C606

a. Rigid couplings: Style 31 couplings as manufactured by Victaulic, Anvil International, or approved equal.
b. For direct connection of ductile pipe to steel pipe of IPS sizes: Victaulic Style 307 transition coupling with offsetting, angle-pattern, bolt pads.
c. Grooved end fittings for AWWA ductile iron pipe: Conform to ANSI A21.10/AWWA C110 for center-to-end dimensions and ANSI A21.10/AWWA C110 or AWWA C153 for wall thickness, with AWWA C606 grooved ends.

7. Sleeve type couplings for connection of two plain end pipes: Dresser Style 38 or 138 as manufactured by Dresser Industries, or equivalent products of Smith-Blair, Romac Industries, Ford Meter Box Co or approved equal.
8. Flanged coupling adaptors for connection of a plain end pipe to a flanged connection: Smith-Blair Type 913, or equivalent products of Klamflex Pipe Couplings (PTY) LTD, Robar Industries LTD or approved equal.

C. Flanged Fittings:

1. Material: AWWA C110/ANSI A21.10, ductile iron.
2. Pressure Rating: 250 psi.
3. Drilling: ANSI B16.1 Class 125

D. Cement-Mortar Lining:

1. All ductile iron pipe and fittings to be provided with cement-mortar lining except those piping systems requiring to have a glass lining.
2. Comply with AWWA C104 for lining of pipe and fittings.
3. Thickness: Standard.

E. Special Linings

1. Glass Lining:

a. Glass lining of ductile iron pipe and fittings scheduled for the secondary scum systems to consist of vitreous and inorganic lining materials applied to the internal surfaces The internal surface shall be prepared in strict accordance with ASTM B1000, Sections 3 and 4.
b. Apply lining in a minimum of two coats, separately applied and separately fired to a maturing temperature of 1350 degree F. Finished dry film thickness: 10 mils minimum.
c. Finished glass lining Acceptance Criteria:

1) Free of visible pin holes or holidays, crazing or fish scales.
2) Surface hardness greater than 6 on the MOHS scale.
3) Able to withstand a strain of 0.001 inch/inch of the base metal without damage to the glass.

4) Inspected and tested in accordance with ASTM B1000 - 15, Section 7. Certified inspection and test report to be furnished with each product shipment.

d. Applicator Qualifications: minimum of 5 years successful experience in the application of high temperature glass/porcelain coatings to the interior of ductile pipe and fittings. Certify complete compliance with all qualification, final inspection and quality guidelines included in Sections 5 and 6 of ASTM B1000 – 15.

2. Epoxy Lining:

a. Line ductile iron pipe and fittings with a ceramic-filled amine-cured epoxy, Protecto 401 by Induron.
b. Lining thickness of 40 mils minimum. Applicator approved by the coating manufacturer and applied in accordance with manufacturer's instructions and under controlled conditions at the applicator's shop or the pipe manufacturer's plant.
c. Submit a certified affidavit of compliance with manufacturer's instructions and requirements specified herein.

F. Exterior Coating:

1. Exposed Service: As specified in Section 09910 - Painting.
2. If required, coatings "hold-backs" to be provided at pipe and fitting ends for satisfactory installation for joint connections in the field.
3. Provide all necessary coating materials to perform field coating applications at joints compatible with or equal to the shop applied material.
4. Field repair of pipe with damaged coating shall receive prior approval of the Engineer. If, in the opinion of the Engineer coating damage is beyond repair, pipe to be replaced at the expense of the Contractor.
5. All flange bearing surfaces shall be uncoated.
6. Mechanically clean or brush blast all surfaces to have exterior coating applied to ductile iron surfaces. Chemical cleaning or wiping with solvent is not acceptable.

2.2 ACCESSORIES

A. Gaskets:

1. full face type SBR per AWWA C111 to provide positive sealing for the flanged ductile iron joints.
2. Thickness 1/8-in
3. NSF61 certified for potable water applications.

2.3 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly.

B. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Shop Drawings.

B. Inspect existing flanges for nonstandard bolt hole configurations or design and verify that new pipe and flange mate properly.

3.2 PREPARATION

A. Thoroughly clean pipe and fittings before installation.

B. Surface Preparation:

1. Clean surfaces to remove loose rust, mill scale, and other foreign substances by power wire brushing.
2. Touch up shop-primed surfaces with primer as specified in Section 09910 - Painting.
3. Solvent-clean surfaces that are not shop primed.

3.3 INSTALLATION

A. Exposed Service Piping:

1. According to ASME B31.3.
2. In compliance with manufacturer’s instructions.
3. Run piping straight along alignment as indicated on Shop Drawings, with minimum number of joints.
4. Clean each length prior to installation.
5. Support per Section 15140.
6. Do not use equipment flanges for support; support pipe separately.

B. Fittings:

1. According to manufacturer instructions.
2. Clean gasket seats thoroughly, and wipe gaskets clean prior to installation.
3. Tighten bolts progressively, drawing up bolts on opposite sides until bolts are uniformly tight; use torque wrench to tighten bolts to manufacturer instructions.
4. Flanged joints to be made using gaskets, bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts to conform to the same ANSI Standard as the flanges.
5. Provide required upstream and downstream clearances from devices as indicated on Drawings.

C. Make taps to ductile iron piping only with service saddle, tapping boss of a fitting or valve body, or equipment casting.

D. Install piping with sufficient slopes for venting or draining liquids and condensate to low points.

E. Support exposed piping as specified in Section 15140 “Hangers and Supports for Process Piping.”

F. Provide expansion joints as specified in Section 15062 - Couplings, Adapters, and Specials for Process Piping, and pipe guides as specified in Section 15140 “Hangers and Supports for Process Piping” to compensate for pipe expansion due to temperature differences.

G. Dielectric Fittings: Provide between dissimilar metals.

H. Field Cuts: According to pipe manufacturer instructions. Cutting by abrasive saw only, leaving a smooth cut at right angles to the axis of the pipe. Damage to the lining repaired to the satisfaction of the Engineer. Seal Field cut ends approved epoxy coating in accordance with manufacturer's instructions.

I. Finish primed surfaces according to Section 09910 “ Painting.”

3.4 TOLERANCES

A. Deflection at joints not to exceed that recommended by the pipe manufacturer.

B. Supply and install fittings, in addition to those shown on Drawings, in areas where conflict exists with existing facilities.

3.5 FIELD QUALITY CONTROL

A. Inspection:

1. Inspect for damage to pipe lining or coating and for other defects that may be detrimental as determined by Engineer.
2. Repair damaged piping or provide new, undamaged pipe at no additional cost to the project.
3. After installation, inspect for proper supports and interferences.

B. Pressure Testing:

1. Test Pressure: Not less than 200 psigor 50 psiin excess of maximum static pressure, whichever is greater 150 percent of maximum operating design pressure.
2. Conduct hydrostatic test for minimum two hours.
3. Filling:

    a. Fill section to be tested with water slowly and expel air from piping at high points.
    b. Install corporation cocks at high points.
    c. Close air vents and corporation cocks after air is expelled.
    d. Raise pressure to specified test pressure.

4. Observe joints, fittings, and valves under test.
5. Remove and renew cracked pipe, joints, fittings, and valves showing visible leakage and retest.

3.6 CLEANING

A. Keep pipe interior clean as installation progresses.

B. After installation, clean pipe interior of soil, grit, and other debris.

C. As pipe laying progresses and at the conclusion of the work thoroughly clean all new pipelines by flushing with water or other means to remove all dirt, stones, pieces of wood or other material which may have entered during the construction period. Debris cleaned from the lines shall be removed from the low end of the pipeline. If, after this cleaning, obstructions remain, they shall be removed.

D. Fire Service piping shall be flushed until no visible debris is evident.

END OF SECTION 15103

SECTION 15100 – LOW-VOLTAGE MOTOR REQUIREMENTS FOR PROCESS EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single- and three-phase motors for application on process equipment provided under other Sections.

B. The manufacturer of the driven equipment shall provide the associated motor.

C. Related Requirements:

1. Section 16056 “Grounding and Bonding for Electrical Systems”.
2. Section 16070 “Identification for Electrical Systems”.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

B. VFC: Variable-frequency motor controller. See VFD.

C. VFD: Variable-frequency drive. Used interchangeably with the term VFC.

1.4 SUBMITTALS

A. Product Data: For each type and rating of motor indicated.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include nameplate data, compliance with specified standards, electrical ratings and characteristics, physical dimensions, frame size, weights, mechanical performance data, support points and the following:

a. Descriptive bulletins, including full description of insulation system.
b. Bearing design data.
c. Efficiency at ½, ¾ and full load.
d. Power factor at ½, ¾ and full load.
e. Conduit entry points and sizes.
f. Special features and accessories (i.e. space heaters, temperature detectors, etc.).

g. Power factor correction capacitor rating and type (when required).

B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

C. Qualifications Statements:

1. Submit qualifications for manufacturer and testing agency.

1.5 QUALITY ASSURANCE

A. Electric motors driving identical equipment shall be identical

B. Motors shall be listed under UL recognized component file as applicable.

C. Motor manufacturer to maintain a documented ISO 9001 quality assurance program implementing suitable procedures and controls to monitor all aspects of production and testing.

D. When electrically driven equipment differs from that indicated, adjust the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed.

E. Testing Agency Qualifications: Member company of NETA.

1.6 DELIVERY, STORAGE AND HANDLING

A. Ship motor fully assembled, capable of being lifted in one piece. Comply with Section 01600, "Product Requirements" for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on site in manufacturer's original packaging and inspect for damage.

C. Storage:

1. Store materials according to manufacturer instructions.
2. Energize motors furnished with space heaters to prevent condensation throughout the storage and construction period. Perform periodic motor insulation resistance tests per manufacturer’s storage recommendations.
3. For extended outdoor storage, remove motors from equipment and store separately.
4. Maintain bearings during storage and construction period, and periodically rotate the motor shaft per manufacturer’s storage recommendations.
5. Lubricate per manufacturer’s recommendations and inspect purged grease for water, rust, or other contaminants.

D. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of motors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion for inverter duty motors.
2. Warranty Period: Five years from date of Substantial Completion for constant speed severe-duty motors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Nidec (US Motors)
2. ABB (Baldor-Reliance)
3. TECO-Westinghouse
4. Toshiba
5. WEG
6. General Electric
7. Or equal

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.

B. Comply with the latest revision of the following as applicable:

1. NEMA MG 1, “Motors and Generators”.
2. IEEE 841 for TEFC motors where driven equipment specification indicates equipment requires motors to be severe-duty, chemical duty, or mill duty.

C. Unless otherwise noted, all motors ½ through 100 horsepower shall be rated 230/460 Volt, three-phase, 60 Hertz A.C.; motors 125 horsepower and above shall be rated 460 Volt, three-phase, 60 Hertz; and motors below ½ horsepower shall be rated 115/230 Volt, single phase, 60 Hertz A.C.

D. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

E. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

F. Horsepower rating: Size for operation within the full load nameplate rating without applying the service factor, throughout the full range of mechanical or hydraulic operating condition.

G. Specific motor application data such as Hp, rpm, enclosure type, accessories, etc., are specified under the detailed driven mechanical equipment specification.

H. Nameplates: Engrave or emboss on 316 stainless steel fastened to the motor frame with stainless steel screws or drive pins with information per NEMA MG 1.

I. Space heater: Include 120-volt space heater for moisture control on all motors rated 50 horsepower and larger.

J. Service Factor: 1.15 service factor on sine wave power and 1.0 service factor on VFD power in a 40 degrees C ambient, unless otherwise noted.

K. Motors and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

L. Enclosures: Conform to one of the NEMA standard enclosure designs as specified under the detailed driven mechanical equipment specification. If no enclosure type is specified, provide TEFC (Totally Enclosed Fan Cooled) enclosures.

M. Motors connected to VFCs: Inverter duty rated and comply with NEMA MG 1, Part 31. First or second torsional critical speed shall be outside the operating speed range for all VFC controlled motors.

N. Three-phase motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Service Factor: 1.15.
3. Multispeed Motors: Variable torque.

    a. For motors with 2:1 speed ratio, consequent pole, single winding.
    b. For motors with other than 2:1 speed ratio, separate winding for each speed.

4. Rotor: Random-wound, squirrel cage.
5. Code Letter Designation:

    a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
    b. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

6. Accessories: Where specified herein, or under process mechanical specification.

2.3 THREE PHASE MOTOR CONSTRUCTION

A. Enclosure and Frame:

1. NEMA enclosure type as specified in the process equipment specification.
2. NEMA frame for the associated horsepower.
3. Motor frames: Cast iron or welded heavy plate steel construction, stiff enough to withstand the rotating forces and torques generated and designed to limit or avoid any undesirable harmonic resonances.
4. Provide a threaded, forged steel, shouldered eyebolt blind tapped into the motor frame for lifting on all frames 254T and larger.

5. Condensate drain openings: Locate drain holes at the low points in the end brackets to allow removal of accumulated moisture from enclosures. Provide corrosion resistant, breather drain plugs for severe-duty motors.
6. Hardware: Hex head, SAE Grade 5 or better, plated for corrosion protection.
7. Nameplates: Engraved or embossed stainless steel plates fastened to the motor frame with stainless steel screws or drive pins. Clearly indicate all items of information listed in the applicable part of NEMA MG 1.
8. Main terminal box: Fabricated steel or cast iron, sized per the NEC for number and size of conduit connections and conductor bending and terminations as indicated on the Drawings. Split box top to bottom with capability to rotate entry point to any quadrant. Provide gaskets between the box and motor frame and between box and its cover. Include ground lug for equipment grounding conductor termination.
9. Bearing housings: Provide machined surfaces for attaching a magnet mounted accelerometer to monitor the motor vibration in the vertical, horizontal, and axial directions at each bearing housing.
10. Frame grounding: provide motor frame grounding pad or threaded stud where supplemental grounding to frame is indicated on the drawings.
11. Corrosion resistant mill and chemical duty paint.

B. Windings:

1. Copper
2. Insulation rating: Class F.
3. Temperature rise: Class B at 1.0 SF, Class F at 1.15 SF.
4. Insulation: Non-hygroscopic, epoxy encapsulated windings for enclosure types WP I and WP II. Provide upgraded insulation by additional dips and bakes to increase moisture resistance for totally enclosed designs. Provide vacuum pressure impregnated (VPI) epoxy insulation for moisture resistance for outdoor motors.
5. Provide chemical and humidity resistance insulation system when IEEE 841 motors are specified.
6. Provide winding surge withstand capability per NEMA 1, Part 31 for VFC driven motors.
7. Provide specified temperature sensing devices for VFC driven equipment. If not specified, provide a winding temperature detector per the accessories paragraph.

C. Motor leads: Non-wicking type, minimum Class F temperature rating and permanently numbered for identification.

D. Stator: Built up core using high grade, low loss silicon steel laminations keyed or dovetailed to the stator frame and securely held in place at each end.

E. Rotor:

1. Forged or rolled steel shaft, machined, smooth finished, with sufficient strength for operation including 25 percent overspeed condition.
2. Shaft end coordinated with driven equipment coupling.
3. Entire assembly coated with protective coating.
4. Inpro seals on both ends of the shaft to prevent grease leakage and entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest. Severe duty motors to have improved sealing per IEEE 841.
5. Vertical Motor Shafts:

a. Provide hollow shaft and P flange mounting to allow driven shaft to extend through provide for vertical pump applications.
b. Coupling for connecting the motor shaft to the driven shaft is located in the top of the motor.
c. Where solid shaft is provided couple the driven shaft below the P flange face.

6. Rotor Core:

a. Solid, built-up stack of fully processed and coated, high-grade, low-loss silicon steel laminations.
b. Die cast aluminum or fabricated copper bars or their respective alloys.
c. Rotors on frames 213T and above to be keyed to shaft and rotating assembly dynamically balanced.

7. Rotor Assembly:

a. Coated with corrosion resistant epoxy insulating varnish or other protective coating, thermally stable, statically and dynamically balanced.
b. Balance weights securely attached to the rotor resistance ring by welding or similar permanent method.

F. Horizontal Bearings: roller type, grease lubricated.

1. Bearings: Anti-friction open or single-shield, vacuum-degassed steel ball or roller bearings, electric motor quality, designed for 45 degrees C maximum temperature rise. Metric size bearings are not acceptable.
2. Life: L 10 life of 100,000 hours for direct coupled applications and 26,000 hours for belted applications based. IEEE 841 motors, L 10 life increased to 150,000 and 50,000 hours respectively.
3. Shaft seals: Provide to prevent grease leakage and the entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest.
4. Shaft currents: Provide mitigation per process equipment specification.
5. Comply with ABMA and refer to process equipment specification for stricter or additional requirements.

G. Vertical Bearings: per manufacturer, thrust type.

1. Bearings: Manufacturer's standard design, constructed with thrust bearings on top to allow inspection and/or replacement without requiring complete disassembly of motor, of type and size to satisfy thrust loading requirements.
2. Life: Rated for an in-service L 10 life of 8800 hours, designed to support the weight of the rotor plus, if required, the weight of the rotating driven equipment parts and the hydraulic thrust created by the driven equipment, with a 40 degrees C maximum temperature rise. Metric bearings are not acceptable.
3. Shaft seals: Provide to prevent grease leakage and the entrance of foreign materials, such as water and dirt, into the bearing area while running, coasting, or at rest.
4. Shaft currents: Provide mitigation per process equipment specification.
5. Comply with ABMA and refer to process equipment specification for stricter or additional requirements.

2.4 THREE PHASE MOTOR ACCESSORIES

A. Space heaters: Silicone rubber strip type, accessible for inspection, rated 120 Volt, single phase, designed to prevent condensation inside the enclosure when the motor is idle, with leads brought out to a separate terminal box. Emboss the heater wattage and voltage on the motor nameplate.

B. Winding temperature switch: Three embedded bi-metallic temperature thermostat switches with normally open or normally closed as shown on the Drawings and leads terminating in the main conduit box.

C. Bearing temperature sensing: Number, type, and location for motor and driven equipment per process equipment specification.

1. RTD: Replaceable 100 Ohm platinum (PT 100) three-wire RTD's, with spring loaded tip. Mount RTD as close as possible to outer surface of each bearing. RTD includes conduit connection head, terminal block, and cabling brought out to a common terminal box.

D. Motor shaft currents: insulate the ODE bearing and provide a shaft grounding strap. Insulate bearing probes to prevent shorting out bearing insulation.

E. Shaft grounding rings: maintenance free, circumferential micro fiber type, AEGIS™ SGR by electro Static Technology or equal to discharge shaft currents to ground.

F. Anti-Backspin Device: Provide shaft mounted, mechanical non-reverse ratchet rated at 100 percent of motor full load torque for immediate protection against reversing due to phase reversals or from backspin at shutdown.

2.5 SOURCE QUALITY CONTROL

A. Factory Testing: Prior to shipment perform manufacturer’s standard tests in accordance with NEMA MG 1 and IEEE 112.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of motor and prior to unloading, inspect equipment for damage.

B. Comply with DELIVERY, STORAGE, AND HANDLING article within this specification.

3.2 INSTALLATION

A. Prepare rigid foundation or mounting surface to minimize vibration and maintain alignment between motor and load shaft.

B. Install the motors per manufacturer's installation instructions.

C. Anchor motor base to load bearing surface with grade 5 steel bolts or better.

D. Align the motor shaft with driven equipment according to manufacturer's written instructions. Adjust axial position of motor frame with respect to load shaft.

E. Accurately adjust flexible couplings for direct drive according to machine manufacturer's guidelines. Check alignment to minimize vibrations. Coupling spacing shall be according to coupling manufacturer guidelines.

F. Install motor branch circuit conduits and conductors in accordance with NEC and local code requirements. Connect motors to rigid conduit system by a short section of liquid-tight flexible conduit to isolate the conduit system from motor vibration. Where motors are installed outdoors, bring conduit into bottom of motor terminal box to avoid standing water at connection point.

G. Terminate the motor leads as shown on the connection diagrams using products intended for vibration applications.

H. Ground equipment according to Section 26056, "Grounding and Bonding for Electrical Systems."

I. Tighten electrical connections and terminals according to manufacturers' published torque values.

J. Install conduit and wiring between motor auxiliary devices and associated indicators, controllers and protective devices in accordance to installation drawings.

K. Connect devices sensitive to electromagnetic interferes such as RTD's, thermistors, thermal protector switches, vibration sensors with shielded instrumentation wiring per installation drawings.

L. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements for identification specified in Section 16070, "Identification for Electrical Systems." Identify field-installed conductors, interconnecting wiring, and components.

3.4 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until motors are ready to be energized and placed into service.

B. Lubrication and Shaft Rotation: Lubricate parts and rotate shaft periodically according to manufacturer's written instructions until motors are ready to be energized and placed into service.

3.5 FIELD QUALITY CONTROL

A. Perform inspections and tests Inspect and test according to the Inspection and Test Procedures for Rotating Machinery state in NETA Acceptance Testing Specification paragraph 7.15.1. Options tests are not required unless called for within the process equipment specification.

B. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Motors will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies the motor and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP AND ADJUSTMENT

A. Complete installation and startup checks according to manufacturer's written instructions. Confirm motor is structurally, mechanically, and electrically ready for start-up. Checks include support system, vibration isolation, alignment, lubrication system, and cleanliness.

B. Start-up motor in accordance with process equipment specification.

C. Verify correct phase rotation at motor with driven equipment uncoupled. Correction for phase rotation to be made in the motor terminal box.

D. Prepare inspection and test reports.

3.7 DEMONSTRATION / SYSTEM FUNCTION TESTS

A. Run motor for system testing as required in motor controller and driven equipment specifications.

B. Confirm correct operation of all protective and metering devices.

C. Measure voltage and motor running current and evaluate relative to load conditions and nameplate full load amperes. Corrective action is required for any current imbalance 10 percent or greater.

D. Prepare driven equipment system testing report. Include results of all tests and check made, meter readings and recordings, and summary adjustments made. Clearly identify any discrepancies and concerns.

END OF SECTION 15100

SECTION 15106 - THERMOPLASTIC PROCESS PIPE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. PVC pipe.
2. PVC tube.
3. Fittings.
4. Accessories for plastic piping.

B. Related Requirements:

1. Section 15062 “Couplings, Adapters, and Specials for Process Piping” for pipe penetrations, restrained joints, flexible connections, expansion joints and loops, and sleeve-type couplings.
2. Section 15140 “Hangers and Supports for Process Piping” for hangers, anchors, sleeves, and sealing of piping to adjacent structures.
3. Section 15108 “Common Requirements for Process Valves” for common product requirements for valves for placement by this Section.

1.3 COORDINATION

A. Coordinate Work of this Section with piping and equipment connections specified in other Sections and indicated on Drawings.

1.4 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's catalog information regarding pipe and fittings.

B. Shop Drawings: Indicate layout of piping systems, including equipment, critical dimensions, sizes, materials lists, location of all fittings, valves, and in-line accessories.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

D. Manufacturer’s recommended butt fusion welding procedures identifying all quality control checks during the fusion procedure including the minimum and maximum allowable bead formation during the heat soak process and the final weld roll back process for the various size pipes.

E. Source Quality-Control Submittals: Indicate results of shop tests and inspections.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statements:

1. Submit qualifications for manufacturer, installer, and licensed professional.
2. Submit manufacturer's approval of installer.

1.5 CLOSEOUT SUBMITTALS

A. See Section 01770 “Closeout Procedures” for submittal requirements.

B. Project Record Documents: Record actual locations of piping, valves and other appurtenances, connections, and centerline elevations (pressure pipe) and invert elevations (gravity pipe).

1.6 QUALITY ASSURANCE

A. Permanently mark each length of pipe with manufacturer's name or trademark and indicate conformance to standards.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum 5 years' experience.

B. Manufacturer: Company listed with the Plastic Pipe Institute as meeting the recipe and mixing requirements of the resin manufacturer for the resin used to manufacture each of the respective thermoplastic pipe systems.

1.8 SYSTEM DESCRIPTION

A. Thermoplastic process piping and fittings to be installed in non-buried location as shown on the Drawings and listed below:

ABOVE-GRADE THERMOPLASTIC PROCESS PIPE AND FITTINGS SCHEDULE

Service	Pipeline Designation	Diameter(s) (inches)	Material	Pipe Schedule	Joints (1)	Flange Gasket Material	Working Pressure (psi)	Test pressure (psi)	Exterior Coating	Insulation and Heat-Tracing Required	Labels
Chemical	NaOCl	1/2" – 2"	PVC	80	Solvent Weld	EPDM	100	150	No	No	Yes
	SAS	1/2" – 3"	PVC	80	Solvent Weld	EPDM	100	150	No	No	Yes
Non-Potable Water	EFW	1/2" – 3"	PVC	80	Solvent Weld	EPDM	100	150	No	No (2)	Yes
Drains	Dr	1/2" – 4"	PVC	80	Solvent Weld	EPDM	50	75	No	No (2)	Yes

Notes: (1) Flanged at equipment as required.
(2) At exterior locations, heat trace and insulate. Heat tracing to be per Spec Section 262729. Pipe insulation to be per Spec Section 404213, Type P-1 insulation material (with 2-inch minimum thickness) covered by aluminum jacket.
(3) At exterior locations, exterior coating required if not insulated.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Inspection:

1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
2. Manufacturer's Packaging: Comply with ASTM D3892.

B. Storage: Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from puncture, abrasion, moisture, dust, and UV by storing in clean, dry location remote from construction operations areas.
2. Protect piping and appurtenances by storing off ground.
3. Provide additional protection according to manufacturer instructions.

1.10 AMBIENT CONDITIONS

A. Minimum and Maximum Temperatures: Do not install pipe when temperature is below 40 degrees F or above 90 degrees F if pipe is exposed to direct sunlight.

B. UV Protection: Provide pipe installed above ground or outside with UV protection.

1.11 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 PVC PIPE, TUBE, AND FITTINGS

A. PVC Pipe and Fittings:

1. Pipe and Fittings:

a. Comply with ASTM D1785, Class 12454.
b. Schedule: 80.
c. Fittings: ASTM D2467, Schedule 80, socket.
d. Flanges: Comply with ASME B16.5, rated for maximum 150 psig working pressure.

B. PVC Tube and Fittings:

1. Tube:

a. Type: Clear.
b. Size and Wall Thickness: As indicated in piping schedule.
c. Pressure Rating: As indicated on Drawings.

2. Fittings:

a. Type: Compression.
b. Materials: Suitable for application.

3. Threads:

a. Type: Straight.
b. Comply with ASME B1.1.

2.2 FINISHES

A. Coat machined faces of metallic flanges with temporary rust-inhibitive coating.

2.3 ACCESSORIES

A. PVC Piping:

1. Flange Bolting:

a. Hex-Head Bolts: Stainless steel; ASTM F593 Grade 316.
b. Hex-Head Nuts: Stainless steel; ASTM F594 Grade 316.

2. Flange Gaskets:

a. Type: Full faced.
b. Material: EPDM.
c. Comply with ASME B16.21.

3. Solvent Cement:

a. Comply with ASTM D2564.
b. Formulated for use with sodium hypochlorite and other caustic solutions.
c. Primers: Comply with ASTM F656.] manufactured by the solvent weld cement manufacturer.

2.4 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed pipe sections

B. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Drawings.

B. Inspect existing flanges for nonstandard bolt hole configurations or design and verify that new pipe and flange mate properly.

3.2 PREPARATION

A. See Section 01730 “Execution” for installation preparation requirements.

B. Ream pipe ends, remove burrs, and bevel plain-end pipe.

C. Thoroughly clean pipe and fittings before installation.

D. Cleaning: Clean surfaces to remove foreign substances.

3.3 INSTALLATION

A. Comply with ASME B31.3 and B31.9.

B. Run piping straight along alignment as indicated on Drawings, with minimum number of joints.

C. Fittings:

1. According to manufacturer instructions.
2. Gaskets:

    a. Clean seats thoroughly.
    b. Wipe gaskets clean prior to installation.

3. Tighten bolts progressively, drawing up bolts on opposite sides until bolts are uniformly tight; use torque wrench to tighten bolts to manufacturer instructions.

D. Provide required upstream and downstream clearances from devices as indicated.

E. Install piping with sufficient slopes for venting or drainage of liquids and condensate to low points.

F. Support exposed piping as specified in Section 15140 - Hangers and Supports for Process Piping.

G. Provide expansion joints as specified in Section 15062 - Couplings, Adapters, and Specials for Process Piping, and provide pipe guides as specified in Section 15140 - Hangers and Supports for Process Piping, to compensate for pipe expansion due to temperature differences.

H. Field Cuts: According to pipe manufacturer instructions.

I. Joining:

1. Heat Joining: Comply with ASTM D2657.

    a. Butt-fusion joints to be done by a factory-qualified joining technician as designated by the pipe manufacturer.
    b. Field Samples: join two sample welds on each size of pipe to be installed using the same fusion welding equipment that will be used for completion of the entire work. These sample welds will be compared to the manufacturer’s sample previously submitted in accordance with Part 1.
    c. Pipe joints with beads in excess of 3/16-in will not be approved by the Engineer.

2. Electrofusion: Comply with ASTM F1290.
3. Primers and Cleaners: Comply with ASTM F402.
4. PVC Solvent-Cemented Joints: Comply with ASTM D2855.

J. Insulation: As indicated on the Drawings and in the piping schedule].

K. Underground Piping: As specified in Section 02622 “Buried Polyvinyl Chloride Pipe and Fittings”.

3.4 FIELD QUALITY CONTROL

A. Inspection:

1. Inspect for piping defects that may be detrimental as determined by the Engineer.
2. Repair damaged piping, or provide new, undamaged pipe.
3. After installation, inspect for proper supports and interferences.

B. Pressure Testing:

1. All pipe and fittings to be pressure tested using water to test pressure as specified in the piping schedule in Paragraph 1.8 above. Test pressure to be 150 percent of maximum operating pressure or not less than 150 psi if not listed in the schedule.
2. Conduct hydrostatic test for minimum two hours.
3. Filling:

    a. Fill section to be tested with water slowly and expel air from piping at high points.
    b. Install corporation cocks at high points.
    c. Close air vents and corporation cocks after air is expelled.
    d. Raise pressure to specified test pressure.

4. Observe joints, fittings, and valves under test.
5. Correct all leakage and repair all damage to the pipe and pipe appurtenances. Repair all leaks and retest.

3.5 CLEANING

A. Keep pipe interior clean as installation progresses.

B. Clean pipe interior of soil, grit, shavings, and other debris after pipe installation.

END OF SECTION 15106

SECTION 15108 - COMMON REQUIREMENTS FOR PROCESS VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Common requirements for valves.
2. Common requirements for valve actuators.
3. Valve tags.

B. Related Requirements:

1. Section 03300 “Cast-in-Place Concrete” for execution requirements for placement of concrete as required by this Section.
2. Section 05502 “Metal Fabrications” for miscellaneous metalwork and fasteners specified by this Section.
3. Section 09910 “Painting” for product and execution requirements for painting specified by this Section.
4. Section 15140 “Hangers and Supports for Process Piping” for product and execution requirements for valve supports specified by this Section.
5. Section 11289 “Actuators for Process Valves and Gates.”
6. Section 15100 “Low-Voltage Motor Requirements for Process Equipment” for single- and three-phase motor requirements for equipment specified in this Section.

1.3 COORDINATION

A. Coordinate Work of this Section with individual process valve specifications.

1.4 ACTION SUBMITTALS

A. Valve Schedule:

1. Submit valve schedule populated with all Division 40 process valves specified for this project.
2. Approval of valve schedule submittal to precede all individual valve submittals. All subsequent individual valve submittals to include the approved valve tag number or group on the submittal cover sheet.

B. Valve Tags:

1. Materials, dimensions and thickness of tags, materials and gauge of cable and splicing hardware.
2. Color palate for Owner selection.
3. Full scale drawing of sample with lettering dimensions and scribe depth.
4. Valve tag lettering provided with Valve Schedule.

C. Power Actuator Data:

1. Sizing calculations

a. Provide fluid pressure and velocity sizing basis.
b. Provide maximum valve torque based on disc shape and flow direction.
c. Clearly indicate safety factors and mechanical ratios of any intermediate gearing.

2. Maximum output torque of actuator and intermediate gearing.
3. Details of actuator mounting, including orientation of actuator and intermediate gearing.
4. Dimensional drawing of actuator assembled on valve.
5. Pneumatic/Hydraulic pressure requirements, electrical power supply, plumbing connection sizes and locations.
6. Wiring diagram, control wiring and protocol.
7. Valve cavitation limits for positioning, modulating and control valves mated to power actuator.

D. Shop Drawings: Valve and actuator model number and size, valve parts list, materials of each part including material standard designation (ASTM or other), position indicators, limit switches, actuator mounting.

E. Provide certified hydrostatic test data, per manufacturer's standard procedure or MSS-SP-61 for all valves.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer Instructions: Submit installation and operation instructions for each component including valve, actuator, gearbox, and any included instrumentation.

B. Source Quality-Control Submittals: Indicate results of integrators facility tests and manufacturers factory tests and inspections.

C. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.6 CLOSEOUT SUBMITTALS

A. Section 01650 “Contract Closeout” for submittal requirements.

1.7 QUALITY ASSURANCE

A. Maintain clearances as indicated on Drawings.

B. Ensure that materials of construction of wetted parts are compatible with process liquid.

C. Mate valves to actuators at manufacturer's or integrator's facility. Fully test assembled product and certify ready for installation prior to shipment to the job site.

1. Only in special cases for extremely large assemblies where installation requires disassembly, may actuators be mounted to the valves in the field.

D. Materials in Contact with Potable Water: Certified to NSF 61 and NSF 372.

E. Furnish affidavit of compliance with testing and manufacturing standards referred in this specification and the individual valve specifications.

F. Provide the services of a qualified and factory-trained service representative of the manufacturer to provide installation inspection and check out, and operational and maintenance instruction, for each type of the following equipment for the following durations:

Equipment	Valve Sizes	Installation Inspection	O and M Instruction
480 volt electric actuators	N/A	1 day, 8 hr.	1 day, 8 hr.
Pressure regulating valves	12-in and up	1 day, 8 hr.	1 day, 8 hr.
Pinch valves	12-in and up	1 day, 8 hr.	1 day, 8 hr.

G. Obtain Manufacturer's Certification of Proper Installation for specified valves and valve assemblies.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing valves and actuators with minimum ten years' documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 01600 "Material and Equipment" for requirements for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Deliver factory mated power actuated valves on rigid wooden skids, fully braced and strapped to prevent damage to valve, actuator or coupling system.

