

ADDENDUM NO. 1

South Custer Booster Pump Station Expansion

City of Monroe 120 East First Street, Monroe, Michigan 48161 Bid Due Date: Monday, June 26, 2023, 10:00 A.M., local time (734) 384–9126 – phone, (734) 384–9108-fax

The Contract Documents identified by the title above are amended to include the supplemental information and instructions as listed below and attached to this addendum, which shall become an integral part of the Contract Documents. The following clarifications are answers to those relevant questions raised prior to the deadline of June 19, 2023 at 4:30 P.M., at the pre-bid meeting, or other clarifications deemed necessary and appropriate by City and consultant staff. Bidder must sign, date, and submit as a part of the bid documents.

See attached Addendum 1 as prepared by Jones and Henry Engineers, Ltd. (77 pages total including plan sheet revisions)

Issued by: City of Monroe Engineering Department, June 21, 2023 at 4:00 P.M.

Bidder's Name (Printed)

Date

Bidder's Signature

City of Monroe, Michigan South Custer Booster Pump Station Expansion

ADDENDUM 1

June 21, 2023

Planholders on the City of Monroe, Michigan, South Custer Booster Pump Station Expansion, are hereby notified of the following amendments to the Contract Documents. This Addendum is hereby made a part of the Contract Documents.

SPECIFICATIONS

Page 01043-8, Paragraph 4.03 H. - Sequence of Construction

After Paragraph G., add the following new paragraph:

"H. All shutdowns require a minimum of 72-hour notification to the City. From July 31 to August 6, the Monroe County Fair is scheduled. No shutdowns are allowed during this week."

Page 01043-8, Paragraph 4.04 B. - Coordination with Electrical Utility

After Paragraph A., add the following new paragraph:

"B. The Contractor to include in the base bid a cost of \$2,250 to be paid to DTE for their cost associated with the transformer replacement."

Section 01568 Pollution Control

Add the following new "Section 01568 - Pollution Control" attached to this Addendum.

After Section 01568, add the following "Soil Erosion Sedimentation Control Permit Application" attached to this Addendum.

After Section 01568, add the following "Monroe County Drain Commissioner" plan set review letter.

Page 11735-8, Paragraph 4.04 A. 6. - Operating Conditions

Delete Paragraph 6., and substitute with the following new paragraph:

"6. The canned vertical turbine pump shall have a suction and discharge flange connection size of 12 inches, both above the operating floor level as shown on the Drawings."

Section 16050 - Electrical Testing

Add the following new "Section 16050 - Electrical Testing" attached to this Addendum.



Jones & Henry Engineers, Ltd.

City of Monroe, Michigan South Custer Booster Pump Station Expansion 538-7766.001 June 21, 2023 Addendum 1

Page 2

Section 16120 - Conductors and Cables (600 Volts and Less)

Add the following new "Section 16120 - Conductors and Cables (600 Volts and Less)" attached to this Addendum.

Section 16121 - Control and Signal Conductors and Cables

Add the following new "Section 16121 - Control and Signal Conductors and Cables" attached to this Addendum.

Section 16122 - Wiring Devices

Add the following new "Section 16122 - "Wiring Devices" attached to this Addendum.

Section 16130 - Conduit Surface Metal Raceways and Accessories

Add the following new "Section 16130 - Conduit Surface Metal Raceways and Accessories" attached to this Addendum.

Section 16132 - Accessories

Add the following new "Section 16132 - Accessories" attached to this Addendum.

Section 16422 - Motor Starters and Contactors

Add the following new "Section 16422 - Motor Starters and Contactors" attached to this Addendum.

Section 16450 - Distribution Transformers

Add the following new "Section 16450 - Distribution Transformers" attached to this Addendum.

Section 16610 - Lightning Protection Systems

Add the following new "Section 16610 - Lightning Protection Systems" attached to this Addendum.

DRAWINGS

Sheet No. C-0.1, 7 of 35

Delete Sheet No. C-0.1, 7 of 35 in its entirety, and substitute with that attached to this Addendum.

Sheet No. C-2, 9 of 35

Add the following new Note:

"3. The 22" steel casing pipe and the 12" water line inside of it are existing and shown for reference as to their location."

Jones & Henry Engineers, Ltd.

City of Monroe, Michigan South Custer Booster Pump Station Expansion 538-7766.001 June 21, 2023 Addendum 1

Page 3

Sheet No. E-3, 32 of 35

Delete Sheet No. E-3, 32 of 35 in its entirety, and substitute with that attached to this Addendum.

Sheet No. E-4, 33 of 35

Delete Sheet No. E-4, 33 of 35 in its entirety, and substitute with that attached to this Addendum.

Sheet No. E-5, 34 of 35

Delete Sheet No. E-5, 34 of 35 in its entirety, and substitute with that attached to this Addendum.

Attachments: Monroe County Drain Commissioner – Soil Erosion Sedimentation Control Permit Application Monroe County Drain Commissioner - Plan Set Review Letter Section 01568 – Pollution Control Section 16050 – Electrical Testing Section 16120 – Conductors and Cables (600 Volts and Less) Section 16121 – Control and Signal Conductors and Cables Section 16122 – Wiring Devices Section 16130 – Conduit Surface Metal Raceways and Accessories Section 16132 – Accessories Section 16422 – Motor Starters and Contactors Section 16450 – Distribution Transformers Section 16610 – Lightning Protection Systems Sheet No. C-0.1, 7 of 35 Sheet No. E-3, 32 of 35 Sheet No. E-4, 33 of 35 Sheet No. E-5, 34 of 35

Recd (18/23

SOIL EROSION SEDIMENTATIO	N CONTROL PERMIT APPLICATION
In accordance with Part 91, Soil Erosion Sedimentation Control of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended	Monroe County Drain Commissioner 1005 South Raisinville Road, Monroe, MI 48161 Phone: (734) 240-3101 Fax: (734) 240-3112
1 Owner's Name: City of Monroe	Today's Date: <u>5-23-2023</u>
Current Mailing Address: 120 East Fr	rst St.
City. State. Zip: Manroe, MI 48161	
Project Name: (Ex: Smith's pole barn or Hickory Creek Subd	ivision) South Curtur Boostor Pump Azition Bypansio
F-mail Address: barry, lange monvoemi, go	V Phone Number: 734-384-9122
Cell Phone Number: $734 - 384 - 9122$	Fax Number: 734 - 384 - 9108
2 Contractor's Name: TRO	Contact Person's Name:
Street Address:	
City State Zin:	
E mail Address:	Phone Number
Coll Dhana Number:	Eav Number:
I, do herby appoint the below named person and / or company as an Au	, as the owner in accordance with Part 91, SESC PA 451 of 1994 as amended, thorized Designated Agent to obtain a SESC permit on my behalf.
(Print the name of the person or company to be the Authorized Desig	nated Agent)
Designated Agent's Street Address:	
City, State, Zip:	
Email Address:	
Call Dhanes	Phone Number:
	Phone Number:
Landowner Signature:	_ Phone Number: _ Fax Number: Date:
Landowner Signature: <u>3</u> Who will be the on-site responsible party; the owner, the cont	_ Phone Number:
 Cell Phone Landowner Signature: Who will be the on-site responsible party; the owner, the cont <u>Site Location</u>: Parcel Identification Number: 58 <u>1'2</u> - <u>7</u> 	Phone Number: Fax Number: Date: ractor, or the designated agent? 20 100 60 *Attach a copy of the legal description
 Cell Phone Landowner Signature: Who will be the on-site responsible party; the owner, the cont <u>Site Location</u>: Parcel Identification Number: 58 <u>1'2</u> - <u>7</u> What are the section number, the town, and the range? Sec 	_ Phone Number: _ Fax Number:
 Cell Phone Landowner Signature: Who will be the on-site responsible party; the owner, the cont <u>Site Location</u>: Parcel Identification Number: 58 <u>1'2 - 2</u> What are the section number, the town, and the range? Sec Site Address: <u>3561</u> S. Costr Poord, Morn 	Phone Number:
 Landowner Signature:	Phone Number:

SOIL EROSION SEDIMENTATION CONTROL PERMIT APPLICATION		
5	Proposed Earth Changes: Approximate acres of earth to be disturbed?	
	Type of soil on the site? (clay, silt, etc.) Clay over rock, some topsoil ~ 12"	
	Describe the project and the earth change activity. Excavate for building expansion to	
	add pumps, drivenay expansion, new emergency backup generator,	
	pipshay installing, lands caping	
	What type of project is this? Commercial or \Box Residential $(6 \circ c + f)$	
	Proposed start date of the project: Aug 2023 Proposed end date of the project: June 2024	
	*Attach a detailed construction schedule listing each phase of the project with the respective start and end dates of each phase.	
6	Name of and distance to all lakes, streams, wetlands, open ditch drains, or water courses: PIVERPHISIM	
7	7 List the number and type of drawings being attached to this application: Documents	
	Soil erosion and sedimentation control plan (Required) Location map (Required) Site plan (Required) Legal Description (Required)	
l (v wit as	ve) affirm that the above information is accurate and that I (we) will conduct the above described earth change in accordance h Part 91, Soil Erosion and Sedimentation Control, of the Natural Resources and Environmental Protection Act, PA 451 of 1994 amended, applicable local ordinances, and the documents accompanying this application.	

Owner's / Designated Agent's Signature:

*The designated agent must submit a written statement from the landowner authorizing him/her to secure a permit in the landowner's name (See page 1).

Please note: The Monroe County Drain Commissioner's office does not accept cash or credit cards. Permit fees can be paid by a check or money order made out to MCDC or Monroe County Drain Commissioner.

5-23-2023

Date:

David P. Thompson MONROE COUNTY DRAIN COMMISSIONER COUNTY AGENCY



1005 South Raisinville Road • Monroe, Michigan 48161-9754 Telephone: (734) 240-3101 • Fax: (734) 240-3112 • Toll Free: (888) 354-5500 ext. 3101 Websire: www.co.monroe.tni.us E-mail: DThompson@monroemi.org



June 19, 2023

Mr. Troy McCallin Brehmer, P.E. Jones & Henry Engineers, LTD. 3103 Executive Parkway, Suite 300 Toledo, OH 43606

> RE: Soil Erosion / Sedimentation Control South Custer Booster Pump Station Expansion 3561 S. Custer Road, 58-12-220-100-00 Monroe Charter Township

Dear Mr. McCallin Brehmer:

I have reviewed your plan set for the above-mentioned project that was received on June 8, 2023. The plans are not approved with regards to soil erosion. Please address the following items and resubmit for further review:

Application:

- Provide contractor name, address, phone number, email address, and contact person (once that information is determined).
- If the owner will not be the person signing for the soil erosion permit (once it is issued), please complete the designated agent portion of the application giving someone else permission to pull the permit and have the owner sign this section (*optional*). Currently, Mr. Barry LaRoy is authorized to sign the SESC permit.
- Fill in #3, on-site responsible party.
- Revise #6 to indicate the River Raisin is approximately 700' north.

<u>SESC Site Plan drawing</u>: A drawing showing the soil erosion measures was not included. Sheet C-1 or C-2 could easily be marked up with the SESC measures to meet this requirement. Be sure the SESC page includes the following items:

- The soil erosion site plan page needs to be drawn to a scale of not more than 1" = 200'.
- Clearly label the physical limits of disruption.
- Show the location of temporary SESC measures for each measure that will be utilized:
 - Construction entrance
 - Silt fence/wattles or vegetative buffer as perimeter protection (it appears silt fence may be needed near the roadside ditch)
 - Inlet bags for any existing storm sewers near the construction zone or laydown area
 - Concrete washout area (include a detail on sheet C-5)
- Label the location of permanent SESC measures/show how the site will be restored:
 - Vegetation
 - Gravel
 - Pavement
 - Riprap (if applicable)
- Include a detailed list of proposed earth changes (OR Add a brief project narrative).

- C-4:
- Include a maintenance plan for the SESC measures. Specifically indicate that "SESC measures will be checked weekly and after a half inch or more storm event and repaired or replaced as necessary."
- Include the soil type information: "clay over rock, with some topsoil" to match the SESC application.
- Include a detailed construction schedule that clearly covers the following:
 - o Estimated date SESC measures will be installed
 - o Estimated date earthwork will begin
 - o Estimated date earthwork will end
 - o Estimated date permanent measures will be installed
 - o Estimated date the site will be fully stabilized and ready for a final inspection (vegetation well established)
 - If estimated dates are not available, estimated lengths of time are acceptable. For example, Install SESC Measures: Day 1, Begin Earthwork: Day 1, End Earthwork: Day 30, etc.

General:

Provide a copy of the updated final construction schedule, once that information has been determined.

Once these items have been addressed, please resubmit the revised sheets only for further review. If you have any questions, please feel free to contact me at (734) 240-3105.

Sincerely,

Jenna Morse County Enforcing Agent

Enclosure

Copy: Mr. Barry LaRoy, P.E., City of Monroe Ms. Kim Fortner, Monroe Charter Township Mr. Eric Kronk, Monroe Charter Township Mr. Mark Mathe, P.E., Mannik & Smith Group Inc. Mr. David Thompson, Monroe County Drain Commissioner Mr. Connor Ferguson, Monroe County Drain Deputy Drain Commissioner SESC File

SECTION 01568 POLLUTION CONTROL

PART 1 GENERAL

1.01 SCOPE

A. This Section includes the requirements for pollution control.

PART 2 PRODUCTS

2.01 GENERAL

A. Dust palliatives shall conform to MDOT Item 922.12A.

PART 3 EXECUTION

3.01 MICHIGAN GENERAL REQUIREMENTS

- A. The Contractor is responsible to obtain and pay for NPDES Permit for storm water discharge.
- B. The Contractor is responsible for following an erosion control plan in accordance with permits required under Act 451, Part 91, as amended (Soil Erosion and Sedimentation Control), Part 303 (Wetland Protection, formerly Act 203), Part 301 (Inland Lakes and Streams, formerly Act 346), Part 31, (Water Resources Protection, Floodplain Regulatory Authority, formerly Act 245 as amended by Act 167), and Part 31 (Water Resources Protection), National Pollutant Discharge Elimination System (NPDES). Secure Federal Section 404, Clean Water Act of 1972, permits, if required. Provide temporary and permanent erosion and sedimentation controls according to the permits.
- C. It shall be the responsibility of the Contractor to prevent or limit pollution of air and water resulting from his operations.
- D. The Contractor shall perform Work required to prevent soil from eroding or otherwise entering onto all paved areas and into natural watercourses, ditches, and public sewer systems, and to prevent dust attributable to his operations from entering the atmosphere.
- E. Water containing suspended material from any part of the Contractor's operations shall be clarified before discharging to drains or streams.
- F. No fill, topsoil, or heavy equipment shall be stored within 200-feet of a stream bank or within the drip line of a treed area.
- G. Excess soil that is stockpiled shall be removed or regraded within 15 days of the completion of construction.