D. Store materials according to manufacturer instructions.

E. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Protect valve ends from entry of foreign materials by providing temporary covers and plugs.
3. Provide additional protection according to manufacturer instructions.

1.10 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to materials ordering or any fabrication.
2. Indicate field measurements on Shop Drawings.

1.11 WARRANTY

A. Section 01740 “Warranties” for requirements for warranties.

PART 2 - PRODUCTS

2.1 VALVES

A. Description: Valves, operator, actuator, handwheel, chainwheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and other accessories as required.

B. All valves of the same type shall be the product of one manufacturer

C. Valve Ends: Compatible with adjacent piping system and as indicated in Contract Documents.

D. Operation:

1. Close by turning clockwise.
2. Cast directional arrow on valve or actuator with OPEN and CLOSE cast on valve in appropriate location.

E. Valve Marking and Labeling:

1. Marking: Comply with MSS SP-25.
.
2. Labeling or tagging as indicated on P&IDs.

F. Valve Construction: As Specified in Valve Sections.

G. Van Stone flanges shall not be used with pinch valves, industrial butterfly valves; elastomer bellows style expansion joints or other piping system components having an elastomer liner (rubber seat) that is used as a gasket.

2.2 VALVE ACTUATORS

A. Provide actuators as indicated on the Drawings**.**

B. Provide mechanical position indicators for power actuated and gearbox actuated valves.

C. Comply with AWWA C541 (Pneumatic and Hydraulic actuators) and C542 (Electric Motor Actuators) as applicable.

D. Provide chain actuators for shutoff valves mounted greater than 7feet above operating floor level.

E. Gear and Power actuators as specified in Section 11289.00 – Actuators for Process Valves and Gates.

2.3 VALVE BOXES

A. Manufacturers:

1. Ford Meter Box Co., Inc., Mueller Co., or Tyler Utilities; Union Foundry Company.

B. Valve boxes and covers, including position indicators and valve extensions.

1. Type: Extension, with slide adjustment.
2. Heavy-pattern cast iron, three-piece, telescoping type box with dome base suitable for installation on the buried valves.

    a. Inside Diameter: 4-1/2 inch.
    b. Barrel Length: Adapted to depth of cover, with a 6-inchlap when in the most extended position.
    c. Covers: Cast iron with integrally-cast direction-to- open arrow.
    d. A means of lateral support for the valve extension shafts in top portion of valve box.

3. Upper sections of boxes have top flanges of sufficient bearing area to prevent settling. The oval bottoms of lower sections enclose the stuffing box and operating nut of the valve.
4. Cover Mark: PLANT WATER, CITY WATER, GAS, or SEWER, as required, to indicate utility.
5. Extension Shafts: Type 304 stainless steel. Provide a factor of safety of four.

    a. Operating Nut: 2-inch square. Top of nut located 2-inch below the rim of the valve box. Pinned to the shafts. Manufacturer will furnish an approved operating wrench or operating key.

6. Fasteners: Type 304 stainless steel.

2.4 INSULATION

A. Insulate all valves installed in insulated piping systems as part of the Work.

2.5 FINISHES

A. Valve Coating: Comply with AWWA C550.

B. Factory finishes are included in individual valve sections.

C. Exposed Primed Valves: As specified in Section 09910 - Painting.

D. Stainless Body Valves: Do not coat.

E. Do not coat flange faces of valves unless otherwise specified.

2.6 SOURCE QUALITY CONTROL

A. Testing: Test valves according to manufacturer's standard testing protocol, including hydrostatic, seal, and performance testing.

B. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that piping system is ready for valve installation.

B. Fully examine valves for debris, damage and interior finish blemishes prior to installation. Do not install valves with soiled interior or any visible damage to seats, discs or interior finish.

C. Identify any piping, plant or equipment clearance issues prior to installation, bring to Engineer’s attention via job meetings, submittal process or request for information process.

3.2 INSTALLATION

A. Install valves, actuators, extensions, valve boxes, and accessories according to manufacturer instructions.

B. Inspect valve interiors before line closure for the presence of debris. At the option of the Engineer, internal inspection of valve and appurtenances may be required any time that the

likelihood of debris is a possibility. Clean connecting pipes prior to installation, testing, disinfection and final acceptance.

C. Disinfect valves installed in potable water lines with approved pipeline disinfection process.

D. Rigidly support valves to avoid stresses on piping.

E. Coat studs, bolts and nuts with anti-seizing lubricant.

F. Dielectric Fittings: Provide between dissimilar metals.

G. Clean field welds of slag and splatter to provide a smooth surface.

H. Mate, adjust and fully test gearboxes, electric, hydraulic and pneumatic actuators to valves at manufacturer's or integrator's facility.

1. Only in special cases for extremely large assemblies where installation requires disassembly may actuators be mounted to the valves in the field. These circumstances require preinstallation meetings.

I. In no case shall stems be installed vertically downward.

J. Unless otherwise indicated on the Drawings:

1. Install Gate, Globe, Ball valves with stem vertical in the 12 o'clock position.
2. Install Plug valves with stem horizontal and plug opening to the top of the body unless position will not allow proper actuator access, in which case stem may be vertical in the 12 o'clock position.
3. Install Butterfly valves 12 inch and smaller with stem horizontal or vertical in the 12 o'clock position,
4. Install Butterfly valves 14 inch and larger with the stem horizontal unless position will not allow proper actuator access, in which case stem may be vertical in the 12 o'clock position.
5. Install Control valves in horizontal pipelines with top works vertically upward.

K. Install all brackets, extension rods, guides, the various types of operators and appurtenances as indicated. Before properly setting these items, check all drawings and figures which have a direct bearing on their location.

L. Inspect all materials for defects in construction and materials. Clean debris and foreign material out of openings, etc. Valve flange covers shall remain in place until connected piping is in place. Verify operability of all operating mechanisms for proper functioning. Check all nuts and bolts for tightness. Repaired or replace valves and other equipment which do not operate easily or are otherwise defective.

M. Where installation is covered by a referenced standard, installation shall be in accordance with that standard, except as herein modified, and the Contractor shall certify such. Also note additional requirements in other parts of this Section.

N. Unless otherwise noted, joints for valves and appurtenances shall be made up utilizing the same procedures as specified under the applicable type connecting pipe joint. Install valves and other

items as recommended by the manufacturer. Verify manufacturers' torqueing requirements for all valves.

O. Coordinate direction of flow through offset type and shaped butterfly valve discs with the mated actuator torque capacity.

P. Rotate valve operators and indicators to display toward normal operation locations. Consult with Engineer prior to installing valves with handwheels to confirm final position of handwheel.

Q. Vertically center floor boxes, valve boxes, extension stems, and low floor stands over the operating nut, with couplings as required.

1. Adjust elevation of the box top to conform to the elevation of the finished floor surface or grade at the completion of the Contract.
2. Support boxes and stem guides during concrete placement to maintain vertical alignment.

R. Install brass male adapters on each side of valves in copper-piped system and solder adapters to pipe.

S. Install 1-inch ball valves with cap for drains at main shutoff valves, low points of piping, bases of vertical risers, and equipment.

T. Install valves with clearance for installation of insulation and to allow access.

U. Provide access where valves and fittings are not accessible.

V. Pipe Hangers and Supports: As specified in Section 15140 “Hangers and Supports for Process Piping.”

W. Comply with Division 15 - Mechanical for piping materials applying to various system types.

X. Install insulation as indicated on Drawings.

3.3 FIELD QUALITY CONTROL

A. Section 01700 “Startup and Demonstration Testing” - Requirements for testing, adjusting, and balancing.

B. Valve Field Testing:

1. Test for proper alignment.
2. If specified by valve Section, field test equipment to demonstrate operation without undue noise, vibration, or overheating.
3. Engineer will witness field testing.
4. Functional Test:

a. Prior to system startup, inspect valves and actuators for proper alignment, quiet operation, proper connection and satisfactory performance.
b. After installation, open and close all manual valves in the presence of the Engineer to show the valve operates smoothly from full open to full close and without leakage.

c. Cycle valves equipped with electric, pneumatic or hydraulic actuators 5 times from full open to full closed in the presence of the Engineer to exhibit operation without vibration, jamming, leakage, or overheating.
d. Operate pressure control and pressure relief valves in the presence of the Engineer to show they perform their specified function at some time prior to placing the piping system in operation and as agreed during construction coordination meetings.

5. Field test pipe lines in which the valves and appurtenances are to be installed. During these tests, adjust, remove or replace defective valve or appurtenance, or otherwise make acceptable to the Engineer. Test regulating valves, strainers, or other appurtenances to demonstrate conformance with the specified operational capabilities. Correct deficiencies, replace device or otherwise made acceptable to the Engineer.

SECTION 15114 - AIR RELEASE VALVES FOR WASTEWATER SERVICE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: Air release valves for wastewater treatment facilities.

B. Related Requirements:

1. Section 09900 “Painting and Coating” for preparing, priming, and painting surfaces, including field-applied and equipment finishing.
2. Section 15140 “Hangers and Supports for Process Piping” for anchors and supports.
3. Section 15108 “Common Requirements for Process Valves” for typical product and installation requirements for valves specified in this Section.

1.3 COORDINATION

A. Coordinate Work of this Section with installation of process piping.

1.4 PREINSTALLATION MEETINGS

A. Section 15108 “Common Requirements for Process Valves.”

1.5 SUBMITTALS

A. Product Data: Submit manufacturer catalog information.

B. Shop Drawings: Indicate on assembly drawings materials, dimensions, weights, and end connections.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

D. Manufacturer Instructions: Submit special procedures and setting dimensions.

E. Source Quality-Control Submittals: Indicate results of factory tests and inspections and provide required certifications.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Manufacturer Reports: Certify that equipment has been installed according to manufacturer instructions.

H. Qualifications Statements:

1. Submit qualifications for manufacturer and installer.
2. Submit manufacturer's approval of installer.

I. American Iron and Steel (AIS): Submit certification indicating compliance with AIS requirements.

1.6 CLOSEOUT SUBMITTALS

A. Section 01770 “Closeout Procedures” for requirements for submittals.

B. Project Record Documents: Record actual locations of air release valves.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum five years' documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Furnish temporary end caps and closures on piping and fittings and maintain in place until installation.
3. Provide additional protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.10 WARRANTY

A. Section 01650 “Contract Closeout” for requirements for warranties.

B. Furnish five-year manufacturer's warranty for air release valves.

PART 2 - PRODUCTS

2.1 AIR RELEASE VALVES FOR WASTEWATER SERVICE – Tag Type ASR

A. Manufacturers:

1. RF Valves, Inc. (Vent-O-Mat)
2. Val-Matic Valve & Manufacturing Corp.
3. Substitutions: As specified in Section 01600 - Product Requirements.

B. Description:

1. Stems and Bodies: Long-float type to minimize clogging.
2. Small orifice assembly air release valves shall automatically release air accumulations from pipe while under positive pressure. When valve body fills with air, float mechanism shall fall to open small orifice and exhaust air to atmosphere. When air has been exhausted, float mechanism shall be buoyed up and shall tightly close small orifice.
3. Shall be specifically designed for secondary sludge service without the need for backwashing.
4. Air release valves shall be supplied with shutoff gate, butterfly or ball valves.

C. Materials:

1. Body and Cover: Ductile iron
2. Float: Type 316 stainless steel
3. Seat: Type 316 stainless steel
4. Internal Trim: Type 316 stainless steel
5. Hardware: Type 316 stainless steel

D. Working Pressure: 150 psig.

E. Size: As indicated in valve schedule.

F. End Connections:

1. Size 1/2 to 3 Inches: Threaded.
2. Size 4 Inches and Larger: Flanged.

2.2 INSULATION

A. As indicated on Drawings

2.3 FINISHES

A. Prepare piping appurtenances for field finishes as specified in Section 099000 - Painting and Coating.

2.4 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly.

B. Certificate of Compliance:

1. If fabricator is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at fabricator's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved fabricator.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Drawings.

B. Inspect existing flanges for nonstandard bolthole configurations or design and verify that new pipe and flanges mate properly.

3.2 PREPARATION

A. Thoroughly clean end connections before installation.

B. Close pipe and equipment openings with caps or plugs during installation.

C. Cleaning: Clean surfaces to remove foreign substances.

3.3 INSTALLATION

A. According to manufacturer instructions.

B. Provide access for operation, removal, and maintenance, and to avoid discharge to occupied areas or other equipment.

C. Vent the valve properly and pipe outlet to nearest tank as directed by the Engineer.

3.4 FIELD QUALITY CONTROL

A. Inspect for interferences and proper supports.

B. Testing:

1. As specified in Section 15108 “Common Requirements for Process Valves.”
2. Demonstrate operation without undue noise or vibration.

C. Manufacturer Services: Furnish services of manufacturer's representative experienced in installation of products furnished under this Section for not less than one day on Site for installation, inspection, startup, field testing, and instructing Owner's personnel in operation and maintenance of equipment.

D. Equipment Acceptance:

1. Adjust, repair, modify, or replace components failing to perform as specified and rerun tests.
2. Make final adjustments to equipment under direction of manufacturer's representative.
3. Repair damaged coatings with material equal to original coating.

E. Furnish installation certificate from equipment manufacturer's representative attesting that equipment has been properly installed and is ready for startup and testing.

3.5 CLEANING

A. Sections 01730 “Execution” and 01770 “Closeout Procedures”: Requirements for cleaning.

B. Keep interior of air release valves clean as installation progresses.

3.6 DEMONSTRATION

A. Demonstrate equipment startup, shutdown, routine maintenance, and emergency repair procedures to Owner's personnel.

END OF SECTION 15114

SECTION 15117 - SOLENOID VALVES FOR PROCESS SERVICE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: Solenoid valves for process applications.

B. Related Requirements:

1. Section 15108 “Common Requirements for Process Valves” for basic materials and methods related to valves commonly used for process systems.
2. Section 13614 “Process Control Descriptions” for functional description of local control stations.

1.3 COORDINATION

A. Coordinate Work of this Section with process piping Work as specified in other Sections and as indicated on Drawings. Note that solenoid valves may be shown on Electrical and/or Mechanical Drawings, or may only be specified, but if so specified or shown, shall be provided. Solenoid valves located in hazardous classified areas shall be provided with electrical enclosures which satisfy the electrical classification as specified or shown on the electrical drawings.

1.4 ACTION SUBMITTALS

A. Product Data: Submit manufacturer information, indicating materials of construction, wiring diagrams, and compliance with indicated standards.

B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

B. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

C. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

D. Qualifications Statement:

1. Submit qualifications for manufacturer.

1.6 QUALITY ASSURANCE

A. Materials in Contact with Potable Water: Certified to NSF 61 and NSF 372.

B. Maintain one copy of each standard affecting Work of this Section on Site.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.10 WARRANTY

A. Section 01770 “Closeout Procedures” for requirements for warranties.

B. Furnish five-year manufacturer's warranty for solenoid valves.

PART 2 - PRODUCTS

2.1 SOLENOID VALVES – Tag Type SV

A. Manufacturers:

1. Solenoid valves less than 2": Red Hat by Automatic Switch Co., ASCO Valve, similar by Circle Seal Controls-Atkomatic Valve Co.
2. Solenoid valves 2" or greater: Type A by Magnatrol Valve Corp
3. Substitutions: As specified in Section 01600 - Product Requirements.

B. Description:

1. Type: As indicated on Drawings.
2. Minimum Working Pressure: 150 psig
3. Minimum Working Pressure Differential: 0 psig.
4. Coil: Continuous duty.
5. Operation: Fail close, energize to open.
6. Enclosures: NEMA 250 Type 4 rated according to area designation.
7. Electrical Characteristics: As indicated on Drawings.
8. End Connections: Screwed.
9. Conduit Connection: Threaded.
10. Valves 2" in size or larger shall include a manual override actuated by a handle-levered plunger mounted to the bottom of the valve body. These valves must be mounted in a horizontal run of piping, with the solenoid up in the vertical position.

C. Materials:

1. Body: Brass.
2. NPT end connections of connected piping
3. Type 304 stainless steel internal parts
4. Buna-N or Ethylene Propylene valve seats.
5. Connections shall be threaded

D. Controls:

1. Provide solenoid valve local control stations (LCS) where shown on the Process and Instrumentation Diagrams (P&IDs).
2. LCS Enclosure Rating: Refer to Electrical Drawings.
3. Functional Description and Control Devices:

    a. Refer to P&IDs for all control devices.
    b. Refer to Section 13614 "Process Control Descriptions" for a functional description of all LCS controls.

2.2 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly.

B. Owner Inspection:

1. Make completed solenoid valves available for inspection at manufacturer's factory prior to packaging for shipment.
2. Notify Owner at least seven days before inspection is allowed.

C. Owner Witnessing:

1. Allow witnessing of factory inspections and test at manufacturer's test facility.
2. Notify Owner at least seven days before inspections and tests are scheduled.

D. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. As specified in Section 15108 “Common Requirements for Process Valves.”

B. Install protective strainers upstream of solenoid valves, pressure-reducing valves, and pressure-sustaining valves.

3.2 FIELD QUALITY CONTROL

A. As specified in Section 15108 “Common Requirements for Process Valves.”

END OF SECTION 15117

SECTION 15131 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for water service

B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.3 DEFINITIONS

A. EPDM: Ethylene propylene diene terpolymer rubber.

B. LLDPE: Linear, low-density polyethylene plastic.

C. PA: Polyamide (nylon) plastic.

D. PE: Polyethylene plastic.

E. PP: Polypropylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

H. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

1. Wiring Diagrams: Power, signal, and control wiring for alarms.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with ASTM F645 for selection, design, and installation of thermoplastic water piping.

E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

1. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.9 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:

1. Notify Engineer and Owner no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without Engineer's and Owner's written permission.

1.10 COORDINATION

A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in “Piping Application” Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

2.2 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B88, Type L, water tube, annealed temper.

1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
2. Copper, Pressure-Seal Fittings:

    a. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
    b. NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

B. Hard Copper Tube: ASTM B88, Type L, water tube, drawn temper.

1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

C. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.

D. Copper Unions:

E. MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

C. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.

1. Grooved-End, Ductile-Iron Pipe Appurtenances:

    a. Grooved-End, Ductile-Iron Fittings: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions matching pipe.

b. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

D. Flanges: ASME 16.1, Class 125, cast iron.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8, BCuP Series.

B. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

C. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.5 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Flexible Connectors:

1. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
2. Ferrous-Metal Piping: Stainless-steel hose covered with stainless-steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.

C. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:

a. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 125 psig minimum at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

a. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 150 psig
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

    a. Description:

        1) Nonconducting materials for field assembly of companion flanges.
        2) Pressure Rating: 150 psig
        3) Gasket: Neoprene or phenolic.
        4) Bolt Sleeves: Phenolic or polyethylene.
        5) Washers: Phenolic with steel backing washers.

5. Dielectric Nipples:

    a. Description:

        1) Standard: IAPMO PS 66
        2) Electroplated steel nipple complying with ASTM F1545.
        3) Pressure Rating: 300 psig at 225 deg F
        4) End Connections: Male threaded or grooved.
        5) Lining: Inert and noncorrosive, propylene.

6.

2.6 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Nonrising-Stem, Metal-Seated Gate Valves:

    a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.

        1) Standard: AWWA C500.
        2) Minimum Pressure Rating: 200 psig.
        3) End Connections: Mechanical joint.
        4) Interior Coating: Complying with AWWA C550.

2. Nonrising-Stem, Resilient-Seated Gate Valves:

    a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.

        1) Standard: AWWA C509.
        2) Minimum Pressure Rating: 200 psig.
        3) End Connections: Mechanical joint.
        4) Interior Coating: Complying with AWWA C550.

3. Nonrising-Stem, High-Pressure, Resilient-Seated Gate Valves:

    a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.

        1) Standard: AWWA C509.

2) Minimum Pressure Rating: 250 psig.
3) End Connections: Push on or mechanical joint.
4) Interior Coating: Complying with AWWA C550.

4. OS&Y, Rising-Stem, Metal-Seated Gate Valves:

a. Description: Cast- or ductile-iron body and bonnet, with cast-iron double disc, bronze disc and seat rings, and bronze stem.

1) Standard: AWWA C500.
2) Minimum Pressure Rating: 200 psig.
3) End Connections: Flanged.

5. OS&Y, Rising-Stem, Resilient-Seated Gate Valves:

a. Description: Cast- or ductile-iron body and bonnet, with bronze or gray- or ductile-iron gate, resilient seats, and bronze stem.

1) Standard: AWWA C509.
2) Minimum Pressure Rating: 200 psig.
3) End Connections: Flanged.

6. UL/FMG, Cast-Iron Gate Valves: UL/FMG, Nonrising-Stem Gate Valves:

a. Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig.
3) End Connections: Flanged.

7. OS&Y, Rising-Stem Gate Valves:

a. Description: Iron body and bonnet and bronze seating material.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig.
3) End Connections: Flanged.

B. Bronze Gate Valves:

1. OS&Y, Rising-Stem Gate Valves:

a. Description: Bronze body and bonnet and bronze stem.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig.
3) End Connections: Threaded.

2. Nonrising-Stem Gate Valves:

a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.

1) Standard: MSS SP-80.

2.7 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:

1. Description: Sleeve and valve compatible with drilling machine.

a. Standard: MSS SP-60.
b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
c. Valve: AWWA, cast-iron, nonrising-stem, resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches in diameter.

1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.8 CHECK VALVES

A. AWWA Check Valves:

1. Description: Swing-check type with resilient seat. Include interior coating according to AWWA C550 and ends to match piping.

a. Standard: AWWA C508.
b. Pressure Rating: 175 psig.

B. UL/FMG, Check Valves:

1. Description: Swing-check type with pressure rating; rubber-face checks, unless otherwise indicated; and ends matching piping.

a. Standards: UL 312 and FMG approved.
b. Pressure Rating: 175 psig.

2.9 DETECTOR CHECK VALVES

1. Detector Description: Galvanized cast-iron body, bolted cover with air-bleed device for access to internal parts, and flanged ends. Include one-piece bronze disc with bronze bushings, pivot, and replaceable seat. Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.

    a. Standards: UL 312 and FMG approved.
    b. Pressure Rating: 175 psig.
    c. Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.

2. Description: Iron body, corrosion-resistant clapper ring and seat ring material, flanged ends, with connections for bypass and installation of water meter.

    a. Standards: UL 312 and FMG approved.
    b. Pressure Rating: 175 psig.

2.10 WATER METERS

A. Water meters will be furnished by utility company.

2.11 PRESSURE-REDUCING VALVES

A. Water Regulators:
    1. Standard: ASSE 1003.
    2. Pressure Rating: Initial pressure of 150 psig.

2.12 VACUUM BREAKERS

A. Pressure Vacuum Breaker Assembly:
    1. Standard: ASSE 1020.
    2. Operation: Continuous-pressure applications.
    3. Pressure Loss: maximum, through middle 1/3 of flow range.
    4. Size: 2 inch.
    5. Accessories: Ball valves on inlet and outlet.

2.13 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

    1. Standard: ASSE 1013
    2. Operation: Continuous-pressure applications.
    3. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
    4. Size: 3 inch.

B. Backflow Preventer Test Kits:

1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 02300 "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

E. Underground water-service piping NPS 3/4 to NPS 3 shall be any of the following:

1. Soft copper tube, ASTM B88, Type K; wrought-copper, solder-joint fittings; and brazed or copper, pressure-seal fittings; and pressure-sealed joints.

F. Underground water-service piping NPS 4 to NPS 8 shall be any of the following:

1. Soft copper tube, ASTM B88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

2. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.

3. Hard copper tube, ASTM B88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

G. Underground Fire-Service-Main Piping NPS 4 to NPS 12 shall be any of the following:

1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.

H. Underground Combined Water-Service and Fire-Service-Main Piping NPS 6 to NPS 12 shall be any of the following:

1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

3.4 PIPING INSTALLATION

A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

C. Make connections larger than NPS 2 with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

D. Make connections NPS 2 and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

E. Comply with NFPA 24 for fire-service-main piping materials and installation.

F. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

G. Sleeves are specified in Section 15013 "Sleeves and Sleeve Seals for Plumbing Piping."

H. Mechanical sleeve seals are specified in Section 15013 "Sleeves and Sleeve Seals for Plumbing Piping."

I. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

J. See Section 15132 "Domestic Water Piping" for potable-water piping inside the building.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices specified in Section 15031 "Hangers and Supports for Plumbing Piping and Equipment."

B. Install hangers for copper tubing with maximum spacing and minimum rod diameters to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting and coupling.

D. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 JOINT CONSTRUCTION

A. Make pipe joints according to the following:

1. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
2. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
3. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
4. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
5. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
6. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
7. Bonded-Joint Fiberglass, Water-Service Piping: According to AWWA M45.
8. Fire-Service-Main Piping: According to NFPA 24.

B. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.7 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.

E. MSS Valves: Install as component of connected piping system.

3.8 ROUGHING-IN FOR WATER METERS

A. Rough-in piping and specialties for water meter installation according to utility company's written instructions.

3.9 VACUUM BREAKER ASSEMBLY INSTALLATION

A. Install pressure vacuum breaker assemblies of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install pressure vacuum breaker assemblies in vault or other space subject to flooding.

3.10 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.11 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install ball drip valves at each check valve for fire department connection to mains.

B. Install protective pipe bollards on two sides of fire department connection. Pipe bollards are specified in Section 05502 "Metal Fabrications."

3.12 ALARM DEVICE INSTALLATION

A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.

B. Supervisory Switches: Supervise valves in open position.

1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.

C. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

3.13 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.

1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.14 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 02300 "Earthwork."

B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel.

3.15 CLEANING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:

    a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.

b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 15131

SECTION 15132 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Piping joining materials.
3. Encasement for piping.
4. Transition fittings.
5. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

C. Comply with NSF 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B88, Type K water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

G. Copper Pressure-Seal-Joint Fittings:

1. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
2. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

H. Copper-Tube, Extruded-Tee Connections:

1. Description: Tee formed in copper tube according to ASTM F2014.

I. Appurtenances for Grooved-End Copper Tubing:

1. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B75/B75M copper tube or ASTM B584 bronze castings.
2. Mechanical Couplings for Grooved-End Copper Tubing:

a. Copper-tube dimensions and design similar to AWWA C606.
b. Ferrous housing sections.

c. EPDM-rubber gaskets suitable for hot and cold water.
d. Bolts and nuts.
e. Minimum Pressure Rating: 300 psig.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys.

D. Flux: ASTM B813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F493.

G. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

H. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 ENCASEMENT FOR PIPING

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Form: Sheet or tube.

C. Color: Black or natural.

2.5 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Standard: ASSE 1079.
2. Pressure Rating: 125 psig minimum at 180 deg F.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Standard: ASSE 1079.
2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Nonconducting materials for field assembly of companion flanges.
2. Pressure Rating: 150 psig.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Standard: IAPMO PS 66.
2. Electroplated steel nipple complying with ASTM F1545.
3. Pressure Rating and Temperature: 300 psig at 225 deg F.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 02300 "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube andductile-iron pipe in PE encasement according to ASTM A674 or AWWA C105/A21.5.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 15015 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 15135 "Domestic Water Piping Specialties."

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install domestic water piping level without pitch and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

J. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

L. Install piping to permit valve servicing.

M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

N. Install piping free of sags and bends.

O. Install fittings for changes in direction and branch connections.

P. Install PEX tubing with loop at each change of direction of more than 90 degrees.

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 15015 "Meters and Gages for Plumbing Piping."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15013 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15013 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15014 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

H. Extruded-Tee Connections: Form tee in copper tube according to ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

I. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

J. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

K. Joint Construction for Grooved-End Steel Piping: Make joints according to AWWA C606. Square cut or roll groove ends of pipe as specified. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

L. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

M. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
3. PVC Piping: Join according to ASTM D2855.

N. Joints for PEX Tubing: Join according to ASTM F1807 for metal insert and copper crimp ring fittings and ASTM F1960 for cold expansion fittings and reinforcing rings.

O. Joints for PEX Tubing: Join according to ASSE 1061 for push-fit fittings.

P. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers, supports, and anchor devices in Section 15031 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for copper ductile iron tubing and piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of copper ductile iron tubing and piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support vertical runs of PEX tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 15035 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

   a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

      1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
      2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

   c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

   a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
   f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

    a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
    b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Fill and isolate system according to either of the following:

        1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
        2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

    c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
    d. Repeat procedures if biological examination shows contamination.
    e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:

1. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. Hard copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
3. Hard copper tube, ASTM B88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:

1. Hard copper tube, ASTM B88, Type L; cast-copper, solder-joint fittings; and brazed joints.
2. Hard copper tube, ASTM B88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.

F. Aboveground domestic water piping, NPS 5 to NPS 8, shall be one of the following:

1. Hard copper tube, ASTM B88, Type L; cast-copper, solder-joint fittings; and brazed joints.
2. Hard copper tube, ASTM B88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 15132

SECTION 15135 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers.
7. Hose stations.
8. Hose bibbs.
9. Wall hydrants.
10. Drain valves.
11. Water-hammer arresters.
12. Air vents.
13. Trap-seal primer systems.
14. Water meters.

B. Related Requirements:

1. Section 15015 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 15132 "Domestic Water Piping" for water meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Standard: ASSE 1001.
2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
3. Body: Bronze.
4. Inlet and Outlet Connections: Threaded.
5. Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers:

1. Standard: ASSE 1011.
2. Body: Bronze, nonremovable, with manual drain.
3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
4. Finish: Rough bronze.

C. Pressure Vacuum Breakers:

1. Standard: ASSE 1020.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 5 psig maximum, through middle third of flow range.
4. Size: .
5. Design Flow Rate: .
6. Selected Unit Flow Range Limits: .
7. Pressure Loss at Design Flow Rate: .
8. Accessories:

    a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Standard: ASSE 1012.
2. Operation: Continuous-pressure applications.
3. Size: NPS 3/4.
4. Body: Bronze.
5. End Connections: Union, solder joint.
6. Finish: Rough bronze.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Standard: ASSE 1013.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig maximum, through middle third of flow range.
4. Size: As shown on plans.
5. Design Flow Rate: .
6. Selected Unit Flow Range Limits: .
7. Pressure Loss at Design Flow Rate: for sizes NPS 2 and smaller; for NPS 2-1/2 and larger.
8. Body: Bronze for NPS 2and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
9. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
10. Configuration: Designed for horizontal, straight-through flow.
11. Accessories:

    a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
    c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Hose-Connection Backflow Preventers:

1. Standard: ASSE 1052.
2. Operation: Up to 10-foot head of waterback pressure.
3. Inlet Size: NPS 1/2 or NPS 3/4.
4. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
5. Capacity: At least 3-gpm flow.

D. Backflow-Preventer Test Kits:

1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Standard: ASSE 1003.

2. Pressure Rating: Initial working pressure of 150 psig.
3. Size: .
4. Design Flow Rate: .
5. Design Inlet Pressure: .
6. Design Outlet Pressure Setting: .
7. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water-Control Valves:

1. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
2. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
3. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.

    a. Size: .
    b. Pattern: Globe-valve design.
    c. Trim: Stainless steel.

4. Design Flow:
5. Design Inlet Pressure:
6. Design Outlet Pressure Setting:
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.6 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Type: Y-pattern globe valve with two readout ports and memory-setting indicator.
2. Body: bronze.
3. Size: Same as connected piping, but not larger than NPS 2.
4. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Standard: ASSE 1017.
2. Pressure Rating: 125 psig.
3. Type: Thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Valve Finish: Rough bronze.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:

    a. Strainers NPS 2 and Smaller: 0.020 inch.
    b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.

6. Drain: Factory-installed, hose-end drain valve.

2.9 HOSE STATIONS

A. Single-Temperature-Water Hose Stations:

1. Standard: ASME A112.18.1.
2. Cabinet: Stainless steel enclosure with exposed valve handle, hose connection, and hose rack. Include thermometer in front.
3. Hose-Rack Material: Stainless steel.
4. Body Material: Bronze with stainless steel wetted parts.
5. Body Finish: Rough bronze.
6. Mounting: Wall, with reinforcement.
7. Supply Fittings: NPS 3/4gate, globe, or ball valve and check valve and NPS 3/4copper, water tubing. Omit check valve if check stop is included with fitting.
8. Hose: Manufacturer's standard, for service fluid, temperature, and pressure; 50 feetlong.
9. Nozzle: With hand-squeeze, on-off control.
10. Vacuum Breaker:

    a. Integral or factory-installed, nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7 on outlet.

2.10 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.

7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Operating key.
12. Operation for Service Areas: Operating key.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.11 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: NPS 3/4
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze.
9. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
10. Nozzle and Wall-Plate Finish: Rough bronze.
11. Operating Keys(s): One with each wall hydrant.

2.12 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.

3. Size: NPS 3/4.
4. Body: ASTM B62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.13 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: Copper tube with piston.
3. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.14 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 degrees F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.15 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

1. Standard: ASSE 1044.
2. Piping: NPS 3/4, ASTM B88, Type L; copper, water tubing.
3. Cabinet: Surface-mounted steel box with stainless steel cover.
4. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.

a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

5. Vacuum Breaker: ASSE 1001.
6. Number Outlets: Eight.
7. Size Outlets: NPS 1/2.

2.16 WATER METERS

A. Displacement-Type Water Meters:

1. Description:

a. Standard: AWWA C700.
b. Pressure Rating: 150-psigworking pressure.
c. Body Design: Nutating disc; totalization meter.
d. Registration: In gallons or cubic feet as required by utility company.
e. Case: Bronze.
f. End Connections: Threaded.

B. Turbine-Type Water Meters:

1. Description:

a. Standard: AWWA C701.
b. Pressure Rating: 150-psigworking pressure.
c. Body Design: Turbine; totalization meter.
d. Registration: In gallonsor cubic feet as required by utility company.
e. Case: Bronze.
f. End Connections for Meters NPS 2and Smaller: Threaded.
g. End Connections for Meters NPS 2-1/2 and Larger: Flanged.

C. Compound-Type Water Meters:

1. Description:

a. Standard: AWWA C702.
b. Pressure Rating: 150-psig working pressure.
c. Body Design: With integral mainline and bypass meters; totalization meter.
d. Registration: In gallons or cubic feet as required by utility company.
e. Case: Bronze.
f. Pipe Connections: Flanged.

D. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

E. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install water regulators with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

C. Install water-control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

F. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve.

G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inchfire-retardant-treated-wood blocking, wall reinforcement between studs.

H. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 06100 "Rough Carpentry."