3.02 STREETS, SIDEWALKS, AND DRIVEWAYS

A. Streets, haul roads, and detours and bypass roads shall be swept by automatic selfcontained sweepers.

- B. Excessive dirt on pavements shall be removed by means of hand shoveling or appropriate mechanical equipment and the area swept as directed above.
- C. Sidewalks and driveways shall be cleaned by means of shovels and hand brooms or appropriate mechanical equipment.
- D. Dust on unsurfaced streets or parking areas and any remaining dust on surfaced streets shall be controlled with calcium chloride dust palliative.
- E. The Contractor shall comply with the above requirements on a daily basis. If the Contractor fails to perform the above Work in a satisfactory manner, all Work, except cleanup operations, shall be stopped until the Contractor has complied with the above requirement.

3.03 EROSION AND SEDIMENT CONTROL

- A. The Contractor shall initiate appropriate vegetative practices on all disturbed areas to remain dormant (undisturbed) for more than 45 days within seven days.
 - 1. Such practices may include: temporary seeding, permanent seeding, mulching, matting sod stabilization, vegetative buffer strips, phasing and protection of trees.
- B. Permanent or temporary soil stabilization shall be applied to disturbed areas within seven days after final grade is reached on any portion of the Site.
- C. When seasonal conditions prohibit the application of temporary or permanent seeding, non-vegetative soil stabilization practices, such as mulching and matting, shall be used.
- D. A stabilization construction entrance shall be provided to reduce vehicle tracking of sediment. The paved street adjacent to the Site entrance shall be swept a minimum of daily, or as needed, to remove any excess mud, dirt, or rock being tracked from the Site.
 - 1. Dust and sediment along any street due to construction on this Site is to be swept a minimum of once at the end of the day or as necessary to prevent a build-up of dust and soil on the pavement surface.
- E. Dump trucks hauling from the construction site shall be covered with a tarpaulin.
- F. No more than 200-feet of trench shall be open at any given time. Trench opening, laying of pipe, and backfilling should occur so as to minimize the amount of disturbed area.
- G. The Contractor shall minimize the width of his work area.
- Existing trees, shrubs, and other ground cover vegetation shall be preserved where possible. Tree removal will be limited to that necessary for construction and will be limited further to the permanent easement wherever possible. No tree removal will be permitted outside the temporary easement.
- I. Storm water runoff and natural stream flow shall be intercepted or diverted when originating upgrade away from the construction site so as to minimize the amount of flow over the construction site.

- J. All dewatering flows are to be settled in siltation basins or directed through filters before discharge to stabilized sites, such as stream or storm sewers, and not onto exposed soils, stream banks, or any other sites where the flow could cause erosion.
- K. When construction occurs near storm sewer inlets, erosion control measures such as inlet filters or hay bales shall be used to prevent silt from entering the storm sewers.
- L. The clean-up and disposal of excess excavated material shall be done as soon as practical after laying of the pipe. Should the Contractor not keep his clean-up within the aforementioned distance, Work shall stop until the clean-up work is accomplished.

3.04 MICHIGAN SEDIMENT CONTROL

- A. The Contractor shall control erosion and trap sediment from all sites remaining disturbed for more than 14 days. Such practices shall include among others, sediment traps, sediment basins, silt fences, and storm drain inlet protection. Silt Fence Fabric shall be in accordance with MDOT Item 910.04 Silt Fence Geotextile.
- B. Timing Sediment control structures shall be functional throughout earth-disturbing activity. Sediment ponds and perimeter sediment barriers shall be implemented as the first step of grading and within seven days from the start of grubbing. They shall continue to function until the upslope development area is restabilized.
- C. Settling Ponds Concentrated storm water runoff from disturbed areas flowing at rates which exceed the design capacity of sediment barriers shall pass through a sediment settling pond. The facility's storage capacity shall be 67 cubic yards per acre of drainage area.
- D. Sediment Barriers Sheet flow from runoff from denuded area shall be intercepted by sediment barriers. Sediment barriers, such as sediment fences or diversions directing runoff to settling facilities, shall protect adjacent properties and water resources from sediment transported by sheet flow.
- E. Other erosion and sediment control practices shall prevent sediment-laden water from entering drain systems. Unless the storm drain system drains to a settling pond. These practices shall divert runoff from distributed areas and steep slopes where practicable and stabilize channels and outfalls from erosive flows.

3.05 CONSTRUCTION OF SLOPES

- A. The Contractor shall comply with the following requirements when working on slopes exceeding 4:1.
 - 1. The pipeline shall be constructed during dry weather, low flow periods as determined by the Engineer. The construction time for this Work shall be limited to the shortest time possible in order to minimize environmental impacts.
 - 2. Construction equipment shall be limited to trenching equipment or rubber tired backhoes in order to prevent soil erosion and maintain slope stabilization.

- 3. Biodegradable mesh shall be used for slope stabilization. The mesh shall cover the entire width of disturbed ground.
- 4. The trench shall be backfilled immediately after installation of the pipe. The disturbed areas shall be graded, seeded, and mulched within 24 hours after backfilling. The Contractor shall maintain all seeded and mulched areas in accordance with the specifications until final acceptance of the Work.
- 5. The Contractor shall place straw or hay bales at the base of the slopes for sedimentation control. The bales shall be placed prior to construction of the pipeline and shall remain until final seeding has germinated and become established.

3.06 RESERVED

3.07 PROHIBITED CONSTRUCTION ACTIVITIES

- A. Disposing of excess or unsuitable excavated material in wetlands or floodplains, even with the permission of the property owner.
- B. Locating stockpile storage areas in environmentally sensitive areas.
- C. Indiscriminate, arbitrary, or capricious operation of equipment in any stream corridors, any wetlands, any surface waters, or outside the easement limits.
- D. Pumping of sediment-laden water from trenches or other excavations directly into any surface waters, any stream corridors, any wetlands, or storm sewers; all such water will be properly filtered or settled to remove silt prior to release.
- E. Discharging pollutants such as chemicals, fuels, lubricants, bituminous materials, raw sewage and other harmful waste into or alongside of rivers, streams, impoundments, or into natural or man-made channels leading thereto.
- F. Permanent or unspecified alteration of the flow line of any stream.
- G. Damaging vegetation outside of the construction area.
- H. Disposal of trees, brush, and other debris in any stream corridors, any wetlands, any surface waters, or at unspecified locations.
- I. Open burning of project debris without a permit.
- J. Discharging injurious silica dust concentrations into the atmosphere resulting from breaking, cutting, chipping, drilling, buffing, grinding, polishing, shaping or surfacing closer than 200 feet to places of residences or places of human occupation.
- K. Storing construction equipment and vehicles and/or stockpiling construction materials on property, public or private, not previously specified on the Drawings or not authorized by the Owner or Engineer for such purpose.
- L. Running well point or pump discharge lines through private property or public property and rights-of-way without the written permission of the property owner and the consent of the Engineer.

PART 4 SPECIAL PROVISIONS

4.01 STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

- A. The Contractor shall be responsible for having a SWPPP prepared for the Work. The SWPPP shall be prepared by an Engineer licensed in the state of Michigan.
- B. The Drawings show recommendations for pollution prevention measures to be provided. The measures shown on the Drawings shall be considered the minimum level of pollution prevention.
- C. The Contractor shall adhere to the SWPPP in accordance with EGLE Guidelines.
- D. The SWPPP shall be updated and maintained throughout the Work.
- E. A copy of the SWPPP shall be available at the Site's construction office.

4.02 MONROE COUNTY DRAIN COMMISSIONER SOIL EROSION AND SEDIMENTATION CONTROL

A. The City has completed the initial SESC application. The Contractor shall provide the City with the requested information and documentation included in the Monroe County Drain Commissioners SESC letter dated June 19, 2023. The Contractor may request CADD drawings from the Engineer for developing the required site drawings.
(Addendum 1, Januard June 21, 2022)

(Addendum 1, Issued June 21, 2023)

END OF SECTION

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SECTION 16050 ELECTRICAL TESTING

PART 1 GENERAL

1.01 SCOPE

A. The Contractor shall furnish all labor, tools, equipment, and materials necessary to perform electrical testing in accordance with the Drawings and as specified herein.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and Section 16010 and shall include:
 - 1. Information for the Record:
 - a. Certified reports of field tests and observations.

1.03 QUALITY ASSURANCE

- A. Testing shall be performed or supervised by the Contractor. Contractor shall be responsible for test records.
- B. Contractor shall visually check equipment, wire, phase matching and rotation in preparation for testing.
- C. Manufacturer's recommended instructions for testing shall be used when applicable.
- D. Testing shall be in compliance with accepted engineering practices, NEC and IEEE Standards.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 COORDINATION

A. Before conducting field tests, the Contractor shall submit to the Engineer a written outline of the methods of testing and equipment to be used.

3.02 FIELD TESTING

- A. Required testing shall be completed and written report submitted to the Engineer for acceptance before the Contractor proceeds with subsequent Work.
- B. Written reports shall be required on tests. Careful records shall be kept of each test and results shall be submitted to the Engineer.
- C. Final payment will not be released until all required written test reports are submitted and distributed for information.

- D. The Contractor shall be responsible for the procurement and installation of compatible components and equipment, and shall perform all Work necessary for the proper operation and guarantee of the equipment.
- E. The Contractor shall make such tests as may be necessary to demonstrate that the Work and equipment, as installed, comply with the Contract Documents. When required by the Engineer, such tests shall be performed in the Engineer's presence.
- F. Any system or equipment failing to meet the Contract requirements, or to function properly, shall be rectified at the Contractor's expense by readjusting or by removing and replacing the faulty Work or equipment, and the tests rerun until the requirements are met.
- G. The Engineer reserves the right to require the Contractor's equipment be checked by an independent instrument tester.

3.03 CONDUIT TESTING

- A. After conduit and accessories have been installed and all concreting operations completed, all conduit runs shall be satisfactorily cleared of all obstructions and foreign matter. Any defects that might damage cable upon installation shall be corrected.
- B. Conduits shall be tested, in the presence of the Engineer if requested, by pulling through each conduit a flexible cylindrical mandrel having an outside diameter 1/4 inch less than the inside diameter of the conduit, followed by a stiff wire brush of the same diameter as the conduit. Where conduits installed under this Contract are connected to conduits installed by others, the entire runs between boxes, manholes, or other termination points shall be tested.
- C. The Contractor shall keep a record, by number, of all conduits tested clear, and shall submit written copies of such record to the Engineer.
- D. Defects or stoppages in conduit runs installed by the Contractor shall be corrected. Defects or stoppages in conduit runs installed by others shall be reported to the Engineer, who shall determine the corrective measure to be taken.

3.04 GROUNDS

- A. The Contractor shall test the ground resistance of the systems.
- B. Dry season resistance of each system shall not exceed 5 ohms. If such resistance cannot be obtained with the system as shown, provide additional grounding as directed by the Engineer.
- C. Where multiple ground rods are required, they shall be 20 feet apart. The Contractor, in the presence of the Engineer if requested, shall test all made grounds for continuity and resistance. Ground resistance of more than 5 ohms shall be reduced to 5 ohms or less by the use of additional, and properly separated, ground rods, or deep driving of ground rods.

D. In addition, where necessary, Ground Enhancement Material (GEM) shall be used to provide low resistance and high conductivity. GEM shall be installed per manufacturer's recommendations.

3.05 LOW-VOLTAGE CIRCUIT BREAKERS

- A. Each low-voltage circuit breaker shall be manually opened and closed five times before being energized.
- B. Acceptance of each ground fault device will be only on an in-person trip and reset cycle demonstration for the Engineer or his representative if the Engineer requests to be present. The Engineer shall be notified at least one week before scheduling this test.

3.06 LOW VOLTAGE SYSTEM (INSULATION RATED AT 600 VOLTS)

- A. The Contractor shall perform insulation resistance testing of 480-volt power feeder circuits with a 500-volt megger.
- B. Written test reports of the results shall be submitted to the Engineer prior to final inspection. Equipment which may be damaged during this test shall be disconnected before the test and reconnected upon completion.
- C. Upon the completion of each electrical system rated 600 volts or less, but before wiring connections are made to equipment, the Contractor shall test each circuit and each piece of equipment for:
 - 1. Continuity.
 - 2. Grounds.
 - 3. Insulation resistance, phase-to-phase and phase-to-ground, of 480 volts conductors and equipment with a 500-volt megohmmeter.
- D. Discontinuities or grounds discovered in low voltage systems shall be corrected before the insulation resistance is measured.
- E. Insulation resistance readings, lower than required by good practices or Code, shall be promptly repaired or replaced. Retesting shall be completed until acceptable readings are acquired.
- F. Installed control cables and conductor terminations for instrumentation and controls shall be tested for properly grounded cable shields. Control cable shields shall be isolated from ground except at the grounding point. The Contractor shall remove all improper grounds at no additional cost to the Owner. This test shall be witnessed by the Engineer if requested.
- G. Following satisfactory completion of circuit and equipment insulation resistance tests, connection of the wiring to equipment, but before it is energized; the tests specified above shall again be carried out.

- H. Defective or improperly installed electrical equipment or wiring provided or installed and connected by the Contractor shall be repaired, replaced, or properly installed by the Contractor until it satisfactorily passes the field tests.
- I. Irregularities or faulty equipment shall be immediately reported to the Engineer.
- 3.07 RESERVED
- 3.08 RESERVED

PART 4 SPECIAL PROVISIONS

Not used.