I. Install water-hammer arresters in water piping according to PDI-WH 201.

J. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 16056 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 16052 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
4. Dual-check-valve backflow preventers.
5. Water pressure-reducing valves.
6. Calibrated balancing valves.
7. Primary, thermostatic, water mixing valves.
8. Primary water tempering valves.
9. Outlet boxes.
10. Hose stations.
11. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 15035 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 15135

SECTION 15140 - HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. This specification requires Contractor to delegate pipe support design to a pipe support design engineer hired by the Contractor. Where the Drawings show support types and/or locations, they shall be analyzed for adequacy to support loads and stresses calculated by the pipe support designer, modified if required, installed generally where shown, and integrated with the pipe support system design provided by the Contractor.

C. Section includes delegated-design.

D. Related Requirements:

1. Section 03100 “Concrete Forming and Accessories” for execution requirements for placement of inserts in concrete forms specified by this Section.
2. Section 03300 “Cast-in-Place Concrete” for execution requirements for placement of concrete housekeeping pads specified by this Section.
3. Section 09910 “Painting” for product and execution requirements for painting specified by this Section.
4. Section 15062 “Couplings, Adapters, and Specials for Process Piping.”
5. Section 15103 “Ductile Iron Process Pipe.”
6. Section 15108 “Thermoplastic Pipe.”

1.2 COORDINATION

A. Coordinate Work of this Section with piping and equipment connections specified in other Sections and indicated on Drawings.

1.3 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's catalog data including load capacity.

B. Shop Drawings: Submit scaled piping layouts for each system. Indicate flow stream, pipe size(s) material(s), schedule(s), lining(s), critical dimensions between pipes, equipment and building features. Indicate by schedule pipe hanger/support type and locations. Provide detail of each type of hangers, supports, anchors, and guides.

C. Manufacturers' Instructions: Submit special procedures and assembly of components.

1.4 DELEGATED-DESIGN SUBMITTALS

A. Delegated Design Submittals: Support System Design

1. Engage the services of an independent registered professional engineer licensed in the State of Rhode Island ordinarily engaged in the business of pipe support systems analysis and design, to analyze system piping and service conditions, and to develop a detailed support system design, specific to the piping material, pipe joints, valves, and piping appurtenances proposed for use.

    a. The proposed support system engineer shall have at least 5 years of experience in the analysis and design of similar systems, including the use of commercial and custom pipe supports and in the use of commercial pipe stress software programs.
    b. Engineer pre-approved support system engineering include the following:

        1) Newman Associates, Inc.
        2) J. Blanco Associates, Inc. Hawthorne, NJ
        3) Fenny Engineering Company, Venice, FL
        4) LCI Engineering, Ottawa, Ontario, Canada.

2. The support system design shall include:

    a. Criteria by piping system.
    b. Summary of Contractor-selected related components including joints, class, valves, appurtenances, etc., and commercial supports and especially including pipe materials.
    c. Dead weight and dynamic analysis, including system thermal effects and pressure thrusts. Computer-based software system equivalent to Bentley Systems AutoPIPE or SST Systems CAEPIPE.

        1) Present each system in an isometric graphic and show the resolved and resultant force and moment systems, as well as all recommended hangers, supports, anchors, restraints, and expansion/flexible joints.

    d. Submit a support system design to the Engineer for review. The submittal needs to be stamped by a professional engineer registered in State of Rhode Island.
    e. All aspects of the analysis and design to comply with the provisions of ANSI B31.3 and the referenced standards.
    f. Coordinate support arrangements to eliminate interference with similar systems to be installed under HVAC, Plumbing, and Electrical; to account for structural expansion joints and to maintain access for both personnel and for the removal of equipment.
    g. Complete pipe support drawings indicating support framing, connections, types of supports, location, magnitude and direction of all loads transmitted to the structure or foundation and anchor bolt type, size, number and embedment and other supporting appurtenances including structural fasteners. Drawings shall be sealed by a Professional Engineer registered in the State of Rhode Island.
    h. Calculations for the pipe supports, including analysis data, signed and sealed by a Professional Engineer registered in the State of Rhode Island. Calculations will not be reviewed by the Engineer and will be for project records.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

B. Welders' Certificate: Submit welders' certification of compliance with AWS D1.1, verifying qualification within previous 12 months.

C. Qualifications Statements:

1. Submit qualifications for manufacturer, fabricator, installer, and licensed professional.
2. Submit manufacturer's approval of installer.

1.6 DEFINITIONS

A. Ferrous Metal: Iron, steel, stainless steel, and alloys with iron as principal component.

B. Wetted or submerged: Submerged, less than 1-foot above liquid surface, below top of channel or tank wall, under cover or slab of channel or tank, or in other damp locations.

C. “Pipe” or “piping” shall mean all piping, piping system(s), hose, tube, fittings, joints, valves, and similar appurtenances.

D. Supports: wherever the word “supports” or “pipe supports” are used, they shall mean pipe supports, hangers, structural connections, concrete inserts (if allowed), anchors, guides, bolts, expansion units, restraints and all restraint, hanging, supporting, allowing controlled expansion, or other means of attaching piping along with the necessary appurtenances.

1.7 DELIVERY, STORAGE AND HANDLING

A. All supports and hangers shall be crated, delivered and uncrated so as to protect against any damage.

B. All parts shall be properly protected so that no damage or deterioration shall occur during a prolonged delay from the time of shipment until installation is completed.

C. Finished metal surfaces not galvanized, that are not of stainless-steel construction, or that are not coated, shall be grease coated, to prevent rust and corrosion.

1.8 QUALITY ASSURANCE

A. Perform Work according to AWS D1.1 for welding hanger and support attachments to building structure.

B. Perform Work according to industry standards.

C. Maintain copy of each standard affecting the Work of this Section on-Site.

1.9 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years' documented experience.

B. Fabricator: Company specializing in fabricating products specified in this Section with minimum three years' documented experience.

C. Licensed Professional: Professional engineer experienced in design of specified Work and licensed in State of Rhode Island.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on-Site in original factory packaging, labeled with manufacturer's identification.

B. Protect products from weather and construction traffic, dirt, water, chemical, and damage by storing in original packaging.

1.11 EXISTING CONDITIONS

A. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

1.12 WARRANTY

A. Section 01740 “Warranties”:

B. Furnish five-year manufacturer's warranty for pipe hangers and supports .

PART 2 - PRODUCTS

2.1 GENERAL

A. Detailed design of process pipe supports and details is generally not shown on the Drawings. The absence of pipe supports and details on the Drawings will not relieve the Contractor of the responsibility for providing them. Process pipe supports indicated on the Drawings are shown only to convey the intent of the design for a particular location and are not intended to represent a complete system. Where the Drawings show support types and/or locations, they shall be analyzed for adequacy to support loads and stresses calculated by the pipe support designer, modified if required, installed generally where shown, and integrated with the pipe support system design provided by the Contractor.

B. Provide piping stress and flexibility analysis for the above-tanks RSL piping shown on the Drawings. The piping stress analysis to be performed for dead weight of the piping and its contents, pressure, thermal, seismic, and wind loading conditions in any combination in accordance with the ASME B31.3 code utilizing an industry standard piping stress analysis

program. Perform weight balance calculations to determine the approximate design load at each pipe support for all other piping systems shown on the Drawings not requiring stress analysis.

C. Support pipe and appurtenances connected to equipment to prevent any strain being imposed on the equipment. Comply with manufacturer's requirements regarding piping loads being or not being transmitted to their equipment. Submit certification stating that such requirements have been met.

D. Support and secure all pipe and tubing in the intended position and alignment to prevent significant stresses in the pipe or tubing material, valves, fittings, and other pipe appurtenances. Design all supports to adequately secure the pipe against excessive dislocation due to thermal expansion and contraction, internal flow forces, and all probable external forces such as equipment, pipe, and personnel contact. Any structural steel members required to brace any piping from excessive dislocation shall conform to the applicable requirements of Section 05502 "Metal Fabrications" and shall be furnished and installed under this Section.

E. Contractor may propose minor adjustments to the piping arrangements in order to simplify the supports, or in order to resolve minor conflicts in the work. Such an adjustment might involve minor change to a pipe centerline elevation so that a single trapeze support may be used.

F. Where flexible sleeve, split ring, vibration, or other couplings are required at equipment, tanks, etc., the end opposite to the piece of equipment, tank, etc., shall be rigidly supported to prevent transfer of force systems to the equipment. Do not install fixed or restraining supports between a flexible coupling and the piece of equipment.

G. Pipe supports:

1. Shall not induce point loadings but shall distribute pipe loads evenly along the pipe circumference.
2. Provide supports at changes in direction and elsewhere as shown in the Drawings or as specified herein.
3. No piping shall be supported from other piping or from metal stairs, ladders, and walkways, unless specifically directed or authorized by the Engineer.
4. Provide pipe supports to minimize lateral forces through valves, both sides of flexible split ring type couplings and sleeve type couplings, and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.
5. Effects of thermal expansion and contraction of the pipe to be accounted for in the pipe support selection and installation.

H. Insofar as is possible, floor supports shall be given preference. Where specifically indicated, concrete supports, as shown on the Drawings, may be used. Base elbow and base tees shall be supported on concrete pedestals.

I. Restraints, flexible connections, expansion items, and related items as included in other specifications and shown on the Drawings.

J. Unless otherwise specified herein, pipe hangers and supports to be standard catalogued components conforming to the requirements of MSS-SP-58.

K. Manufacturers:

1. Anvil International, Inc.
2. Carpenter & Patterson, Inc.
3. PHS Industries, Inc.
4. Or equal.

L. Only the following type of hangers, supports, and support components with the associated standards will be allowed:

1.	Adjustable Steel Clevis Hanger:	MSS Type 1
2.	Three Bolt Pipe Clamp Hanger:	MSS Type 3
3.	Adjustable Steel Band Hanger:	MSS Type 7
4.	Two Bolt Extension Riser Clamp:	MSS Type 8
5.	Adjustable Swivel-Ring Band Hanger:	MSS Type 10
6.	Extension Split Pipe Clamp:	MSS Type 12
7.	Concrete Insert for Threaded Rod:	MSS Type 18
8.	Center Beam Clamp:	MSS Type 21
9.	Welded Beam Attachment:	MSS Type 22
10.	U-bolts:	MSS Type 24
11.	Steel Beam Clamp:	MSS Type 28
12.	Medium Welded Steel Bracket:	MSS Type 32
13.	Heavy Welded Steel Bracket:	MSS Type 33
14.	Pipe Slide and Slide Plate:	MSS Type 35
15.	Pipe Saddle:	MSS Type 36
16.	Pipe Stanchion Saddle:	MSS Type 37
17.	Adjustable Pipe Saddle:	MSS Type 38
18.	Welded Protection Saddle:	MSS Type 39
19.	Protection Shield:	MSS Type 40
20.	Roller Chair:	MSS Type 44
21.	Adjustable Pipe Roller Stand:	MSS Type 46
22.	Welding Lug:	MSS Type 57
23.	Trapeze Hanger:	MSS Type 59

2.2 PERFORMANCE REQUIREMENTS/DESIGN CRITERIA

A. All supports and appurtenances shall be standard products from approved manufacturers wherever possible and shall be adequate to maintain the supported load in proper position under all operating conditions. Any reference to a specific figure number of a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary. Note that different materials required, as specified in Part 2 MATERIALS, may require different figures or model numbers than those shown.

1. The minimum working factor of safety for all items, with the exception of springs, shall be five times the ultimate tensile strength of the material, assuming 10 feet of water-filled pipe being supported and normal test pressures.
2. Design for all loads using a safety factor of 5.

B. All items shall be designed with strength and stiffness to support, restrain, and allow expansion of the respective pipes under the maximum combination of peak loading conditions to include

pipe weight, liquid weight, liquid movement and pressure forces, thermal expansion and contraction, vibrations, and all probable externally applied forces.

C. Support spacing shall be per MSS SP 58 unless otherwise specified.

D. Complete design details of the pipe system components shall be submitted for review and approval as specified in Part 1. No support shall be installed without approved support system Drawings.

E. The pipe support system shall not impose loads on the supporting structures in excess of the loads for which the supporting structure is designed.

F. Design the pipe supports to withstand the effects of gravity loads, seismic loads, wind loads, snow loads, ice loads, and thermal expansion loads in accordance with Rhode Island State Building Code, SBC-1, and by reference International Building Code and ASCE/SEI 7.

2.3 MATERIALS

A. For support of metallic pipe:

1. Submerged, buried, or within outdoor structures (vaults, etc.): Type 316 stainless steel (SS).
2. Within chemical areas: Vinyl ester fiberglass reinforced plastic (FRP) for pipe size up to 2 inch, epoxy coated steel for 2-1/2 inches size and larger.
3. Other locations: steel with hot-dipped galvanized finish where noted, or if not otherwise noted, coating as required in Division 09 Finished Painting.
4. Copper piping: Copper plated or plastic-coated supports.
5. Additional requirements (including dielectric insulation): see following paragraphs.

B. For support of non-metallic pipe:

1. Submerged, buried, or within vaults: Type 316 stainless steel..
2. Within chemical areas: vinyl ester FRP with 316 SS or plastic hardware.
3. Other locations: steel with galvanizing where noted, or if not otherwise noted, coating as required in Division 09 Finished Painting; all with local stress protection shields.
4. Additional requirements (including stress protection shields): see following paragraphs

C. Wherever stainless steel is noted, it shall be Type 316 unless noted otherwise.

2.4 SUPPORT AND RESTRAINT SYSTEMS

A. Steel or Ductile Iron Piping

1. Cast iron and ductile iron, carbon steel and stainless steel piping to be supported at a maximum support spacing of 10 feet with a minimum of one support per pipe section at the joints.
2. Support spacing for carbon steel and stainless steel piping 2-in and smaller diameter not to exceed 5 feet.

B. Copper Piping

1. Supports for copper pipe to be copper plated or shall have a 1/16 inch plastic coating.
2. Support spacing for copper piping and tubing 2 inch and smaller diameter not to exceed 5 feet and greater than 2 inch diameter not to exceed 8 feet.
3. Where pipe supports come in contact with copper piping, provide protection from galvanic corrosion by: wrapping pipe with 1/16 inch thick neoprene sheet material and galvanized protection shield; isolators similar to Cooper B-Line B3195CT; or copper-plated or PVC-coated hangers and supports.

C. Non-Metallic Piping

1. All uninsulated non-metallic piping such as PVC, CPVC, etc., to be protected from local stress concentrations at each support point. Protection to be provided by non-metallic protection shields or other method as approved by the Engineer.

    a. Furnish 180-degree arc shields where pipes are bottom supported. Where 360-degree arc support is required, such as U-bolts, provide protection shields for the entire pipe circumference. All U-bolts or clamps for non-metallic pipes to be plastic coated.
    b. Protection shields to have an 18-gauge minimum thickness, not less than 12 inches in length, and be securely fastened to pipe with Type 316 stainless steel straps not less than 1/2 inch wide.

2. Individually supported plastic pipes to be supported as recommended by the pipe manufacturer except that support-spacing to not exceed 3 feet. Individual clamps, hangers, and supports in contact with plastic pipe to provide firm support but not so firm as to prevent longitudinal movement due to thermal expansion and contraction. For long horizontal runs of single plastic pipes hung from above, provide continuous support along the length of the pipe using V-trough with clevis hangers.

3. Supports for horizontal multiple plastic piping:

    a. To be continuous wherever possible.
    b. Multiple, suspended, horizontal plastic PVC pipe runs, where possible, to be supported by ladder type cable trays such as: Husky Ladder Flange Out by MPHusky; or equal.
    c. Rung spacing to be 12 inches. Tray width to be approximately 6 inch for single runs and 12 inches for double runs.
    d. Ladder type cable trays to be furnished complete with all hanger rods, rod couplings, concrete inserts, hanger clips, etc., required for a complete support system. Individual plastic pipes to be secured to the rungs of the cable tray by strap clamps or fasteners similar to: Globe, Series 600; Unistrut Pipe/Conduit Clamps and Hangers; or equal.
    e. Spacing between clamps not to exceed 9 feet. The cable trays shall provide continuous support along the length of the pipe. Individual clamps, hangers, and supports in contact with plastic pipe to provide firm support but not so firm as to prevent longitudinal movement due to thermal expansion and contraction.

D. Framing Support System

1. See Part 2 MATERIALS for materials of construction.

2. Beams: Size such that beam stress does not exceed 25,000 psi and maximum deflection does not exceed 1/240 of span.
3. Column Members: Size in accordance with manufacturer's recommended method.
4. Support Loads: Calculate using weight of pipes filled with water.
5. Maximum Spans:

    a. Steel and ductile iron pipe, 3-inch diameter and larger: 10 feet centers, unless otherwise shown.
    b. Other pipelines and special situations: Same as noted in previous paragraphs. Supplementary hangers and supports may be required.

E. All vertical pipes shall be supported at each floor or at intervals of not more than 12 feet by approved pipe collars, clamps, brackets, or wall rests and at all points necessary to ensure rigid construction. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

F. For insulated horizontal cold piping, provide galvanized steel insulation protection shields with 180 degree arc that meet MSS Type 40 standards to protect the vapor barrier on the insulation. For insulated vertical cold piping, provide galvanized steel insulation protection shields with full 360 degree arc. For insulated horizontal large diameter hot piping provide welded protection saddles that meet MSS Type 39 standards to protect insulation from damage during pipe movement due to expansion/contraction. The interior void of the saddle to be filled with insulation that matches the adjoining insulation.

G. For longitudinal pipe movement caused by expansion and contraction, provide an appropriate pipe roll support that meets MSS Type 44 standards or an appropriate pipe slide welded to the pipe. For vertical and lateral adjustment in addition to expansion and contraction, provide an adjustable pipe roll stand that meets MSS Type 46 standards. Provide pipe alignment guides as necessary to control pipe movement caused by expansion and contraction.

2.5 ANCHOR BOLTS/SYSTEMS

A. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear, and pullout loads imposed by loading and spacing on each particular support. DO NOT USE ADHESIVE ANCHOR BOLTS ON ANY PIPE SUPPORT HUNG FROM A ROOF OR CEILING, unless specifically noted otherwise. Provide type, size, quantity and embedment for anchor bolts.

B. All post-installed anchors in concrete shall have current published ICC-ES Evaluation Report indicating the anchor is approved for installation in cracked concrete.

C. The latest edition of the following specification and recommended practices shall become part of this specification as if written herein. Wherever requirements conflict, the more stringent shall govern.

1. ACI 318, Chapter 17.
2. ACI 355.2, Mechanical Anchors “Qualification of Post-Installed Mechanical Anchors in Concrete”
3. Anchor manufacturer’s published installation requirements.

D. Expansion anchors:

1. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1 inch behind the steel reinforcement.
2. Manufacturers:

a. Hilti Kwik-Bolt TZ;
b. Simpson Strong-Tie Strong Bolt 2 Wedge Anchor;
c. DeWalt Power-Stud+ SD1 (DeWalt Power-Stud+ SD6 for stainless steel)

E. Unless otherwise noted: use Type 304 stainless steel anchoring parts/bolts and hardware for non-submerged supports, Type 316 stainless steel for submerged anchors.

F. Size of anchor bolts as designed by manufacturer, 1/2 inch minimum diameter, or as shown on the Drawings.

G. Anchors to concrete in chemical areas shall be epoxy secured vinyl ester FRP all thread, insertion depth and size as required by the manufacturer for the design loads. Nuts, bolts and hardware shall all be vinyl ester FRP construction.

2.6 HANGER RODS

A. Where use of steel is allowed, hanger rods to be hot-rolled steel, machine-threaded, and galvanized after fabrication or Type 316 stainless steel. The strength of the rod to be based on its root diameter.

1. Hanger rods to be attached to concrete attachment plates and expansion anchors or single concrete inserts that meet MSS Type 18 standards or continuous concrete inserts. Where use of steel is allowed, inserts shall be malleable iron or steel with galvanized finish.
2. Beam-clamps or welded-beam attachments shall be used for attaching hanger rods to structural steel members. C-clamps will not be allowed.

B. Minimum rod size for metallic rod hangers: (* For pipe diameters less than 14 inch, if using pipe roller, use 2 hanger rods with minimum diameter noted below for pipe's diameter).

	Nominal Pipe / Tube Diameter	Minimum Hanger Rod Diameter
1	Less than 2-1/2 inch	1/4 inch*
2	3 to 8 inches	1/2 inch
3	10 to 14 inches	3/4 inch*
4	16 to 20 inches	2 at 1 inch
5	24 inches	2 at 1-1/4 inch
6	30 inches	2 at 1-1/2 inch

2.7 SINGLE PIPE HANGERS

A. Single pipes to be supported by hangers suspended by hanger rods from structural steel members, concrete ceilings, bottom of trapeze hangers, and wall-mounted steel angle brackets.

B. Except as otherwise specified herein, pipe hangers to be adjustable clevis type that meets the MSS Type 1 standards and be hot-dipped galvanized or stainless steel.

C. Where pipes are near walls, beams, columns, etc., and located an excessive distance from ceilings or underside of beams, provide welded steel wall brackets that meet the MSS Type 32 or 33 standards for hanging pipe. Where single pipes rest on top of bracket pipe supports, provide attachments that meet requirements as specified under multiple pipe hangers.

2.8 MULTIPLE PIPE HANGERS

A. Suspended multiple pipes, running parallel in the same horizontal plane that are adjacent to each other, shall be suspended by trapeze type hangers or wall brackets. Where use of steel is allowed, trapeze hangers to be hot-dipped galvanized structural steel channel supported from galvanized threaded rod or attached to concrete walls, columns, or structural steel support members. See previous paragraphs about multiple PVC pipe supports.

B. Except as otherwise specified herein, pipe anchors used for attaching pipe to trapeze or multiple pipe wall brackets to be hot-dipped galvanized steel or stainless steel U-bolts that meet MSS Type 24 standards or roller chairs that meet MSS Type 44 standards.
   1. U bolts to be tightened to allow freedom of movement for normal expansion and contraction except where pipe must be anchored to control direction of movement or act as a thrust anchor.

2.9 SINGLE PIPE SUPPORTS FROM BELOW

A. Single pipes located in a horizontal plane close to the floor to be supported by one of the following methods:

   1. Pipes 3-inch in diameter and larger:

      a. Support by adjustable stanchion that meets MSS Type 38 standards with U-bolt, 4 inch adjustment and anchoring flange.

   2. Pipes less than 3 inch in diameter

      a. Hold in position by supports fabricated from framing channel, welded post base similar to Unistrut, Figure P1000, where use of steel is allowed; and pipe clamps similar to Unistrut, Figures P1109 through 26.
      b. Where required to assure adequate support, fabricate supports using two vertical members and post bases connected by horizontal member of sufficient load capacity to support pipe.
      c. Fasten supports to nearby walls or other structural member to provide horizontal rigidity.
      d. More than one pipe may be supported from a common fabricated support.

B. Provide pipe stanchion with pipe roller supports where required to accommodate thermal movement in conjunction with axial supports.

2.10 WALL SUPPORTED SINGLE AND MULTIPLE PIPES

A. Single or multiple pipes located adjacent to walls, columns, or other structural members to be supported using welded steel wall brackets that meet MSS Type 32 or 33 standards

B. Where noted, multiple pipes may be supported on C-channel with steel brackets similar to Unistrut pipe clamps; with pipe anchor chairs; or equal.

C. Securely fasten all members to wall, column, etc., using expansion anchors or other method as approved by the Engineer. Provide additional wall bearing plates as required.

2.11 BASE ANCHOR SUPPORT

A. Bend Support: Where pipes change direction from horizontal to vertical via a bend, install a welded or cast base bend support to carry the load. Fasten base bend to the floor, pipe stanchion, or concrete pedestal using expansion anchors or other method as approved by the Engineer.

B. Concrete Supports: Fastening pipe bends to concrete supports with metal bands will not be allowed.

2.12 VERTICAL PIPE SUPPORTS

A. Where vertical pipes are not supported by a Unistrut type system as specified, they shall be supported in one of the following methods.

1. For pipes 1/4 to 2 inch in diameter,

    a. Provide extension hanger ring with an extension rod and hanger flange.
    b. The rod diameter shall be as recommended by the manufacturer for the type of pipe to be supported.
    c. Where use of steel is allowed, the hanger ring shall be galvanized malleable iron- or PVC-clad depending on the supported pipe material of construction that meets MSS Type 12 standards.
    d. Where use of steel is allowed, the anchor flange to be galvanized malleable iron.

2. For pipes equal to or greater than 2 inch in diameter,

    a. extended pipe clamps similar to Carpenter & Patterson, Figure No. 267 may be used.
    b. Attach hanger to concrete structures using expansion anchors.
    c. Attach hanger to metal support members using welding lugs.

B. Pipe supports to be provided for closely spaced vertical piping systems required to provide a rigid installation. The interval of vertical support spacing shall be as specified, but in no case to

exceed 12 feet. The support system shall consist of a framework suitably anchored to floors, ceilings, or roofs.

C. Unless otherwise specified, shown, or specifically approved by the Engineer, vertical runs exceeding 12 feet to be supported by base elbows/tees, clamps, brackets, wall rests, and pipe collars, all located as required to ensure a rigid installation.

D. Provide pipe riser clamps that meet MSS Type 8 standards to support all vertical pipes extending through floor slabs. Where use of steel is allowed, riser clamps to be hot-dipped galvanized steel.

E. Copper-clad or PVC-coated clamps shall be used on copper pipes. Insulation to be removed from insulated pipes prior to installing riser clamps. Insulation snot to be damaged by clamp installation.

2.13 SPECIAL SUPPORTS

A. Frame work supports

1. Vertical and horizontal supporting members shall be U-shaped channels similar to Unistrut, Series P1000. Vertical piping to be secured to the horizontal members by pipe clamps or pipe straps. See pipe clamp and strap requirements.
2. For piping 3 inch and smaller, framework shall be as manufactured by:

    a. the Unistrut Corporation;
    b. Power-Strut (or Ackinstrut where fiberglass systems are specified);
    c. Multi-Strut by Carpenter-Paterson
    d. or equal.

3. For piping larger than 3 inch, the support frame to be fabricated from structural stainless steel or steel shapes, depending upon the support location, and secured through the use of drop in, adhesive or expansion anchors.
4. Assemblies to be furnished complete with all nuts, bolts, and fittings required for a complete assembly including end caps for all Unistrut members.
5. Electrical Conduit Support: Under Division 26.
6. Design of each individual framing system to be the responsibility of the Contractor. Submit shop drawings, and show all details of the installation, including dimensions and types of supports. In all instances the completed frame to be adequately braced to provide a complete rigid structure when all the piping has been attached. See also Article SUPPORT AND RESTRAINT.

B. Supports not otherwise described in this Section to be fabricated or constructed from standard structural stainless steel or steel shapes in accordance with applicable provisions of Section 05502 “Metal Fabrications,” or Unistrut-type frame; have anchor hardware similar to items previously specified herein; to meet the minimum requirements listed below; and be subject to the approval of the Engineer.

C. Additional Pipe Support Situations

1. Supporting Multiple Chemical and Related Piping:

a. Location: indicated on Drawings or otherwise required, especially adjacent to chemical pumps.
b. Use: framework support.
c. Materials: FRP, with proper local stress protection.

2.14 SHOP FACTORY FINISHING

A. Prepare and prime metallic (except stainless steel) supports in accordance with Division 09.

2.15 ACCESSORIES

A. Vibration Isolation Pad: Install under base flange of pedestal type pipe supports adjacent to equipment, and where required to isolate vibration.

1. Isolation pads to be neoprene, waffle type.
2. Manufacturers:

a. Mason Industries, Type W;
b. Korfund.

B. Dielectric Barrier

1. Install between carbon steel members and copper or stainless steel pipe.
2. Install between stainless steel supports and non-stainless steel ferrous metal piping.
3. All stainless steel piping shall be isolated from all ferrous materials, including galvanized steel by use of neoprene sheet material and protection shields.

C. Electrical Isolation: Install 1/4 by 3 inch neoprene rubber wrap between submerged metal pipe and oversized clamps.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify field dimensions as indicated on Drawings.

3.2 INSTALLATION

A. Obtain permission from Engineer before using powder-actuated anchors.

B. Obtain permission from Engineer before drilling or cutting structural members.

C. Inserts:

1. Install inserts for placement in concrete forms. Before setting inserts, all drawings and figures shall be checked that have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports is included under this Section.

2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 in and larger.
4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut [recessed into and grouted flush with slab.

D. Pipe Hangers and Supports:

1. Install according to: MSS SP 58.
2. Support horizontal piping as indicated on Shop Drawings, depending upon pipe size.
3. Install hangers with minimum 1/2 in space between finished covering and adjacent Work.
4. Place hangers within 12 in of each horizontal elbow.
5. Use hangers with 1-1/2 in minimum vertical adjustment.
6. Support horizontal cast iron pipe adjacent to each hub, with 5 ft maximum spacing between hangers.
7. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
8. Where piping is installed in parallel and at same elevation, provide multiple pipe or trapeze hangers.
9. Support riser piping independently of connected horizontal piping.
10. Provide copper-plated hangers and supports for copper piping.
11. Design hangers for pipe movement without disengagement of supported pipe.
12. Support piping independently so that equipment is not stressed by piping weight or expansion in piping system.
13. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
14. Provide welded steel brackets where piping is to be run adjacent to building walls or columns.
15. Use beam clamps where piping is to be suspended from building steel.
16. Use offset clamps where pipes are indicated as offset from wall surfaces.
17. Proceed with installation of piping and supports only after any building structural work has been completed and new concrete has reached its 28-day compressive strength.
18. The installation of pipe support systems shall not interfere with the operation of any overhead bridge cranes, monorails, access hatches, etc. No piping to be supported from stairs, other pipes, ladders, and walkways unless authorized by the Engineer.
19. Repair mounting surfaces to original condition after attachments are made.
20. Brace horizontal pipe movements by both longitudinal and lateral sway bracing.
21. Where supports are required in areas to receive chemical resistant seamless flooring, install supports prior to application of flooring system.

E. Prime Coat:

1. Prime coat exposed steel hangers and supports.
2. Conform to Section 09910 - Painting.

3.3 FIELD QUALITY CONTROL

A. All pipe support systems shall be tested after installation in conjunction with the respective piping pressure tests. If any part of the pipe support system proves to be defective or inadequate, it shall be repaired, augmented or replaced to the satisfaction of the Engineer.

B. After the work is installed, but before it is filled for start-up and testing, the Support System Design Engineer shall inspect the work and shall certify its complete adequacy. Each system to be inspected and certified in the same way.

C. Submit a report, including all field modifications and including all certificates.

1. Insert state where project is located
2. The report shall bear the stamp of a professional engineer registered in State of Rhode Island and shall be subject to the review of the Engineer.

END OF SECTION 15140

SECTION 15152 - FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Cleanouts.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Pipe and fittings.
2. Non-pressure and pressure couplings
3. Cleanouts.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Product Certificates: For each type of pipe and fitting.

C. Field quality-control reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

1.7 FIELD CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Engineer no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Engineer's written permission.

PART 2 - PRODUCTS

2.1 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A74, Service class.

B. Gaskets: ASTM C564, rubber.

C. Calking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A888 or CISPI 301.

B. CISPI-Trademark, Shielded Couplings:

1. Description: ASTM C1277 and CISPI 310, with stainless steel corrugated shield; stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Shielded Couplings:

1. Description: ASTM C1277 and ASTM C1540, with stainless steel shield; stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.3 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

2. Top-Loading Classification(s): Heavy Duty.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A74, Service class, cast-iron soil pipe and fittings.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 02300 "Earthwork."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details to indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

D. Install gravity-flow, nonpressure, drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 1 percent unless otherwise indicated.
2. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
3. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."

E. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A674 or AWWA C105/A21.5:

1. Hub-and-spigot, cast-iron soil pipe.
2. Hubless cast-iron soil pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Expansion joints and deflection fittings.

F. Clear interior of piping of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure, drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.5 IDENTIFICATION

A. Comply with requirements in Section 02300 "Earthwork" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.

1. Use detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.6 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:

    a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
    b. Close openings in system and fill with water.
    c. Purge air and refill with water.
    d. Disconnect water supply.
    e. Test and inspect joints for leaks.

6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Test plastic gravity sewer piping according to ASTM F 1417.
    b. Test concrete gravity sewer piping according to ASTM C1628.

7. Force Main: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig.

    a. Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
    b. PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.

8. Manholes: Perform hydraulic test according to ASTM C969.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.7 CLEANING

A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 15152

SECTION 15153 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Galvanized-steel pipe and fittings.
4. Copper tube and fittings.
5. Encasement for underground metal piping.

B. Related Requirements:

1. Section 15152 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Waste, Force-Main Piping: 50 psig.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A74, Service class(es).

B. Gaskets: ASTM C564, rubber.

C. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A888 or CISPI 301.

B. Single-Stack Aerator Fittings: ASME B16.45, hubless, cast-iron aerator and deaerator drainage fittings.

C. Heavy-Duty, Hubless-Piping Couplings:

1. Standards: ASTM C1277 and ASTM C1540.
2. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Hubless-Piping Couplings:

1. Standard: ASTM C1277.
2. Description: Two-piece ASTM A48/A48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.5 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A53/A53M, Type E, Standard Weight class. Include square-cut-grooved or threaded ends matching joining method.

B. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12, threaded.

C. Steel Pipe Pressure Fittings:

1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Schedule 40, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.

D. Cast-Iron Flanges: ASME B16.1, Class 125.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.6 DUCTILE-IRON PIPE AND FITTINGS

A. Ductile-Iron, Mechanical-Joint Piping:

1. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot ends unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Ductile-Iron, Grooved-Joint Piping: AWWA C151/A21.51, with round-cut-grooved ends according to AWWA C606.

C. Ductile-Iron, Grooved-End Pipe Appurtenances:

1. Grooved-End, Ductile-Iron Fittings: ASTM A536 ductile-iron castings, with dimensions matching AWWA C110/A21.10 ductile-iron pipe or AWWA C153/A21.53 ductile-iron fittings, and complying with AWWA C606 for grooved ends.
2. Grooved Mechanical Couplings for Ductile-Iron Pipe: ASTM F1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber center-leg gasket suitable for hot and cold water; and bolts and nuts.

2.7 COPPER TUBE AND FITTINGS

A. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B88, Type L and Type M, water tube, drawn temper.

D. Soft Copper Tube: ASTM B88, Type L, water tube, annealed temper.

E. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

F. B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

G. Solder: ASTM B32, lead free with ASTM B 813, water-flushable flux.

2.8 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Nonpressure Transition Couplings:

    a. Standard: ASTM C1173.
    b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. End Connections: Same size as and compatible with pipes to be joined.
    d. Sleeve Materials:

        1) For Cast-Iron Soil Pipes: ASTM C564, rubber.
        2) For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
        3) For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

3. Shielded, Nonpressure Transition Couplings:

    a. Standard: ASTM C1460.
    b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. End Connections: Same size as and compatible with pipes to be joined.

4. Pressure Transition Couplings:

    a. Standard: AWWA C219.
    b. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
    c. Center-Sleeve Material: Manufacturer's standard.
    d. Gasket Material: Natural or synthetic rubber.
    e. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. Dielectric Unions:

    a. Description:

        1) Standard: ASSE 1079.

2) Pressure Rating: 125 psig minimum at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

2. Dielectric Flanges:

a. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 125 psig minimum at 180 deg F.
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

3. Dielectric-Flange Insulating Kits:

a. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.
5) Washers: Phenolic with steel backing washers.

4. Dielectric Nipples:

a. Description:

1) Standard: IAPMO PS 66.
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig at 225 deg F.
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

2.9 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch or high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.

C. Form: Sheet or tube.

D. Color: Black or natural.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 02300 "Earthwork."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

    a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2Insert number percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A674 or AWWA C105/A 21.5.

N. Install steel piping according to applicable plumbing code.

O. Install stainless-steel piping according to ASME A112.3.1 and applicable plumbing code.

P. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

Q. Install engineered soil and waste and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

R. Install force mains at elevations indicated.

S. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
b. Comply with requirements for cleanouts specified in Section 15154 "Sanitary Waste Piping Specialties."

2. Install drains in sanitary waste gravity-flow piping.

a. Comply with requirements for drains specified in Section 15154 "Sanitary Waste Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 15013 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 15013 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 15014 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.

C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

1. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
c. Do not use pipe sections that have cracked or open welds.

E. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

F. Join copper tube and fittings with soldered joints according to ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

G. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

I. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D 2661 appendixes.
3. PVC Piping: Join according to ASTM D2855 and ASTM D 2665 appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:

    a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
    b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges .
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. Comply with requirements in Section 15022 "Ball Valves for Plumbing Piping" and Section 15024 "Check Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install gate or full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 15031 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel Insert material pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for cast-iron and steel soil piping, with maximum horizontal spacing and minimum rod diameters to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical runs of cast iron and steel soil piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Section 15154 "Sanitary Waste Piping Specialties."
6. Equipment: Connect waste piping as indicated.

a. Provide shutoff valve if indicated and union for each connection.
b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:

1. Sanitary Sewer: To exterior force main.
2. Sewage Pump: To sewage pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 15035 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

    a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
    b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
    c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

    a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
    b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
    c. Air pressure must remain constant without introducing additional air throughout period of inspection.
    d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.

    a. Isolate test source and allow to stand for four hours.
    b. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, vent piping shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.

    a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.

5. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Underground, soil, waste, and vent piping NPS 4 and smaller shall be the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.

E. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be the following:

1. Galvanized-steel pipe, pressure fittings, and threaded joints.

F. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 shall be the following:

1. Galvanized-steel pipe, pressure fittings, and threaded joints.

END OF SECTION 15153

SECTION 15154 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cleanouts.
2. Through-penetration firestop assemblies.
3. Miscellaneous sanitary drainage piping specialties.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. FOG: Fats, oils, and greases.

C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping
3. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
4. Closure: Countersunk or raised-head, cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

1.
2. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Heavy-duty, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Cast-iron plug.
9. Adjustable Housing Material: Cast iron with threads set screws or other device.
10. Frame and Cover Material and Finish: Rough bronze.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure Plug:

a. Brass.
b. Countersunk head.
c. Drilled and threaded for cover attachment screw.
d. Size: Same as or not more than one size smaller than cleanout size.

5. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
6. Wall Access: Square, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Standard: UL 1479 assembly of sleeve-and-stack fitting with firestopping plug.
2. Size: Same as connected soil, waste, or vent stack.
3. Sleeve: Molded-PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
4. Stack Fitting: ASTM A48/A48M, gray-iron, hubless-pattern wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains Insert drawing designation, if any:

1. Description: Shop or field fabricate from ASTM A74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C564 rubber gaskets.
2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

    a. NPS 2: 4-inch-minimum water seal.
    b. NPS 2-1/2 and Larger: 5-inch-minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

2.5 MOTORS

A. General requirements for motors are specified in Section 15011 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, motor shall be large enough, so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 07620 "Sheet Metal Flashing and Trim."

E. Assemble open drain fittings and install with top of hub 1 inch above floor.

F. Install deep-seal traps on floor drains and other waste outlets, if indicated.

G. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

H. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

I. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

J. Install wood-blocking reinforcement for wall-mounting-type specialties.

K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 15153 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

A. Comply with requirements in Section 07620 "Sheet Metal Flashing and Trim."

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 07620 "Sheet Metal Flashing and Trim."

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

1. Nameplates and signs are specified in Section 15035 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain FOG disposal systems.

END OF SECTION 15154

SECTION 15155 - SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Floor drains.
2. Trench drains.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene styrene.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene.

D. PE: Polyethylene.

E. PP: Polypropylene.

F. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains FD:

1. Basis-of-Design Product: Subject to compliance with requirements, provide WATTS; FD-320 or a comparable product by one of the following:

    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. Zurn Industries, LLC.

2. Standard: ASME A112.6.3.
3. Pattern: Area drain.
4. Body Material: Cast iron.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device:: Required.
8. Outlet: Bottom, inside caulk.
9. Backwater Valve:: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Ductile iron.
13. Top Shape: Round.
14. Dimensions of Top or Strainer: 8-inch.
15. Top Loading Classification: Extra Heavy Duty.
16. Funnel: Not required.
17. Inlet Fitting: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
18. Trap Material: Cast iron.
19. Trap Pattern: Deep-seal P-trap.

2.3 TRENCH DRAINS

A. Trench Drains TD:

1. Basis-of-Design Product: Subject to compliance with requirements, provide WATTS; FD-760-FC or a comparable product by one of the following:

    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. Zurn Industries, LLC.

2. Standard: ASME A112.6.3 for trench drains.
3. Material: Ductile or gray iron.
4. Flange: Seepage.
5. Clamping Device: Required.
6. Outlet: Bottom, inside caulk.
7. Grate Material: Ductile iron.
8. Dimensions of Frame and Grate: 6 inches by 12 inches.
9. Top Loading Classification: Extra Heavy Duty.
10. Trap Material: Cast iron.
11. Trap Pattern: Standard P-trap.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.

a. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

B. Install trench drains at low points of surface areas to be drained.

1. Set grates of drains flush with finished surface, unless otherwise indicated.

C. Install open drain fittings with top of hub 1 inch above floor.

3.2 CONNECTIONS

A. Comply with requirements in Section 15153 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 15154 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

D. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 15035 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 15155

SECTION 15181 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Submersible sump pumps.
2. Sump-pump basins and basin covers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

2.2 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Double-Seal Sump Pumps SP-1,2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Zoeller Pump Company; Model 295 or a comparable product by one of the following:

    a. Bell and Gossett.
    b. Federal Pump.
    c. PACO Pumps; Grundfos Pumps Corporation, USA.
    d. Weil Pump.

2. Description: Factory-assembled and -tested sump-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced,, non-clog design for clear wastewater handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

    a. Motor Housing Fluid: Oil.

8. Controls:

    a. Enclosure: NEMA 250, Type 4X.
    b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
    e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

9. Controls:

a. Enclosure: NEMA 250, Type 4X; wall mounted.
b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

10. Control-Interface Features:

a. Remote Alarm Contacts: For remote alarm interface.

2.3 SUMP-PUMP CAPACITIES AND CHARACTERISTICS

A. Number of Pumps: Two.

B. Each Pump:

1. Capacity: 30 gpm.
2. Total Dynamic Head: 65 feet.
3. Discharge Size: 2 NPS.
4. Electrical Characteristics:

a. Motor Horsepower: 2 hp.
b. Volts: 480 V ac.
c. Phases: Three.
d. Hertz: 60.

C. Unit Electrical Characteristics:

1. Full-Load Amperes: 6.1 A.
2. Maximum Overcurrent Protection: 15 A.

2.4 SUMP-PUMP BASINS AND BASIN COVERS

A. Basins: Concrete basin provided under Division 03.

1. See Structural Drawings.

B. Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, power cables and anchor bolts.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.
2. Thickness: 0.5-inch
3. See drawings for size and quantity of pipe openings.
4. Consult with sump pump manufacturer for size and quantity of power and control cable openings.
5. Anchor bolt openings: 0.375-inch outside diameter, minimum 24 inches on center.

2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 15011 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and filling are specified in Section 02300 "Earthwork."

3.2 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.3 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.4 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Pumps and controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 15181

SECTION 15243 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Pressure Gages
5. Manual gas shutoff valves.
6. Pressure regulators.
7. Labeling and Identifying

1.3 DEFINITIONS

A. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping
2. Piping specialties.

3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.

5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4 inch per foot.

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in the State of Rhode Island responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.8 DELIVERY, STORAGE AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.9 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig but not more than 5 psig, and is reduced to secondary pressure of more than 0.5 psig but not more than 2 psig.

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer registered in the State of Rhode Island, using performance requirements and design criteria indicated.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A 3M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.

2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless-steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. PE Pipe: ASTM D2513, SDR 11.

1. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11; and steel pipe complying with ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet.
    b. Casing: Steel pipe complying with ASTM A53/A53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.
    c. Aboveground Portion: PE transition fitting.
    d. Outlet shall be threaded or flanged or suitable for welded connection.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet connected to steel pipe complying with ASTM A53/A53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
    b. Outlet shall be threaded or flanged or suitable for welded connection.
    c. Bridging sleeve over mechanical coupling.
    d. Factory-connected anode.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.5 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.

2. Case: Liquid-filled Sealed cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Gage Attachments:

1. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
2. Valves: Brass ball, with NPS 1/4, ASME B1.20.1 pipe threads.

2.6 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.

5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B584.
2. Plug: Bronze.
3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig.
6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Body: Cast iron, complying with ASTM A126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural gas.
5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Body: Cast iron, complying with ASTM A126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural gas.
5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. PE Ball Valves: Comply with ASME B16.40.

1. Body: PE.
2. Ball: PE.

3. Stem: Acetal.
4. Seats and Seals: Nitrile.
5. Ends: Plain or fusible to match piping.
6. CWP Rating: 80 psig.
7. Operating Temperature: Minus 20 to plus 140 deg F.
8. Operator: Nut or flat head for key operation.
9. Include plastic valve extension.
10. Include tamperproof locking feature for valves where indicated on Drawings.

I. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.7 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. American Meter Company.
   b. Fisher Control Valves & Instruments; a brand of Emerson Process Management.
   c. Invensys.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.

11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Fisher Control Valves & Instruments; a brand of Emerson Process Management.
    b. Invensys.
    c. Maxitrol Company.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig.

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Dormont; a WATTS brand.
    b. Eaton.
    c. Harper Wyman Co.
    d. Maxitrol Company.
    e. SCP, Inc.

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 5 psig.

2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 24 inches below finished grade. Comply with requirements in Section 02300 "Earthwork" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 24 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

E. Install fittings for changes in direction and branch connections.

F. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 15046 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe

with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15044 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15044 "Sleeves and Sleeve Seals for HVAC Piping."

3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground.

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 05502 "Metal Fabrications" for pipe bollards.

3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 15061 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Install hangers for corrugated stainless-steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support vertical runs of corrugated stainless-steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

A. Comply with requirements in Section 15065 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.11 PAINTING

A. Comply with requirements in Section 09910 “Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

    a. Prime Coat: Alkyd anticorrosive metal primer.
    b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
    c. Topcoat: Exterior alkyd enamel (flat).
    d. Color: Yellow (high pressure) or Gray (low pressure)

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Use 3000-psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 03300A "Cast-in-Place Concrete."

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.14 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be the following:
1. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with steel welding fittings and welded joints.

B. Aboveground, distribution piping shall be the following:

C. Underground, below building, piping shall be the following:

1. Steel pipe with steel welding fittings and welded joints.

2. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.17 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground:

1. PE valves.
2. NPS 2 and Smaller: Bronze plug valves.
3. NPS 2-1/2 and Larger: Cast-iron, lubricated plug valves.

3.18 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 15243

SECTION 15291 - PROCESS PIPING ELECTRICAL RESISTANCE HEAT TRACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Self-regulating cables.
2. Heat-tracing controls.

1.3 DEFINITIONS

A. Self-Regulating Index (SRI): The rate of change of power output in Watts per degree F, as measured between the temperatures of 50- and 100-degrees F.

1.4 COORDINATION

A. Coordinate Work of this Section with installation of process piping.

1.5 PREINSTALLATION MEETINGS

A. Convene minimum at least two weeks prior to commencing Work of this Section.

1.6 ACTION SUBMITTALS

A. Product Data: Submit manufacturer information for system materials and component equipment, including thermal properties, electrical characteristics, and connection requirements.

B. Shop Drawings:

1. Indicate system materials and component equipment.
2. Submit wiring and control diagrams, installation and anchoring requirements, fasteners, and other details.

1.7 INFORMATIONAL SUBMITTALS

A. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

B. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

C. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

D. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

E. Manufacturer Reports: Certify that equipment has been installed according to manufacturer instructions.

F. Qualifications Statement:

1. Submit qualifications for manufacturer.

1.8 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of piping and appurtenances receiving heat tracing, and locations of source power and controls.

1.9 QUALITY ASSURANCE

A. Perform Work according to the following standards:

1. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers (IEEE).
3. American Society for Testing and Materials (ASTM).
4. National Fire Protection Association (NFPA).
5. National Electric Code (NEC).
6. Factory Mutual (FM).
7. Underwriters Laboratories (UL).
8. National Electrical Manufacturers Association (NEMA).
9. Occupational Safety and Health Administration (OSHA).

1.10 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.12 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.13 WARRANTY

A. Furnish five-year manufacturer's warranty for heat tracing and components.

PART 2 - PRODUCTS

2.1 SELF-REGULATING CABLE

A. Manufacturers:

1. Raychem/Pentair Thermal/Chemelex.
2. Chromolox.
3. Thermon.
4. Or equal.

B. Description:

1. Bus Wires:

a. Quantity: Two.
b. Orientation: Parallel.
c. Material: Nickel-coated copper.
d. Minimum Size: 14 gauge.

2. Heating Element: Self-regulating polymeric core.
3. Jacketing:

a. Description: Tinned copper braid with resistance less than cable bus wire resistance.
b. Comply with ASTM B193.
c. Insulating Jacket: Polyolefin.

4. Cable Temperature Identification Number (T-Rating):

a. T6, without use of thermostats.
b. Comply with NEC.

5. Output:

    a. As indicated on Drawings.
    b. Minimum 3 W/ft..

C. Performance and Design Criteria:

1. Power Output: Vary relative to temperature of surface of pipe or appurtenance.
2. Cable can be cut to length on Site.
3. Minimum SRI:

    a. Cable Rating 3 W/ft.:0.038 W/degrees F.
    b. Cable Rating 5 W/ft.: 0.060 W/degrees F.
    c. Cable Rating 8 W/ft.: 0.074 W/degrees F.
    d. Cable Rating 10 W/ft.:0.100 W/degrees F.

D. Operation:

1. Electrical Characteristics:

    a. Voltage: 208 V, three phase, 60 Hz.
    b. Maximum Circuit Breaker Size: 30 A.
    c. Minimum Circuit Ampacity: 20 A.
    d. Ground-Fault Protection Device: Set at 30 mA, with nominal 100-ms response time, to protect each circuit.

2. Disconnect Switch: Factory mounted in control panel.

E. Accessories:

1. Splicing connectors.
2. End terminations.
3. T-connectors.
4. Power termination kits.

2.2 HEAT-TRACING CONTROLS

A. Control and Monitoring Panel:

1. Materials: Nonmetallic.
2. Rating: NEMA 250 Type 4X.
3. Configuration: Wall mounted.
4. Temperature Controller:

    a. Microprocessor based.
    b. Diagnostic self-testing capability.

5. ON-OFF Control: Soft start.
6. Real-Time Data Indication:

    a. Temperature.

b. Heater current.
c. Ground leakage current.

7. Alarms:

a. LOW TEMPERATURE.
b. HIGH TEMPERATURE.
c. LOW HEATER CURRENT.
d. HIGH HEATER CURRENT.
e. GROUND LEAKAGE CURRENT.
f. DAMAGED RTD SENSOR.

B. Single Thermostat:

1. Description: Stainless-steel remote bulb with 6-foot capillary encased in flexible stainless-steel armor.
2. Housing:

a. FM approved.
b. Rating: NEMA 250 Type 4X.

3. Set-Point Range: 35 to 235 degrees F.

2.3 SOURCE QUALITY CONTROL

A. Testing:

1. Retain at least 75 percent of rated power after 20 years of operation at maximum published continuous exposure temperature.
2. Retain at least 90 percent of rated power after 1,000 hours of operation at maximum published intermittent exposure temperature.
3. Cable Dielectric Test: Passing 2.5 kV dielectric test for one minute according to ASTM D2633 after undergoing a 0.5 kg-m impact.
4. Before shipment, demonstrate cable insulation resistance of 20 megohms minimum bus to braid using a 2,500-V dc megger, and demonstrate tolerance for one minute at voltage equal to twice rated plus 1,000 V applied bus to braid.
5. Thermal Runaway:

a. Ensure that cable produces less than 0.5 W/ft. when energized and heated to 350 degrees F for 30 minutes.
b. After testing and reenergizing, demonstrate that cable does not have an increasing power output leading to thermal runaway.

B. Owner Witnessing:

1. Allow witnessing of factory inspections and tests at manufacturer's test facility.
2. Notify Owner at least seven days before inspections and tests are scheduled.

C. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01730 “Execution”: Requirements for installation examination.

B. Verify that surfaces of pipes, valves, and fittings are clean and dry.

C. Verify that piping has been inspected and is ready for insulation.

3.2 INSTALLATION

A. Install heat tracing before insulation is installed.

B. Install equipment according to manufacturer instructions.

C. If required, spiral heat-trace cable around piping to obtain proper heating per length of piping.

D. Do not overlay cable over cable.

E. Cover installed heating cable with thermal insulation and waterproof jacketing as soon as possible.

F. Affix following label to exterior of thermal insulation every 15 feet and readily visible from ground level: CAUTION: ELECTRIC HEAT TRACING.

3.3 FIELD QUALITY CONTROL

A. Section 01730 “Execution”: Requirements for testing, adjusting, and balancing.

B. After installation, inspect for proper operation.

C. Equipment Acceptance:

1. Adjust, repair, modify, or replace components failing to perform as specified and rerun tests.
2. Make final adjustments to equipment under direction of manufacturer's representative.

D. Furnish installation certificate from equipment manufacturer's representative attesting that equipment has been properly installed and is ready for startup and testing.

3.4 ADJUSTING

A. Check control functions and adjust as required.

3.5 DEMONSTRATION

A. Demonstrate equipment startup, shutdown, routine maintenance, and emergency repair procedures to Owner's personnel.

END OF SECTION 15291

SECTION 15305 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

D. Valve Schedules: Valve numbering scheme.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Carlton Industries, LP.
d. Champion America.
e. Craftmark Pipe Markers.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: White and orange.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.

2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping: Painting of piping is specified in Section 09912 "Interior Painting."

B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit a view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15305

SECTION 15312 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anticorrosion coated or galvanized, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig minimum.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Composite plastic.
5. Connecting Bolts and Nuts: Stainless steel, Type 316, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

C. Plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, Use NT.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Permathane®/Acryl-R®; ITW Polymers Sealants North America.
c. Polymeric Systems, Inc.
d. Sherwin-Williams Company (The).
e. The Dow Chemical Company.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. May National Associates, Inc.; a subsidiary of Sika Corporation.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

2. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.

3.2 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Use grout or silicone sealant, to seal the space around outside of sleeve-seal fittings.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Cast-iron pipe sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system or Sleeve-seal fittings.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: PVC pipe sleeves.
b. Piping NPS 6 and Larger: PVC pipe sleeves.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Steel pipe sleeves .
b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 15312

SECTION 15314 - GENERAL-DUTY VALVES FOR FIRE PROTECTION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Two-piece ball valves with indicators.
2. Check valves.
3. Bronze OS&Y gate valves.
4. Iron OS&Y gate valves.
5. Indicator posts.
6. Trim and drain valves.

1.3 DEFINITIONS

A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Main Level: HAMV - Fire Main Equipment.

a. Level 1: HCBZ - Indicator Posts, Gate Valve.
b. Level 1: HLOT - Valves.

1) Level 3: HLUG - Ball Valves, System Control.
2) Level 3: HLXS - Butterfly Valves.
3) Level 3: HMER - Check Valves.
4) Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.

a. Level 1: VQGU - Valves, Trim and Drain.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:

a. Indicator posts.
b. Valves.

1) Gate valves.
2) Check valves.

a) Single check valves.

3) Miscellaneous valves.

C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

D. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.

3. ASME B31.9 for building services piping valves.

E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

F. NFPA Compliance: Comply with NFPA 24 for valves.

G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

H. Valve Sizes: Same as upstream piping unless otherwise indicated.

I. Valve Actuator Types:

1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

A. Description:

1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
2. Minimum Pressure Rating: 175 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 CHECK VALVES

A. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.4 BRONZE OS&Y GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Threaded.

2.5 IRON OS&Y GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged.

2.6 INDICATOR POSTS

A. Description:

1. Standard: UL 789 and FM Global standard for indicator posts.
2. Type: Underground.
3. Base Barrel Material: Cast or ductile iron.
4. Extension Barrel: Cast or ductile iron.
5. Cap: Cast or ductile iron.
6. Operation: Wrench.

2.7 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Description:

a. Pressure Rating: 175 psig.

b. Body Design: Two piece.
c. Body Material: Forged brass or bronze.
d. Port size: Full or standard.
e. Seats: PTFE.
f. Stem: Bronze or stainless steel.
g. Ball: Chrome-plated brass.
h. Actuator: Handlever.
i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:

1. Description:

a. Pressure Rating: 175 psig.
b. Body Material: Brass or bronze.
c. Ends: Threaded.
d. Stem: Bronze.
e. Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

1. Description:

a. Pressure Rating: 175 psig.
b. Body Material: Bronze with integral seat and screw-in bonnet.
c. Ends: Threaded.
d. Stem: Bronze.
e. Disc Holder and Nut: Bronze.
f. Disc Seat: Nitrile.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Comply with requirements in the following Sections for specific valve installation requirements and applications:

1. Section 15317 "Facility Fire-Suppression Water-Service Piping" for application of valves in fire-suppression water-service piping outside the building.
2. Section 15331 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the pipe center.

F. Install valves in position to allow full stem movement.

G. Install valve tags. Comply with requirements in Section 15305 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 15314

SECTION 15315 - HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Fastener systems.
3. Equipment supports.
4. Materials.
5. Delegated-design.

B. Related Requirements:

1. Section 05502 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer registered in the State of Rhode Island. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

1.4 DELEGATED-DESIGN SUBMITTALS

A. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in the State of Rhode Island responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer registered in the State of Rhode Island, as defined in Section 01400 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

C. NFPA Compliance: Comply with NFPA 13.

D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe and Tube Hangers:

1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.3 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Indoor Applications: Stainless steel.
   2. Outdoor Applications: Stainless steel.

2.4 EQUIPMENT SUPPORTS

A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.5 MATERIALS

A. Aluminum: ASTM B 221.

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout, suitable for interior and exterior applications.

   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal strut systems.

D. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Install in accordance with approvals and listings.
2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.

a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.

b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 09911 "Exterior Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use thermal hanger-shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.

6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Comply with NFPA requirements.

L. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. C-Clamps (MSS Type 23): For structural shapes.
3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

M. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

N. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

P. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 15315

SECTION 15317 - FACILITY FIRE-SUPPRESSION WATER-SERVICE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes fire-suppression water-service piping and related components outside the building and service entrance piping through floor into the building and the following:

1. Pipes, fittings, and specialties.
2. Fire-suppression specialty valves.
3. Alarm devices.

B. Utility-furnished products include water meters that are furnished to the site, ready for installation.

C. Related Requirements:

1. Section 15322 "Fire-Department Connections" for exposed-, flush-, and yard-type, fire-department connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying the water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with FM Global's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-suppression water-service piping.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Fire-Suppression Water-Service Piping: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:

1. Notify Engineer no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner's written permission.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B88, Type K and ASTM B88, Type L, water tube, annealed temper.

B. Hard Copper Tube: ASTM B88, Type K and ASTM B88, Type L, water tube, drawn temper.

C. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

D. Copper, Pressure-Seal Fittings:
1. Standard: UL 213.
2. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
3. NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.

F. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.

B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end.

C. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end.

D. Grooved-End, Ductile-Iron Pipe Appurtenances:
1. Grooved-End, Ductile-Iron Fittings: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions matching pipe.
2. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

E. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

F. Push-on-Joint, Ductile-Iron Fittings: AWWA C153, ductile-iron compact pattern.

1. Gaskets: AWWA C111, rubber.

G. Flanges: ASME B16.1, Class 125, cast iron.

2.3 SPECIAL PIPE FITTINGS

A. Ductile-Iron Flexible Expansion Joints:

1. Description: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
2. Pressure Rating: 250 psig minimum.

B. Ductile-Iron Deflection Fittings:

1. Description: Compound, ductile-iron coupling fitting with sleeve and one or two flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
2. Pressure Rating: 250 psig minimum.

2.4 JOINING MATERIALS

A. Gaskets for Ferrous Piping and Copper-Alloy Tubing: ASME B16.21, asbestos free.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series.

C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

2.5 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Tubular-Sleeve Pipe Couplings:

1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners, and with ends of same sizes as piping to be joined.

2. Standard: AWWA C219.
3. Center-Sleeve Material: Manufacturer's standard.
4. Gasket Material: Natural or synthetic rubber.
5. Pressure Rating: 200 psig minimum.
6. Metal Component Finish: Corrosion-resistant coating or material.

2.6 PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Standard: ASSE 1003.
2. Pressure Rating: Initial pressure of 150 psig.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water Control Valves:

1. Description: Pilot-operation, diaphragm-type, single-seated main water control valve with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
2. Pressure Rating: Initial pressure of 150 psig minimum.
3. Main Valve Body: Cast or ductile iron with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
   a. Trim: Stainless steel.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.7 BACKFLOW PREVENTERS

A. Reduced-Pressure-Detector, Fire-Protection Backflow Preventer Assemblies:

1. Standards: ASSE 1047 and UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig maximum, through middle one-third of flow range.

B. Backflow Preventer Test Kits:

1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.8 ALARM DEVICES

A. General: UL 753 and FM Global's "Approval Guide" listing, of types and sizes to mate and match piping and equipment.

B. Water-Flow Indicators: Vane-type water-flow detector, rated for 250-psig working pressure; designed for horizontal or vertical installation; with two single-pole, double-throw circuit switches to provide isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal when cover is removed.

C. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position.

D. Pressure Switches: Single pole, double throw; designed to signal increase in pressure.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with excavating requirements in Section 02300 "Earthwork" and trenching, and backfilling in Section 02333 “Trenching and Backfilling.”

3.2 PIPING INSTALLATION

A. Water-Main Connection: Arrange with water utility company for tap of size and in location indicated in water main.

B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

C. Make connections larger than NPS 2 with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

D. Make connections NPS 2 and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company's standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

E. Comply with NFPA 24 for fire-service-main piping materials and installation.

F. Install copper tube and fittings according to CDA's "Copper Tube Handbook."

1. Install encasement for tubing according to ASTM A674 or AWWA C105.

G. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

1. Install encasement for piping according to ASTM A674 or AWWA C105.

H. Install PE pipe according to ASTM D2774 and ASTM F645.

I. Install PVC, AWWA pipe according to ASTM F645 and AWWA M23.

J. Install fiberglass AWWA pipe according to AWWA M45.

K. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

L. Comply with requirements for fire-suppression water-service piping inside the building in the following Sections:

1. Section 15331 "Wet-Pipe Sprinkler Systems”

M. Comply with requirements in Section 15132 "Domestic Water Piping" for potable-water piping inside the building.

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15312 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15312 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure rating same as or higher than systems pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in tubing NPS 2 and smaller.

C. Install flanges, flange adaptors, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of tubes and remove burrs.

E. Remove scale, slag, dirt, and debris from outside and inside of pipes, tubes, and fittings before assembly.

F. Copper-Tubing, Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

G. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.

H. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.

I. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts.

J. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with bolts according to ASME B31.9.

K. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

L. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D2774 or ASTM D3139.

M. Fiberglass Piping Bonded Joints: Use adhesive and procedure recommended by piping manufacturer.

N. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

O. Do not use flanges or unions for underground piping.

3.4 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Locking mechanical joints.
3. Set-screw mechanical retainer glands.
4. Bolted flanged joints.
5. Heat-fused joints.
6. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches in fire-suppression water-service piping according to NFPA 24 and the following:

1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
3. Bonded-Joint Fiberglass, Water-Service Piping: According to AWWA M45.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.5 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

C. UL-Listed or FM Global-Approved Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. UL-Listed or FM Global-Approved Valves Other Than Gate Valves: Comply with NFPA 24.

E. MSS Valves: Install as component of connected piping system.

F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

G. Pressure-Reducing Valves: Install in vault or aboveground between shutoff valves. Install full-size valved bypass.

H. Support valves and piping, not direct buried, on concrete piers. Comply with requirements for concrete piers in Section 03300A "Cast-in-Place Concrete."

3.6 DETECTOR CHECK VALVE INSTALLATION

A. Install in vault or aboveground.

B. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.

C. Support detector check valves and piping on concrete piers. Comply with requirements for concrete piers in Section 03300A "Cast-in-Place Concrete."

3.7 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 and larger backflow preventers and piping on concrete piers. Comply with requirements for concrete piers in Section 03300A "Cast-in-Place Concrete."

3.8 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install ball drip valves at each check valve for fire-department connection to mains.

B. Install protective pipe bollards on two sides of each freestanding fire-department connection. Pipe bollards are specified in Section 05502 "Metal Fabrications."

3.9 ALARM DEVICE INSTALLATION

A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.

B. Supervisory Switches: Supervise valves in open position.

1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.

C. Locking and Sealing: Secure unsupervised valves as follows:

1. Valves: Install chain and padlock on open OS&Y gate valve.
2. Post Indicators: Install padlock on wrench on indicator post.

D. Pressure Switches: Drill and thread hole in exposed barrel of fire hydrant. Install switch.

E. Water-Flow Indicators: Install in water-service piping in vault. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.

F. Connect alarm devices to building's fire-alarm system. Wiring and fire-alarm devices are specified in Section 16846 "Conventional Fire-Alarm Systems."

3.10 CONNECTIONS

A. Connect fire-suppression water-service piping to interior fire-suppression piping.

B. Connect waste piping from concrete vault drains to sanitary sewerage system. Comply with requirements in Section 15152 "Facility Sanitary Sewers" for connection to sanitary sewer.

3.11 FIELD QUALITY CONTROL

A. Use test procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described below.

B. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

C. Hydrostatic Tests: Test at not less than one-and-one-half times the working pressure for two hours.

1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for one hour; decrease to zero psig. Slowly increase again to test pressure and hold for one more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

D. Prepare test and inspection reports.

3.12 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground fire-suppression water-service piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in various Division 16 sections.

B. Permanently attach equipment nameplate or marker indicating plastic fire-suppression water-service piping or fire-suppression water-service piping with electrically insulated fittings, on main electrical meter panel. Comply with requirements for identifying devices in Section 15305 "Identification for Fire-Suppression Piping and Equipment."

3.13 CLEANING

A. Clean and disinfect fire-suppression water-service piping as follows:

1. Purge new piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:

    a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow it to stand for 24 hours.
    b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow it to stand for three hours.
    c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
    d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 15317

SECTION 15322 – FIRE DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Exposed-type fire-department connections.
2. Flush-type fire-department connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.1 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

A. Standard: UL 405.

B. Type: Exposed, projecting, for wall mounting.

C. Pressure Rating: 175 psig minimum.

D. Body Material: Corrosion-resistant metal.

E. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

F. Caps: Brass, lugged type, with gasket and chain.

G. Escutcheon Plate: Round, brass, wall type.

H. Outlet: Back, with pipe threads.

I. Number of Inlets: Two.

J. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."

K. Finish: Rough brass or bronze.

L. Outlet Size: NPS 5.

2.2 FLUSH-TYPE FIRE-DEPARTMENT CONNECTION

A. Standard: UL 405.

B. Type: Flush, for wall mounting.

C. Pressure Rating: 175 psig minimum.

D. Body Material: Corrosion-resistant metal.

E. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

F. Caps: Brass, lugged type, with gasket and chain.

G. Escutcheon Plate: Rectangular, brass, wall type.

H. Outlet: With pipe threads.

I. Body Style: Square.

J. Number of Inlets: Two.

K. Outlet Location: Back.

L. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."

M. Finish: Rough brass or bronze.

N. Outlet Size: NPS 5.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.

B. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-type fire-department connections.

B. Install yard-type fire-department connections in concrete slab support. Comply with requirements for concrete in Section 03300A "Cast-in-Place Concrete."

C. Install two protective pipe bollards on sides of each fire-department connection. Comply with requirements for bollards in Section 05502 "Metal Fabrications."

D. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 15322

SECTION 15331 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Specialty valves.
3. Sprinklers.
4. Alarm devices.
5. Manual control stations.
6. Control panels.
7. Pressure gages.
8. Delegated design.

B. Related Requirements:

1. Section 15322 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
2. Section 15314 "General-Duty Valves for Fire Protection Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.3 DEFINITIONS

A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig, but not higher than 250 psig.

B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

C. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.5 DELEGATED-DESIGN SUBMITTAL

A. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in the State of Rhode Island responsible for their preparation.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.
2. Compressed air piping.
3. HVAC hydronic piping.
4. Items penetrating finished ceiling include the following:

a. Lighting fixtures.
b. Air outlets and inlets.

B. Qualification Data: For qualified Installer and professional engineer registered in the State of Rhode Island.

C. Design Data:

1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

D. Welding certificates.

E. Field Test Reports:

1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
2. Fire-hydrant flow test report.

F. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services, registered in the State of Rhode Island, needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer registered in the State of Rhode Island.

B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.