(Addendum 1, Issued June 21, 2023)

END OF SECTION

SECTION 16120 CONDUCTORS AND CABLES (600 VOLTS AND LESS)

PART 1 GENERAL

1.01 SCOPE

A. This Section includes 600-volt, single or multi-conductor power or control cable.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and shall include:
 - 1. Shop Drawings for Review:
 - a. Manufacturer's technical product sheets on each component to be furnished.
 - b. A list of materials needed for construction giving manufacturer's names and catalog numbers.
 - 2. Information for the Record:
 - a. Manufacturer's recommended method of installation for the products to be furnished.

1.03 QUALITY ASSURANCE

A. Comply with ICEA, UL, NFPA and NEMA publications for "Non-shielded Power Cables rated 2000 Volts or Less."

PART 2 PRODUCTS

2.01 MATERIALS

- A. Wires shall be identified by surface markings indicating manufacturer's name, conductor size, conductor material, voltage rating, UL Symbol, type designations, and optional ratings.
- B. Conductors shall be oil and gasoline resistant.
- C. Single conductors for 600-volt power, lighting, and receptacle circuits shall be Type THHN/THWN dual-rated or XHHW-2 and as follows:
 - 1. Conductors shall be stranded, soft-drawn, or annealed copper.
 - 2. Single conductors for general use for power, lighting, and receptacles shall be a minimum size of No. 12 AWG stranded, unless otherwise noted on the Drawings.
 - 3. Minimum wire size for controls shall be No. 14 AWG unless noted otherwise.
 - 4. Single conductors, for power distribution, No. 4 AWG and larger, shall be Type XHHW-2.

- 5. Single conductors, for power distribution, smaller than No. 4 AWG for use in conduits and ducts shall be Type THHN/THWN dual-rated.
- 6. Single conductors, for power distribution where exposed to sunlight, shall be listed and marked as sunlight-resistant as manufactured by Okonite, "Okoguard-Okolon" Type RHH or RHW-2 or USE-2, VH-1, or equal.
- D. Underground feeder and branch circuit cable for direct burial in earth shall be Type UF, RHW-2, or USE-2 for use in wet or dry locations. Cable shall include a ground wire and be listed and approved for such application.
- E. Interlocked Armored Cable (IAC):
 - 1. Cable shall be suitable for aerial installation, direct burial, metal racks, open trays, troughs, or continuous rigid cable supports.
 - 2. Cable shall include 3 stranded copper conductors, XLP insulation, bare ground copper conductor, aluminum armor, and PVC jacket.
 - 3. Cable jacket shall be UL listed as sunlight resistant. IAC cable shall be capable of operating continuously at a maximum conductor temperature of 90 degrees Celsius in wet or dry locations. Cable shall be as manufactured by The Okonite Company, Pirelli Cables North America, Southwire Company, or equal.
- F. Flexible power cords shall be 3 or 4 conductor including ground, No. 12 AWG minimum wire size, rubber insulated, hard service cord, meeting UL requirements for flexible cord. Flexible power cords shall be rated for 600 VAC and have oil resistant thermoset insulation for use in wet locations (Type SOOW). Ampacity shall be in accordance with NEC Table 400.5(A) and any pertinent derating factors.
- G. Flexible control cords shall be 2, 3 or 4 conductor, No. 18 AWG minimum wire size, rubber insulated, hard service cord, meeting UL requirements for flexible cord. Flexible control cords shall be rated for 600 VAC and have oil resistant thermoset insulation for use in wet locations (Type SOOW).
- H. All wire and cable insulation and all cable outer coverings shall be listed and approved for the conditions under which the wire or cable is to be used.
- I. 1000V Variable Frequency Drive Cable
 - 1. Shall be manufactured by Lutze DriveFlex, or equal.
 - 2. General: Variable frequency drive cable shall be multiple conductor type and conforming to UL Standards 1277 and 2277
 - 3. Flexible stranded tinned copper conductors per ASTM standard
 - 4. Insulation for current-carrying conductors: Thermoset Type XHHW-2 or RHW-2 Cross-Linked Polyethylene (XLPE)
 - 5. Non-wicking fibrous or insulation material extruded fillers shall be used in cable construction.

- 6. Conductors shall be configured as either a four-conductor design (three current carrying conductors, plus one equivalent-sized ground) or a symmetrical insulated ground design (three current carrying conductors, plus three symmetrical ground conductors of reduced size)
- 7. Individually numbered current carrying conductors. Each current carrying conductor shall be labeled clearly and concisely no more than every six inches along the length of each conductor. Ground conductor shall be green/yellow and conform to IEC 60446 Section 5.3.2 and NFPA 79 2018 edition, article 13.2.2.
- 8. Dual layer shielding for EMC compliance is required. Shielding shall consist of overlapping aluminum mylar foil and tinned copper braid shield. A tinned copper drain wire shall be included on the exterior of the braid shield.
- 9. Black TPE or PVC jacket with flexible, and oil resistant construction. Specifically formulated for easy stripping during field installation.
- 10. Cable shall be sunlight resistant and suitable for direct burial.
- 11. Cables shall be oil resistant.
- 12. Cable Voltage Rating: Minimum 1000 Volts phase to phase
- 13. Cable Temperature Rating: 90 degree Celsius for normal operation.

2.02 COMPONENTS AND ACCESSORIES

- A. Splicing materials shall be as follows:
 - 1. Plastic tape shall be 3M Scotch Electrical Tape No. 33+ or 88, or equal.
 - 2. Neoprene tape shall be Okonite Company "Okoprene", or equal.
 - 3. Insulating putty shall be 3M "Scotchfill Electrical Putty", or equal.
 - 4. Tapes and other splicing materials shall be used only as recommended by the manufacturer, and only if their condition is such as to meet the manufacturer's standards.
 - 5. Heat-shrinkable tubing shall be Raychem or equal.
- B. Connectors:
 - 1. Wire connectors for No. 6 AWG and smaller wires shall have sharp internal threading which prevents pulling off, but are removable. Connectors shall be Type Y, Type R, Type G, or Type B, as manufactured by 3M Company or equal.
 - 2. Indentor butt connectors shall be Burndy "Hylinks", or equal.
 - 3. Indentor pigtail connectors shall be Thomas & Betts "Sta-Kon" connectors, or equal, applied to the twisted conductors, and covered with a nylon cap of the same manufacturer.

- 4. Indentor or compression connectors shall be Thomas & Betts "Sta-Kon" connectors, or equal. The insulation of conductors No. 2 AWG and larger shall be penciled to the diameter of the conductor. Wires connected to screw terminal block points shall have fork tongue lug terminals.
- 5. Splices to uncut main runs shall be made with Burndy "Crimpits", or equal, for cables No. 4/0 to No. 10 AWG, and Burndy "Hytaps", or equal, for cables larger than No. 4/0 AWG.
- 6. Cable fittings for armored cable shall be Crouse-Hinds, or equal, and shall be compatible with the cable used as recommended by cable manufacturer.
- 7. Bus Bar Taps Bus bars shall be tapped using one of the following connectors.
 - Two-hole, crimp-type lugs, 600V 35 kV, sized as required to match bus bar width and conductor in use. Connector metal shall match bus metal. Connector shall be UL listed as manufactured by Thomas & Betts Catalog No. 542XX, or equal.
 - Heavy duty compression, 600V 35 kV, sized as required to match conductor in use. Connector metal shall match bus metal. Connector shall be UL listed as manufactured by Thomas & Betts Catalog No. 251-31446-XX, or equal.

C. Power Blocks:

- 1. All power blocks whether in terminal boxes, motor control, and other locations, shall be equal to Allen-Bradley Bulletin 1492 UL-listed, 600V AC/DC, 3-pole suitable for copper conductors, and rated for 75 degrees C, minimum.
- 2. Power blocks shall have sufficient current carrying capacity as required, and shall not be adjacent to control wiring terminal blocks.
- D. Wire Pulling Lubricants Pulling lubricants shall be American Polywater Corp. Type J, Ideal Yellow 77 Plus, Thomas & Betts Polymer Base, or equal. Follow manufacturer's recommendations for compatibility with wire insulation, cable jacket, and conduit materials.

2.03 IDENTIFICATION

A. All wires and cables, except at lighting and 120 VAC convenience receptacles, shall be identified by means of tags with wire names. Tags shall be on all connections, splices, and terminations, and shall also be applied where entering and leaving common wireway and at a minimum of 30-foot centers within the wireway. Wire tags shall be as specified in Section 16030.

2.04 FACTORY TESTS

- A. Wire shall be tested in accordance with:
 - 1. UL Standard for type THHN/THWN wire and the optional Gasoline and Oil Resistant II listings.

- 2. UL Standard for Type XHHW-2.
- 3. UL and ICEA requirements for Type MC Cable.

PART 3 EXECUTION

3.01 COORDINATION

- A. Inspect raceways for compliance with specifications and Drawings. Do not proceed with installation until defective conditions have been corrected.
- B. Conduit layouts shall provide for cable separation between various systems and between various signals within given systems. The combining of conductors of various systems within one conduit system shall not be permitted.

3.02 INSTALLATION

- A. Wiring, above ground, 120 volts and higher, shall be in conduit, wireways, or cable trays.
- B. Extreme care shall be used to prevent any injury or damage to the wiring. The Contractor shall observe the installation instructions and precautions issued by the manufacturer of the wire and cable.
- C. Cables shall be pulled through conduits in such a manner as not to overstress, stretch, score, cut, twist, or damage the protective covering or insulation of the conductor. If mechanical means are employed for pulling the cables or wires, a dynamometer shall be used.
- D. The ends of low-voltage cables installed in damp or wet locations shall be carefully sealed until permanently connected or spliced. The Contractor shall be responsible for maintaining a dry condition while the cables are being pulled.
- E. Underground circuit cables for direct burial in earth shall be installed per NEC and IEEE Standards, and as recommended by the cable manufacturer.
- F. Keep rocks and rough materials away from direct buried cables.
- G. Direct buried cable shall be backfilled with 6 inches of sand over the top of cable to prevent stone bruises and cuts to cable.
- H. If single conductor cable is used, space cables evenly at least 6 inches between cable centers. Sand shall be used to fill around cables. Be certain there are no cable crossovers.
- I. Cables emerging from the ground shall be installed in conduit from at least 18-inch below grade up to the termination point.
- J. Spare conductors or cables shall be individually and uniquely numbered. They shall have sufficient length to reach the farthest termination point within the enclosure. They shall be coiled and stored in a neat and workmanlike manner. The coil shall be tagged to indicate the location of the other end of the spare conductors.

- All 120 volt "home runs" in excess of 100 feet shall be No. 10 AWG minimum. All 120-volt branch circuits supplying heating, air conditioning, or lighting loads of 1500 watts or more shall be No. 10 AWG minimum.
- L. Conductors in vertical runs shall be adequately supported with approved conductor supports, as outlined in the NEC.
- M. All underground feeder and branch circuit cables for direct burial in earth shall be installed per the NEC, National Electrical Safety Code Section 35, IEEE Standard 590, and as noted on the drawings and as recommended by the cable manufacturer. Cable shall be installed in an "S-Loop" to allow for ground movement. Backfill trench to provide 18 to 24 inches of cover above the top of the highest wire or cable. Place a 6-inch wide, foil-backed, yellow tape with black lettering reading "ELECTRIC LINE" in the trench, and then complete backfilling operations. Tape shall be Thomas & Betts "E-Z-CODE" NAF-0708, or equal.
- N. Conductors No. 12 AWG and smaller shall not be in the same conduit with wires No. 6 AWG and larger.
- O. Conductor Combination and Separation:
 - 1. The combining of conductors of various systems within one raceway system shall not be permitted. Raceway layouts shall provide for the cable separation requirements between parallel raceways of various systems, and between various signals within given systems throughout Division 16 as required. Each of the following shall be maintained in a separate raceway system apart from the others.
 - a. Lighting and 120 VAC utility.
 - b. Power Distribution, 600 VAC or less.
 - c. Power Distribution, greater than 600 VAC.
 - d. Communications Systems (Telephone, Intercom, Ethernet).
 - e. Fire Alarm Systems.
 - f. Security Systems.
 - g. Analog cables for Instrumentation and Control.
 - h. PLC Communications Systems (Data Highway, Modbus, etc.).
 - i. Intrinsically Safe Systems.
 - j. Elevator Controls.
 - k. Motor Branch Circuits.
 - I. Class 3 Motor and Equipment Controls.
 - 2. Where Motor Branch Circuit conductors are less than No. 4 AWG, they may be combined with related Class 3 motor and equipment control conductors.

3. Fiber Optic Cables may share raceways of other systems except where prohibited by the NEC.

3.03 SPLICES AND TERMINATIONS

- A. Wire and cable lengths shall be continuous and without splices between the points of connection, except as otherwise specified or indicated on the Drawings.
- B. Splices and terminations where specified or indicated on the Drawings shall be made in strict accordance with the conductor manufacturer's recommendations.
- C. Splices and connections shall have a conductivity and insulation resistance at least equal to that of the cable.
- D. Terminated conductors shall be bundled and identified to match approved Contractor submitted drawings.
- E. Owner and Engineer may inspect any and all joints before they are taped. If they are taped without being inspected, the tape may be ordered removed from any joint or joints, and the Contractor shall correct any defect found. After inspection and correction of any fault found, the Contractor shall properly re-tape the joints with new tape.
- F. Splices:
 - 1. Dry Locations No. 6 AWG and Smaller, Single Conductor:
 - a. Using either an insulated spring or an indentor butt connector shall be followed by wrapping with two half-lapped layers of approved plastic tape extending a minimum distance of 1 inch from the connector.
 - 2. Dry Locations No. 4 AWG and Larger, Single Conductor:
 - a. No. 4 AWG conductor and larger shall be spliced using indentor or compression connectors, penciled to the diameter of the connector, and wrapped with two half-lapped layers of approved plastic tape extending a distance from the connector of twice the outside diameter of the larger conductor, or 1 inch, whichever is greater.
 - b. Splices to uncut main runs shall be made with "Crimpits", or equal, for Cable Nos. 4/0 AWG to 10 AWG, and "Hytaps", or equal, for cables larger than No. 4/0 AWG, and wrapped with two half-lapped layers of approved plastic tape.
 - c. Electrical insulating putty shall be used as filler before applying tape, where necessary, to provide a smooth taping surface.