1.10 FIELD CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13.

B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

C. High-Pressure Piping System Component: Listed for 250-psig minimum working pressure.

D. Delegated Design: Engage a qualified professional engineer registered in the State of Rhode Island, as defined in Section 01400 "Quality Requirements," to design wet-pipe sprinkler systems.

E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

C. Galvanized- and Uncoated-Steel Couplings: ASTM A 865/A 865M, threaded.

D. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

E. Malleable- or Ductile-Iron Unions: UL 860.

F. Cast-Iron Flanges: ASME 16.1, Class 125.

G. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.

    a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
    b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.

H. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

I. Grooved-Joint, Steel-Pipe Appurtenances:
1. Pressure Rating: 175-psig minimum.
2. Galvanized Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

J. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

2.3 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:

1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
2. High-Pressure Piping Specialty Valves: 250-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Alarm Valves:

1. Standard: UL 193.
2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, and fill-line attachment with strainer.
4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Automatic (Ball Drip) Drain Valves:

1. Standard: UL 1726.
2. Pressure Rating: 175-psig minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4.
5. End Connections: Threaded.

2.4 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 175-psig minimum.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Standard: UL 199.
2. Pressure Rating: 175 psig.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Standard: UL 1474.
2. Pressure Rating: 250-psig minimum.
3. Body Material: Steel pipe with EPDM-rubber O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Standard: UL 1474.
2. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: 175-psig minimum.
4. Size: Same as connected piping, for sprinkler.

2.5 SPRINKLERS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating for Residential Sprinklers: 175-psig maximum.

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Pressure Rating for High-Pressure Automatic Sprinklers: 250-psig minimum.

E. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Residential Applications: UL 1626.
4. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

F. Open Sprinklers with Heat-Responsive Element Removed: UL 199.

1. Nominal Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8.
2. Nominal Orifice: 17/32 inch with discharge coefficient K between 7.4 and 8.2.

G. Sprinkler Finishes: bronze.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

I. Sprinkler Guards:

1. Standard: UL 199.
2. Type: Wire cage with fastening device for attaching to sprinkler.

2.6 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm:

1. Standard: UL 753.
2. Type: Mechanically operated, with Pelton wheel.
3. Alarm Gong: Cast aluminum with red-enamel factory finish.
4. Size: 8-1/2-inches diameter.
5. Components: Shaft length, bearings, and sleeve to suit wall construction.
6. Inlet: NPS 3/4.
7. Outlet: NPS 1 drain connection.

C. Electrically Operated Alarm Bell:

1. Standard: UL 464.
2. Type: Vibrating, metal alarm bell.
3. Size: 6-inch minimum- diameter.
4. Finish: Red-enamel factory finish, suitable for outdoor use.

5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Water-Flow Indicators:

1. Standard: UL 346.
2. Water-Flow Detector: Electrically supervised.
3. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
4. Type: Paddle operated.
5. Pressure Rating: 250 psig.
6. Design Installation: Horizontal or vertical.

E. Pressure Switches:

1. Standard: UL 346.
2. Type: Electrically supervised water-flow switch with retard feature.
3. Components: Single-pole, double-throw switch with normally closed contacts.
4. Design Operation: Rising pressure signals water flow.

F. Valve Supervisory Switches:

1. Standard: UL 346.
2. Type: Electrically supervised.
3. Components: Single-pole, double-throw switch with normally closed contacts.
4. Design: Signals that controlled valve is in other than fully open position.
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 MANUAL CONTROL STATIONS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve.

B. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.8 CONTROL PANELS

A. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves.

1. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" when used with thermal detectors and Class A detector circuit wiring.

2. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

C. Manual Control Stations: Hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

D. Panels Components:

1. Power supply.
2. Battery charger.
3. Standby batteries.
4. Field-wiring terminal strip.
5. Electrically supervised solenoid valves and polarized fire-alarm bell.
6. Lamp test facility.
7. Single-pole, double-throw auxiliary alarm contacts.
8. Rectifier.

2.9 PRESSURE GAGES

A. Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch diameter.

C. Pressure Gage Range: 0- to 250-psig minimum.

D. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 15317 "Facility Fire-Suppression Water-Service Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Engineer before deviating from approved working plans.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.

N. Pressurize and check preaction sprinkler system piping and air-pressure maintenance devices.

O. Fill sprinkler system piping with water.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15312 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15312 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

J. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

K. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

L. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

M. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

N. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

O. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

P. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.

Q. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

R. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

S. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

3.5 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and NFPA 13 or NFPA 13R for supports.

3.6 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.7 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.8 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

END OF SECTION 15331

SECTION 15372 - REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Adjustable blade face registers.
2. Fixed face registers.

B. Related Requirements:

1. Section 15715 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 REGISTERS

A. Adjustable Blade Face Register, SR:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Krueger.
b. Price Industries.
c. Titus.

2. Material: Steel, aluminum or stainless steel as required for duct system served.

3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Vertical spaced3/4 inchapart.
5. Rear-Blade Arrangement: Horizontal spaced 3/4 inch apart.
6. Frame: 1-1/4 inches wide.
7. Mounting: Countersunk screw.
8. Damper Type: Adjustable opposed blade.

B. Fixed Face Register, RR, ER:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Krueger.
   b. Price Industries.
   c. Titus.

2. Material: Steel, aluminum or stainless steel as required for duct system served.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.
5. Frame: 1-1/4 inches wide.
6. Mounting: Countersunk screw.
7. Damper Type: Adjustable opposed blade.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Engineer for a determination of final location.

C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 15372

SECTION 15476 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Thermostat-control, electric, tankless, domestic-water heaters.
2. Domestic-water heater accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Thermostat-Control, Electric, Tankless, Domestic-Water Heaters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell Water Heaters; TX027-3T4-G or a comparable product by one of the following:

a. Chronomite Laboratories, Inc; a division of Morris Group International.
b. Niagara Industries, Inc.

2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 499 for electric, tankless, (domestic-water heater) heating appliance.
4. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.

a. Connections: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Heating Element: Resistance heating system.
d. Temperature Control: Thermostat.
e. Safety Control: High-temperature-limit cutoff device or system.
f. Jacket: Stainless Steel NEMA 4X.

5. Support: Bracket for wall mounting.
6. Capacity and Characteristics:

a. Flow Rate: 3 gpmat 66 deg F temperature rise.
b. Temperature Setting: 110 deg F.

c. Electrical Characteristics:

1) Volts: 480 V.
2) Phases: Three.
3) Hertz: 60 Hz.
4) Full-Load Amperes: 35 A.
5) Maximum Overcurrent Protection: 50 A.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.

B. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least 18 inches above floor on wall bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

B. Install electric, domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 15022 "Ball Valves for Plumbing Piping."

C. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Fill electric, domestic-water heaters with water.

E. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 15132 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 15035 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain tankless, electric, domestic-water heaters. Training shall be a minimum of one hour.

END OF SECTION 15476

SECTION 15517 - GAS VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Listed double-wall vents.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

B. Shop Drawings: For vents.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. DuraVent, Inc.
2. Heatfab Saf-T Vent.
3. Metal-Fab, Inc.
4. Selkirk Corporation.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: Stainless-steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Special Gas Vent: Positive pressure appliances.

3.3 INSTALLATION OF LISTED VENTS

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07720 "Roof Accessories."

B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

E. Lap joints in direction of flow.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 15517

SECTION 15554 - GAS-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes gas-fired unit heaters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For gas-fired unit heaters. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer registered in the State of Rhode Island detailing fabrication and assembly of gas-fired unit heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings or comparable products by one of the following:

1. REZNOR, a brand of Nortek Global HVAC.
2. Sterling HVAC Products; a Mestek company.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.

B. Gas Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

C. Type of Venting: Indoor, separated combustion, power vented.

D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.

1. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
2. Discharge Louvers: Independently adjustable, blades.

E. Accessories:

1. Four-point suspension kit.
2. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

F. Heat Exchanger: Stainless steel.

G. Burner Material: Stainless steel.

H. Propeller Unit Fan:

1. Formed-steel or Aluminum propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

I. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 15042 "Common Motor Requirements for HVAC Equipment."

J. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Single stage.
2. Ignition: Electronically controlled electric spark with flame sensor.
3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
4. Control transformer.
5. High Limit: Thermal switch or fuse to stop burner.
6. Thermostat: Devices and wiring are specified in Section 15935 "Temperature Instruments."
7. Wall-Mounted Thermostat:

    a. Single stage.
    b. 24-V ac.
    c. 50 to 90 deg F operating range.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

B. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.

1. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 15061 "Hangers and Supports for HVAC Piping and Equipment" and Section 15064 "Vibration Controls for HVAC."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to gas-fired unit heater, allow space for service and maintenance.

C. Gas Piping: Comply with Section 15243 "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Vent Connections: Comply with Section 15517 "Gas Vents."

E. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

END OF SECTION 15554

SECTION 15712 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

B. Related Sections:

1. Section 15905 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 15715 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.

11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal

Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 15715 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork shall be Type 316 stainless steel.

2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 15091 "Duct Insulation."

3.4 DUCT SEALING

A. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, mechanical expansion fasteners or adhesive fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install mechanical expansion fasteners or adhesive fasteners after concrete is placed and completely cured.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 15715 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 09911 "Exterior Painting" and Section 09912 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 15013 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 15715 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

G. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.10 STARTUP

A. Air Balance: Comply with requirements in Section 15905 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. See drawings for duct construction determinants schedule.

END OF SECTION 15712

SECTION 15715 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Fire dampers.
4. Flange connectors.
5. Turning vanes.
6. Duct-mounted access doors.
7. Duct Access Panel Assemblies
8. Flexible connectors.
9. Duct accessory hardware.

B. Related Requirements:

1. Section 16846 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No. 2 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Greenheck Fan Corporation.
2. Pottorff.
3. Ruskin Company.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2500 fpm.

D. Maximum System Pressure: 3-inch wg.

E. Frame: Hat-shaped, 0.063-inch-thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, off-center pivoted, maximum 6-inch width, 0.050-inch-thick aluminum sheet with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Tie Bars and Brackets: Aluminum.

J. Return Spring: Adjustable tension.

K. Bearings: synthetic pivot bushings.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Material: Aluminum.
6. Screen Type: Bird.
7. 90-degree stops.

M. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Greenheck.
b. McGill AirFlow LLC.
c. Pottorff.
d. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Frame: Hat-shaped.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Oil-impregnated bronze or Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

N. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Greenheck.
    b. McGill AirFlow LLC.
    c. Pottorff.
    d. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.

6. Blade Axles: Stainless steel or Nonferrous metal.
7. Bearings:

    a. Oil-impregnated bronze or Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

O. Standard, Type 316 Stainless Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Greenheck.
   b. McGill AirFlow LLC.
   c. Pottorff.
   d. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.

6. Blade Axles: Stainless steel or Nonferrous metal.
7. Bearings:

   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

P. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

Q. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Greenheck.
    b. McGill AirFlow LLC.
    c. Pottorff.
    d. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.

6. Blade Axles: Stainless steel or Nonferrous metal.
7. Bearings:

    a. Oil-impregnated bronze or Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

B. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.

D. Include elevated platform for insulated duct mounting

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Greenheck Fan Corporation.

2. Pottorff.
3. Ruskin Company.

B. Type: Static; rated and labeled according to UL 555 by an NRTL.

C. Fire Rating: 1-1/2 and 3 hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.6 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Elgen Manufacturing.

B. Description: Add-on orroll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Aero-Dyne Sound Control Co.
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.

4. Elgen Manufacturing.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Greenheck Fan Corporation.
4. Pottorff.
5. Ruskin.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.

d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.9 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Stainlesssteel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.10 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 15065 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

O. Connect flexible ducts to metal ducts with draw bands.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 15715

SECTION 15724 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sidewall propeller fans.
2. Tubular destratification fans
3. In-line centrifugal fans

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Prefabricated roof curbs.
9. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 SIDEWALL PROPELLER FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings or comparable products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Loren Cook Company.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

C. Fan Wheel: Replaceable, aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Fan Drive:

1. Belt drive.
2. Resiliently mounted to housing.
3. Statically and dynamically balanced.
4. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
5. Extend grease fitting to accessible location outside of unit.
6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L(10) of 100,000 hours.

9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
12. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

2.2 TUBULAR DESTRATIFICATION FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Airius, LLC.
2. Continental Fan Manufacturing, Inc.

B. Housing: Plastic or steel with corrosion resistant coating.

C. Fan Blades: Composite or steel.

D. Motor: PSC AC motor.

E. Controls: Variable speed controller.

F. Listed to conform to UL 507.

2.3 IN-LINE CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Loren Cook Company.
2. PennBarry.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 15042 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify according to AMCA 99.

F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION OF HVAC POWER VENTILATORS

A. Install power ventilators level and plumb.

B. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 15064 "Vibration Controls for HVAC."

C. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops.

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Section 15065 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 15715 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 16055 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 15905 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 15724

SECTION 15733 - INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes indirect, gas-fired heating and ventilating units, including the following components:

1. Casings.
2. Fans, drives, and motors.
3. Air filtration.
4. Dampers.
5. Indirect, gas-fired burners.
6. Unit control panel.
7. Controls.

B. Related Requirements:

1. Section 15042 “Common Motor Requirements for HVAC Equipment”
2. Section 15905 "Testing, Adjusting, and Balancing for HVAC."
3. Section 15914 "Direct Digital Control (DDC) System for HVAC."
4. Section 15712 "Metal Ducts."
5. Section 15715 "Air Duct Accessories."
6. Section 16052 "Low-Voltage Electrical Power Conductors and Cables."
7. Section 16055 "Control-Voltage Electrical Power Cables."
8. Section 16056 "Grounding and Bonding for Electrical Systems."

1.3 DEFINITIONS

A. DDC: Direct digital control.

1.4 ACTION SUBMITTALS

A. Product Data: For each indoor, indirect, gas-fired heating and ventilating unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.

4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include filters with performance characteristics.
7. Include direct, gas-fired burners with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's warranty.

B. Startup service reports.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For indirect, gas-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each unit.

1.8 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than one year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings or comparable products by one of the following:

1. Cambridge Engineering, Inc.
2. Greenheck Fan Corporation.
3. Hastings HVAC.
4. Modine Manufacturing Company.
5. REZNOR, a brand of Nortek Global HVAC.
6. Weather-Rite, a brand of Specified Air Solutions.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Heating and Ventilating Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

B. Configuration: Horizontal unit with horizontal discharge for floor-mounted installation.

C. Double-Wall Construction:

1. Floor Plate: Galvanized steel.
2. Casing Insulation:

    a. Insulation Thickness: 2 inches.
    b. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

3. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. Panels, Doors, and Windows:

1. Panels:

    a. Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
    b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

2. Doors:

    a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

3. Locations and Applications:

    a. Fan Section: Doors.
    b. Access Section: Doors.
    c. Gas-Fired Burner Section: Doors.
    d. Damper Section: Doors.
    e. Filter Section: Doorslarge enough to allow periodic removal and installation of filters.
    f. Mixing Section: Doors.

2.4 FAN, DRIVE, AND MOTOR

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
2. Shaft Bearings: Heavy-duty, self-aligning, permanently lubricated ball bearings with an L50 rated life of 200,000 hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
4. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
5. Shaft Lubrication Lines: Extended to a location outside the casing.
6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Drive: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.25 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 15042 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure: Open, dripproof.
4. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

2.5 AIR FILTRATION

A. Particulate air filtration is specified in Section 15771 "Particulate Air Filtration."

B. Panel Filters:

1. Description: Pleatedfactory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Cleanable Filters:

1. Cleanable metal mesh.

D. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized-steel track.

a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.6 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated minimum turndown ratio: 10 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

D. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

E. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.

F. Heat Exchanger: Stainless steel.

G. Heat-Exchanger Drain Pan: Stainless steel.

H. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.
2. Vent Flow Verification: Differential pressure switch to verify open vent.
3. High Limit: Thermal switch or fuse to stop burner.
4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
5. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
8. Control Transformer: 24 V ac.

2.7 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted or Recessed, with trim ring, remote panel, with engraved plastic cover, and the following lights and switches:

1. On-off fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250, Type 4.

2.8 CONTROLS

A. Comply with requirements in Section 15914 "Direct Digital Control (DDC) System for HVAC."

B. Fan Control, Interlocked: Fan to start automatically with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

C. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:

1. Minimum 50 percent outdoor air.
2. Outdoor-air quantity adjusted by potentiometer on control panel.
3. Outdoor-air quantity to maintain minimum building static pressure.

D. Temperature Control:

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
2. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

E. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:

a. Room temperature.
b. Discharge-air temperature.
c. Burner operating.

2. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.9 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install heating and ventilating units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 03300A "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 15064 "Vibration Controls for HVAC."

B. Suspended Units:

1. Suspend units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided.
2. Comply with requirements for vibration isolation devices specified in Section 15064 "Vibration Controls for HVAC."
3. Comply with requirements for rods, hangers and building attachments specified in Section 15061 “Hangers and Supports for HVAC Piping and Equipment.”

C. Install gas-fired units in accordance with NFPA 54.

D. Install controls and equipment shipped by manufacturer for field installation with indirect, gas-fired heating and ventilating units.

E. Do not operate fan system until filters (temporary or permanent) are in place.

3.3 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Gas Piping: Comply with requirements in Section 15243 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 15153 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.

C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

A. Connect supply and return ducts to indirect, gas-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 15715 "Air Duct Accessories" for flexible duct connectors.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 16070 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 16055 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Inspect for visible damage to burner combustion chamber.
b. Inspect casing insulation for integrity, moisture content, and adhesion.
c. Verify that clearances have been provided for servicing.
d. Verify that controls are connected and operable.
e. Verify that filters are installed.
f. Clean furnace flue and inspect for construction debris.
g. Purge gas line.
h. Inspect and adjust vibration isolators.
i. Verify bearing lubrication.
j. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

k. Adjust fan belts to proper alignment and tension.
l. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
m. Verify that shipping, blocking, and bracing are removed.
n. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.

B. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete.
4. Operate unit for initial period recommended by manufacturer.
5. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

   a. Measure gas pressure at manifold.
   b. Inspect operation of power vents.
   c. Measure combustion-air temperature at inlet to combustion chamber.
   d. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
   e. Measure flue-gas temperature at furnace discharge.
   f. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.

6. Calibrate thermostats.
7. Adjust and inspect high-temperature limits.
8. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
9. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
10. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
11. Measure and record motor electrical values for voltage and amperage.
12. Measure and record airflow. Plot fan volumes on fan curve.
13. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

14. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
15. Verify drain-pan performance.
16. Verify outdoor-air damper operation.

3.8 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

1. Instructor shall be factory trained and certified.
2. Provide not less than 2 hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.
7. Video record the training sessions and provide electronic copy to Owner.

END OF SECTION 15733

SECTION 15806 - PACKAGED TERMINAL AIR-CONDITIONERS, OUTDOOR, WALL-MOUNTED UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, terminal, outdoor, wall-mounted air conditioners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For packaged, terminal air conditioners.

1. Include plans, elevations, sections, details for wall penetrations, and attachments to other work.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For packaged, terminal air conditioners, for tests performed by manufacturer and witnessed by a qualified testing agency.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged, terminal air conditioners to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Substantial Completion, including components and labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Liebert; Vertiv Holdings Co.
2. Marvair.

2.2 MANUFACTURED UNITS

A. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, heating, and temperature controls; fully charged with refrigerant and filled with oil; with hardwired chassis and circuit breaker.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASHRAE Thermal Comfort: Applicable requirements in ASHRAE 55.

E. ASHRAE ERV Testing: Applicable requirements in ASHRAE 84.

F. AHRI Rating: Applicable requirements in AHRI 1060.

G. UL listed and ETL performance certified.

2.3 CHASSIS

A. Cabinet: Sloped top, 0.052-inch-thick steel with removable front panel with concealed latches.

1. Mounting: On exterior wall.
2. Discharge Grille: Extruded-aluminum discharge grille.
3. Return Grille: Extruded-aluminum grille.
4. Finish: Baked enamel.
5. Access Door: Hinged door in top of cabinet for access to controls.
6. Insulation: Cooling and heating sections fully insulated with 1-inch-thick fiberglass insulation.
7. Wall Sleeves: Galvanized steel with polyester finish.

B. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with liquid line filter dryer, externally equalized expansion valve, high-pressure switch, low-pressure switch, fan cycle, control, lockout relay, common alarm, vibration isolation, and overload protection.

1. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins.
2. Charge: R-410A.

C. Indoor Fan: Forward curved, centrifugal; with constant-speed motor(s) and positive-pressure ventilation damper with concealed manual operator.

D. Filters: 2-inch, pleated, disposable MERV 6, serviceable from front of the unit.

E. Condensate Drain: Coated galvanized-steel drain pan to direct condensate to outdoor coil for re-evaporation.

F. Outdoor Fan: Forward curved, centrifugal, or propeller type with separate motor.

1. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 15042 "Common Motor Requirements for HVAC Equipment."

a. Fan Motors: Permanently lubricated split capacitor.
b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 HEATING

A. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.

2.5 CONTROLS

A. Low Ambient Cooling: Unit shall cool down to 0 degrees F.

B. Economizer Operation: Motorized intake-air damper controlled by an enthalpy sensor and a mixed-air sensor to provide natural cooling when the outdoor air temperature is favorable.

C. Four Unit Control: Hinged cover with integral temperature and humidity sensor that will maintain space temperature and humidity and cycle units on and off to equalize run time. The Four Unit Controller shall provide auto sequencing and displays on status and operating status parameters. The unit shall have a CAT6 ethernet port to view built-in graphic screens or communicate via Modbus.

D. Three-Phase Power Rotation Monitor: Three-phase monitoring to protect compressor from reverse rotation and to protect the unit from phase failure. Monitor manually reset.

E. Dehumidification Circuit: Supply-air stream, independent coil using hot gas to reheat the airstream.

2.6 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."

B. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.

B. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 07920 "Joint Sealants."

C. Comply with requirements for vibration isolation devices specified in Section 15064 “Vibration Controls for HVAC.”

D. Comply with requirements for rods, hangers and building attachments specified in Section 15061 “Hangers and Supports for HVAC Piping and Equipment.”

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Unit is level on base and is flashed in exterior wall.
4. Unit casing has no visible damage.
5. Compressor, air-cooled condenser coil, and fans have no visible damage.
6. Labels are clearly visible.
7. Controls are connected and operable.
8. Shipping bolts, blocks, and tie-down straps are removed.
9. Filters are installed and clean.
10. Drain pan and drain line are installed correctly.
11. Electrical wiring installation complies with manufacturer's submittal and installation requirements in electrical Sections.

12. Installation: Perform startup checks according to manufacturer's written instructions, including the following:

    a. Lubricate bearings on fan.
    b. Check fan-wheel rotation for correct direction without vibration and binding.

13. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
14. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. After performance test, change filters.

D. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.3 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged, terminal air conditioners.

END OF SECTION 15806

SECTION 15816 – DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. AHRI Certified Performance:

1. Performance certification in accordance with AHRI Standard 210/240.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 03300A "Cast-in-Place Concrete."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Seven years from date of Substantial Completion.
b. For Parts: Five years from date of Substantial Completion.
c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Daikin.
2. LG.
3. Samsung HVAC.

2.2 PERFORMANCE REQURIEMENTS

A. Outdoor unit Sound rating: not to exceed 55 dB(A).

B. Indoor unit Sound rating: not to exceed 50 dB(A).

C. Minimum allowable indoor and outdoor vertical separation: 98 feet.

D. Minimum allowable line set length: 98 feet.

E. Cooling operating temperature range:

1. Outdoor: 0 to 115 deg Fwith or without the addition of wind baffle accessory.
2. Indoor: 67 to 90 deg F

F. Heating operating temperature range:

1. Outdoor: Minus 4 to 75 deg F.
2. Indoor: 50 to 82 deg F.

G. Testing: Indoor and outdoor units individually run tested at the factory.

2.3 WALL MOUNTED INDOOR UNIT

A. Description: Factory-assembled complete unit with components, piping, wiring, and controls required for mating to piping, power, and control board with field connections.

B. Cabinet:

1. Material: High impact plastic chassis and fascia.
2. Mounting: Manufacturer-designed provisions for field installation. Wall mounted with front panel access to the filter.
3. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
4. Outside Air Intake: Knockout panel for outside ventilation air.

C. DX Coil Assembly:

1. Construction: Nonferrous construction, aluminum fins coated on copper tubing.
2. Coil Tubes: Copper with internal grooves.
3. Internal Tubing: Copper tubing with brazed joints.
4. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
5. Field Piping Connections: Manufacturer's standard.
6. Factory Charge: Dehydrated air or nitrogen.
7. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted condensate pump with check valve, with a maximum vertical lift of 29 inches.
3. Condensate Float Switch: Disable unit operation in the event of condensate overflow.
4. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan: Direct-drive fan(s) driven by a single motor statically and dynamically balanced.
2. Construction: Fabricated from non-ferrous components.
3. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

5. Speed Settings and Control: Three or more speed settings with a speed range of least 50 percent.

F. Filter Assembly:

1. Access: Included with fascia panel, to accommodate filter replacement without the need for tools.
2. Efficiency: MERV 8.

G. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls, 208/230 V, single phase, 60 hertz.
3. Control Transformer: Manufacturer's standard, factory installed.
4. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.4 OUTDOOR UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Galvanized steel, with a powder coated baked enamel finish.
2. Piping Connections: Make pipe connections inside the outdoor unit chassis. Refrigerant pipes can exit through the front, side, rear, or bottom sides of the outdoor unit.

C. Compressor and Motor Assembly:

1. Twin positive-displacement, inverter driven, scroll compressors.
2. Vibration Control: Integral isolation to dampen vibration transmission.
3. Accumulator: Systems shall have an accumulator with accumulator return valve control.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics, to control refrigerant flow to the indoor unit.
5. Protection: Systems shall have a high-pressure safety switch, fuse, over-current protection, over-voltage protection, temperature limit protection logic, compressor overload sensing.

D. Condenser Coil Assembly: Aluminum, flat fin, micro-channel with integral guard.

E. Condenser Fan and Motor Assembly:

1. Fans: One or two, propeller type.

a. Horizontal discharge airflow.
b. Direct-drive arrangement.
c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.

2. Fan Guards: Raised guards to protect moving parts.
3. Motor(s): Brushless dc with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Control Transformer: Manufacturer's standard.
4. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.5 REMOTE CONTROLLER

A. Description: Wall mounted controller with LCD display and built-in temperature sensor where system operating parameters are observed and input.

B. Casing: Suitable for indoor dry locations.

2.6 SYSTEM CONTROLS

A. Description: Each indoor unit and outdoor unit contain a microprocessor and are associated with a remote controller connected by communications cable.

B. Indoor unit microprocessor capabilities:

1. Monitoring return air temperature and indoor coil temperature.
2. Receiving and processing commands from a remote controller.
3. Operating the system without a remote controller.
4. Controlling the outdoor unit.

C. Outdoor unit microprocessor capabilities:

1. Receiving and processing commands from the indoor unit controller.
2. Controlling the components of the outdoor unit.

2.7 REFRIGERANT

A. ASHRAE 34, Class A1 refrigerant classification.

B. Refrigerant: A full charge of R-410A is included for the condensing unit by system manufacturer for lines sets up to 25 feet. Provide additional refrigerant based on diameters and lengths of system liquid refrigerant lines, and indoor equipment model and quantity.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 07720 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03300A "Cast-in-Place Concrete."
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 15064 "Vibration Controls for HVAC."
4. Comply with requirements for hangers and building attachments specified in Section 15061 “Hangers and Supports for HVAC Piping and Equipment.”

E. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Insert startup steps if any.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 15816

SECTION 15905 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

    a. Constant-volume air systems.

2. Testing, Adjusting, and Balancing Equipment:

    a. Motors.
    b. Condensing units.
    c. Heat-transfer coils.

3. Testing, adjusting, and balancing existing systems and equipment.
4. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

E. Certified TAB reports.

F. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. TAB Specialists Qualifications: Certified by NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.6 FIELD CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

E. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

K. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete, and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 15091 "Duct Insulation," Section 15092 "HVAC Equipment Insulation,"

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 15712 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.

8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.7 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.8 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.9 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Engineer's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.

d. Face and bypass damper settings at coils.
e. Fan drive settings including settings and percentage of maximum pitch diameter.
f. Inlet vane settings for variable-air-volume systems.
g. Settings for supply-air, static-pressure controller.
h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.

h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.

g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.

g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Instrument Calibration Reports:

1. Report Data:

    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.12 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Engineer.

B. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

F. Prepare test and inspection reports.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 15905

SECTION 15914 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delegated-design.

B. Related Requirements:

1. Communications Cabling:

a. Section 16055 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.

2. Raceways:

a. Section 16058 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.

3. Section 16070 "Identification for Electrical Systems" for identification requirements for electrical components.

1.3 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.

3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. E/P: Voltage to pneumatic.

L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

M. HLC: Heavy load conditions.

N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

O. I/P: Current to pneumatic.

P. LAN: Local area network.

Q. LNS: LonWorks Network Services.

R. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

S. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

T. Modbus TCP/IP: An open protocol for exchange of process data.

U. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

V. MTBF: Mean time between failures.

W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Y. Peer to Peer: Networking architecture that treats all network stations as equal partners.

Z. POT: Portable operator's terminal.

AA. PUE: Performance usage effectiveness.

BB. RAM: Random access memory.

CC. RF: Radio frequency.

DD. Router: Device connecting two or more networks at network layer.

EE. Server: Computer used to maintain system configuration, historical and programming database.

FF. TCP/IP: Transport control protocol/Internet protocol.

GG. UPS: Uninterruptible power supply.

HH. USB: Universal Serial Bus.

II. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

JJ. VAV: Variable air volume.

KK. WLED: White light emitting diode.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. Shop Drawings:

1. General Requirements:

   a. Include cover drawing with Project name, location, Owner, Engineer, Contractor and issue date with each Shop Drawings submission.
   b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.

2. Schematic drawings for each controlled HVAC system indicating the following:

    a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
    b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
    c. A graphic showing location of control I/O in proper relationship to HVAC system.
    d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
    e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
    f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
    g. Narrative sequence of operation.
    h. Graphic sequence of operation, showing all inputs and output logical blocks.

3. Control panel drawings indicating the following:

    a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
    b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
    c. Front, rear, and side elevations and nameplate legend.
    d. Unique drawing for each panel.

4. DDC system network riser diagram indicating the following:

    a. Each device connected to network with unique identification for each.
    b. Interconnection of each different network in DDC system.
    c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
    d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

5. DDC system electrical power riser diagram indicating the following:

    a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
    c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    d. Power wiring type and size, race type, and size for each.

6. Monitoring and control signal diagrams indicating the following:

    a. Control signal cable and wiring between controllers and I/O.
    b. Point-to-point schematic wiring diagrams for each product.

c. Control signal tubing to sensors, switches and transmitters.
d. Process signal tubing to sensors, switches and transmitters.
e. Pneumatic main air and control signal tubing to pneumatic damper and valve actuators, pilot-positioners if applicable, and associated transducers.

7. Color graphics indicating the following:

a. Itemized list of color graphic displays to be provided.
b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
c. Intended operator access between related hierarchical display screens.

D. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

a. Loss of power.
b. Loss of network communication signal.
c. Loss of controller signals to inputs and outpoints.
d. Operator workstation failure.
e. Server failure.
f. Gateway failure.
g. Network failure
h. Controller failure.
i. Instrument failure.
j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.5 DELEGATED-DESIGN SUBMITTAL

A. For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

a. Flow at Project design and minimum flow conditions.
b. Face velocity at Project design and minimum airflow conditions.
c. Pressure drop across damper at Project design and minimum airflow conditions.

d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

a. Flow at Project design and minimum flow conditions.
b. Pressure-differential drop across valve at Project design flow condition.
c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

a. Instrument flow range.
b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.
e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Systems Provider Qualification Data.

2. Manufacturer's qualification data.

B. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list shall be indicated for each year.

1.9 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.
    c. Product manufacturing, testing and quality control.
    d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
    e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 50 miles of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope and value.
5. Each person assigned to Project shall have demonstrated past experience.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 16 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:

1. Automated Logic Corporation.
2. Honeywell International Inc.
3. Johnson Controls, Inc.
4. Schneider Electric USA, Inc.
5. Siemens Industry, Inc., Building Technologies Division.
6. Trane.

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

A. DDC system shall be Web based.

1. Web-Based Access to DDC System:

a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system shall manage HVAC systems.
b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
d. DDC system shall operate while unattended by an operator and through operator interaction.
e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors: Type 4 or Type 4X.
b. Outdoors at wastewater treatment facilities: Type 4X.
c. Indoors, Heated with Filtered Ventilation: Type 1 or Type 2.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2 or Type 12.
e. Indoors, Heated and Air Conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 12 Type 4 Type 4X.
2) Air-Moving Equipment Rooms: Type 1, Type 2 or Type 12.
3) Rooms with exposed water: Type 4 or Type 4X.
4) Rooms with water or wastewater pumps: Type 4 or Type 4X.

g. Localized Areas Exposed to Washdown: Type 4 or Type 4X.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2, Type 3 or Type 12.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4 or Type 4X.
j. Hazardous Locations: Explosion-proof rating for condition.
k. Chemical storage rooms: Type 4X.

D. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors: Type 4 or Type 4X.
b. Outdoors at wastewater treatment facilities: Type 4X.
c. Indoors, Heated with Filtered Ventilation: Type 1 or Type 2.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2 or Type 12.
e. Indoors, Heated and Air-conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 12, Type 4 or Type 4X.
2) Air-Moving Equipment Rooms: Type 1, Type 2 or Type 12.
3) Rooms with exposed water: Type 4 or Type 4X.
4) Rooms with water or wastewater pumps: Type 4 or Type 4X.

g. Localized Areas Exposed to Washdown: Type 4 or Type 4X.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2, Type 3 or Type 12.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4 or Type 4X.
j. Hazardous Locations: Explosion-proof rating for condition.
k. Chemical storage rooms: Type 4X.

E. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring

immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

2.6 SYSTEM SOFTWARE

A. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation.

B. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be any of the following:

    a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

        1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
        2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

    b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
    c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.7 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

2.8 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.9 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30-character point name and up to -character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.

d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:

1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.

2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:

    a. Reset air-handling unit supply temperature set points.
    b. Reset space temperature set points.
    c. De-energize equipment based on priority.

4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:

    a. Addition and deletion of loads controlled.
    b. Changes in demand intervals.
    c. Changes in demand limit for meter(s).
    d. Maximum shutoff time for equipment.
    e. Minimum shutoff time for equipment.
    f. Select rotational or sequential shedding and restoring.
    g. Shed and restore priority.

7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:

    a. Total electric consumption.
    b. Peak demand.
    c. Date and time of peak demand.
    d. Daily peak demand.

J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:

1. Support any of the following control loops, as applicable to control required:

    a. Two-position (on/off, open/close, slow/fast) control.
    b. Proportional control.
    c. Proportional plus integral (PI) control.
    d. Proportional plus integral plus derivative (PID) control.

        1) Include PID algorithms with direct or reverse action and anti-windup.

2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.10 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.

5. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch- high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 4X SS:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Hoffman; a brand of nVent.

2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Construct enclosure of Type 316L stainless steel, not less than the following:

    a. Size Less Than 24 Inches: 0.053 inchthick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

6. Outside body and door of enclosure with brushed No. 4 finish.
7. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches Tall: Two hinges.
    b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
    c. Sizes Larger 48 Inches Tall: Four hinges.

8. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless-steel handle with integral locking mechanism.
10. Removable internal panel shall be 0.093-inch solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
12. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
13. Include enclosure with stainless-steel mounting brackets.

2.11 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 40 VA.
3. Transformer shall have both primary and secondary fuses.

B. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.

4. Performance:

    a. Output voltage nominally 25-V dc within 5 percent.
    b. Output current up to 100 mA.
    c. Input voltage nominally 120-V ac, 60 Hz.
    d. Load regulation within 0.5 percent from zero- to 100-mA load.
    e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
    f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.12 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 18 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inchlay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements.

    a. Cable shall be plenum rated.
    b. Cable shall have a unique color that is different from other cables used on Project.

2.13 RACEWAYS

A. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.14 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label bearing unique identification.

    a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be 0.25 inch minimum.
3. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

C. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Section 15922 "DDC Control Dampers."
2. Airflow sensors and switches, which are specified in Section 15924 "Flow Instruments."

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07920 "Joint Sealants."

G. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

H. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

J. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

    a. Laboratory exhaust-air streams.
    b. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 16058 "Raceways and Boxes for Electrical Systems."
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 84 inches of finished floor.

3.5 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel strut and hardware.
2. For NEMA 250, Type 4 or NEMA 250, Type 4X Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top of adjacent enclosures.

D. Install floor-mounted enclosures locatedon concrete housekeeping pads. Attach enclosure legs using stainless-steel anchors.

3.6 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 16286 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 16070 "Identification for Electrical Systems" for identification products and installation.

B. Install self-adhesive labels with unique identification on face for each of the following:

1. Operator workstation.
2. Server.
3. Printer.
4. Gateway.
5. Router.
6. Protocol analyzer.
7. DDC controller.
8. Enclosure.
9. Electrical power device.
10. UPS unit.
11. Accessory.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control damper and valve actuator connected to a DDC controller.

E. Warning Labels and Signs:

1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.8 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Every network device shall have an assigned and documented MAC address unique to its network.

b. Ethernet Networks: Document MAC address assigned at its creation.
c. ARCNET or MS/TP networks: Assign from 00 to 64.

2. Network Numbering:

a. Assign unique numbers to each new network.
b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.
b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field shall support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field shall support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."
2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to Drawings or table sindicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.9 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

2. Terminate wiring in a junction box.

    a. Clamp cable over jacket in junction box.
    b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

3. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
4. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
5. Use shielded cable to transmitters.
6. Use shielded cable to temperature sensors.
7. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "16058 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.

3.10 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

B. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Results: Record test results and submit copy of test results for Project record.

3.11 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
2. Verify that control dampers are installed correctly for flow direction.
3. Verify that proper blade alignment, either parallel or opposed, has been provided.
4. Verify that damper frame attachment is properly secured and sealed.
5. Verify that damper actuator and linkage attachment is secure.
6. Verify that actuator wiring is complete, enclosed and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.12 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.13 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.14 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.15 FINAL REVIEW

A. Submit written request to Engineer and Construction Manager when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Engineer and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.

2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:

    a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
    b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
    c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
    d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
    e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
    f. Trends, summaries, logs and reports set-up for Project.
    g. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
    h. Execution of digital and analog commands in graphic mode.

3.16 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.17 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

    1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.18 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

END OF SECTION 15914

SECTION 15922 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of control dampers and actuators for DDC systems:

1. Rectangular control dampers.
2. General control-damper actuator requirements.
3. Electric and electronic actuators.
4. Delegated-design.

1.3 DEFINITIONS

A. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.

1.5 DELEGATED-DESIGN SUBMITTAL

A. Schedule and design calculations for control dampers and actuators, including the following.

1. Flow at project design and minimum flow conditions.
2. Face velocity at project design and minimum airflow conditions.
3. Pressure drop across damper at project design and minimum airflow conditions.
4. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
5. Maximum close-off pressure.
6. Leakage airflow at maximum system pressure differential (fan close-off pressure).
7. Torque required at worst case condition for sizing actuator.
8. Actuator selection indicating torque provided.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional, as defined in Section 01400 "Quality Control," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

F. Selection Criteria:

1. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
2. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
3. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Insulated Rectangular Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Greenheck.
   b. Pottorff.
   c. Ruskin Company.

2. Performance:

   a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 4 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 4000 fpm.
   d. Temperature: Minus 72 to plus 185 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure.
   f. Damper shall have AMCA seal for both air leakage and air performance.

3. Construction:

   a. Frame:

      1) 4 inches x 1-inch x minimum 0.081 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.

   b. Blades:

      1) Style: Airfoil-shaped, single-piece.
      2) Action: Opposed.
      3) Orientation: Horizontal.
      4) Material: Heavy duty 6063-T5 extruded aluminum. Blade cavities filled with polyurethane foam.
      5) Width: Maximum 4 inches.

   c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.

   d. Axles: 0.50-inch- diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:

1) Molded synthetic sleeve, turning in hole in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

C. Fiberglass Airfoil Control Damper:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Ruskin Company.
b. MK Plastics.
c. Perry Fiberglass Products, Inc.

2. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 4 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Max temperature rating of 200 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure.
f. Damper shall have AMCA seal for both air leakage and air performance.

3. Construction:

a. Frame: 8-inch-deep x 23/16" inch flanged style, minimum 1/4" thick, FRP, vinyl-ester resin based.

b. Blades:

1) Style: Hollow airfoil shape, minimum 1/4" thick and contain pultruded slot for insertion of blade seal.
2) Action: Opposed.
3) Orientation: Horizontal.
4) Material: FRP, vinyl-ester resin based.
5) Width: Maximum 8 inches.

c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the extrusions.

d. Axles: Minimum ¾-inch diameter constructed of an FRP vinyl ester-based material, combined with continuous strand roving, and complete with surfacing veil.

e. Bearings: Molded PTFE

f. Linkage: 316 Stainless steel out of airstream.

g. Transition:

1) Factory mount damper in a sleeve with a close transition to mate to field connection.
2) Damper size and sleeve shall be connection size plus 2 inches.
3) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
4) Sleeve material shall match adjacent duct.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. See Drawings.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. Voltage selection is delegated to professional designing control system or as specified on the drawings.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

    a. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.

G. Position Feedback:

1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open position.
2. Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor, wet and unprotected applications.
4. NEMA 250, Type 4X for corrosive applications.
5. NEMA 250, Type 7 for explosion proof applications.
6. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:

1. Operate damper from fully closed to fully open within 90 seconds.

2. Operate damper from fully open to fully closed within 90 seconds.
3. Move damper to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL-DAMPER APPLICATIONS

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.
    c. Classified area exhaust and return airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 16286 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems."

3.5 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 15715 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.6 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 16056 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper.

3.8 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. Verify that control dampers are installed correctly for flow direction.
5. Verify that proper blade alignment, either parallel or opposed, has been provided.
6. Verify that damper frame attachment is properly secured and sealed.
7. Verify that damper actuator and linkage attachment are secure.
8. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
9. Verify that damper blade travel is unobstructed.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 15922

SECTION 15924 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Airflow switches.
2. Delegated-design.

B. Related Requirements:

1. Section 15914 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. FEP: Fluorinated ethylene propylene.

B. PEEK: Polyetheretherketone.

C. PTFE: Polytetrafluoroethylene.

D. PPS: Polyphenylene sulfide.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

5. Product certificates.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 DELEGATED-DESIGN SUBMITTAL

A. Schedule and design calculations for flow instruments, including the following.

1. Flow at Project design and minimum flow conditions.
2. Pressure drop at Project design and minimum flow conditions.

1.6 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 AIRFLOW SWITCHES

A. Stainless Steel Single Vane Switch:

1. Description:

a. Velocities up to 2000 fpm.
b. Suitable for mounting with air direction in horizontal.

2. Performance:

a. Voltage: 125-, 240-, and 480-V ac.
b. Full Load Current: 9.8 A at 125-V ac.
c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm.
d. Maximum Process Temperature: 180 deg F.
e. Maximum Ambient Temperature: 125 deg F.

3. Construction:

a. Stainless steel vane.
b. Vane actuates a SPDT snap switch.
c. Enclosure Material: Die-cast metal.
d. Enclosure with removable cover.
e. NEMA 250, Type 1 enclosure.
f. Screw set-point adjustment.
g. Electrical Connections: Screw terminals.
h. Conduit Connections: 1-inch trade size conduit knock outs on top and bottom.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Engineer on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
3. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 16286 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at

points of connection. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.

6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

C. Switches: Calibrate switches to make or break contact at set points indicated.

END OF SECTION 15924

SECTION 15935 - TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Air temperature switches.

B. Related Requirements:

1. Section 15914 "Direct Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. RTD: Resistance temperature detector.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors: Type 4 or Type 4X.
    b. Outdoors at wastewater treatment facilities: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 1 or Type 2.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 2 or Type 12.
    e. Indoors, Heated and Air Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 12 Type 4 Type 4X.
        2) Air-Moving Equipment Rooms: Type 1, Type 2 or Type 12.
        3) Rooms with exposed water: Type 4 or Type 4X.
        4) Rooms with water or wastewater pumps: Type 4 or Type 4X.

    g. Localized Areas Exposed to Washdown: Type 4 or Type 4X.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2, Type 3 or Type 12.

i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4 or Type 4X.
j. Hazardous Locations: Explosion-proof rating for condition.
k. Chemical storage rooms: Type 4X.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

a. Range: Minus 50 to 275 deg F.
b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
c. Repeatability: Within 0.5 deg F.
d. Self-Heating: Negligible.

4. Transmitter Requirements:

a. Transmitter required for each 100-ohm RTD.
b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Thermal Resistors (Thermistors): Common Requirements:

1. 1,000 or 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

a. Range: Minus 50 to 275 deg F.
b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
c. Repeatability: Within 0.5 deg F.
d. Drift: Within 0.5 deg F over 10 years.
e. Self-Heating: Negligible.

4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

C. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Dwyer Instruments, Inc.
b. Honeywell International Inc.
c. Johnson Controls Inc.

2. Temperature Range: Minus 50 to 275 deg F.

3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches long).
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2- inch trade size.

D. Thermistor Averaging Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Dwyer Instruments, Inc.
    b. Honeywell International Inc.
    c. Johnson Controls Inc.

2. Temperature Range: Minus 50 to 275 deg F.
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch trade size.

E. Thermistor Outdoor Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Dwyer Instruments, Inc.
    b. Honeywell International Inc.
    c. Johnson Controls Inc.

2. Temperature Range: Minus 50 to 275 deg F.
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

F. Thermistor Space Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Dwyer Instruments, Inc.
b. Honeywell International Inc.
c. Johnson Controls Inc.

2. Temperature Range: Minus 50 to 212 deg F.
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic or flush, brushed-aluminum cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

G. Space Air Temperature Sensors for Use with DDC Controllers:

1. 100- or 1000-ohm platinum RTD or thermistor.
2. Thermistor:

a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.

3. Temperature Transmitter Requirements:

a. Mating transmitter required with each 100-ohm RTD.
b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

4. Provide digital display of sensed temperature.
5. Provide sensor with local control.

a. Local override to turn HVAC on.
b. Local adjustment of temperature set point.
c. Both features shall be capable of manual override through control system operator.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Honeywell International Inc.
b. Johnson Controls Inc.
c. White Rodgers.

2. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.

d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

a. Operating Temperature Range: 15 to 55 deg F.
b. Temperature Differential: 5 deg F, non-adjustable and additive.
c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
d. Sensing Element Maximum Temperature: 250 deg F.
e. Voltage: 120-V ac.
f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.

4. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 feetlong.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.

B. Thermostat and Switch for High Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Honeywell International Inc.
b. Johnson Controls Inc.
c. White Rodgers.

2. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
3. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

4. Performance:

a. Temperature Range: 100 to 160 deg F.
b. Temperature Differential: 5 deg F.
c. Ambient Temperature: Zero to 260 deg F.
d. Voltage: 120-V ac.
e. Current: 16 FLA.
f. Switch Type: SPDT snap switch.

5. Construction:

    a. Sensing Element: Helical bimetal.
    b. Enclosure: Metal, NEMA 250, Type 1.
    c. Electrical Connections: Screw terminals.

C. Thermostat and Switch for Space Temperature Applications (NEMA 1):

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Honeywell International Inc.
    b. Johnson Controls Inc.
    c. White Rodgers.

2. Description:

    a. Two-position control.
    b. Field-adjustable set point.
    c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

    a. Temperature Range: 40 to 110 deg F or as appropriate for application.
    b. Temperature Differential: 3 deg F or as appropriate for application.
    c. Voltage: 120-V ac.
    d. Current: 16 FLA.
    e. Switch Type: SPDT snap switch or DPDT.

4. Construction:

    a. Sensing Element: Coiled copper or remote copper bulb
    b. Enclosure: Metal, NEMA 250, Type 1.
    c. Electrical Connections: Screw terminals.

D. Thermostat and Switch for Space Temperature Applications (NEMA 4X):

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Chromalox.
    b. TPI Corporation.
    c. PECO.

2. Description:

    a. Two-position control.
    b. Field-adjustable set point.

c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

a. Temperature Range: 40 to 110 deg F or as appropriate for application.
b. Temperature Differential: 3 deg F or as appropriate for application.
c. Voltage: 120-V ac.
d. Current: 16 FLA.
e. Switch Type: SPDT snap switch.

4. Construction:

a. Sensing Element: Coiled Stainless or
b. Enclosure: Metal, NEMA 250, Type 4X.
c. Electrical Connections: Screw terminals.

E. Thermostat and Switch for Space Temperature Applications (Explosion Proof):

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Chromalox.
b. Dwyer Instruments, Inc.
c. Larson Electronics

2. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

a. Temperature Range: 40 to 80 deg F or as appropriate for application.
b. Temperature Differential: 2.5 deg F or as appropriate for application.
c. Voltage: 120-V ac.
d. Current: 16 FLA.
e. Switch Type: SPDT snap switch.

4. Construction:

a. Sensing Element: Coiled Stainless or
b. Enclosure: Metal, NEMA 250, Type 7&9.
c. Electrical Connections: Screw terminals.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:

1. Duct, less than 4 square feet: Thermistor, single point.
2. Duct, greater than 4 square feet: Thermistor, averaging.
3. Outdoor, all: Thermistor.
4. Space, all: Thermistor or RTD.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.

2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 16286 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems."

3.5 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

   a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
   b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

      1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
      2) Do not begin installation without submittal approval of mounting location.

   c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Engineer on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

END OF SECTION 15935

SECTION 16045 - SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Removal of existing electrical equipment, wiring, and conduit in areas to be remodeled; removal of designated construction; dismantling, cutting and alterations for completion of the Work.
2. Disposal of materials.
3. Storage of removed materials.
4. Identification of utilities.
5. Salvaged items.
6. Protection of items to remain as indicated on Drawings.
7. Relocate existing equipment to accommodate construction.

B. Related Sections:

1. Section 02222 “Selective Demolition” for removal of designated building equipment and construction.”

1.3 ACTION SUBMITTALS

A. Shop Drawings: Indicate demolition; location and construction of temporary work. Describe demolition removal procedures and schedule.

1.4 CLOSEOUT SUBMITTALS

A. Section 01730 “Execution” for requirements for submittals.

B. Project Record Documents: Record actual locations of capped conduits and equipment abandoned in place.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with State of Rhode Island standard.

1.6 SEQUENCING

A. Section 01010 “Summary of Work” for requirements for sequencing.

1.7 SCHEDULING

A. Section 01311 “Construction Scheduling” for requirements for scheduling.

B. Schedule work to coincide with new construction.

C. Cease operations immediately when structure appears to be in danger and notify Engineer/Engineer. Do not resume operations until directed.

1.8 COORDINATION

A. Section 01311 “Construction Scheduling” for requirements for coordination.

B. Conduct demolition to minimize interference with adjacent building areas.

C. Coordinate demolition work with other trades.

D. Coordinate and sequence demolition so as not to cause shutdown of operation of surrounding areas.

E. Equipment, building or structures scheduled for complete demolition shall be made safe from electrical shock hazard prior to demolition.

F. Shut-down Periods:

1. Arrange timing of shut-down periods of in-service panels with Owner. Do not shut down any utility without prior written approval.
2. Keep shut-down period to minimum.
3. Maintain life-safety systems in full operation in occupied facilities.

G. Identify salvage items in cooperation with Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01730 “Execution,” for verification of existing conditions before starting work.

B. Verify wiring and equipment indicated to be demolished serve only abandoned facilities.

C. Verify termination points for demolished services.

3.2 PREPARATION

A. Erect, and maintain temporary safeguards, including warning signs and lights, barricades, and similar measures, for protection of the public, Owner, Contractor's employees, and existing improvements to remain.

B. Temporary egress signage and emergency lighting

3.3 REMOVAL AND DISPOSAL OF LEGALLY REGULATED MATERIALS

A. Material and equipment indicated to be removed and disposed of will become the Contractor's property. Dispose of material and equipment offsite, unless otherwise directed by the Owner. Provide the Owner with a receipt indicating the acceptable disposal of any legally regulated materials or equipment.

B. Assume that the ballasts in each existing lighting fixture contain PCB's, unless specifically marked with a label indicating "No PCBs." Remove ballasts from each lighting fixture and pack them in accordance with EPA PCB regulations. Ship ballasts in approved containers to an EPA approved recycling facility; pay all shipping, packaging and recycling costs.

C. Remove, package, ship and dispose of PCBs, mercury and PCB/mercury contaminated equipment, in accordance with all State and Federal regulations. Retain the services of a firm licensed and regularly engaged in the removal of PCBs and PCB contaminated equipment. Retain a firm licensed in the State or States in which the contaminated material is handled, shipped and disposed of. Pay all fees associated with the removal of the contaminated material and equipment. Submit documentation indicating acceptable disposal.

D. If PCB’s or mercury contaminated equipment are discovered that were not identified; cease work on or about the equipment and notify the Engineer immediately.

3.4 DEMOLITION

A. Demolition Drawings are based on casual field observation and existing record documents. Report discrepancies to Owner and Engineer before disturbing existing installation.

B. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

C. Remove conduit, wire, boxes, and fastening devices to avoid any interference with new installation.

D. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

E. Remove, relocate, and extend existing installations to accommodate new construction.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Remove exposed abandoned grounding and bonding components, fasteners and supports, and electrical identification components. Cut embedded support elements flush with walls and floors.

H. Protect and retain power to existing active equipment remaining.

I. Cap abandoned empty conduit at both ends.

3.5 EXISTING PANELBOARDS

A. Ring out circuits in existing panel affected by the Work. Where additional circuits are needed, reuse circuits available for reuse. Install new breakers.

B. Tag unused circuits as spare.

C. Where existing circuits are indicated to be reused, use sensing measuring devices to verify circuits feeding Project area or are not in use.

D. Remove existing wire no longer in use from panel to equipment.

E. Provide new updated directories where more than three circuits have been modified or rewired.

3.6 CLEANING

A. Section 01650 “Contract Closeout” for requirements for cleaning.

B. Remove demolished materials as work progresses. Legally dispose.

C. Keep workplace neat.

3.7 PROTECTION OF FINISHED WORK

A. Section 01650 “Contract Closeout” for requirements for protecting finished Work.

B. Do not permit traffic over unprotected floor surface.

END OF SECTION 16045

SECTION 16052 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Fire-alarm wire and cable.
3. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 16055 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

2. Section 16846 “Conventional Fire-Alarm Systems” for fire alarm initiating and signaling devices and control panels.

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden Inc.
2. Okonite Company (The).
3. Southwire Company.
4. Or equal.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Conductor Insulation:

1. Type RHW-2: Comply with UL 44. For conductor sizes 250kCMIL and larger.
2. Type THHN and Type THWN-2: Comply with UL 83. For control conductors.
3. Type XHHW-2: Comply with UL 44. For conductor sizes No. 12 through 4/0 AWG.

F. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.2 FIRE-ALARM WIRE AND CABLE

A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.3 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M Electrical Products.
2. Emerson Electric Co. (Automation Solutions - Appleton - O-Z/Gedney).
3. Hubbell Incorporated (Hubbell Power Systems).
4. Or equal.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: One hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; stranded.

B. Branch Circuits: Copper; stranded, except lighting and receptacle wiring may be solid.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type XHHW-2, single conductors in raceway; Type RHW-2, single conductors in raceway.

B. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway; Type RHW-2, single conductors in raceway.

C. Exposed Branch Circuits, Including in Crawlspaces: Type XHHW-2, single conductors in raceway.

D. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

F. VFC Output Circuits: Type TC-ER cable with braided shield.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 16058 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 16057 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRING

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal pathway according to Section 16713.29 "Hangers and Supports for Communications Systems."

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system shall be installed in a dedicated pathway system. This system shall not be used for any other wire or cable.

C. Wiring Method:

1. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.

2. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is permitted.
3. Signaling Line Circuits: Power-limited fire-alarm cables may be installed in the same cable or pathway as signaling line circuits.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

F. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

G. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.

H. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

D. Comply with requirements in Section 16846 “Conventional Fire-Alarm Systems” for connecting, terminating, and identifying wires and cables.

3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 16070 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 16064 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
   b. Test bolted connections for high resistance using one of the following:

      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.

   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.
   f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
   g. Continuity test on each conductor and cable.
   h. Uniform resistance of parallel conductors.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 16052

SECTION 16055 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Backboards.
2. Category 6 balanced twisted pair cable.
3. Balanced twisted pair cabling hardware.
4. Identification products.
5. Instrumentation cables.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

D. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency, RCDD, layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. RoHS compliant.

2.2 BACKBOARDS

A. Description: Plywood, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 06100 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat black latex paint. Comply with requirements in Section 09912 "Interior Painting."

2.3 CATEGORY 6 BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Belden CDT Networking Division/NORDX.
3. General Cable; General Cable Corporation.
4. Or equal.

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP).

F. Cable Rating: Riser.

G. Jacket: Blue thermoplastic.

2.4 BALANCED TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate balanced twisted pair copper communications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Belden CDT Networking Division/NORDX.
3. General Cable; General Cable Corporation.
4. Or equal.

C. General Requirements for Balanced Twisted Pair Cable Hardware:

1. Comply with the performance requirements of Category 6.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

D. Source Limitations: Obtain balanced twisted pair cable hardware from single source from single manufacturer.

E. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

F. Plugs and Plug Assemblies:

1. Male; eight-position; color-coded modular telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Comply with IEC 60603-7-1, IEC 60603-7-2, IEC 60603-7-3, IEC 60603-7-4, and IEC 60603-7.5.
3. Marked to indicate transmission performance.

G. Jacks and Jack Assemblies:

1. Female; eight-position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standards:
   a. Category 6, unshielded balanced twisted pair cable shall comply with IEC 60603-7-4.
   b. Category 6, shielded balanced twisted pair cable shall comply with IEC 60603-7.5.
4. Marked to indicate transmission performance.

H. Faceplate:

1. Two port, vertical single-gang faceplates designed to mount to single-gang wall boxes.
2. Metal Faceplate: Stainless steel, complying with requirements in Section 16276 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of balanced twisted pair, optical fiber, and coaxial work area cords.

I. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

2.5 INTRUMENTATION CABLE

A. Paired Cable:

1. One pair, No. 16 AWG, stranded and twisted on 2-in lay.
2. PVC insulation, 600V rating, 90 degrees C rating.
3. Shielded: 100 percent mylar tape with drain wire.
4. PVC jacket with UL subject 277, UL 1581 and manufacturer's identification.
5. Manufacturers: Belden, or equal.

2.6 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test twisted pair cables according to TIA-568-C.2.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
2. Flexible metal conduit shall not be used.

B. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.
3. Comply with requirements specified in Section 16058 "Raceways and Boxes for Electrical Systems."

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 GROUNDING

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 16056 "Grounding and Bonding for Electrical Systems."

3.5 IDENTIFICATION

A. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 16055

SECTION 16056 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:

1) Test wells.
2) Ground rods.
3) Ground rings.
4) Grounding arrangements and connections for separately derived systems.

b. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Emerson Electric Co. (Automation Solutions - Appleton - O-Z/Gedney).
2. nVent (ERICO).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.

2. Stranded Conductors: ASTM B8.
3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

J. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

K. Straps: Solid copper, cast-bronze clamp. Rated for 600 A.

L. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

M. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.

    a. Material: Die-cast zinc alloy.
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

2.6 EXOTHERMIC WELDING

A. Exothermic welding shall be by CADWELD process, or equal. Molds and powder shall be furnished by the same manufacturer and sized and selected per manufacturer's instructions for specific combination of conductors and connected items.

B. Welds used indoors in occupied buildings or confined spaces shall be the low emission type, CADWELD EXOLON or equal.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 4/0 AWG minimum.

1. Bury at least 30inches below grade.
2. Duct-Bank Grounding Conductor: Install per Details as shown on the Drawings.

C. Grounding Conductors: Green-colored insulation.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Separately derived systems such as transformers or generators (if identified as such) shall bond neutral and ground together with a bonding jumper at the equipment in accordance with NEC

250.102. Connection to the grounding electrode system via the electrode grounding conductor shall be in accordance with NEC Table 250.66 or as shown on the Drawings.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Duct banks.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 INSTALLATION

A. Grounding Electrode Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

1. Where conductors pass through floor slabs, walls, etc., they shall be installed in conduit or sleeved.
2. Conductors subject to mechanical damage shall be protected by non-ferrous conduit to avoid a choke effect for fault currents.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Use exothermic welds for all below-grade connections.
3. Rods shall be installed vertically and not allowed to be deformed or driven at an angle. Where driving is difficult or where rock is encountered, Contractor shall use purpose-designed drilling equipment, install the rod into the drilled hole and backfill around rod using ground enhancement material (GEM) mixed with water to form a slurry in accordance with the Manufacturer's instructions.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 16063 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect

grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart or as shown on the Contract Drawings.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of area or item indicated.

1. Install copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.
3. Lay all underground conductors slack, and where exposed to mechanical injury, protect by pipes or other substantial guards. If guards are iron pipe, or other magnetic material, electrically connect conductors to both ends of the guard.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70 Article 250.52.

K. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at ground test wells , and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 16056

SECTION 16057 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Nonmetallic slotted support systems.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer registered in the State of Rhode Island. For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
5. Anchorage

    a. Details of anchorage of the equipment to the foundation including anchor bolt type, size, material, embedment depth and minimum edge distance.
    b. Summary of maximum vertical and horizontal reactions at each anchor bolt considering all applicable load and load combinations, based upon the specified seismic design category.

6. Manufacturer's specification and data including recommended design values and physical characteristics of the selected anchors to the concrete foundation.

C. Post-Installed Expansion Anchors:

1. Design Data: Submit manufacturer's specifications and data including recommended design values and physical characteristics for expansion anchors.
2. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, materials and finishes for post-installed expansion anchors installed into cracked concrete and masonry.
3. Installation Procedures: Submit procedures stating product proposed for use, and complete installation method.

D. Post-Installed Adhesive Anchoring System:

1. Design Data: Submit manufacturer's specifications and data including recommended design values and physical characteristics, including temperature, humidity, and moisture limitations for adhesive anchoring system.
2.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ductwork, piping, fittings, and supports.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items mounted from the ceiling, including the following:

    a. Luminaires.
    b. Air outlets and inlets.

B. Adhesive Anchoring System Installation Procedure: Submit installation procedure for post-installed adhesive anchoring system; including method of drilling.

C. Anchoring System Qualification Data:

1. Installer: Indicate manufacturer's training date and a list of personnel trained on installation of adhesive anchoring system.

D. Anchoring System Evaluation Reports: From ICC-ES for anchoring system, for installation of post-installed anchors into cracked concrete, as applicable, indicating conformance with current ICC ES Acceptance Criteria.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer registered in the State of Rhode Island to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according Section 01882 "Seismic Performance Requirements."

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. In dry indoor areas, hangers, rods, backplates, beam clamps, channel, etc. shall be galvanized iron or steel.

B. Aluminum channel with stainless steel hardware shall be used in areas designated "WET" or "CORROSIVE" on the Drawings and in outdoor locations. Fiberglass channel shall be resistant to the chemicals present in the area in which it is used.

C. Aluminum channel with stainless steel hardware shall be used in hazardous areas designated "Class I, Division 1" on the Drawings.

D. Furnish any and all necessary supports, brackets, conduit sleeves, racks and bracing as required. All boxes and hardware shall be galvanized zinc plated steel except that stainless steel shall be used in areas designated as "WET" or "CORROSIVE" on the Drawings.

E. Conduit Supports:

1. Trapezes:

a. In dry indoor areas, beams, channels, struts, hangers, bracing, rods, beam clamps, accessories and components shall be galvanized steel.

b. PVC coated steel beams, channels, struts or fiberglass beams, channels, struts with stainless steel hangers, bracing, rods, beam clamps, accessories and components shall be used in areas designated "WET", "DAMP" and "CORROSIVE" where indicated and in outdoor locations. Fiberglass channels shall be resistant to the chemicals resent in the area in which it is used.

c. Aluminum beams, channels, struts with stainless steel hangers, bracing, rods, beam clamps, accessories and components shall be used in hazardous areas designated “Class I, Division 1” on the Drawings.

2. Flush Mounted Supports:

d. In dry indoor areas, channels, struts, accessories and components shall be galvanized steel.

e. PVC coated steel channels, struts or fiberglass channels, struts with stainless, accessories and components shall be used in areas designated "WET", "DAMP" and "CORROSIVE" where indicated and in outdoor locations. Fiberglass channels, struts shall be resistant to the chemicals present in the area in which it is used.

f. Aluminum channels and struts with stainless steel accessories and components shall be used in hazardous areas designated “Class I, Division 1” on the Drawings.

3. Conduit Racks:

a. In dry indoor areas, conduit racks, accessories and components shall be galvanized steel.

b. PVC coated steel conduit racks or fiberglass conduit racks with stainless, accessories and components shall be shall be used in areas designated "WET", "DAMP" and "CORROSIVE" where indicated and in outdoor locations. Fiberglass channels shall be resistant to the chemicals present in the area in which it is used.

c. Aluminum conduit racks with stainless steel accessories and components shall be used in hazardous areas designated “Class I, Division 1” on the Drawings.

4. Conduit Hangers:

a. In dry indoor areas, conduit clamps, rods, beam clamps, bracing, accessories and components shall be galvanized steel.

b. Stainless steel conduit clamps, rods, beam clamps, bracing, accessories and components shall be shall be used in areas designated "WET", "DAMP" and "CORROSIVE" where indicated and in outdoor locations.

c. Aluminum shall be used in hazardous areas designated “Class I, Division 1” on the Drawings.

F. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB (Electrification Products Division).
b. Atkore International (Unistrut).
c. Flex-Strut Inc.
d. Or equal.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Stainless steel, Type 316.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

G. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32-inch- diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB (Electrification Products Division).
b. Atkore International (Unistrut).
c. Flex-Strut Inc.
d. Or equal.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channel Material: 6063-T5 aluminum alloy.
4. Fittings and Accessories Material: 5052-H32 aluminum alloy.
5. Channel Width: Selected for applicable load criteria.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

H. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c., in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Atkore International (Allied Tube & Conduit).
    b. Eaton (B-line).
    c. G-Strut.
    d. Or equal.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channel Width: Selected for applicable load criteria.
4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
5. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
6. Rated Strength: Selected to suit applicable load criteria.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

I. Conduit and Cable Support Devices: Stainless-steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

J. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

K. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

L. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors:

    a. Fastening to Concrete Substrate: Zinc plated carbon steel wedge type anchors, complete with zinc plated nuts and washers, unless otherwise noted.
    b. Submerged or Weather Exposed Substrates: ASTM A276 Type 316 stainless steel wedge type anchors, complete with Type 316 stainless steel nuts and washers, unless otherwise noted.
    c. Meet ICC ES AC193.
    d. Basis-of-Design: Anchorage designs indicated are based on Hilti, Kwik-Bolt TZ, unless otherwise noted. Acceptable Anchors: Hilti Kwik-Bolt TZ; Simpson Strong-Tie Strong Bolt 2 Wedge Anchor; DeWalt Power-Stud+ SD6; or equal.

2. Adhesive Anchoring System:

    a. Fastening to Concrete Substrate: Manufactured system consisting of post installed threaded rods, nuts, washers, other anchoring hardware, and chemical dispenser for installation in hammer drilled holes.
    b. Anchors: Meet ICC ES AC308.

c. Injection Adhesive: Two-component epoxy system consisting of a hardener and a resin, furnished in pre-measured side-by-side cartridges which keep both components separate.
d. Adhesive Cartridge: Side-by-side design to accept a static mixing nozzle which thoroughly blends both components and allows injection directly into a drilled hole.
e. Anchor: Type 316 stainless steel as indicated consisting of an all-thread anchor rod with nut and washer, of matching material to anchor rod.
f. Basis-of-Design: Anchorage designs indicated are based on Hilti HIT- RE 500 V3, unless otherwise noted. Acceptable Manufacturers: Hilti HIT- RE 500 V3; Simpson Strong Tie SET-3G; ITW Ramset Red Head Epcon G5+; or equal.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05502 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 102.
4. NECA 105.
5. NECA 111.

B. Comply with requirements for raceways and boxes specified in Section 16058 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 50 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, RMC may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To New Concrete: Bolt to concrete inserts.
2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
3. To Existing Concrete: Expansion anchor fasteners.
4. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts .
5. To Light Steel: Sheet metal screws.
6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05502 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 ANCHORING SYSTEM INSTALLATION

A. General:

1. Install anchoring system in strict compliance with manufacturer's published installation instructions and approved Shop Drawings. Comply with recommended surface preparation, temperature, and moisture of substrate and ambient conditions.
2. Coordinate installation with Special Inspector.