3. Wet Locations:

a. Single-conductor, with nonmetallic covering, shall be spliced using either indentor (compression) or insulated butt connectors followed by wrapping with four half-lapped layers of approved plastic tape extending a distance from the connector of twice the outside diameter of the larger conductor or 1 inch, whichever is greater.

- b. The insulation of Conductors No. 2 AWG and larger shall be penciled to the diameter of the conductor and wrapped with four half-lapped layers of approved plastic tape extending a distance from the connector of twice the outside diameter of the larger conductor or 1 inch, whichever is greater.
- c. Splices in manholes shall only be permitted where specifically shown on Drawings. Where permitted, in manholes, splices No. 4 AWG and smaller shall be in submersible NEMA 6 terminal boxes within easy reach of ground level.
- d. Electrical insulating putty shall be used as filler before applying tape, where necessary, to provide a smooth taping surface.
- G. Terminations When connecting conductors at terminals, the following methods shall be used, unless otherwise specified:
 - 1. Indentor or compression terminals shall be applied to the conductor. Terminals shall be held in place at terminal posts or studs with approved locknuts or lock washers.
 - 2. The shields of shielded, multi-conductor control and metering cables, unless otherwise specified by equipment manufacturers, shall be terminated at one end of the cable only.
 - 3. Shield shall be stripped back, intact, applying a compression grounding terminal to the twisted shield, and securely fastening the terminal to the appropriate point on the equipment or device.
 - 4. Shield at the non-terminated end of shielded cables shall be stripped back at least 2 inches beyond the stripped inner conductor's cutoff, and the cable taped with two half-lapped layers of plastic tape where the shield emerges from the outer sheath.
 - 5. Where dead-ending low-voltage wires and cables, the ends shall be insulated and sealed in a manner similar to a standard splice for the particular location and type of wire or cable.
 - 6. All power system terminations shall be phased-out.
- H. Where specified, bus bar tapping shall be in strict accordance with bus bar and connectors' manufacturer's recommendations.

PART 4 SPECIAL PROVISIONS

Not used.

(Addendum 1, Issued June 21, 2023)

END OF SECTION

SECTION 16121 CONTROL AND SIGNAL CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SCOPE

- A. The Section includes the installation of all wire, cable, and terminators for a complete instrumentation and control package.
- B. Work shall include but not be limited to the following major items:
 - 1. Communications cable between programmable controller components, processors, graphic interface units, and printers.
 - Communications cable between PLC I/O Panels and programmable controller processors.
 - 3. Programmable controller power supplies to processors and I/O chassis.
 - Analog signal wiring between controls, instruments, equipment, field devices, PLC I/O panels, annunciators, or other instrumentation and control components required to complete the Work.
 - 5. Signal wiring, data highway, fiber optic, conduit materials, and installation not provided under Division 16.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and Section 16010 and shall include:
 - 1. Shop Drawings for Review:
 - a. A list of materials needed for construction giving manufacturer's names and catalog numbers.
 - b. Manufacturer's technical product sheets on each component to be furnished.
 - 2. Information for the Record:
 - a. Manufacturer's qualifications.
 - b. Certified copies of factory test procedures and results.
 - c. Manufacturer's recommended method of installation for the products to be furnished.
 - d. Provide warranty for review; executed copies shall be submitted when completed with copies included in the operation and maintenance manuals.

1.03 QUALITY ASSURANCE

- A. The installation of equipment and materials shall conform to the recommendations and instructions of the respective manufacturers of equipment and materials.
- B. Fiber-optic cable terminations shall be by certified cable installers. The Contractor shall provide a documented listing of fiber optic cable installation experience.

PART 2 PRODUCTS

2.01 CONTROL CONDUCTORS

- A. Control conductors shall, unless noted otherwise on the Drawings, be supplied as single conductor, No. 14 AWG, 19 stranded, 600 volts, 90-degree C of Type THHN/THWN dual rated.
- B. Wire shall be supplied in three different integral color codes as follows: brown, orange, and red.
- C. Intrinsically safe wiring shall be color coded light blue.
- D. Direct current control conductors shall be color coded dark blue.
- E. Control wire circuits from external sources shall be color-coded yellow.

2.02 TRANSMITTER CABLE

A.	Indoor Use:

- 1. Cable shall be 2-conductor, No. 16 AWG stranded tinned copper with minimum No. 18 AWG stranded tinned copper drain wire.
- 2. Cable shall have a 100% aluminum foil shield with PVC jacket, rated for 60 degrees C and 600 volts.
- 3. Cable shall have maximum capacitance of 23 pF (picofarads) per foot between conductors.
- 4. Cable shall have nominal outside diameter of 0.313 inches.
- 5. Cable shall be Belden 8719, or equal.
- B. Indoor, Outdoor, Transition between Indoor/Outdoor and where subject to damp or wet conditions:
 - 1. Cable shall be 2-conductor, No. 16 AWG stranded, tinned copper with a drain wire. Insulation shall be PVC with a nylon overcoat.
 - 2. Cable shall have a 100% aluminum foil shield with PVC jacket, rated for 90 degrees C and 600 volts. Jacket shall be sunlight resistant.
 - 3. Cable shall be suitable for direct burial and outdoor applications.
 - 4. Nominal outside diameter shall be 0.294 inches.
 - 5. Cable shall be Belden 1118A, or equal.

C. Inside Control Panels and Connected to Analog I/O Modules:

- 1. Cable shall be 2-conductor, No. 22 AWG stranded tinned copper with polyethylene insulation, and No. 22 AWG stranded tinned copper drain wire. Color code: Black, Clear.
- 2. Cable shall have a 100% aluminum-polyester foil shield with PVC jacket, rated for 60 degree-C and 300 volts.
- 3. Cable shall have maximum capacitance of 24 pF per foot between conductors.
- 4. Cable shall have nominal outside diameter of 0.175 inches.
- 5. Cable shall be Belden 8761.
- D. Transmitter cable shall be identified by the initials "PR".

2.03 COMMUNICATION CABLE (DATA HIGHWAY AND REMOTE I/O CABLE)

- A. Indoor Use:
 - 1. Cable shall be 78 ohms, 2 conductor No. 20 stranded tinned copper, twin axial transmission line cable, with 55% tinned copper braid, and 100% shield coverage with PVC jacket.
 - 2. Cable shall be Belden 9463, or equal.
- B. Direct burial applications, in below-grade conduits or when exposed in wet locations:
 - 1. Cable shall be 78 ohms, 2 conductor No. 20 stranded tinned per, twin axial transmission line cable, with gel-filled 55% tinned copper braid, and 100% shield coverage with LDPE jacket.
 - 2. Cable shall be suitable for the specified programmable control system.
 - 3. Cable shall be Belden 9463DB, or equal.
- C. This cable shall be identified by the initials "DH+".
- D. Nominal OD shall be 0.240 inches.

2.04 RESERVED

2.05 CATEGORY 5 AND 6 ETHERNET CABLE

- A. The Ethernet cable shall be No. 23 AWG solid bare copper with polyolefin insulation, PVC jacketed, unshielded, four twisted pair.
- B. DC resistance shall be 28.6 ohms per 1000 feet.
- C. Capacitance shall be 15 pF per foot maximum.
- D. Nominal velocity of propagation shall be 70%.
- E. Cable shall be EIA/TIA 568-B.2-1 Category 6 verified.

- F. Suitable applications: Industrial Ethernet Cable, harsh environments, 350 MHz
 Enhanced Category 6, Gigabit Ethernet, 100BaseTX, 100BaseVG ANYLAN, 155 ATM,
 622 ATM, NTSC/PAL Component or Composite Video, AES/EBU Digital Video, RS-422,
 RJ-45 Compatible.
- G. Nominal OD shall be 0.475 by 0.265 inches.
- H. Cable shall be Belden 11872A, or equal.

2.06 THREE-CONDUCTOR SHIELDED CABLE

A. Indoor Use:

- Cable shall be 3-conductor, No. 16 stranded, tinned copper with a minimum No. 18 stranded, tinned copper drain wire. Conductor insulation shall be polyethylene.
- 2. Cable shall have a 100% aluminum-polyester foil shield, PVC jacket, and be rated for 60 degrees C, 600 volts.
- 3. Nominal outside diameter shall be 0.327 inches.
- 4. Cable shall be Belden 8618, or equal.
- B. Indoor, outdoor, transition between indoor/outdoor, and where subject to damp or wet conditions:
 - Cable shall be 3-conductor, No. 16 stranded, tinned copper with a minimum No. 18 stranded, tinned copper drain wire. Conductor shall be PVC insulated with a nylon overcoat.
 - Cable shall have a 100%, aluminum-polyester, foil shield with PVC jacket and be rated for 600 volts, 75 degrees C - wet and 90 degrees C - dry. Jacket shall be sunlight resistant.
 - 3. Cable shall be suitable for direct burial and outdoor applications.
 - 4. Nominal OD shall be 0.317 inches.
 - 5. Cable shall be Belden 1119A, or equal.
- C. Three conductor shielded cable shall be identified as "Triad" or "Triplex."

2.07 CONTOLNET CABLE

- A. This cable shall be Quad-Shielded RG-6/U coaxial cable, 18 gauge (solid) 0.040 bare copper covered steel with DC resistance of 28 ohms per 1000 feet.
- B. The center conductor shall be insulated with foamed polyethylene with a diameter of 0.180 inches.
- C. The outer jacket shall be black CPE with a nominal outside diameter of 0.298 inches.
- D. The shields shall consist of Belden Duobond IV Quad Shield foil/60% aluminum braid/foil 40% aluminum braid.

- E. The nominal impedance of the cable assembly shall be 75 ohms.
- F. The nominal velocity of propagation shall be 82%.
- G. The nominal capacitance shall be 16.5 pF per foot.
- H. The nominal attenuation in dB per 100 feet shall be:

0.36 @	1 MHz
0.38 @	2 MHz
0.45 @	5 MHz
0.59 @	10 MHz
0.86 @	20 MHz
1.38 @	50 MHz

I. The cable shall be NEC Type CL2R and CMR.

J. Cable shall be Belden 3092A, or equal.

2.08 MODBUS CABLE

- A. The Modbus cable shall be No. 22 AWG stranded copper, three twisted pairs with an overall shield and No. 22 AWG stranded tinned copper drain wire.
- B. Modbus Cable shall have an oil and UV resistant, black, PVC jacket.
- C. Modbus Cable shall be rated for use at 300 volts.
- D. Nominal DC conductor resistance shall be 14.7 ohms per 1000 feet.
- E. Nominal DC shield resistance shall be 1.5 ohms per 1000 feet.
- F. Nominal capacitance between conductors shall be 11.0 pF per foot maximum.
- G. Nominal capacitance between one conductor and other conductors connected to shield shall be 20.9 pF per foot maximum.
- H. Nominal velocity of propagation shall be 78%.
- I. Nominal impedance shall be 120 ohms.
- J. Modbus Cable shall be EIA Industrial RS-485 PLTC/CM.
- K. Nominal OD shall be 0.42 inches.
- L. Modbus Cable shall be Belden 3108A, or equal.

2.09 ACCESSORIES

- A. Control Wiring Terminal Blocks:
 - 1. Terminal blocks, whether in terminal boxes, motor control components, instrumentation, plant communication system, and other locations, shall be Allen-Bradley Bulletin 1492-W4, or equal, suitable for DIN Rail mounting.

- 2. Separate terminal strips shall be provided for analog and discrete signal wires, with the discrete terminal strip located on the left side of the enclosure.
- 3. Terminals shall be provided for cable shields.
- 4. Terminal blocks shall be identified in accordance with Section 16030.

2.10 SOURCE QUALITY CONTROL

 Wire/cable shall meet IEEE flame test; UL 1581, "Vertical Tray Flame Test"; and ANSI/NFPA Standard 262-1985 (UL-910) "Horizontal Flame and Smoke Test" requirements.

PART 3 EXECUTION

3.01 COORDINATION

A. Examine raceways and other elements receiving cables for compliance with requirements for installation tolerances and other conditions affecting performance of transmission media.

3.02 INSTALLATION

- A. Control wiring shall be identified and tagged per Section 16030.
- B. Each wire number shall be "solid", preprinted, and not pieced from single or double digit tags.
- C. Wire shall be installed with different color conductor in common conduit, for maximum convenience, with individual conductor identification, which shall be in addition to fiber tag identification as specified herein.
- D. The Contractor shall observe the installation instructions and precautions issued by the manufacturer of the wire/cable.
- E. Communication cable shall be installed in 1-inch rigid galvanized steel or PVC coated RGS conduit with one cable per conduit.
- F. Analog signal cable shall be installed in galvanized rigid steel or PVC coated RGS conduit.
- G. No mixing of signal conductors and AC voltage conductors shall be permitted within a single conduit.
- H. Instrument cable, communication, and analog signal conduits shall be separated a minimum of 12 inches from any AC voltage source or conductor.
- I. Instrument cable shields shall be grounded to a common ground terminal in the control panel unless device manufacturer recommends otherwise. Shields shall not be grounded at the field device or at any intermediate point.
- J. Each programmable controller component shall be grounded to earth ground as well as the cable shield between them. Grounding field wiring shall be in accordance with the

manufacturer's recommendations. In no case, shall the cable shield be grounded at both ends.

- K. Each instrument cable wire shall be identified and terminated at marked terminal strips.
- L. Analog instrument cables inside panels shall be justified right as described in Section 16903 and shall terminate at separate terminal strips.
- M. Each instrument cable shall be installed in continuous lengths between terminations. No splicing shall be permitted.
- N. 20% spare twisted pairs shall be provided in each conduit run between panels where cables serve more than one device.
- O. Conductors carrying high voltage and/or high current shall be installed in separate ducts from low power conductors and PLC component cables.
- P. All cable (power, instrument, communication) in panels shall have the same physical properties as in the field, to minimize the possibilities of transients.

3.03 SPLICES AND TERMINATIONS

- A. Spacing between adjacent terminal strips shall not be less than five inches as measured from the individual terminal block edges.
- B. Wire and cable lengths shall be continuous and without splices between the points of connection, except as otherwise specified or indicated on the Drawings.
- C. Splices and terminations where specified or indicated on the Drawings shall be made in strict accordance with the conductor manufacturer's recommendations.
- D. Splices and connections shall have a conductivity and insulation resistance at least equal to that of the cable.
- E. Terminated conductors shall be bundled and identified to match approved Contractor submitted drawings.