3. Use drill bit of correct diameter and drill to required depth using rotary impact type hammer drills with carbide-tipped bits.
4. Drill holes perpendicular to concrete surface, unless otherwise indicated.
5. Use oil free compressed air to blast out loose particles and dust from drilled holes.

B. Expansion anchors:

1. Check expansion anchors for tightness a minimum of 24 hours after initial installation.

C. Adhesive anchoring system:

1. Perform installation only by personnel trained in anchor installation and having certification required in PART 1 - GENERAL.
2. Inject adhesive and install anchors and reinforcing bar dowels that are clean and free of dirt, oil, grease, ice or other deleterious material which would reduce bond.

3.5 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Concrete materials, reinforcement, and placement requirements are specified in Section 03300A "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 09910 “Painting” for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 16057

SECTION 16058 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures, and cabinets.

B. Related Requirements:
1. Section 16063 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. RNC: Rigid nonmetallic conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer registered in the State of Rhode Island.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Atkore International (Allied Tube & Conduit).
b. Southwire Company.
c. Wheatland Tube Company.
d. Or equal.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. ARC: Comply with ANSI C80.5 and UL 6A.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

a. Comply with NEMA RN 1.
b. Coating Thickness: 0.040 inch, minimum.

6. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Atkore International (Allied Tube & Conduit).
b. Southwire Company.
c. Wheatland Tube Company.
d. Or equal.

2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for GRC or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Atkore International (AFC Cable Systems).
    b. Hubbell Incorporated (Raco Taymac Bell).
    c. Topaz Lighting & Electric.
    d. Or equal.

2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. RNC: Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Atkore International (AFC Cable Systems).
    b. Hubbell Incorporated (Raco Taymac Bell).
    c. Topaz Lighting & Electric.
    d. Or equal.

2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

    a. Fittings for LFNC: Comply with UL 514B.

4. Solvents and Adhesives: As recommended by conduit manufacturer.

C. Conduit Supports: Provide the following types of conduit supports.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton (B-line).
3. Schneider Electric USA (Square D).
4. Or equal.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 4 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Flanged-and-gasketed type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 MISCELLANEOUS FITTINGS

A. Flexible Couplings:

1. Manufacturers: Provide products by one of the following:

a. “Type ECGJH,” by the Crouse-Hinds Co.
b. Appleton Electric Co.
c. Killark Electric Manufacturing Co.
d. Or equal.

B. Conduit Hubs:

1. Manufacturers: Provide products by one of the following:

a. Myers Electric Products, Inc.
b. Or equal.

C. Conduit Wall Seals for New Concrete Walls Below Grade:

1. Products: Provide one of the following:

a. O.Z./Gedney Co., Type WSK.
b. Spring City Electrical Manufacturing Co., Type WDP.
c. Or equal.

D. Conduit Wall Seals for Cored Holes:

1. Products: Provide one of the following:

a. Type CSMC as manufactured by the O.Z./Gedney Co.
b. Or equal.

E. Conduit Wall and Floor Seals for Sleeved Openings:

1. Products: Provide one of the following:

a. Type CSMI as manufactured by the O.Z./Gedney Co.
b. Or equal.

F. Combination Expansion-Deflection Fittings Embedded in Concrete:

1. Products: Provide one of the following:

a. Type XD as manufactured by the Crouse-Hinds Co.
b. Type DX as manufactured by O.Z./Gedney Co.
c. Type DF as manufactured by Appleton Electric Co.
d. Or equal.

G. Combination Expansion-Deflection Fittings Installed Exposed:

1. Products: Provide one of the following:

a. Type XD as manufactured by Crouse-Hinds Co.
b. Type DX as manufactured by O.Z. Gedney Co.
c. Type DF as manufactured by Appleton Electric Co.
d. Or equal.

H. Explosion Proof Fittings:

1. Manufacturers: Provide products by one of the following:

a. Crouse-Hinds Co.
b. Appleton Electric Co.
c. O.Z./Gedney Co.
d. Or equal.

I. Conduit Sealing Bushings:

1. Products: Provide one of the following:

a. O.Z./Gedney, Type CSB.
b. Or equal.

J. Grounding Bushings: Malleable iron with integral insulated throat rated for 300 degrees F, with solderless lugs.

1. Products: Provide one of the following:

a. Crouse Hinds/Cooper, Series HGLL.
b. Appleton, Series GIB.
c. O.Z./Gedney, Type HBLG.
d. Or equal.

2.5 BOXES, ENCLOSURES, AND CABINETS (NON-HAZARDOUS LOCATIONS)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton (Crouse-Hinds).
3. Hubbell Incorporated.
4. Or equal.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1 aluminum, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep .

K. Gangable boxes are prohibited.

L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

2.6 HAZARDOUS (CLASSIFIED) LOCATION BOXES

A. Design explosion-proof boxes for Class 1, Group D, Division 1 hazardous locations. Provide cast iron with cadmium-zinc or hot-dipped galvanized finish, stainless steel or hot-dipped galvanized bolts;

1. Manufacturer: Provide products by one of the following:

a. "Type EJB," by the Crouse-Hinds Company.
b. Appleton Electric Co.
c. The Pyle-National Co.
d. Or equal.

B. Design explosion-proof boxes for Class 1, Group D, Division 1 hazardous locations, provided with O-ring seals to meet NEMA 4 requirements.

1. Boxes and Covers: Aluminum, with stainless steel hinges and stainless steel bolts.
2. Manufacturer: Provide products by one of the following:

a. "Type EJB-N4," by the Crouse-Hinds Co.
b. Appleton Electric Co.
c. Adalet-PLM
d. Or equal.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

TABLE 16058-1
Raceway Application Guidelines

Location/Circuit Type	Raceway Type
<u>All locations</u> ▪ Class 2 and 3 signal wiring and 4-20 mA instrumentation cables, non-fiber (copper) data highway. ▪ Fire alarm, security, and communications system wiring (non-fiber)	▪ Exposed – GRC conduit. Use PVC coated rigid steel conduit in corrosive areas. Hazardous areas, areas designated as wet and outdoor areas. ▪ Concealed – GRC conduit. ▪ Underground – GRC conduit in concrete reinforced ductbank. Use PVC coated steel conduit for single conduit direct burial applications.
<u>All locations</u> ▪ Fiber Optic wiring systems (Fire alarm, security, and communications system wiring)	▪ Exposed – GRC conduit. ▪ Concealed – RNC conduit. ▪ Underground – RNC conduit in concrete reinforced ductbank.
<u>Clean, dry non-finished areas</u> – electrical rooms, generator rooms, mechanical rooms,	▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – GRC conduit.

TABLE 16058-1 Raceway Application Guidelines	
Location/Circuit Type	Raceway Type
shops, dry storage, etc.	▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – RNC conduit when embedded within concrete floor slabs. GRC conduit when embedded within masonry block walls.
Process areas – non-corrosive, non-hazardous locations designated as DAMP or WET on the Drawings.	▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – GRC conduit. ▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – RNC conduit when embedded within concrete floor slabs. GRC conduit when embedded within masonry block walls.
Corrosive areas - chemical storage and handling areas, underground vaults, within tanks or clearwells, filter pipe galleries and locations where designated corrosive on the Drawings.	▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – PVC coated rigid steel. ▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – RNC conduit when embedded within concrete floor slabs or structures.
Hazardous areas – all locations – Class 1, Division 1 and 2.	▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – ARC conduit. ▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – GRC conduit.
Outdoor areas – all locations.	▪ Exposed conduit for power wiring, lighting, switch, and receptacle circuits – ARC conduit. RNC conduit shall not be used exposed. ▪ Concealed conduit for power wiring, lighting, switch, and receptacle circuits – RNC conduit when embedded within concrete structures.

A. Minimum Raceway Size: 3/4-inch trade size.

B. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

C. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

D. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with requirements in Section 16057 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Complete raceway installation before starting conductor installation.

F. Arrange stub-ups so curved portions of bends are not visible above finished slab.

G. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

H. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

I. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

J. Support conduit within 12 inches of enclosures to which attached.

K. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Engineer for each specific location.

L. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

M. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

N. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

O. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

P. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

Q. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

R. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

S. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where an underground service raceway enters a building or structure.
2. Conduit extending from interior to exterior of building.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.

c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 36 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. Locate boxes so that cover or plate will not span different building finishes.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

CC. A maximum continuous run of conduit shall not exceed 300 feet and shall be reduced by 75 feet for each 90-degree elbow.

DD. Provide a 4-inch concrete housekeeping pad at all slab and grade penetrations. Provide a 45 degree, 3/4-inch chamfer at all exposed edges.

EE. Protect metallic finish conduit installed in contact with concrete or below grade with two coats of bitumastic paint, heat shrink tubing, or approved equivalent.

FF. In hazardous locations, seal conduits terminating at boxes enclosing circuit opening equipment at the entrance to the enclosure with approved compound filled sealing fittings to prevent passage of explosive or combustible gases through the conduits. Similarly seal all conduits leading from or entering hazardous locations at points of exit or entrance. Seal exposed conduits passing through hazardous locations at both the entrance to and the exit from the hazardous locations. A sealing compound installation schedule shall be presented to the Engineer for approval. Sign off on each installation and present the compound installation schedule to the Engineer for final sign-off. Each fitting shall be legibly marked with red paint to indicate that the sealing compound has been installed.

GG. Install conduit sealing and drain fittings in all hazardous (classified) areas designated Class 1, Division 1, and Class 1, Division 2.

HH. Use liquid-tight flexible metal conduit for all motor terminations, the primary and secondary of transformers, generator terminations and other equipment where vibration is present or may require removal. The length of liquid-tight flexible metal conduit shall not exceed 36 incheswhen used for vibration isolation and shall not exceed 72 inchesin length when attaching to luminaires. Non-metallic flexible conduit shall only be allowed for use with rigid PVC conduit systems.

II. Flexible couplings shall be used in hazardous locations for all motor terminations and other equipment where vibration is present.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install 0sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 16064 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 16058

SECTION 16063 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic condiuts.
3. Duct accessories.
4. Precast concrete handholes and structures.
5. Precast manholes.
6. Utility structure accessories.
7. Delegated design.

B. Related Requirements:

1. Section 16058 “Raceways and Boxes for Electrical Systems” for Table 16058-1 Raceway Application Guidelines and interior raceways.

1.3 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. GRC: Galvanized rigid steel conduit.

E. RNC: Rigid nonmetallic conduit.

F. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including spacers and miscellaneous components.
2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include frame and cover design and manhole chimneys.
e. Include grounding details.
f. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
g. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

C. Design Calculations:

1. Precast Manholes and Structures:

a. Submit calculations and calculations for structures.
b. Submit buoyancy calculations.

1.5 DELEGATED DESIGN SUBMITTAL

A. Delegated-Design Submittal: For precast manholes and structures.

1. Provide complete submittal, including structural shop drawings and design calculations signed and sealed by a professional structural engineer registered in the State of Rhode Island meeting the requirements of Division 00 and Division 01.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer registered in the State of Rhode Island.

B. Qualification Data: For professional engineer registered in the State of Rhode Island and testing agency responsible for testing nonconcrete handholes and boxes.

C. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

D. Source quality-control reports.

E. Field quality-control reports.

1.7 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.9 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENT

A. Delegated Design: Engage a qualified professional engineer registered in the state of Rhode Island to design precast manholes, included in Article “Underground Enclosure Application.”

2.2 METAL CONDUIT AND FITTINGS

A. Comply with requirements for metal conduit and fittings specified in Section 16058 “Raceways and Boxes for Electrical Systems.”

2.3 RIGID NONMETALLIC CONDUIT

2.4 Comply with requirements for rigid nonmetallic conduit specified in Section 16058 “Raceways and Boxes for Electrical Systems.”DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Atkore International (Allied Tube & Conduit).
b. Cantex Inc.
c. Carlon; a brand of Thomas & Betts Corporation.
d. Or equal.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 16070 "Identification for Electrical Systems."

2.5 PRECAST CONCRETE HANDHOLES AND STRUCTURES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or structure.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Christy Concrete Products.
2. Oldcastle Precast, Inc.
3. Utility Concrete Products, LLC.
4. Or equal.

C. Design Criteria:

1. Precast Concrete

    a. Minimum Compressive Strength: 5000 psi at 28 days.
    b. Maximum water to concrete ratio shall be 0.40 by weight.
    c. Minimum cement content shall be 600 pounds of cement per cubic yard of concrete.
    d. Minimum reinforcing shall be #5@12 EW, EF.

2. Manufactured Products: Conform to ACI 318.

    a. Products capable of supporting their own weight, weight of soil above at 130 lb/cu. yd. and a live load equal to AASHTO H20 applied to top slab. Depth of soil will be calculated from finished grade.
    b. Cast base slab and walls together to form a monolithic base section.
    c. Structure walls: Design for an equivalent lateral fluid pressure of 90 lb/cu. yd. Originate pressure diagram at finished ground surface. Include lateral pressure from vehicles in accordance with AASHTO.
    d. Consider discontinuities in structure produced by openings and joints. Provide additional reinforcing around openings. Frame openings to carry full design loads to support walls.
    e. Prevent flotation, with ground water level at finished ground surface, by dead weight of structure and soil load above structure. Do not consider skin friction, soil friction, or weight of equipment or contents in structure. Factor of safety against buoyancy shall be 1.15. If a concrete slab is required to prevent flotation, design the slab and provide anchorage of the structure to the slab.
    f. Design structure with a minimum number of joints.
    g. Provide lifting hooks for the top slab.
    h. Locate access openings, knockouts, and penetrations as indicated.

3. The date of manufacture, name and trademark of manufacturer shall be marked on the inside of each precast section.
4. Provide integrally cast knock-out panels in precast concrete manhole and handhole sections at locations indicated and with sizes indicated. Knock-out panels shall have no steel reinforcing.
5. Seal tongue and groove joints of precast manhole and handhole sections with rubber O-ring gasket. O-ring gasket shall conform to ASTM C443. In lieu of the O-ring gasket, a flexible joint sealant may be used. Sealant shall be Kent Seal No. 2; ConSeal No. 2; Ram-Nek or equal. Completed joints shall withstand 15 psi internal water pressure without leakage or displacement of gasket or sealant.

D. Comply with ‘Design Criteria’ above and ASTM C 858 for design and manufacturing processes.

E. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, as indicated for each service.

H. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

I. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

1. Extension shall provide increased depth of 12 inches.
2. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.

J. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

K. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Center window location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panels shall be framed with at least two additional No. 5 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick.

L. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.

M. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.6 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Elmhurst-Chicago Stone Co.
2. Hubbell Incorporated (Quazite).
3. Oldcastle Precast, Inc.
4. Utility Concrete Products, LLC.
5. Or equal.

C. Comply with ASTM C 858.

D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Center window location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick.

F. Ground Rod Sleeve: Provide a 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the duct entering the structure.

G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Elmhurst-Chicago Stone Co.
2. Hubbell Incorporated (Quazite).
3. Oldcastle Precast, Inc.
4. Utility Concrete Products, LLC.
5. Or equal.

C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 36 inches.

a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.

    a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
    b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

    a. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.

D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

H. Ground Rod Sleeve: 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

J. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches in width by nominal 24 inches long; punched with 14 hook holes on 1-1/2-inch centers for cable-arm attachment.
2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 PREPARATION

A. Drawings are diagrammatically depicted. Coordinate with other (new and existing) utilities, yard piping, yard structures, and field conditions to determine required depths and install ducts, raceways, conduit, manholes and handholes at the required depths. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Engineer if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Engineer.

C. Refer to Table 16058-1 and comply with requirements for raceways specified in Section 16058 “Raceways and Boxes for Electrical Systems.”

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

C. Duct for Electrical Branch Circuits: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.

D. Underground Ducts Crossing Walks and Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

E. Stub-ups: Concrete-encased PVC-coated GRC.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with Section 02300 "Earthwork," but do not use heavy-duty, hydraulic-operated, compaction equipment.

3.4 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of two 90-degree bends or the total of all bends shall be no more 180 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 16064 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

I. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

J. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.

K. Concrete-Encased Ducts and Duct Bank:

1. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
2. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
3. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
4. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
5. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
6. Elbows: Use manufactured PVC coated GRC elbows for stub-ups, at building entrances, and GRC elbows at changes of direction in duct run.

    a. Couple RNC duct to GRC with adapters designed for this purpose and encase coupling with 3 inches of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inchesabove finished floor and minimum 3 inchesfrom conduit side to edge of slab

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be flush with finished floor and no less than 3 inchesfrom conduit side to edge of slab

7. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
8. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

9. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
10. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

11. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03300A "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

L. Underground-Line Warning Tape: Bury conducting underground line specified in Section 16070 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below frost line below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Dampproofing: Coat outer surfaces of precast manholes with two coats of dampproofing in accordance with manufacturer's instructions.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.

G. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.6 GROUNDING

A. Ground underground ducts and utility structures according to Section 16056 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 16056 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.8 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 16063

SECTION 16064 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal fittings.
3. Grout.
4. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

C. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

D. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

E. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CALPICO, Inc.
b. Pipeline Seal and Insulator, Inc.
c. Proco Products, Inc.
d. Or equal.

2. Sealing Elements: Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. HOLDRITE; Reliance Worldwide Company.
b. Or equal.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07920 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 16064

SECTION 16070 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E and Section 16071 “Power System Studies” requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage.

B. Color-Coding for Identification, 600 V or Less: Use colors listed below for conductors.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
d. Neutral: White.

3. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.
d. Neutral: Gray.

4. Color for Equipment Grounds: Green.
5. Colors for Isolated Grounds: Green with two or more yellow stripes.

C. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification and Source Nameplates:

1. Black letters on a white field.
2. Nameplates shall be engraved, laminated plastic, not less than 1/16-inch thick by ¾-inch by 2-1/2-inch with 3/16-inch high lettering.
3. All electrical equipment furnished under Divisions 26, 27, 28 and all equipment control panels furnished under other Divisions shall include equipment identification nameplates. Equipment includes switchgear, switchboards, motor control centers, panelboards, transformers, disconnect switches, separately mounted motor controllers, transfer switches, control panels, named terminal cabinets, etc. The designation of the equipment shall correspond to the designation shown on the Drawings.
4. Equipment identified in the previous paragraph above shall also include a nameplate with the power source identified

G. Device Identification Labels:

1. Black letters on a white field.
2. Labels shall be self-adhesive type and machine generated with ¼-inch high letters.
3. All receptacles, wall switches, lighting fixtures, photo cells, emergency lights, exit lights, instruments, etc. shall be identified with the panel and circuit to which it is connected.

2.3 LABELS

A. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.
d. Or equal.

2. Minimum Nominal Size:

a. 1-1/2 by 6 inches for raceway and conductors
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Panduit Corp.
    c. Or equal.

2.5 TAPES AND STENCILS

A. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Carlton Industries, LP.
    b. Seton Identification Products; a Brady Corporation company.
    c. Or equal.

B. Underground-Line Warning Tape:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Marking Services, Inc.
    c. Seton Identification Products; a Brady Corporation company.
    d. Or equal.

2. Tape:

    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines by either conductive or inductive location techniques.
    b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

    a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
    c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag: :

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, compounded for direct-burial service.
b. Width: 6 inches.
c. Overall Thickness: 5 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft..
f. Tensile according to ASTM D882: 150 lbf.

C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Marking Services, Inc.
c. Seton Identification Products; a Brady Corporation company.
d. Or equal.

2.7 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services, Inc.
d. Or equal.

2. Engraved legend.
3. Thickness:

a. For signs up to 20 sq. in., minimum 1/16 inch thick.
b. For signs larger than 20 sq. in., 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Self-adhesive.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.
4. Or equal.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings,

manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER."
2. "FIRE ALARM"

L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

M. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

O. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

P. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

Q. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

R. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

S. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

T. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape as indicated on the Drawings.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

U. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized cable ties.

V. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

W. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

X. Equipment Nameplates:

1. Nameplates shall be screw mounted to NEMA 1 enclosures.
2. Nameplates shall be bonded to all other enclosure types using an epoxy or similar waterproof adhesive.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl tape applied in bands.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER."
2. "FIRE ALARM."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

H. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

I. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

J. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

K. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.

M. Arc Flash Warning Labeling: Self-adhesive labels.

N. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Install identification and power source nameplates at all electrical equipment.

O. Junction and Pull Box Nameplates:

1. All voltages (e.g. 480 volts, 120 volts, etc.) within pull boxes, junction boxes etc. shall be identified on the front exterior cover. Provide Signs with red background with white engraved lettering. Provide lettering a minimum of 1 inch high.

P. Panelboard Identification

1. Label branch circuit wires with associated pole number using vinyl cloth wrap around labels.
2. Provide typed as built circuit directories giving location and nature of load served. Install circuit directories in each panelboard.
3. Provide each panelboard with two nameplates. The first shall be provided by the panelboard manufacturer and shall identify the panel. The second shall be field installed by the Contractor to identify the panel's upstream power source.

END OF SECTION 16070

SECTION 16071 - POWER SYSTEM STUDIES

ELECTRICAL SYSTEM TESTING AND SETTINGS:

1. A plant wide short circuit, protective device selective coordination and arc flash study are being performed by the Engineer. The following shall be included under this Contract:

2. Test and set / adjust all protective relays, timers, etc, associated with this Contract, in accordance with the Protective Device Selective Coordination Study.

3. Test and set / adjust all protective relays, timers, etc, associated with existing electrical equipment, in accordance with the Protective Device Selective Coordination Study.

4. Arc Flash labels provided and installed by the Engineer.

END OF SECTION

SECTION 16090 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes equipment and systems used to monitor and control electrical consumption:

1. Power meters.
2. Monitoring and control of power distribution equipment.
3. Raceways and boxes.
4. Wires and cables.
5. Surge protection devices.

1.3 DEFINITIONS

A. Active Power: The average power consumed by a unit. Also known as "real power."

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.

D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.

F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

G. LAN: Local area network.

H. L-G: Line to ground.

I. L-L: Line to line.

J. L-N: Line to neutral.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

L. Modbus TCP/IP: An open protocol for exchange of process data.

M. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

N. N-G: Neutral to ground.

O. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

P. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

Q. TCP/IP: Transport control protocol/Internet.

R. UPS: Uninterruptible power supply; used both in singular and plural contexts.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for power monitoring and control.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For power monitoring and control equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.

    a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:

        1) Location of the meters and gateways, and routing of the connecting wiring.
        2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
6. Surge Suppressors: Data for each device used and where applied.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

    a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
    b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
    c. As-built versions of submittal Product Data.
    d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
    e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
    f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
    g. Engineering, installation, and maintenance manuals that explain how to do the following:

        1) Design and install new points, panels, and other hardware.
        2) Perform preventive maintenance and calibration.
        3) Debug hardware problems.
        4) Repair or replace hardware.

    h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
    i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
    j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
    k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
    l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
    m. Owner training materials.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power monitoring and control units to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Software licenses.
3. Software service agreement.
4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
7. Device address list.
8. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:

1. Electrical meters that monitor, control, and connect to the data transmission network.

2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.

B. Provide an Internet-based electrical power monitoring and control system.

1. System Software: Server thin-client architecture, designed around open standards of Internet technology.
2. Access to Power Monitoring System: A basic Internet browser to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
3. Security: Provide password-protected Internet access.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.

1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Backup Power Source:

1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 POWER METERS “DMU”

A. Manufacturers: Provide power meters that are compatible with equipment specified in Section 16249 “Motor Control Centers.”

B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.

1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of minus 20 to 70 deg C dry bulb and 20 to 90 percent relative humidity, noncondensing.
2. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. Neutral Current Measurement: Not more than 0.65 percent.
3. Power: 0.6 percent.
4. Power Factor: 0.5 percent.
5. Active Energy: 0.6 percent.
6. Reactive Energy: 2.5 percent.
7. Frequency: 0.05 percent.
8. THD: 1.0 percent.
9. Waveform Sampling: 32 per cycle.

F. Data Link:

1. CAT-6 Ethernet Modbus TCP protocol. Confirm required protocol with the Owner.

    a. Provide for firmware and software updates through the communications port.

G. Meter Physical Characteristics:

1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display shall include the following:

    a. All meters, including those listed under the following:

        1) Measurements.
        2) THD.
        3) Energy.
        4) Demand.
        5) Minimum and maximum values.
        6) Power demand.

H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 32 samples per cycle, simultaneously on all voltage and current channels of the meter.

I. Meters:

1. Measurements: Instantaneous, in real time, rms to the 15th harmonic.

a. Voltage: L-L each phase, L-N each phase, and three-phase average.
b. Current: Each phase, three-phase average, and neutral.
c. Unbalanced current, L-L V ac and L-N V ac.
d. Active Power (+/- kW): Each phase and three-phase total.
e. Reactive Power (+/- kVAR): Each phase and three-phase total.
f. Apparent Power (+/- kVA): Each phase and three-phase total.
g. Displacement Power Factor: Each phase and three-phase total.
h. Distortion Power Factor: Each phase and three-phase total.
i. Frequency.

2. THD from measurements simultaneously from the same cycle, through 15th harmonic.

a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
b. Current THD: Each phase and three-phase average.
c. Total demand distortion.

3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.

a. Active kWh.
b. Reactive kVARh.
c. Apparent kVAh.

4. Demand: Present, last, predicted, peak.

a. Three-phase average current.
b. Three-phase total active power (kW).
c. Reactive power (kVAR).
d. Apparent power (kVA).

5. Minimum and Maximum Values:

a. L-L and L-N voltages.
b. Current in each phase.
c. Power factor.
d. Active power total.
e. Reactive power total.
f. Apparent power total.
g. THD L-L and L-N voltages.
h. THD current in each phase.
i. Frequency.

J. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
b. Fixed block that calculates demand at end of the interval.
c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
c. Provide for synchronizing the demand with the internal of this instrument.

K. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Minimum and maximum of real-time rms measurement.
2. Energy.
3. Demand values.
4. Alarms, store the last 40 events.

L. Alarms: Transmit a digital output and show on display when alarmed. Provide for no fewer than 15 metered items. Each alarm shall be user configured, by using the following options:

1. Date and time stamp.
2. Enable-disable (default) or enable.
3. Pickup magnitude.
4. Pickup time delay.
5. Dropout magnitude.
6. Dropout time delay.
7. Alarm type.
8. Alarm label.

M. Output Signals: Provide two mechanical relays, rated not less than 250-V ac, 2-A resistive, and rated for 200-k cycles or more. The relays shall be user configurable in one of the following listed modes:

1. Normal contact closure where the contacts change state for as long as the signal exists.
2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.

N. Meter Face:

1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
3. Provide for the reset of metered peak values.

O. Capacities and Characteristics:

1. Power Supply: 120-V ac, 60 Hz.
2. Circuit Connections:

    a. Voltage: Measurements autoranging, 60- to 400-V ac L-N. Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
    b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
    c. Frequency: 45 to 65 Hz.
    d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT “EGW”

A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.

B. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Ethernet Connectivity:

1. Hardware and cabling required for the Ethernet connection to the network shall be included within the power distribution equipment. Serial communications is unacceptable.

D. Ethernet Gateways:

1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (RJ-45) Ethernet port, that is accessible from the front of the equipment. Initial setup shall be limited to basic Ethernet addressing parameters, as assigned by Owner.
3. Common Gateway Features:

    a. User configurable, with secure password-protected login process.
    b. Include communications diagnostic information for Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
    c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's port(s) through a standard web browser.
    d. Allow firmware upgrades through the communications port.

4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
5. Implement a common user interface ("look and feel") across all styles of power equipment.

E. Fiber Optic Module:

1. Provide ports as shown on the Overall Power Monitoring Riser Diagram Modifications in the Drawings.

2. Conform to the requirements of Section 16722 “Communications Optical Fiber Backbone Cabling.”

2.5 RACEWAYS AND BOXES

A. Comply with requirements in Section 16058 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

2.6 WIRES AND CABLES

A. Electrical Power Wiring: Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

1. Copper conductors are Type THHN/THWN-2.

B. Control Wiring: Comply with requirements in Section 16722 "Communications Optical Fiber Backbone Cabling."

2.7 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA, Inc.
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 A. The peak surge current rating shall be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.

D. Comply with UL 1283.

E. Protection modes and UL 1449 SPD for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. L-N: 1200 V for 480Y/277 V.
2. L-G: 1200 V for 480Y/277 V.
3. N-G: 1200 V for 480Y/277 V.
4. L-L: 2000 V for 480Y/277 V.

F. SCCR: Equal or exceed 65 kA.

G. Nominal Rating: 20 kA.

H. Indoor Enclosures: NEMA 250, Type 12**.**

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation:

1. Comply with Section 16052 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 16055 "Control-Voltage Electrical Power Cables" for control wiring.

E. Raceways Installation:

1. Comply with Section 16058 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

F. Identification Installation:

1. Comply with Section 16052 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 271323 "Communications Optical Fiber Backbone Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.3 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.4 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.

B. For low-voltage control wiring and cabling, comply with requirements in Section 16056 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Wiring and cabling will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 FINAL REVIEW

A. Submit written request to Engineer and Construction Manager when the power monitoring and control system is ready for final review. Written request shall state the following:

1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
4. The system is complete and ready for final review.

B. Review by Construction Manager will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

END OF SECTION 16090

SECTION 16223 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Grounded to enclosure.

C. Coils: Continuous windings without splices except for taps.

1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

E. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.

    a. Finish Color: Gray weather-resistant enamel.

F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

G. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

H. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

I. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.

2. Indicate value of K-factor on transformer nameplate.

J. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

K. Wall Brackets: Manufacturer's standard brackets.

2.4 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 16070 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to ANSI/IEEE C57.12.01 and NEMA ST-20-2014.

1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 16056 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

C. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 16056 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 16052 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Perform specific inspections and mechanical tests recommended by manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Measure resistance at each winding, tap, and bolted connection.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16223

SECTION 16246 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.

3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Height: 84 inches maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions. Trims shall cover all live parts and shall have no exposed hardware.
4. Finishes:

    a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Same finish as panels and trim.

G. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

    a. Plating shall run entire length of bus.
    b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.

J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES IN PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
3. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

2.5 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:

1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Mount top of trim 90 inches above finished floor unless otherwise indicated.

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

J. Install filler plates in unused spaces.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 16070 "Identification for Electrical Systems."

B. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

C. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

D. Install warning signs complying with requirements in Section 16070 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 16246

SECTION 16249 - MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:

1. Feeder-tap units.
2. Measurement and control.
3. Auxiliary devices.

B. Related Requirements

1. Section 16071 "Power System Studies" for arc-flash analysis and arc-flash label requirements.
2. Section 16090 “Electrical Power Monitoring and Control” for power monitoring requirements.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCC: Motor-control center.

C. MCCB: Molded-case circuit breaker.

D. MCP: Motor-circuit protector.

E. OCPD: Overcurrent protective device.

F. PID: Control action; proportional plus integral plus derivative.

G. PT: Potential transformer.

H. SPD: Surge protective device.

I. SCR: Silicon-controlled rectifier.

J. VFC: Variable-frequency controller.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for MCCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for each cell of the MCC.

B. Shop Drawings: For each MCC, manufacturer's approval drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
g. Specified optional features and accessories.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
3. Nameplate legends.
4. Vertical and horizontal bus capacities.
5. Features, characteristics, ratings, and factory settings of each installed unit.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each MCC.

D. Source quality-control reports.

E. Field quality-control reports.

F. Load-Current and Overload Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

H. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:
2. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications incorporated during construction by manufacturer, Contractor, or both.
3. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
4. Manufacturer's written instructions for setting field-adjustable overload relays.
5. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
6. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
7. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, and marked for intended use.

D. UL Compliance: MCCs shall comply with UL 845 and shall be listed and labeled by a qualified testing agency.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handle MCCs according to the following:

1. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."

B. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; install temporary electric heating, with at least 250 W per vertical section.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace MCC and SPD that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Rockwell Automation, Inc.
3. Schneider Electric USA (Square D).
4. Siemens Industry, Inc., Energy Management Division.
5. Or equal.

2.2 SYSTEM DESCRIPTION

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F and not exceeding 104 deg F, with an average value not exceeding 95 deg F over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F
3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding 6600 feet, or 3300 feet if MCC includes solid-state devices.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to Section 01882 “Seismic Performance Requirements.”

B. Capacities and Characteristics:

1. MCC Enclosure and Assembly:

   a. Nominal System Voltage: 277/480-V ac.
   b. Service Equipment Rated: No.
   c. Enclosure: NEMA 250, Type 12.

2. Integrated Short-Circuit Rating for MCC:
   a. Fully rated65 kA.

3. Integrated Short-Circuit Rating for Each Unit:
   a. Fully rated; 65 kA.

4. Wiring Class: II-S, Type B.
5. Bus:

   a. Horizontal Bus: 65 kA.
   b. Neutral Bus: Full size.

6. Main Disconnect Device:

   a. Main Disconnect: MCCB, UL 489, three pole. Manually operated, electrically tripped.
   b. SPD: UL 1449, Type 2.

7. Magnetic Controllers: As shown on the Drawings.

8. VFCs: As shown on the Drawings.

9. Controller-Mounted Auxiliary Devices:

    a. Push Buttons and Selector Switches: Heavy-duty, oiltight type.
    b. Feeder Tap Units: Main Disconnect: MCCB, UL 489, three pole. Manually operated, electrically tripped.

2.4 MOTOR CONTROL CENTER ENCLOSURES

A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 1 unless otherwise indicated to comply with environmental conditions at installed location.

B. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.5 ASSEMBLY

A. Structure:

1. Comply with UL requirements for service entrance equipment.
2. Units up to and including Size 3 shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
3. Units in Type B and Type C MCCs shall have pull-apart terminal strips for external control connections.
4. Pull Boxes:

    a. Include provisions for ventilation to maintain temperature in pull box within same limits as the MCC.
    b. Set the box back from front to clear circuit-breaker removal mechanism.
    c. Covers: Removable covers forming top, front, and sides.
    d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
    e. Cable Supports: Arranged to facilitate cabling and adequate to support cables, including supports for future cables.
    f. When equipped with barriers, supply with access to check bus bolt tightness.

B. Compartments: Modular; individual lift-off doors with concealed hinges and quick-captive screw fasteners.

1. Interlock compartment door to require that the disconnecting means is "off" before door can be opened or closed, except by operating a concealed release device.
2. Compartment construction shall allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC.
3. The same-size compartments shall be interchangeable to allow rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

C. Bus Transition and Incoming Pull Sections: Included and aligned with the structure of the MCC.

D. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same-size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

E. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in bottom and top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

F. Provisions for Future:

1. Compartments marked "future" shall be bused, wired and equipped with guide rails or equivalent, and ready for insertion of drawout units.
2. Compartments marked "spare" shall include provisions for connection to the vertical bus.