PART 4 SPECIAL PROVISIONS

4.01 SPARE PARTS

A. Extra terminal block points shall be provided in the quantity of 30% over the quantity used. (Addendum 1, Issued June 21, 2023)

END OF SECTION

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SECTION 16122 WIRING DEVICES

PART 1 GENERAL

1.01 SCOPE

A. This Section includes providing wiring devices in accordance with the Drawings and as specified herein.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and shall include:
 - 1. Shop Drawings for Review:
 - a. A list of materials needed for construction giving manufacturer's names and catalog numbers.
 - b. Manufacturer's technical product sheets on each component to be furnished.

2. Information for the Record:

- a. Manufacturer's qualifications.
- b. Certified copies of factory test procedures and results.
- c. Manufacturer's recommended method of installation for the products to be furnished.
- d. Manufacturer's recommended spare parts list for components and accessories.
- e. Operation and maintenance manuals for equipment provided, including accessories, and maintenance instructions.
- f. Provide warranty for review; executed copies shall be submitted when completed with copies included in the operation and maintenance manuals.

1.03 PRODUCT HANDLING

A. Handle wiring devices and components carefully to avoid breakage, impacts, denting, and scouring finishes. Do not install damaged equipment.

PART 2 PRODUCTS

2.01 MATERIALS

A. Switches shall be specification grade, totally enclosed, quiet tumbler, ac type, meeting NEMA Performance Standards and FS and capable of control of 100% tungsten filament lamp loads.

- B. Switches shall be rated at 20 amps, 120/277 volts. Operating handles shall be phenolic colored brown. Switches shall have screw terminals.
- C. Receptacles shall be specification grade, meeting NEMA Performance Standards, and FS, and having a contact arrangement such that contact is made on two sides of each inserted blade without detent.
- Receptacles shall be two-pole, three-wire grounding type with rating of 20 amps, 125 volts, NEMA configuration 5-20R, and have screw-type wire terminals suitable for No. 12 thru No. 10 AWG designated CO/ALR. Bases shall be phenolic composition colored brown.
- E. Receptacles for outdoor installation and where shown on the drawings shall be provided with ground-fault protection with push-to-test capabilities.
- F. Switches shall be rated 20 amp, 120/277 volts. Switches shall be as manufactured by Appleton Electric Company, Catalog Number EDS175, or equal.
 - 1. Switches shall be factory-sealed, designed to UL Standards. Switches shall be enclosed in separate sealing chambers.
 - 2. Screws and handle shall be stainless steel.
 - 3. Switch shall be clearly marked to indicate ON-OFF position, and shall be lockable in either position.
- G. Provide welding receptacles, NEMA 4X, Crouse-Hinds, 480 VAC, 3-wire, 4-pole, 30 or 60 amps.
- H. Welding receptacles shall be interlocked with enclosed safety switch and Class RK5 (time delay, dual element) fuses as specified in fuses subsection. Contractor shall furnish the Owner with APJ male plugs with cable grip and neoprene bushing, 3-wire, 4-pole.
- I. Dimmer switches shall be solid state conforming to NEMA WD 1, mounted in outlet boxes as indicated and in accordance with the following:
 - 1. Incandescent Lamp Dimmers:
 - a. Modular dimmer switches for incandescent fixtures; switch poles and wattage as indicated, 120 volts, 60 Hz, with continuously adjustable linear slide, anodized aluminum face.
 - b. Equipped with electromagnetic filter to eliminate noise, RF and TV interference, and 5-inch wire connecting leads.
 - 2. Fluorescent Lamp Dimmers:
 - Full wave, modular type ac dimmer switches for fluorescent fixtures.
 Wattage and voltage ratings as indicated and electromagnetic filters to minimize noise, and RF and TV interference.
b. Constructed with continuously adjustable trim potentiometer for adjustment of low end dimming, anodized heat sinks, 5-inch wire connecting leads and quiet on-off switch.

- J. For flush-mount devices, the Contractor shall provide specification grade, one-piece,
 0.040-inch nominal thickness, No. 430 satin finish stainless steel device plates with ovalhead, matching mounting screws.
- K. For surface-mount or weatherproof devices, the Contractor shall provide cast metal device plates of malleable ferrous metal, with gaskets and oval-head, stainless-steel screws.
- L. Wall plates for receptacles located outside of building, and inside of buildings in wet or damp locations, shall be the weatherproof type. Weatherproof receptacles, where exposed to weather or in other wet locations, shall be in a weatherproof enclosure, the integrity of which is not affected when the receptacle is in use (attachment plug cap inserted), per NEC 406.8. Enclosures shall be as manufactured by TAYMAC Corporation, Tempe, Arizona, RACO, or equal.
- M. Where weatherproof switches are designated or required, provide the switch specified mounted in the specified box with a gasketed, weatherproof, cast-metal cover plate incorporating an external operator for the internal switch and with stainless steel mounting screws. Cover plate shall be Crouse-Hinds Cat. No. DS181, or equal.

2.02 PERFORMANCE REQUIREMENTS

A. GFCI receptacles which cannot pass their internal test function shall render themselves incapable of delivering power or indicate by visual or audible means that the receptacle must be replaced. GFCI receptacles shall not provide power if the source wires are connected to the load terminals per UL943.

PART 3 EXECUTION

3.01 COORDINATION

A. Switch and outlet boxes shall be cleaned from foreign materials before devices are installed. Wall plates and covers shall be installed after all wall treatments have been completed.

3.02 INSTALLATION

- A. Outlet, fixture, and device boxes in unfinished areas shall be surface mounted. Outlet, fixture, and device boxes shall conform to the requirements specified in the paragraphs herein.
- B. Concealed galvanized steel outlet and switch boxes for electric lights, wall switches, and receptacles, etc., shall have plaster rings installed where required. In every instance, boxes shall be of such form and dimension as to be adapted to the number, size, and arrangement of conduits connected thereto.
 - 1. Outlet boxes shall be firmly anchored in place, and shall be provided with approved 3/8-inch fixture studs where required.

- 2. Junction boxes shall be provided with blank covers to match other covers in the same area.
- C. Ceiling outlet boxes shall be 4 inch octagonal or 4-11/16 inches square, when required, and not less than 1-1/2 inches deep. Switch and receptacle outlet boxes shall be 4 inches with provisions for standard switch and receptacle covers.
- D. Outlets boxes in exterior locations and interior exposed locations shall be "FS" or "FD", and PVC where used with PVC conduit.
- E. Wall mounted convenience receptacles shall be mounted 18 inches from the finished floor to the bottom of the box unless shown otherwise on the Drawings, required by the NEC, or where required to clear radiators, grilles, louvers, or other mechanical equipment.
- F. Wall mounted switches shall be mounted 44-48-inches above finished floor to the center of the box unless directed otherwise. Space between door openings and switches shall be as uniform as possible throughout the buildings.
- G. Special purpose outlets shall be located as shown on the Drawings, or in accordance with project or manufacturer's requirements.
- H. Splices made with wire nuts, crimp connectors, terminal blocks, split-bolts, or similar connectors shall be in boxes that are readily accessible. Terminal boxes shall be located a maximum of 8 feet above finished floor, and shall have a vertical-facing orientation.
- I. Unless otherwise required, all receptacles shall be installed vertically with their ground pins up. Where horizontal receptacles are used, they shall be installed with the neutral conductor uppermost.
- J. Conventional 120 VAC receptacles shall not be wired to the load side of GFCI receptacles unless both devices are contained in the same box.
- K. Isolated ground (IG) receptacles in nonmetallic boxes shall have nonmetallic wall plates.
- L. Cables connected to Category 5 and 6 computer jacks shall not have more than 1 inch of the conductors exposed outside of the cable's outer jacket. No more than 0.5 inch of the individual conductors shall be untwisted.

3.03 TESTING

- Prior to energizing circuits, test wiring for electrical continuity and for short circuits in accordance with Section 16050. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.
- B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer's recommendations.

PART 4 SPECIAL PROVISIONS

Not used.

(Addendum 1, Issued June 21, 2023)

END OF SECTION

SECTION 16130 CONDUIT, SURFACE METAL RACEWAYS, AND ACCESSORIES

PART 1 GENERAL

1.01 SCOPE

A. This Section includes all labor, tools, equipment, and materials necessary to provide conduits and surface metal raceways in accordance with the Drawings and as specified herein.

1.02 SUBMITTALS

A. Submittals shall be in accordance with the requirements of Section 01300 and Section 16010 and shall include:

1. Shop Drawings for Review:

- a. Wiring schematics with wire termination points identified.
- b. A list of materials needed for construction, manufacturer's name and catalog numbers.
- Provide conduit layout drawings. All conduit layouts shall show conduits and conduit types with anticipated number, size, and type of power, control or instrumentation conductors/cables, spares and grounds for each and every section of Division 16 requiring separate conduits. Location of floor and wall penetrations and separation between parallel conduits shall be dimensioned.
- 2. Information for the Record:
 - a. Manufacturer's qualifications.
 - b. Manufacturer's technical product sheets on each component to be furnished.
 - c. Certified copies of field test procedures and results.
 - d. Manufacturer's recommended method of installation for the products to be furnished.
 - e. Operation and maintenance manuals for equipment provided, including accessories, and maintenance instructions.
 - f. Manufacturer's recommended spare parts list for the system components and accessories.
 - g. Provide warranty for review; executed copies shall be submitted when completed with copies included in the operation and maintenance manuals.

- h. Conduit layouts shall consist of "as-installed" drawings showing the exact location and routing of all conduits and conduit duct banks that are installed in or under paved areas, concrete slabs, direct buried, or otherwise concealed.
- Conduit layouts shall show conduits with number, size, and type of power, control or instrumentation conductors/cables, spares, and grounds for each and every section of Division 16 requiring separate conduits.
- j. Copies of certificates issued by the manufacturer of PVC coated rigid galvanized steel conduit to installers who have successfully completed the manufacturer's installation training program.

1.03 QUALITY ASSURANCE

- A. Applicable Standards:
 - 1. NEMA.
 - 2. UL.
 - 3. ASTM.
 - 4. NEC.
 - 5. NFPA.

1.04 PRODUCT HANDLING

A. Care shall be taken when handling materials. Deformed conduit and surface metal raceway materials shall not be installed. Conduits and surface metal raceways damaged during construction shall be replaced.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Metallic Conduit:
 - 1. Metallic conduit, including couplings, nipples, elbows, and bends shall conform to the Standard for Rigid Metallic Conduit of the UL accessories such as locknuts and connectors shall be zinc-coated for use with hot-dipped galvanized conduit.
 - 2. Rigid galvanized steel conduit shall conform to UL-6 Specification, ANSI C80.1, and FS WW-C581E.
- B. PVC Coated Conduit:
 - 1. A plastic coating shall completely encapsulate metallic conduit to provide total protection against corrosion.
 - 2. Conduit shall be galvanized inside and outside, including the threads.

- 3. Threads shall be coated with urethane over the galvanized threads. A minimum thickness of 40 mil PVC exterior coating shall be permanently fused to the galvanized rigid steel conduit.
- 4. A urethane or polyurethane interior coating shall be applied at a nominal 2 mil thickness to the interior of the conduit and over the galvanized threads.
- 5. The PVC coating on all form 8 fittings shall form a gasket-like flange covering the top of the fitting around the opening. All fittings shall have a minimum of 40 mils PVC coating even around the edge of covers.
- 6. GUA type boxes shall be supplied with WOD type covers. (Feraloy iron instead of aluminum to prevent corrosive reaction between dissimilar metals.)
- 7. Conduit fittings (couplings, elbows, etc.) shall be of the same material as the conduits and fittings to which they are attached.
- 8. PVC coated conduit shall be UL listed and conform to the same standards as metallic conduit.
- PVC coated conduit shall be "OCAL BLUE" as manufactured by OCAL, Inc., "Permacote," "KorKap" or "Plasti-Bond" as manufactured by Robroy Industries, or equal.
- 10. Conduit shall be supported by corrosion resistant straps and clamps.

C. PVC Conduit:

- 1. Conduit shall be a minimum of Schedule 40 for use only when encased in concrete.
- 2. Concrete encasement for conduits shall be Class B as specified in Section 03300.
- 3. Schedule 80 shall be used for direct-burial and exposed applications where shown on the Drawings.
- 4. PVC conduit systems shall conform to FS WC 1094A, ASTM 512, NEMA TC2 and TC3, and to UL 651 and 514 b. All components shall be "Sunlight resistant" and so marked.
- D. Flexible Steel Conduit:
 - 1. Flexible steel conduit shall be liquid tight Appleton Electric Company "Sealtite" or equal.
 - 2. Flexible steel conduit fittings shall be Thomas & Betts, Appleton, O-Z/Gedney, or equal.
- E. Flexible Metal Conduit Flexible metal conduit (Greenfield) shall be used only where indicated on Drawings and approved by the Engineer.

F.	EMT Conduit:						
	1.	EMT (Thin wall) shall be used only where indicated on Drawings and approved by the Engineer.					
	2.	EMT steel conduit shall be of standard and uniform circular cross-section and weight, and shall be hot-dipped galvanized.					
	3.	Conduit shall bear UL label and manufacturer's name or trademark.					
	4.	Couplings and fittings shall all be in compliance with the NEC.					
G.	e Metal Raceways:						
	1.	Surface mounted metal raceways shall only be provided where shown on the drawings or approved by the Engineer.					
	2.	Surface mounted metal raceways shall be UL 5 listed and approved.					
	3.	Surface mounted metal raceways and associated couplings and fittings shall be made by the same manufacturer.					
	4.	Surface mounted metal raceways and associated couplings and fittings shall be made of steel and provided with a finish that can be painted over.					
	5.	Surface mounted metal raceways may be used in combination with multioutlet assemblies made by the same manufacturer.					
	6.	Surface mounted metal raceways shall be distinguishable from other types of raceways.					
	7.	Surface mounted metal raceways and their elbows, couplings, and similar fittings shall be designed so that the sections can be electrically and mechanically coupled together and installed without subjecting the wires or cables to abrasion.					
	8.	Surface mounted metal raceways shall be as manufactured by Wiremold, or equal.					
Н.	Explosion-Proof Flexible Conduit:						
	1.	Explosion-proof flexible conduit shall be rated for use in Class I Division 1 Group D or Class II Division 1 Groups E, F and G.					
	2.	Explosion-proof flexible conduit shall be provided with two removable male nipples or with one removable male nipple and one removable male union.					
Ι.	Bituminous Coating - All rigid galvanized conduit buried underground shall be coated on the outside with a standard petroleum self-priming asphaltic coating. This material shall meet the requirements of FS TT-V-51F, Varnish: Asphalt. It shall be free of lead and chromate hazards. This material shall be lead and alkali resistant. PVC coated rigid galvanized conduit shall be exempt from bituminous coating requirement.						

2.02 CONDUIT FITTINGS - GENERAL

- A. Fittings shall be vapor proof, weatherproof, and explosion-proof where so shown on the Drawings and required by NEC.
- B. Fittings for use with EMT and Greenfield shall be compatible with the type of conduit, and shall be of the same manufacturer.

2.03 CONDUIT FITTINGS - METALLIC

- A. Bushings 1-1/4 inches and larger shall be Type B insulated bushings as manufactured by O-Z/Gedney, Thomas & Betts, or equal.
- B. Ground bushings shall be Type BL bushings as manufactured by O-Z/Gedney, Thomas & Betts, or equal.
- C. Conduit fittings for use with metallic conduit shall be standard threaded type of cast ferrous construction to suit the location and purpose. Fittings shall be Crouse-Hinds, Appleton Electric, or equal.
- D. Covers shall be domed sheet metal, except in corrosive areas, where they shall be cast. All covers shall have gaskets.
- E. Exposed fittings, junction boxes, outlet boxes, terminal boxes, etc., shall be cast ferrous material threaded-hub type.

2.04 CONDUIT FITTINGS - PVC COATED

A. Fittings for use with PVC coated conduit shall be compatible with the type of the PVC coated conduit, and shall be of the same manufacturer.

2.05 CONDUIT FITTINGS - PLASTIC

- A. Fittings for use with plastic conduit shall be compatible with the type of plastic conduit or duct used, and shall be of the same manufacturer.
- B. Adhesives for use with plastic conduit shall be compatible with the type of plastic conduit or duct used and shall be approved by the conduit or duct manufacturer.

PART 3 EXECUTION

3.01 COORDINATION

- A. Coordinate with other Work including metal and concrete deck work to interface installation of conduits, surface metal raceways, and support components.
- B. Level and square conduits and surface metal raceways and install at proper elevations and heights.
- C. Complete the installation of conduits and surface metal raceways before installing any cables or wires.

3.02 OPENINGS AND SLEEVES

- A. Electrical penetrations through an exterior surface shall be sealed and made water-tight with a modular mechanical seal of rubber links as manufactured by Link-Seal, O-Z/Gedney, or equal.
- B. Electrical penetrations through fire resistance rated walls or floors shall be fire stopped as required by the NEC using the approved method as recommended by the manufacturer. Fire stops (e.g. caulk) shall have a 3-hour, fire-resistance rating, and shall be made by the 3M Company, or equal.
- C. Electrical penetrations to hazardous areas shall be gas-tight and fire-stopped using "Link-Seal" FD or FS seals as manufactured by Thunderline Corporation, or equal.

3.03 EXCAVATION AND BACKFILL

- A. Excavation and backfill required for the installation of underground conduits shall be done in accordance with Section 02200.
- B. Excavation shall not be done until immediately before installation of the specified appurtenances. Cuts shall be done in a workmanlike manner so as to cause the least possible damage.
- C. After backfilling, the excavation shall be kept well filled and maintained in a smooth and well-drained condition until permanent surfaces are restored. All surplus excavated material shall be removed and properly disposed of by the Contractor.
- D. Direct-buried conduit shall be backfilled to provide 18 to 24 inches of cover above the top of the highest conduit.
- E. Place a 6-inch-wide, yellow, foil-backed, yellow tape with black lettering reading "ELECTRIC LINE" in the trench, and then complete backfilling operations. Tape shall be Thomas & Betts "E-Z-CODE" NAF-0708, or equal.
- F. Directional drilling shall be allowed only in areas known to be free of existing underground piping and electrical systems.

3.04 MOUNTING AND ATTACHMENT

A. The Contractor shall provide all devices and materials such as expansion bolts, foundation bolts, screws, channels, angles, and other attaching means required to fasten conduits to concrete bases or structures which are existing, or provided under other sections of the Contract.

3.05 CONDUIT AND FITTINGS - GENERAL

- A. Minimum size of conduit shall be 3/4 inch, except that concealed homeruns, underground, and embedded conduits shall not be less than 1 inch.
- B. Conduits shall be located for protection from mechanical damage.
- C. Conduits shall be sized in accordance with the NEC and based on 40% fill based on over two wires, or as shown on Drawings, whichever conduit size is larger.

- D. Conduit stub-ups between underground or slab construction and exposed or concealed wall construction shall be elbows of rigid metallic conduit, and shall have an ample coating of asphaltic paint prior to the placement of concrete unless otherwise noted.
- E. Conduits with free ends not containing conductors shall be threaded and provided with plumber's caps or with couplings and plugs where flush terminations are required.
- F. Flexible connections to all equipment subject to movement or vibration shall be made by means of liquid tight flexible steel conduit equal in length to approximately ten times the diameter of the conduit, but not exceeding 3 feet in length. Explosion-proof flexible couplings shall be used in place of liquid tight flexible steel conduit in Class I, Division 1 and Class II, Division 1 hazardous areas.
- G. Conduit runs subject to motion in excess of the capacities of the fittings specified above shall be provided with other approved means of compensating for the motion. Unless otherwise specified or required, expansion fittings shall be installed at the midpoint of their extension.
- H. Conduits to pumps or other equipment shall, unless otherwise shown on the Drawings, be routed through or below concrete floor slabs.
- I. Runs on floor slabs are not permitted unless specifically shown as such on the Contract Drawings.
- J. Conduits shall be concealed in all locations where walls are faced with glazed tile or ceilings are suspended and where called for on the Drawings. Wherever conduit is concealed in masonry of any type, it shall be the responsibility of the Contractor to maintain a clear passageway throughout the entire conduit system, and to clean the conduit system before installing the conductors.
- K. Conduit runs in poured concrete structures containing expansion joints, approved expansion/deflection joints shall be provided in the conduit. All such expansion joints shall be made watertight. Similar expansion/deflection joints shall be installed wherever conduit crosses structural expansion joints, or is attached to two separate structures, or wherever the conduit run is more than 100 feet in straight length.
- Where conduit bushings are constructed wholly of insulating material, a locknut shall be installed both inside and outside the enclosure to which the conduit is attached.
 Ungrounded conductors of No. 4 AWG or larger shall be protected with insulated throat bushings or hubs where entering or leaving an enclosure in conduit systems.
- M. Pulling distances shall be limited to a maximum of 200 feet so as not to exceed the wire manufacturer's maximum pulling tensions, and suitable pull boxes, etc., shall be provided whether shown on the Drawings or not.
- N. Unused openings in conduit bodies and cast enclosures shall be plugged using Appleton Cat. No. PL6, or equal.

- O. The sum of the conduit bend angles between pull points shall not exceed 270 degrees. Bends in conduit containing medium voltage cables shall have a minimum radius of 36 inches.
- P. In hazardous areas, all fittings, material, and equipment shall be rigid metallic steel or PVC coated rigid metallic steel.
- Q. Conduits between hazardous and non-hazardous areas shall include seal-off fittings as required by the NEC and local codes, and the complete installation shall be in accordance with the requirements of such codes.
- R. Seal-off fittings shall be exposed. Sealing compound shall be "Chico" by Crouse-Hinds, or equal. All components and installation in hazardous areas shall conform to the requirements of NEC and all local codes.
- S. Conduits through which moisture may contact live energized parts shall be sealed or plugged at either or both ends per NEC 300.5(G) and 230.8. Spare or unused conduits shall also be sealed. Provide drains and breathers so moisture will not accumulate inside conduit.
- T. Conduits subject to motion at right angles to the direction of the run and all conduits in concrete shall be equipped with O-Z/Gedney Type DX, Thomas & Betts, or equal expansion and deflection fittings.
- U. Inside surfaces of all conduits shall be free from any imperfection likely to damage conductors or cables during installation.
- V. During construction, open ends of conduits shall be capped or plugged to keep out debris. These caps or plugs shall remain in place until wires or cables are pulled through the conduit.
- W. Spare conduits and those provided by the contractor for use by others shall have a pull string installed. Coil up at least 24 inches of extra string at each end.

3.06 CONDUIT AND FITTINGS - METALLIC

- A. Exposed conduit shall be rigid metallic conduit unless otherwise noted.
- B. Rigid metallic conduit shall be installed in true alignment and sloped for drainage wherever necessary; underground conduits shall be drained to manholes or pull boxes.
- C. Rigid metallic conduit shall be reamed free from burrs and carefully cleaned before installation.
- D. When required, conduit unions shall be provided. Running threads will not be permitted.
- E. Conduit fastened directly to structures shall be held with one-hole, malleable iron clamps and clampbacks, or otherwise suitably spaced from concrete or masonry surfaces. Concealed rigid metallic conduit shall be installed in as direct a line as possible and shall be rigidly supported by approved methods and materials.

- F. Exposed rigid metallic conduit shall be installed parallel with or at right angles to the lines of the structure, except as otherwise shown, and supported in an approved manner.
- G. Conduits entering a NEMA 3R, 4, 4X, or 12 enclosures shall be installed using watertight fittings of die cast zinc material. Fittings shall be Appleton HUB-XXD, or equal.
- H. Expansion fittings shall be installed in all rigid metallic conduit runs which cross expansion joints, and shall be Type AX as manufactured by O-Z/Gedney or Thomas & Betts.

3.07 CONDUIT AND FITTINGS - PVC COATED RIGID GALVANIZED STEEL

- A. PVC coated rigid galvanized steel (RGS) conduit shall be installed per the manufacturer's instructions. Only tools approved by the manufacturer of the conduit shall be used.
- B. Installers of PVC coated RGS conduit must be certified by the conduit manufacturer to install this type of conduit. Proof of certification shall be furnished to the Engineer.
- C. PVC coated RGS conduit shall be used wherever shown on the Drawings by the notation "PVC/RGS", and in all areas where highly corrosive or highly humid atmospheres can exist, whether shown on the Drawings or not. Such areas include, but are not limited to, chemical feed and storage areas, solids storage facilities, wet wells, near the surfaces of standing or running water such as in aeration tanks, digestion tanks, open channels, and clarifiers or settling tanks.
- D. PVC coated galvanized rigid steel conduit shall only be used with threaded fittings. Threadless fittings shall not be used.
- E. The installation of PVC coated RGS conduit shall conform to the requirements for metallic conduit.
- F. Before assembly, field-cut threads shall be coated with an electrically conductive compound approved by the conduit manufacturer.

3.08 UNDERGROUND CONDUIT

- A. Underground non-concrete encased conduit shall be installed with a detectable warning tape. If the conduit contains a detectable wire, a warning tape shall still be provided. Underground conduit shall be concrete-encased where shown. The top of underground conduit shall be not less than 30 inches below grade unless otherwise specified. Concrete encasement shall provide a minimum cover of 6 inches on top and bottom, and 6 inches on the sides. Horizontal curves, where necessary, shall be drawn on radii of not less than 6 trade diameters of the largest conduit in the duct bank.
- B. PVC conduit and fittings for use in underground duct banks shall be Schedule 40. PVC conduit shall be Schedule 80 where direct-buried.
- C. Conduits for concrete-encased duct banks shall be securely held in place by approved window type spacer supports, and shall be laid with joints staggered.

- D. The ends of each conduit run which is not to contain wiring under this Contract shall be plugged or capped with manufactured plugs or caps.
- E. Conduits shall enter manholes and structures at right angles unless otherwise shown.
- F. Conduits shall terminate with a bell end at each manhole entrance.
- G. Under pavement conduit crossings shall have a 6-inch minimum concrete cover all around and be reinforced as detailed for a length extending 5 feet on each side of the pavement.
- H. Slope for drainage away from building interiors shall be provided. Where inverted elevations are specified, they shall be adhered to, unless the Contractor obtains approval on an alternative layout.
- I. Concrete for all underground conduit encased in concrete shall be mixed with five pounds of red dye for each cubic yard of concrete. Red topped concrete shall not be permitted instead of red dyed concrete.

3.09 SURFACE METAL RACEWAYS

- A. Surface mounted metal raceways shall only be used in dry locations where exposed or under raised floors of information technology rooms per Section NEC 645.5(D)(2).
- B. Surface mounted metal raceways shall not be used in Class I hazardous areas, where subject to severe physical damage, where the voltage between the wires is greater than 300 volts, where subject to corrosive vapors, in hoistways, and concealed locations not mentioned in A. above.
- C. The number and size of conductors within surface metal raceways shall not exceed what the raceway was designed for. See the manufacturer's installation instructions to determine capacity.
- D. Cables shall be permitted to be installed in surface metal raceways only where such use is permitted by the respective cable article in the NEC.
- E. Surface metal raceways shall be securely fastened to the surface on which they are mounted in accordance with the manufacturer's instructions.
- F. Surface metal raceways shall be grounded and bonded in accordance with NEC Articles 250 and 386.
- G. Splices shall not be made within surface metal raceways.

3.10 EXPLOSION-PROOF CONDUIT FITTINGS

- A. The cross-sectional area of the conductors permitted in a seal shall not exceed 25% of the cross-sectional area of a rigid metal conduit of the same trade size unless it is specifically listed for a higher percentage of fill.
- B. Motors and other devices subject to vibration and movement located in Class I, Division 1 and Class II, Division 1 areas shall be connected using explosion-proof flexible

couplings. Explosion-proof flexible couplings may also be used in place of rigid conduit in difficult bend situations.

3.11 BELOW-GRADE GALVANIZED CONDUIT

- A. All rigid galvanized conduit buried underground shall be coated on the outside with a self-priming, standard petroleum asphaltic coating. This coating shall have a thickness when dry of at least 1 mil.
- B. The asphaltic coating may be dipped, brushed, or sprayed on the exterior surface of the conduit.
- C. Before application, surface should be free of grease, oil, dirt, fingerprints, drawing compounds, any other contaminant, and surface passivation treatments to ensure optimum adhesion and coating performance properties.