G. Integrated Short-Circuit Rating:

1. Short-Circuit Current Rating for Each Unit: Fully rated; 65 kA.
2. Short-Circuit Current Rating of MCC: Fully rated with its main overcurrent device; 65 kA.

H. Control Power:

1. 120-V ac; obtained from CPT integral with controller; with primary and secondary fuses. The CPT shall be of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

I. Factory-Installed Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

1. Wiring Class: NEMA ICS 18, Class II-S, Type B, for starters larger than Size 3.
2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

J. Bus:

1. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections.
2. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.
3. Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated alloy, with compression connectors for outgoing conductors.

4. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size 1/4-by-2 inches. Equip with compression connectors for outgoing conductors.
5. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Insulation temperature rating shall not be less than 105 deg C.

2.6 MAIN DISCONNECT AND OVERCURRENT PROTECTIVE DEVICE(S)

A. MCCB (to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.

1. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be shown by the position of the handle, and manual push-to-trip push button.

2. Switch operator power shall be from control power specified in "Assembly" Article.

B. Surge Suppression: Factory installed as an integral part of the incoming feeder, complying with UL 1449, SPD Type 2.

2.7 MAGNETIC CONTROLLERS

A. Controller Units: Combination controllers.

B. Disconnects:

1. MCP:

a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

C. Controllers: Comply with UL 508.

1. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

a. Classification: As shown on the Drawings.

D. Overload Relays:

1. Bimetallic Overload Relays:

a. Inverse-time-current characteristic.
b. Class 10 tripping characteristic.

c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. NC isolated overload alarm contact.
3. External overload reset push button.

2.8 VFC

A. Controller Units: Combination controllers, consisting of variable-frequency power converter that is factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged for self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

B. Disconnects:

1. MCCB:

a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

C. Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.

6. Overload Capability:

    a. For variable-torque controllers, 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
    b. For constant-torque controllers, 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

7. Starting Torque: Minimum of 100 percent of rated torque from 3 to 60 Hz.
8. Speed Regulation: Plus or minus 0.5 percent.
9. Output Carrier Frequency: Field selectable.
10. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
11. Internal Adjustability Capabilities:

    a. Minimum Speed: 5 to 25 percent of maximum rpm.
    b. Maximum Speed: 80 to 100 percent of maximum rpm.
    c. Acceleration: 0.1 to 999.9 seconds.
    d. Deceleration: 0.1 to 999.9 seconds.
    e. Current Limit: 30 to a minimum of 150 percent of maximum rating.

12. Self-Protection and Reliability Features:

    a. Input transient protection by means of SPDs for three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
    b. Under- and overvoltage trips.
    c. Inverter overcurrent trips.
    d. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved and listed and labeled by an NRTL.
    e. Instantaneous line-to-line and line-to-ground overcurrent trips.
    f. Loss-of-phase protection.
    g. Reverse-phase protection.
    h. Short-circuit protection.
    i. Motor overtemperature fault.

D. Operator Station:

1. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.
2. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
3. Panel-mounted, manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

    a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
    b. Security Access: Electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

E. Displays:

1. Historical Logging Information and Displays:

a. Real-time clock with current time and date.
b. Running log of total power versus time.
c. Total run time.
d. Fault log, maintaining last four faults with time and date stamp for each.

2. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including the following:

a. Output frequency (Hz).
b. Motor speed (rpm).
c. Motor status (running, stop, fault).
d. Motor current (amperes).
e. Motor torque (percentage).
f. Fault or alarming status (code).
g. DC-link voltage (V dc).
h. Set-point frequency (Hz).
i. Motor output voltage (V ac).

F. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

G. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

H. Communication Port: Ethernet connection capable of connecting a printer and a notebook computer.

2.9 CONTROLLER-MOUNTED AUXILIARY DEVICES

A. Control-Circuit and Pilot Devices: Factory installed in controller enclosure cover unless otherwise indicated. Comply with NEMA ICS 5.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

a. Push Buttons: Recessed types; momentary contact unless otherwise indicated.
b. Pilot Lights: LED types; push to test.
c. Selector Switches: Rotary type.

B. Auxiliary Dry Contacts: Reversible NC/NO.

2.10 MEASUREMENT AND CONTROL DEVICES

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
2. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Listed or recognized by a nationally recognized testing laboratory.
2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
3. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
    e. Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
    i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.

4. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Motor Protection Relays: See Control Wiring Diagrams on the Drawings.

2.11 FEEDER TAP UNITS

A. MCCBs (to 1200 A): Fixed mounted, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Comply with UL 489, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
2. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

3. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 16090 "Electrical Power Monitoring and Control."
4. With built-in digital ammeter and a digital display, showing tripping cause.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
11. Electrical Operator: Remote control for on, off, and reset operations.

B. Fusible Switches (to 600 A): Fixed-mounted, manually operated, fusible, quick-make, quick-break switch with 200-kA interrupting and short-circuit current rating when fitted with UL 248-8 Class J fuses. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. Include fuse clips and fuses.
3. Electrically tripped switches shall include the following:

    a. Shunt trip.
    b. Ground-fault protection, with adjustable time delay and test panel.
    c. Single-phase protection, tripping the switch on loss of a source phase.
    d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

2.12 SOURCE QUALITY CONTROL

A. MCC Testing: Test and inspect MCCs according to requirements in NEMA ICS 18.

B. VFC Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

C. MCCs will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.

B. Floor Mounting: Install MCCs on 4-inch nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 03300A "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible switch.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 16283 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 16070 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Install required warning signs.

3. Label MCC and each cubicle with engraved nameplate.
4. Label each enclosure-mounted control and pilot device.
5. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central-control system. Comply with requirements in Section 16055 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 16058 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 16056 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
5. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

D. MCCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to NETA Acceptance Testing Specification and manufacturer's written instructions.

3.8 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.

B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.

D. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

E. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion. Refer to Section 13614 “Process Control Descriptions” for additional details of VFC control.

F. Set field-adjustable circuit-breaker trip ranges as specified in Section 16071 "Power System Studies."

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 16249

SECTION 16276 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. Cord and plug sets.
4. Toggle switches, 120/277 V, 20 A.
5. Wall plates.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with requirements in this Section.

F. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

G. Device Color:

1. Wiring Devices Connected to Normal Power System: Gray unless otherwise indicated or required by NFPA 70 or device listing.

H. Wall Plate Color: For plastic covers, match device color.

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Hubbell Incorporated (Wiring Device-Kellems).
c. Leviton Manufacturing Co., Inc.

d. Or equal.

2. Description: Two-pole, three-wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.

2.3 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Hubbell Incorporated (Wiring Device-Kellems).
c. Leviton Manufacturing Co., Inc.
d. Or equal.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two-pole, three-wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Hubbell Incorporated (Wiring Device-Kellems).
c. Leviton Manufacturing Co., Inc.
d. Or equal.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two-pole, three-wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498 and UL 943 Class A.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.5 TOGGLE SWITCHES, 120/277 V, 20 A

A. Three-Way Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Leviton Manufacturing Co., Inc.
   d. Or equal.

2. Comply with UL 20 and FS W-S-896.

2.6 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Unfinished Spaces: Galvanized steel.
3. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, surface mount, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 16070 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 16276

SECTION 16283 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Motor-control centers.
c. Panelboards.
d. Enclosed controllers.
e. Enclosed switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
4. Coordination charts and tables and related data.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in PDF format.
3. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton (Bussmann & Edison).
2. Littelfuse, Inc.
3. Mersen USA.
4. Or equal.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 16070 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 16283

SECTION 16286 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than of each size and type.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL or a NRTL if approved by the Owner and/or Engineer and marked for intended location and application.

D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
3. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Compression type, suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
3. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Compression type, suitable for number, size, and conductor material.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint or Owner approved color and paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1), gray baked enamel paint or Owner approved color and paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12), or a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X 316 stainless steel or fiberglass if approved by Owner and Engineer).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Enclosures designated as NEMA 250 Type 4, 4X 316 stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the device is ON and to prevent turning the device ON when the enclosure cover is open.

E. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Outdoor Locations: NEMA 250, Type 4X.
2. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.
3. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 with cover attached by Type 316 stainless steel bolts.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 16070 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.

c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 16286

SECTION 16292 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Combination full-voltage magnetic motor controllers.
3. Enclosures.
4. Accessories.
5. Identification.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. NC: Normally closed.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SCPD: Short-circuit protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.

2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:

1. Each installed magnetic controller type.
2. NRTL listing.
3. Factory-installed accessories.
4. Nameplate legends.
5. SCCR of integrated unit.
6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.

    a. Listing document proving Type 2 coordination.

7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

    a. Routine maintenance requirements for magnetic controllers and installed components.
    b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
    c. Manufacturer's written instructions for setting field-adjustable overload relays.
    d. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 50 W per controller.

1.9 FIELD CONDITIONS

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 23 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet for electromagnetic and manual devices.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

2.2 MANUAL MOTOR CONTROLLERS

A. Integral Horsepower Manual Controllers (IHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton.
b. Schneider Electric USA (Square D).
c. Siemens Industry, Inc., Energy Management Division.

d. Or equal.

2. Configuration: Nonreversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.

2.3 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLER

A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, in a single enclosure.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA (Square D).
3. Siemens Industry, Inc., Energy Management Division.
4. Or equal.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

G. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.
b. Class 10 tripping characteristic.
c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

H. MCCB Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.4 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty or oil-tight.

B. Breather assemblies, to maintain interior pressure and release condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

C. Space heaters, with NC auxiliary contacts, to mitigate condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

D. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.6 IDENTIFICATION

A. Controller Nameplates: Laminated acrylic or melamine plastic signs, as described in Section 16070 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Provided and installed by Engineer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 16057 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with drawings and specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the unit is clean.
    e. Inspect contactors:

        1) Verify mechanical operation.
        2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

    f. Motor-Running Protection:

        1) Verify overload element rating is correct for its application.
        2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.
b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Perform operational tests by initiating control devices.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.

3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 16292

SECTION 16296 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Requirements:

1. Section 16249 "Motor-Control Centers" for VFCs installed in motor-control centers.

1.3 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller. See VFD.

L. VFD: Variable-frequency drive. Used interchangeably with the term VFC.

1.4 PROJECT / SITE REQUIREMENTS

A. VFC Technologies: For each VFC indicated.

1. 50 hp and Below: 6-pulse PWM VFC with line reactor
2. Above 50 hp: 18-pulse PWM VFC with an input phase-shifting transformer as an integral part of the drive or technology that compares to or exceeds.

B. VFCs Serving HVAC Equipment: Specifically designed to HVAC market requirements for fan, pump, and fluid control applications.

C. Provide VFC disconnect switches capable of lock-out.

D. As a minimum, provide input line reactors for all 6-pulse drives furnished under this Section. Line reactors are specified herein.

E. Provide shunt type harmonic filters for each drive if the specified harmonic distortion limits cannot be obtained by the addition of line reactors or if required to meet the specified input true power factor.

1. Filters: Second order high pass design utilizing line reactors, capacitors, and damping and bleeder resistors.

    a. Switch-in: Does not create power source transient disturbances which cause shutdown of other VFC equipment already online.
2. Provide an input line contactor with overcurrent and short circuit protection.

    a. Line Contactor: Interlocked with VFC operation and includes blown fuse and filter overtemperature shutdown interlocks with contacts for remote alarm.

3. Match the compensation kVAR to the kVAR demand such that true power factor is between 0.95 and 0.85 lagging.
4. Capacitors: Do not affect steady state operation of the VFC while operating under either utility or generator power.

    a. Voltage Rating: 600 Volts for operation on a nominal 480 Volt system.

5. Filter Cabinet: Force ventilated and similar in construction to VFC cabinets.

F. Output dV/dT Filter

1. Provide output dV/dT motor protection filters for VFCs located more than 50 feet from the driven equipment to protect the cable and motor, or where shown on the Drawings.

1.5 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, heat dissipation, electrical characteristics, AIC rating, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Provide harmonic data on VFCs to the Study Engineer for inclusion in the harmonic study under Section 260473 “Power System Studies.”

E. The VFC supplier shall submit written confirmation that the motor characteristics (i.e. torque type, FLA, etc.) have been coordinated with the supplier of the driven equipment and that the VFCs being supplied are matched properly for the driven load.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

c. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
d. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.10 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Schneider Electric USA, Inc.
3. Siemens Industry, Inc. (Building Technologies Division).
4. Or equal.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Constant torque and variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.

4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds for variable-torque applications; 1.5 times the base load current for 60 seconds for constant-torque applications; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 0.5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Instantaneous line-to-line and line-to-ground overcurrent trips.
7. Loss-of-phase protection.
8. Reverse-phase protection.
9. Short-circuit protection.
10. Motor-overtemperature fault.

J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

M. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

2.3 CONTROLS AND INDICATION

A. Controls shall, as a minimum, perform the control logic indicated on the Contract Drawings and as specified herein.

B. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

C. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

D. Historical Logging Information and Displays:

1. Running log of total power versus time.
2. Total run time.
3. Fault log, maintaining last four faults with time and date stamp for each.

E. System Communication

1. Hardwire control functions between the VFC and the SCADA system using discrete and analog wiring. Provide analog 4-20 mA signals for input speed control and output speed reference. Optically isolate the input speed control and output speed reference signals.

2. Digital communication to SCADA: Provide a copper Ethernet for interconnection to the SCADA system. Modbus RTU is the communication protocol. Provide all necessary cables, connectors, software, and hardware to interface with the SCADA system.
3. Local communication: Provide an RJ-45 port for communication with a computer for setup or downloading of VFC parameters, fault diagnostics, or data logs.
4. Provide VFCs with interfacing hardware and software for control and monitoring from the plant computer system. Include serial communications links between the VFCs and plant computer system via communication cables as shown on the Drawings. Ensure the VFCs and plant computer system are coordinated and compatible. Include proof of coordination with Division 13 with the VFC submittals.

2.4 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Provide factory-wired 5 percent line impedance at 480 Volts capable of 200 percent overload for at least one minute and is UL recognized or approved.

B. Output Filtering:

1. dV/dT: Provide a factory-wired filter, comprised of passive components only, that limits peak voltage at the motor terminals to 150% or less of the VFD's DC bus voltage for motor leads of 1000 feet or shorter.

    a. Waveform pulses: Limit the maximum dV/dT at the motor terminal to 200 volts per microsecond.
    b. Insertion Loss: 3% of rated maximum voltage.
    c. Filter: UL listed.

2. Sine Wave: Provide a factory-wired filter, comprised of passive components only, that limits total harmonic voltage distortion in the waveform feeding the motor to 5 percent typical at full load and 60 Hz.

    a. Carrier Frequencies: 2 to 8 kHz and motor leads up to 15,000 feet.
    b. Insertion Loss: 10 percent maximum of rated maximum voltage.
    c. Filter: UL listed.

2.5 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Outdoor Locations: Type 4X.
2. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.6 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Recessed.

2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling and Exhaust System: For NEMA 250, Type 4X; UL 508 component recognized: Provide integral air conditioner.

I. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.7 ADDITIONAL CONSTRUCTION REQUIREMENTS

A. Disconnect handle height shall not exceed NEC requirements with VFC is located on 4-inch high housekeeping pad.

B. VFC’s shall utilize 115 VAC control power for operator devices, cooling fans, motor space heaters and external control circuits. Control power transformer shall be fused on the primary and secondary. Control circuits shall be isolated from power circuits.

C. VFC shall include a copper ground bus.

D. All bus and exposed copper shall be tin plated.

E. All floor mounted enclosures shall have complete 18" (minimum) clear space in bottom of the cubical for line, motor and field cable terminations. All wall mounted enclosures shall have

complete 12" (minimum) clear space in bottom of the enclosure for line, motor and field cable terminations.

F. A switchable LED light shall be provided within each floor mounted section of the enclosure.

G. Barriers shall be provided on terminals that remain energized with the power disconnect OFF.

H. All circuit boards shall be conformal coated to help protect them from hydrogen sulfide gases.

I. Identification

1. All wiring shall be numbered at each end with typed sleeve type labels at each termination. Labels shall correspond to the wiring diagrams. Wiring less than 6 inches may be numbered at only one end.
2. Provide warning signs on terminals that are energized with the power disconnect OFF.
3. Provide 2-inch by 5-inch, nominal, engraved three-layer laminated plastic master nameplates on each VFD fastened with stainless steel screws or rivets. Nameplates shall be black letters with white background core, 3/8-inch high lettering and shall indicate equipment designation as shown on the Drawings.
4. Provide legend plates or 1-inch by 3-inch engraved nameplates with 1/4-inch lettering for identification of pilot devices and meters.
5. Provide permanent warning signs as follows:

    a. "DANGER - HIGH VOLTAGE - KEEP OUT" on all enclosure doors.
    b. "WARNING - HAZARD OF ELECTRIC SHOCK - DISCONNECT POWER BEFORE OPENING OR WORKING ON THIS UNIT".

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 16057 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 03300A "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 16283 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 16055 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Field test all the hardwired discrete and analog connections and any software communication (Ethernet, Profibus, ControlNet, Modibus, etc.) that are connect to remote control equipment when the VFC is placed in remote. The manufacturer shall at a minimum verify with the proper testing equipment that the following can be achieved:

    a. The drive can be started and stopped remotely
    b. The drive can have its speed changed remotely
    c. The remote equipment can read the VFC discrete status information.
    d. The remote equipment can read the VFC speed feedback information.

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges as specified in Section 16071 "Power System Studies."

E. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

3.10 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

B. Replace all cabinet ventilation filters upon commencement of the Contract warranty period.

END OF SECTION 16296

SECTION 16411 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes lightning protection system for ordinary structures.

B. Related Requirements:

1. Section 16056 “Grounding and Bonding for Electrical Systems” for grounding system interconnections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 01783 "Project Record Documents."
b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Letter of Findings Limited Scope Inspection Report.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advanced Lightning Technology, Ltd.
2. National Lightning Protection.
3. nVent (ERICO).
4. Or equal.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.

C. Delegated Design:

1. Provide a complete lightning protection system for the Return Sludge Pump Station No. 3.

2. Employ the services of a licensed lightning protection systems engineering company to design and install the lighting protection system and prepare detailed installation drawings and material specifications. Submit in accordance with Article "Informational Submittals."

3. Employ the services of a UL field inspector upon completion of the installation. Assume full responsibility for the correctness of the installation and make all corrections and additions deemed necessary by the UL inspector. Pay for all costs of the UL inspection and any subsequent reinspection as required.

4. Coordinate with Division 7 for roofing system connection and provide appropriate rod bases and cable supports.

2.3 MATERIALS

A. Air Terminals:

1. Aluminum unless otherwise indicated.
2. 1/2-inch diameter by 18 inches long.
3. Pointed tip.
4. Threaded base support.

B. Air Terminal Bracing:

1. Aluminum.
2. 1/4-inch diameter rod.

C. Class 1 Main Conductors:

1. Aluminum: 98,600 circular mils in diameter.

D. Secondary Conductors:

1. Aluminum: 41,400 circular mils in diameter.

E. Ground Loop Conductor: Stranded copper**.**

F. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Rods shall be not less than 120 inches long.

G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed installations in UL 96A.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: high compression.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Letter of Findings.

B. Prepare test and inspection reports and certificates.

END OF SECTION 16411

SECTION 16513 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of LED luminaires:

1. Linear industrial.
2. Lowbay.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
3. Structural members to which luminaires will be attached.
4. Items penetrating finished ceiling, including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Sprinklers.
d. Access panels.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Product Test Reports: For each type of luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Ambient Temperature: 41 to 104 deg F.

1. Relative Humidity: Zero to 100 percent.

B. Altitude: Sea level to 1000 feet.

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles.

1. Label shall include the following lamp characteristics:

C. Recessed luminaires shall comply with NEMA LE 4.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

2.3 LINEAR INDUSTRIAL “DL”.

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton (Lighting).
2. Holophane; Acuity Brands Lighting, Inc.
3. RAB Lighting.
4. Or equal.

B. Nominal Operating Voltage: 120-277 V ac.

C. Lamp:

1. Minimum 6,000 lm.
2. Minimum allowable efficacy of 100 lm/W.
3. CRI of minimum 80. CCT of 5000 k.
4. Rated lamp life of 60,000 hours to L92.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.

D. Housings:

1. Frosted polycarbonate housing and aluminum heat sink.

E. Housing and Heat Sink Rating:

1. NEMA 4X.
2. IP 66.
3. Wet locations.
4. CSA C22.2 No 137.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Diffusers and Globes:

1. Frosted polycarbonate.

H. With integral mounting provisions.

I. Standards:

1. UL Listing: Listed for damp location.

2.4 LOWBAY “WL”

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton (Lighting).
2. Holophane; Acuity Brands Lighting, Inc.
3. OSRAM SYLVANIA.
4. Or equal.

B. Nominal Operating Voltage: 120-277 V ac.

C. Lamp:

1. Minimum 8,000 lm.
2. Minimum allowable efficacy of 100 lm/W.
3. CRI of minimum 80. CCT of 5000 K.
4. Rated lamp life of 60,000 hours to L89.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:

1. Aluminum housing and heat sink.
2. White powder-coat finish.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. Prismatic glass.
2. Glass: Borosilicate glass unless otherwise indicated.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:

1. UL Listing: Listed for wet location.

2.5 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for sheet steel.

C. Stainless Steel:

1. Manufacturer's standard grade.
2. Manufacturer's standard type, ASTM A 240/240 M.

D. Galvanized Steel: ASTM A 653/A 653M.

E. Aluminum: ASTM B 209.

2.6 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.7 LUMINAIRE SUPPORT

A. Comply with requirements in Section 16057 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Engineer, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.

4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

D. Suspended Luminaires:

1. Ceiling Mount:

a. Pendant mount with 5/32-inch- diameter aircraft cable supports.

2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

E. Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace drivers or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Engineer or Engineer

END OF SECTION 16513

SECTION 16522 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires and signs shall be certified by manufacturer.
b. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which equipment will be attached.
3. Items penetrating finished ceiling including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Sprinklers.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: Three years from date of Substantial Completion. Full warranty shall apply for the luminaire and prorated for the battery.
2. Warranty Period for Self-Powered Exit Sign Batteries: Five years from date of Substantial Completion. Full warranty shall apply for the luminaire and prorated for the battery.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.

1. Emergency Connection: Operate four lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.

2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding 3300 feet.

4. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: Sealed, maintenance-free, lithium iron phosphate or nickel-cadmium types.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.2 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Lighting Unit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Dual-Lite.
    b. Eaton (Lighting).
    c. Lithonia Lighting; Acuity Brands Lighting, Inc.
    d. Or equal.

2. Emergency Lighting Unit: “BU” as indicated on Drawings.
3. Operating at nominal voltage of 120-347 V ac.

4. Wall-mountwith universal junction box adaptor.
5. UV stable thermoplastic housing, rated for wet locations.
6. Two LED lamp heads.
7. Internal emergency power unit.

C. Remote Emergency Lighting Units:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Dual-Lite; A Hubbell Company.
    b. Eaton (Lighting).
    c. Lithonia Lighting; Acuity Brands Lighting, Inc.
    d. Or equal.

2. Emergency Lighting Unit: “RH” as indicated on Drawings.
3. Operating at nominal voltage of Emergency Lighting Unit battery output.
4. Wall-mount with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for wet locations.
6. Two LED lamp heads.
7. External emergency power unit.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924.

1. Sign Colors:

    a. White housing.
    b. Red letters and chevrons, as indicated on the Drawings.

2. Visibility: 100-foot viewing distance
3. Lettering Size: 6” high with ¾” stroke.

B. Internally Lighted Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Lighting).
    b. Hubbell Incorporated (Hubbell Industrial Lighting).
    c. Lithonia Lighting; Acuity Brands Lighting, Inc.
    d. Or equal.

2. Operating at nominal voltage of 120/277 V ac.
3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
5. UV stable thermoplastic housing, rated for wet locations.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Clear, UV-stabilized acrylic.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Thermoplastic.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 16057 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20-gage backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.

a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 16522

SECTION 16553 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.

2. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES LM-80.

a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Photoelectric relays.
7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

C. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

D. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Source quality-control reports.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.9 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Engineer prior to the start of luminaire installation.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures, including luminaire support components.
    b. Faulty operation of luminaires and accessories.
    c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. CRI of 70. CCT of4000 K.

E. L90 lamp life of 50,000 hours.

F. Lamps dimmable from 100 percent to 0 percent of maximum light output.

G. Internal driver.

H. Nominal Operating Voltage: 120-277 V ac.

I. In-line Fusing: Separate in-line fuse for each luminaire.

J. Lamp Rating: Lamp marked for outdoor use.

K. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 LUMINAIRE TYPES

A. Area and Site:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Lighting).
    b. Lithonia Lighting; Acuity Brands Lighting, Inc.
    c. RAB Lighting.
    d. Or equal.

2. Luminaire Shape: Square.
3. Mounting: Pole with extruded-aluminum rectangular arm, 13 inches in length.
4. Luminaire-Mounting Height: 30’-0”.
5. Distribution: Forward throw.
6. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. Zinc-infused thermoset powder-coat finish.

B. Wall pack:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Lighting).
    b. Lithonia Lighting; Acuity Brands Lighting, Inc.

c. RAB Lighting.
d. Or equal.

2. Shape: Square.
3. Height Above Finished Grade: as shown on the Drawings.
4. Mounting: 3 point cast aluminum base.
5. Distribution: Type III.
6. Diffusers and Globes: Diffuse glass.
7. Housings:

a. Extruded-aluminum housing and heat sink.
b. Zinc-infused thermoset powder-coat finish.

2.3 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Glass: Annealed crystal glass unless otherwise indicated.
2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. Lamp diameter, shape, size, wattage and coating.
b. CCT and CRI for all luminaires.

2.4 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

2.5 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 16057 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls and roofs for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Engineer, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Fasten luminaire to structural support.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

F. Wiring Method: Install cables in raceways. Conceal raceways and cables.

G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

H. Coordinate layout and installation of luminaires with other construction.

I. Adjust luminaires that require field adjustment or aiming.

J. Comply with requirements in Section 16052 "Low-Voltage Electrical Power Conductors and Cables" and Section 16058 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 16058 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

a. IES LM-79.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Engineer.

END OF SECTION 16553

SECTION 16722 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. Optical fiber cable connecting hardware, patch panels, and cross-connects.
3. Cabling identification products.

B. Related Requirements:

1. Section 16276 "Wiring Devices."
2. Section 16057 "Hangers and Supports for Electrical Systems”
3. Section 16070 "Identification for Electrical Systems."

1.3 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

1.4 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics including the following:

    a. Telecommunications system access points.
    b. Cross-connects.
    c. Patch panels.
    d. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Optical fiber cable testing plan.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Product Certificates: For each type of product.

D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Patch-Panel Units: One of each type.
2. Plugs: Ten of each type.
3. Jacks: Ten of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by a Technician.

2. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified as an Technician to supervise on-site testing.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

2.2 62.5/125-MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM1)

A. Description: Multimode, 62.5/125-micrometer, 12-fiber, nonconductive, tight buffer, optical fiber cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden CDT Networking Division/NORDX.
2. Corning Cable Systems.

3. General Cable; General Cable Corporation.
4. Or equal.

C. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA for detailed specifications.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.0 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-Length Product: 220 MHz-km at 850 nm.

F. Jacket:

1. Jacket Color: Orange.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.

2.3 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden CDT Networking Division/NORDX.
2. Corning Cable Systems.
3. Optical Cable Corporation.
4. Or equal.

B. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

C. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

D. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

E. Connector Type: Type SC complying with TIA-604-3-B, Type ST complying with TIA-604-2-B, connectors.

F. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.75 dB.
3. Marked to indicate transmission performance.

G. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.75 dB.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

2.4 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.5 SOURCE QUALITY CONTROL

A. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Comply with NECA 1 and NECA 301.

B. General Requirements for Optical Fiber Cabling Installation:

1. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
2. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified by the manufacturer. Use lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
7. In the communications equipment room, provide a 10-foot-long service loop on each end of cable.
8. Pulling Cable: Comply with manufacturer recommendations. Monitor cable pull tensions.
9. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Group connecting hardware for cables into separate logical fields.

3.3 GROUNDING

A. Comply with requirements in Section 16056 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
b. Link End-to-End Attenuation Tests:

1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.

2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 16722

SECTION 16846 - CONVENTIONAL FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Graphic annunciator.
7. Delegated design.

B. Related Requirements:

1. Section 16052 "Low-Voltage Electrical Power Conductors and Cables" for cables and conductors for fire-alarm systems.
2. Section 16058 “Raceways and Boxes for Electrical Systems” for electrical boxes, fittings, and raceway systems.

1.3 DEFINITIONS

A. FACP: Fire Alarm Control Panel.

B. NICET: National Institute for Certification in Engineering Technologies.

1.4 ACTION SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Engineer.
2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.
b. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, and profiles and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct smoke detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include floor plans to indicate final outlet locations showing zone designation of each device. Show size and route of cable and conduits and point-to-point wiring diagrams.

1.5 DELEGATED-DESIGN SUBMITTAL

A. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer registered in the State of Rhode Island responsible for their preparation.

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances. Perform battery calculations.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

D. Manufacturer’s Instructions.

E. List of spare parts to be provided.

F. List of recommended spare parts.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide the "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Record copy of site-specific software.
f. Provide the "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

g. Manufacturer's required maintenance related to system warranty requirements.
h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.

2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke and Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

C. A.Prior to submitting shop drawings, the arrange a pre-submittal meeting, at a time and place acceptable to all parties, between the manufacturer's representative, the Engineer, the Local Authority Having Jurisdiction, and the Owner. The purpose of the meeting is to answer any questions which the manufacturer and Contractor may have to clarify specification requirements and to establish the formal submittal procedures for shop drawings in order to permit expeditious review and acceptance. Copies of a preliminary submittal shall be distributed to all parties no later than two weeks before the meeting.

D. Manufacturer’s Equipment (hardware and software) and System Configuration: Comply with or exceed the functional intent of a Remote Supervising Station Fire Alarm System as required by NFPA 72.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Construction Manager's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design:

1. Engage a licensed fire alarm protection systems company to provide a complete fire alarm protection system and prepare detailed installation drawings and materials to be signed and sealed by a professional engineer registered in the State of Rhode Island.
2. Coordinate with the State Fire Marshall’s office and local Fire Department to ensure all Federal, State, and Local requirements are met.
3. Comply with the applicable local building codes and the Americans with Disabilities Act (ADA). Where local codes are silent on an issue, comply with NFPA 101. Comply with NFPA 72 for the application, installation, performance, and maintenance of the fire alarm protection system.

B. Inspections: Engage the State Fire Marshall to inspect the fire alarm protection system during design and upon completion of the installation. Assume full responsibility for the correctness of the installation and make all corrections and additions deemed necessary by the Authority Having Jurisdiction. Pay for all costs of the inspections and any subsequent re-inspections as required.

2.2 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with and operate as an extension of existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded system dedicated to fire-alarm service only.

C. All components provided shall be listed for use with the selected system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm zone at fire-alarm control unit.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Record events in the system memory.
5. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and systems:

1. Duct smoke detector.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in internal circuits of fire-alarm control unit.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit.

E. System Trouble and Supervisory Signal Actions:

1. Initiate notification appliances.
2. Annunciate at fire-alarm control unit.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

2.4 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Gamewell - FCI by Honeywell.

2. Fire-Lite

    a. To match existing fire alarm system.

B. General Requirements for Fire-Alarm Control Unit:

1. Modular, power-limited design with electronic modules, UL 864 listed.

    a. Include a real-time clock for time annotation of events.
    b. The FACP shall be listed for connection to a central-station signaling system service.

C. Alphanumeric Display and System Controls: Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, two lines of 80 characters, minimum.

D. Circuits:

1. No Fewer Than Five Initiating-Device Circuits:

    a. Two circuits, NFPA 72, Class B.
    b. Three circuit(s), NFPA 72, Class A.

2. No Fewer Than Two Notification-Appliance Circuits: NFPA 72, Class B.

E. Notification-Appliance Circuit: Operation shall sound a pattern that matches the existing fire alarm system.

F. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

G. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by the 24-V dc source.

1. Alarm current draw of the entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

H. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed, valve-regulated, recombinant lead acid.

2.5 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show

visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, breaking-glass or plastic-rod type.
2. Station Reset: Key- or wrench-operated switch.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

B. Photoelectric Smoke Detectors: Comply with UL 268.

C. Ionization Smoke Detector: Comply with UL 268.

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Remote indication and test station.
2. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
4. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.7 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.

C. NEMA 4X (wet and corrosion-resistant) Heat Detector: Fixed temperature, mounted in a cast metal back box threaded for 1/2 –in rigid conduit with matching cover plate.

1. Detector pigtail wiring: Epoxy potted for moisture resistance.
2. Contacts: Silver clad, normally open, rated 2 Amps at 24 VDC.
3. NEMA 4X Heat Detectors: UL listed.

D. Continuous Linear Heat-Detector System:

1. Detector Cable: Rated detection temperature 155 deg F. Listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short circuit wires at the location of elevated temperature.
2. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
3. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. Flashing shall be in a temporal pattern, synchronized with other units.
3. Strobe Leads: Factory connected to screw terminals.
4. Mounting Faceplate: Factory finished, red.
5. Environment (damp and wet):

    a. UL listed for wet locations.
    b. Provide gasketed weatherproof backboxes and gasketed trim plates for all surface-mounted audible/visible alarm notification appliances.
    c. All Components: Enameled or plated for protection against corrosion.

2.9 GRAPHIC ANNUNCIATOR

A. Graphic Annunciator Panel:

1. Update the existing graphic annunciator panel with a site plan showing all building outlines including the new Final Clarifiers No. 7 and 8, Return Sludge Pump Station No. 3, and UV Disinfection Facility.
2. Provide all required additional features to match existing in all aspects.
3. Obtain approval by the State of Rhode Island Fire Marshall and the local Fire Department having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Expand, modify, and supplement the existing control equipment as necessary to extend the existing control functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place, except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

G. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

H. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

I. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Comply with the requirements in Section 16058 “Raceways and Boxes for Electrical Systems.”

3.4 CONNECTIONS

A. Connect supervised interface devices to the following devices and systems. Install the interface device less than 36 inches from the device controlled.

1. Supervisory connections at valve supervisory switches.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16070 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with the visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 16846