PART 4 SPECIAL PROVISIONS

4.01 CONDUIT LOCATION SCHEDULE

- A. Exterior above grade RGS.
- B. Exterior below grade.
 - 1. In duct bank SCH 40 PVC.
 - 2. Direct bury SCH 80 PVC.
- C. Interior RGS.

(Addendum 1, Issued June 21, 2023)

END OF SECTION

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SECTION 16132 ACCESSORIES

PART 1 GENERAL

1.01 SCOPE

A. This Section includes all labor, tools, equipment, and materials necessary to provide electrical boxes and fittings in accordance with the Drawings and as specified herein.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and Section 16010 and shall include:
 - 1. Shop Drawings for Review:
 - a. A list of materials needed for construction, giving quantities, manufacturer's name, and catalog numbers.
 - b. Manufacturer's technical product sheets on each component to be furnished.
 - 2. Information for the Record:
 - a. Manufacturer's qualifications.
 - b. Certified copies of factory test procedures and results.
 - c. Manufacturer's recommended method of installation for the products to be furnished.
 - d. Operation and maintenance manuals for equipment provided, including accessories, and maintenance instructions.
 - e. Manufacturer's recommended spare parts list for the system components and accessories.
 - f. Provide warranty for review; executed copies shall be submitted when completed with copies included in the operation and maintenance manuals.

1.03 QUALITY ASSURANCE

- A. Applicable Standards:
 - 1. UL.
 - 2. NEMA.
 - 3. FS.
 - 4. NEC.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Except as otherwise specified in non-corrosive areas, metallic outlet, device, terminal, junction, pullboxes, and conduit fittings shall be appropriate to the related conduit specification.
 - 1. Cast ferrous metal boxes shall be used with rigid galvanized conduit. Threaded openings shall have a minimum of 5 threads and neoprene-gasketed, cast covers held in place with stainless steel screws.
 - Boxes whose weight in cast ferrous metal would exceed 75 pounds shall be made of sheet steel with 5-thread bosses and neoprene-gasketed covers held in place with stainless steel screws. Similarly, sheet aluminum boxes shall be provided in the larger sizes.
 - 3. Boxes larger than 6-inch shall be equipped with cap screws and hinged covers.
- B. In areas designated as NEMA 4X, outlet, device, terminal, junction and pullboxes shall be NEMA 4X of stainless steel or FRP. Sheet metal boxes where permitted above, shall be NEMA 4X watertight boxes made of 12-gauge stainless steel.
- C. Terminal and junction boxes used for control, signal, or communication wiring shall be NEMA 4X stainless or FRP, except where located in a dry area or electric room, where they shall be NEMA 12. Terminal boxes shall have white-painted backplates, barriered terminal blocks of sufficient quantity for all field taps and for all spare deadends.
- D. Cast boxes used indoors in non-corrosive locations not subject to flooding or hosing shall:
 - 1. Be dust-tight equal to O-Z/Gedney Electrical Manufacturing Company Type YU flush boxes and Type YS surface boxes.
 - 2. Include mounting lugs, with threaded openings having a minimum of 3 threads and neoprene-gasketed covers held in place with stainless steel screws.
- E. Sheet-metal boxes where permitted, including junction boxes and pullboxes at motor control centers, shall be hot-dip galvanized NEMA 12 with neoprene-gasketed covers held in place with stainless steel screws.
- F. In hazardous areas, NEMA 7 pull boxes and junction boxes shall meet all requirements of Class I, Division 1, Group D unless noted otherwise.
 - 1. Enclosures shall have hinged covers and captive cover screws, multiple threaded for fast removal, and an O-ring added to make the enclosure watertight.
 - 2. Enclosures shall be as manufactured by Killark Electric Manufacturing Company, or equal.
- G. Checkered covers shall be provided for boxes in floors or sidewalks.

- H. Concealed outlet and switchboxes for electric lights, wall switches, and receptacles, etc., shall consist of standard galvanized steel boxes and plaster rings where required. Boxes shall be National Steel City, or equal.
- I. Outlets in exterior locations or in exposed conduit shall be "FS" or "FD", and PVC where used with PVC conduit.
- J. Interior junction boxes and gutters shall conform to NEC thickness and dimensional requirements, minimum.
- K. Cut edges or knockouts on all FRP boxes shall be sealed with a catalyzed resin compatible with the original resin and as recommended by the manufacturer. The sealing of the edges shall prevent premature fraying at the field cut edges.

2.02 RESERVED

PART 3 EXECUTION

3.01 COORDINATION

A. Layout and installation of electrical cabinets, boxes, and fittings shall be coordinated with other installations.

3.02 INSTALLATION

- A. Install electrical boxes and fittings as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA "Standard of Installation", and in accordance with recognized industry practices to fulfill project requirements.
- B. Install items where indicated and where required to suit code requirements and installation conditions.
 - 1. Cap unused knockout hole where blanks have been removed and plug unused conduit hubs so as to maintain the NEMA rating of the box.
 - 2. Install boxes in locations which ensure ready accessibility to enclosed electrical wiring and avoid installing boxes back-to-back in walls where there would be less than 6 inches (150 mm) separation. Fasten boxes firmly and rigidly to substrates or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry.
 - 3. Do not install aluminum products in concrete.
- C. Outlet and device boxes for flush mounted installation shall be a minimum of 4 inch square or octagonal and positioned accurately to allow for surface finish thickness.
- D. Junction boxes, pullboxes, and enclosures with hinged doors which are surface mounted shall utilize spacers to maintain 1/4-inch clearance from the wall.
- E. Floor boxes shall be installed level and flush with finished flooring material.

- F. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and secure connections when fastened with locknut or bushing on rounded surfaces.
- G. Provide electrical connections for installed boxes.

3.03 GROUNDING

A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

3.04 CLEANING AND FINISH REPAIR

A. Upon completion of installation, inspect components, remove burrs, dirt, and construction debris, and repair damaged finish including chips, scratches, abrasions, and weld marks.

PART 4 SPECIAL PROVISIONS

Not used.

(Addendum 1, Issued June 21, 2023)

END OF SECTION

SECTION 16422 MOTOR STARTERS AND CONTACTORS

PART 1 GENERAL

1.01 SCOPE

A. This Section includes all labor, tools, equipment, and materials necessary to furnish and install motor controllers in accordance with the Drawings and as specified herein.

1.02 SUBMITTALS

A. Submittals shall be in accordance with the requirements of Section 01300 and shall include:

1. Shop Drawings for Review:

- a. Furnish manufacturer's product data, test reports, and materials certifications as required.
- Wiring diagrams from manufacturer including single line, elementary control and schematics showing internal and external wiring. All control schematics shall use ladder type diagram format incorporating line numbers, and format shall be as defined by NFPA 79, Annex D. Independent wire numbers shall be assigned for each circuit.
- c. Time current characteristic curves for overcurrent protective devices including motor circuit protector devices and fuses.
- d. Footprint layout, including if wall or floor mount and overall dimensions and weights.
- e. Furnish manufacturer's name(s) and catalog numbers.
- f. Furnish manufacturer's technical product sheets on each component to be furnished.

2. Information for the Record:

- a. Operation and maintenance manuals.
- b. Upon completion of the installation and acceptance by the Owner and Engineer, all drawings and related support material shall be corrected and amended to reflect the installed system. All final drawings and electronic copy (CD) (AutoCAD format) shall be turned over to the Engineer and Owner.

1.03 QUALITY ASSURANCE

A. Work shall be in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these Drawings and specifications.

- B. Equipment and materials shall be new and, if of the same type as other performing parts of the same system, shall be the products of the same manufacturer.
- C. Equipment and material shall be furnished by a manufacturer of motor controls whose products have been in satisfactory use in similar service for not less than five years.
- D. Applicable Standards:
 - 1. NEC.
 - 2. UL.
 - 3. NEMA.

1.04 ELECTRICAL AND CONTROL COORDINATION

A. Motor controllers shall be coordinated with other equipment installations for size adjustments if required. This includes checking motor horsepower, current and voltage rating during installation to confirm actual size.

1.05 PRODUCT HANDLING

- A. Deliver motor controllers properly packaged in factory fabricated type containers or wrappings, which properly protect devices from damage.
- B. Store motor controllers in original packaging and protect from weather and construction traffic. Wherever possible, store indoors. Where necessary to store outdoors, store above grade and enclose with watertight wrapping.
- C. Handle motor controllers carefully to prevent physical damage. Do not install damaged switches, breakers, or starters. Remove damaged devices from Site, and replace with new.

PART 2 PRODUCTS

2.01 RESERVED

2.02 GENERAL ASSEMBLY FOR MOTOR CONTROLLERS AND CONTACTORS

- A. Motor controllers and contactors shall be fully assembled, front accessible, with mounting feet and disconnect switch along with each starter unit.
- B. Enclosures shall be NEMA 12 rated for general indoor units, NEMA 4X for outdoor units and wet/corrosive indoor units and NEMA 7 for explosion-proof (Class I, Division 1, Group C and D), unless otherwise noted.
- C. Motor controllers and contactors shall have 42,000-amp minimum interrupting capacity when used on 480V systems. Ampere and interrupting capacity ratings shall be as shown on the Drawings.
- D. Motor controllers and contactors shall be factory assembled and tested unless otherwise noted.

- E. Full voltage starters for motors 10 hp and larger shall have terminals provided for power factor correction capacitors. These terminals shall be factory wired to the load side of the contactor so that capacitor current does not pass through the overload.
- F. Motor controllers and contactors shall match existing manufacturer or be compatible with manufacturer if replacing existing units in a Motor Control Center, or be manufactured by Allen-Bradley, Cutler-Hammer, Square D, or equal.
- G. Pilot lights, pushbuttons, and selector switches shall fit in a 22 millimeter or larger diameter hole.
- H. All pilot lights shall be transformer type, incandescent, Press-to-test type.
- I. Each motor starter shall include a green pilot light with legend plate indicating ON and a red pilot light with legend plate indicating OFF. Each contactor shall include a green pilot light with legend plant indication ON and a red pilot light with legend plate indicating OFF.
- J. Each motor starter shall include NEMA rated, Trip Class 10 solid state overload protection for each pole/phase. Protective device shall be trip free with visual trip indication. Reset shall be manual.
- K. For each motor starter, an overload reset pushbutton, mounted through the panel door, shall be provided to permit resetting the overload protective device without opening the panel door. However, this shall not apply to explosion-proof, NEMA 7 and 9 enclosures.
- L. Each motor starter or contactor shall include a control power transformer with 120 volt secondary unless otherwise indicated. The transformer shall have sufficient capacity to serve the connected load and limit voltage variation to 10% during operation. Each control power transformer shall have an additional 100 VA capacity above the standard size for the respective starter. No control power transformers less than 150 VA capacity will be approved. Both legs of the primary; winding shall be fused. One leg of the secondary winding shall be fused and the other grounded.
- M. Each motor starter or contactor shall include a three-position [LOCAL-OFF-REMOTE]
 [HAND-OFF-PCS] [HAND-OFF-AUTO] selector switch with appropriate legend plate. The REMOTE/PCS/AUTO position shall have an extra set of contacts that close when the switch is in that position. Other control operators shall be as shown on the drawings.
- N. Each motor starter or contactor's control wiring shall be according to Section 16121.
- O. Each magnetic motor starter or contactor, NEMA Size 3 or larger, shall include a lowenergy interposing relay.
- P. Each magnetic motor starter, contactor and relay shall include a transient suppressor across the coil.
- Q. Provide auxiliary contacts wired to terminal blocks for the following:
 - 1. Unit disconnecting means for ON/OFF/TRIPPED indication (1-NO and 1-NC).

- 2. Starter coil energized for motor running indication (2-NO and 2-NC).
- 3. Starter coil energized for hold-in contact (1-NO per coil).
- 4. Reversing and two speed starter interlocking contacts (1-NC per coil).
- R. Starters and contactors shall have replaceable power contacts.
- S. Each motor starter shall include an elapsed time meter. Meter shall be non-resettable, six-digit minimum, with readout in hours and tenths of hours.

2.03 LABELS

- A. Provide products that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the NEC, Article 100.
- B. Install label inside enclosure identifying the type of motor circuit protector installed, its overcurrent rating, its interrupt rating and the UL class. Where applicable, trip settings and time delays should be provided on permanent labels along with overload sizes.
- C. Provide arc flash warning labels on all doors and access panels.

2.04 MOTOR CIRCUIT PROTECTORS

- A. MCPs shall be as manufactured by Cutler-Hammer, Square D, or equal.
- B. The instantaneous trip setting of the MCP for all motors except Design E motors shall be at least 700% but not more than 1300% of the full load current shown on the motor's nameplate. However, settings between 1100% and 1700% of the motor's full load current are permitted for Design E motors.
- C. The MCP shall have trip indication independent of the ON and OFF positions of the switch.
- D. Each pole shall be provided with arc chutes and individual trip mechanisms.
- E. MCPs shall have three poles with an internal common trip crossbar to provide simultaneous tripping.
- F. MCPs shall be designed to comply with the applicable requirements of UL Standard 489.
- G. Internal accessories shall be installed at the factory and the case shall be sealed. No internal maintenance, adjustments or replacement items are to be provided.
- H. MCP input and output terminals shall be labeled LINE and LOAD respectively.
- I. A minimum of one Normally Open (NO) auxiliary contact that closes when the MCP is closed shall be provided in each MCP. Indication of the operator position is not acceptable.

2.05 SOLID STATE OVERLOAD RELAYS

A. Solid state overload relays shall have adjustable current ratings with an approximate
 3 to 1 ratio from highest to lowest setting.

- B. Solid state overload relays shall have Class 10 trip settings unless noted otherwise on the drawings or in Part 4 of this specification. Solid state overload relays that have adjustable trip class settings shall include a setting for Class 10 protection.
- C. Solid state overload relays shall have a means to be manually reset. If they include an automatic reset feature, it shall be possible to defeat the automatic reset capability. It shall be possible to manually reset the overload relay without opening the enclosure door except when the starter is enclosed in an explosion-proof enclosure.
- D. Solid state overload relays shall provide phase loss protection for the motor. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor.
- E. Solid state overload relays shall compensate for the difference in ambient temperature between the motor and starter locations.
- F. Solid state overload relays shall be self-powered.
- G. Solid state overload relays shall have one NO and one NC auxiliary contact. Contacts shall be rated 5 amps at 250 VAC.

2.06 CONTACTORS

- A. Contactors shall be UL listed with amperage ratings and number of poles as indicated on the Drawings.
- B. Overcurrent protective devices shall be in compliance with Sections 16431 and 16432 on circuit breakers and fuses respectively.
- C. In addition to standard ON/OFF markings, switch handle accessories shall provide provisions for locking handle in the ON or OFF position by safety lockout hasps and/or padlocks.
- D. Contactors shall be NEMA Size 1 as a minimum and shall be complete with disconnecting means (circuit breaker or fuses as shown on the drawings), control transformer (if required), pilot lights, pushbuttons, and/or selector switches and wired out to terminal blocks in the panel. Schematics for each contactor shall be provided, along with unique individual wire numbers.
- E. All fuses shall be furnished and installed by the contractor.
- F. Control voltage shall be 120 volts, 60 Hz, unless noted otherwise on the drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Locate independently mounted motor controllers and contactors and install in accordance with manufacturer's written installation instructions. This would include in existing panels, MCC, etc.

- B. Wall mounted motor controllers and contactors shall be bolted to the wall if it will support the unit or a frame made of channel shall be constructed to support the motor controller or contactor.
- C. All floor mounted motor controllers and contactors without legs shall be mounted on a 4-inch-high concrete housekeeping pad provided by the Contractor.
- D. Check connectors, terminals, bus joints, and mountings for tightness. Tighten fieldconnected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and UL 486B.
- E. Provide equipment grounding connections for individually mounted units as indicated and as required by the NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.
- F. Upon completion of installation, inspect devices. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.
- G. Doors of MCCs and combination starter enclosures shall be interlocked with the disconnecting means operating handles to prevent opening when the operator is in the ON position. Provide a means to allow authorized personnel to release the interlock for inspection purposes when the switch is ON.

3.02 IDENTIFICATION

- A. Identify components in accordance with Section 16030.
- B. Individual nameplates shall be engraved to match the single line drawings.

3.03 TESTING AND INSPECTION

- A. Verify indicated ratings and settings to be appropriate for final system arrangement and parameters. Where discrepancies are found, test organization shall recommend final protective device ratings and settings. Use accepted revised ratings or settings to make the final system adjustments.
- B. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
- C. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
- D. Check tightness of electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
- E. Prior to energization of motor controller equipment, check for phase-to-phase and phase-to-ground insulation resistance levels to be up to standards. Also, check for electrical continuity and any short circuits or grounded circuits.

- F. Check all motors for correct rotation and change phases of motor leads as needed to correct the rotation.
- G. Check harmonics on all drives and provide filtering if causing electrical load or signal problems.

3.04 MOTOR CIRCUIT PROTECTORS

- A. The instantaneous trip setting of the MCP for all motors except Design E motors shall be at least 700% but not more than 1300% of the full load current shown on the motor's nameplate. However, settings between 1100% and 1700% of the motor's full load current are permitted for Design E motors.
- B. Provide a means to lock the MCP in the OFF position with heavy-duty industrial type padlocks.
- C. Doors of MCCs and combination starter enclosures shall be interlocked with the MCP switch handles to prevent opening when the operator is in the ON position. Provide a means to allow authorized personnel to release the interlock for inspection purposes when the switch is ON.
- D. Line conductors shall not be connected to load terminals of MCPs.

PART 4 SPECIAL PROVISIONS

4.01 SPARE PARTS

- A. The Contractor shall provide a minimum of 10% spare fuses of each size installed with at least 3 of each size to be the minimum.
- B. The Contractor shall provide at least 3 spare indicating lights of each type installed.

(Addendum 1, Issued June 21, 2023)

END OF SECTION

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SECTION 16450 DISTRIBUTION TRANSFORMERS

PART 1 GENERAL

1.01 SCOPE

A. This Section includes furnishing and installing single phase and three phase general purpose individually mounted dry-type distribution transformers with primary voltages less than or equal to 600 VAC of the two-windings, self-cooled type, complete and in place, ready for service.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and shall include:
 - 1. Shop Drawings for Review:
 - a. General arrangement drawings, kVA rating, primary and secondary voltage, impedance.
 - b. Wiring schematics and termination identifications
 - c. Manufacturer's data sheets including all maintenance data, No-load sound level, Full-load sound level, temperature rise, No-load losses, and Full-load losses.
 - 2. Information for the Record:
 - a. Manufacturer's qualifications.
 - b. Manufacturer's storage and handling requirements.
 - c. Equipment acceptance test procedures.
 - d. Certified factory test reports.
 - e. Sound level test reports.
 - f. Field test reports.
 - g. Equipment warranty.
 - h. Operation and maintenance manuals.

1.03 QUALITY ASSURANCE

- A. Transformers shall be designed, constructed, rated, and tested in accordance with UL, NEMA, ANSI, IEEE, NFPA, and OSHA standards.
- B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five years.

- C. Manufacturers shall be registered firms in accordance with ISO 9001:2000; which includes the design and manufacture of low voltage dry-type power, distribution, and specialty transformers.
- D. Transformers and accessories described herein shall be furnished by a supplier who shall be responsible for the performance of the equipment in its entirety.

1.04 PRODUCT HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions.
 A copy of these instructions shall be included with the equipment at the time of shipping.

1.05 GUARANTEE

A. Transformers shall be warranted against defects in materials, workmanship, and performance for five years after the date of substantial completion.

PART 2 PRODUCTS

2.01 EQUIPMENT

- A. Transformers smaller than 15 kVA shall be totally enclosed non-ventilated with continuously wound coils and shall be completely encapsulated in a polyester resin compound to provide a shock-resistant, moisture-proof, seal. Insulation temperature class shall be based on 180 degrees C system minimum.
- B. Transformers 15 kVA and larger shall be a ventilated, dry-type with a UL listed 220 degrees C insulation system minimum.
- C. Transformer cores shall be constructed with low hysteresis and eddy current losses. Magnetic flux densities shall be below the saturation point to prevent core overheating by harmonic voltage distortion and load current offset.
- D. Completed core and coil shall be bolted to the base of the enclosure but isolated by means of rubber vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap.
- E. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
- F. Transformer enclosure shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring.
- G. Transformers shall be constructed of a rugged steel base suitable for lifting with a fork lift vehicle.
- H. Transformers shall have a securely attached nameplate providing complete electrical ratings, wiring diagrams, tap connections and catalog numbers as applicable.
- I. Indoor/outdoor transformers shall be dry-type, self-ventilated, 3-phase, 60 Hz with delta-connected primaries and 208Y/120-volts secondaries or single-phase primary and

120/240-volts secondary. Units located outdoors shall be rated NEMA 3R rain-tight and provided with weather shield kit. Ratings shall be kVA as indicated on the Drawings.

- J. Transformers rated up to 15 kVA shall have provisions for wall mounting.
- K. Transformers shall be UL listed 506 or 1561.
- L. Each transformer shall have a securely attached nameplate providing complete electrical ratings, wiring diagram, tap connections, and catalog number as applicable.

2.02 PERFORMANCE REQUIREMENTS

- A. Transformers shall be supplied with NEMA standard taps in the high voltage windings. Exact voltages and taps to be designated in the transformer schedule of Part 4.
- B. Transformer sound levels shall meet the requirements as established by NEMA ST-20:
 - 1. Up to 9 kVA 40 dB.
 - 2. 10 to 50 kVA 45 dB.
 - 3. 51 to 150 kVA 50 dB.
 - 4. 151 to 300 kVA 55 dB.
 - 5. 301 to 500 kVA 60 dB.
 - 6. 501 to 700 kVA 62 dB.
 - 7. 701 to 1000 kVA 64 dB.
 - 8. 1001 to 1500 kVA 65 dB.
- C. Transformers shall be provided with high-voltage taps as follows:

Three-Phase 480 Volts Delta Primary – 208Y/120 Volts Secondary				
0–9 kVA	2-5.0% of Full Capacity Below Normal			
15 kVA	4-2.5% of Full Capacity, 2 Above and 2 Below Normal			
30-300 kVA	6-2.5% of Full Capacity, 2 Above and 4 Below Normal			
500 kVA	4-2.5% of Full Capacity, 2 Above and 2 Below Normal			
750 kVA	4-3.5% of Full Capacity, 2 Above and 2 Below Normal			
1000 kVA	2-5.0% of Full Capacity, 1 Above and 1 Below Normal			
Single-Phase 480 Volts Primary – 120/240 Volts Secondary				
0-25 kVA	2-5% of Full Capacity Below Normal			

D. Transformers shall utilize the insulation system that has been temperature classified and approved by UL. Transformers shall be capable of operating at 100% of nameplate rating continuously in an ambient temperature of 40 degrees C.

The winding temperature rise shall be as follows:

Three-Phase 480 Volts Delta Primary – 208Y/120 Volts Secondary			
0-15 kVA	115 degrees C		
0-1000 kVA	150 degrees C		

Single-Phase 480 Volts Primary – 120/240 Volts Secondary				
0-25 kVA 115 degrees C				

E. Dry-type transformers shall not exceed the sound pressure level of dB(A) over the load range measured 3 feet from the transformer as follows:

0-9 kVA	40 dB(A)
10-50 kVA	45 dB(A)
51-150 kVA	50 dB(A)
51-300 kVA	55 dB(A)
301-500 kVA	60 dB(A)

F. Transformer impedance shall be as high as possible for transformer size so as to reduce available short circuit current.

2.03 ACCESSORIES

- A. Transformers located indoors subject to moisture conditions shall have weather shields.
- B. Transformers located outdoors shall have NEMA 3R enclosures.
- C. Transformers in corrosive areas indoors or outdoors shall have stainless steel enclosures.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Floor-Mounted Units Provide concrete housekeeping pad(s) for floor mounted units in accordance with Section 03300.
- B. Anchor transformer to floor with Type C expansion anchors in accordance with Section 05500.
- C. Tighten all lugs to manufacturer's specifications, and adjust transformer taps to provide secondary voltage to within 2% of nominal system rating.
- D. Transformers, whether wall or floor mounted, shall be supported in a manner to reduce the noise level to a minimum. All wall mounted indoor transformers shall be mounted 6 in. minimum from the ceiling.

3.02 FIELD TESTING

- A. Measure primary and secondary winding resistance for shorted or open windings.
- B. Measure primary and secondary voltages for proper tap settings.
- C. Measure impedance from neutral to ground.
- D. Submit written report of test results to Engineer.

PART 4 SPECIAL PROVISIONS

4.01 TRANSFORMER SCHEDULE

- A. Transformers shall be identified as to their location, size, voltages, enclosures, and accessories as per the following schedule.
- B. The following schedule is intended to aid the Contractor in identifying transformer location and size. It is intended to supplement the Drawings and Specifications and is not guaranteed to be complete. All transformers shown on the drawings shall be furnished and installed by the Contractor whether or not listed in the schedule.

		Indoor		Primary	Secondary		
Location	ID Tag	Outdoor	Size kVA	Voltage	Voltage	Accessories	Enclosure
Pump	XFMR	Indoor	15 kVA	480V-3ph	240V-1ph	WMB	1
Station							

Accessor	ies:	
WS	=	Weather Shield
WMB	=	Wall Mounting Bracket
CMB	=	Ceiling Mounting Bracket
Enclosure	es:	
1	=	NEMA 1
3R	=	NEMA 3R
4X	=	Stainless Steel
		(Addendum 1, Issued June 21, 2023)

END OF SECTION

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SECTION 16610 LIGHTNING PROTECTION SYSTEMS

PART 1 GENERAL

1.01 SCOPE

- A. This Section includes furnishing, designing, planning, and coordinating all labor, equipment, materials, tools, plant supplies, testing, and adjusting necessary for a complete lightning protection system.
- B. The Contractor shall provide all lightning conductors, air terminals, ground terminals, cable connectors, conduit, fasteners, tripod point braces, air terminal bases, and all other accessories shown on the Drawings, specified, or required for a complete system.
- C. The Contractor shall provide related excavation, backfilling, concrete work, cutting and patching, and the restoration of all surfaces to their original condition.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01300 and shall include:
 - 1. Shop Drawings:
 - a. Drawings shall be submitted for approval before delivery of materials and beginning of Work.
 - b. Drawings shall show number of points, locations, conductor routes and size, grounding, and details of connectors.
 - c. Submit a list of materials giving quantities, manufacturer's name, and catalog numbers.
 - d. Submit manufacturer's technical product sheets on each component to be furnished.
 - 2. Information for the Record:
 - a. Qualifications of design professional of lighting system.
 - b. Manufacturer's recommended method of installation for the products to be furnished.
 - c. Certified copies of the field test procedures and results.
 - d. Operation and maintenance manuals.
 - e. Provide warranty for review; executed copies shall be submitted when completed with copies included in the operation and maintenance manuals.
 - f. Manufacturer's qualifications, including a list of similar installations.

1.03 QUALITY ASSURANCE

- A. Design services for lighting shall be performed by a licensed professional in the state of the project.
- B. Applicable Standards:
 - 1. NEC.
 - 2. NFPA 780.
 - 3. NESC.
 - 4. Installation Requirements for Master Labeled Lightning Protection Systems.
 - 5. UL96 and UL96A.
 - 6. OSHA.
 - 7. United States Safety Standards pertaining to lightning protection.
- C. Lightning System shall be installed by an accredited lightning protection contractor and shall be certified with the UL Master Label of Lightning Rod Equipment.
- D. Locations of equipment shown on the Drawings or specified herein shall be considered as approximate. Exact locations shall be approved by the Engineer.
- E. Equipment and materials shall be new and products of the same manufacturer.

1.04 PRODUCT HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions.
 A copy of these instructions shall be included with the equipment at the time of shipping.
- B. Equipment damaged in shipment or storage shall not be installed and shall be replaced by the responsible party. Equipment damaged during construction shall be replaced by the contractor.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Generally, all materials shall be copper and/or copper-bronze. Where system components are mounted on aluminum or galvanized-aluminum coated steel surfaces, such as steel siding and standing seam metal roofs, aluminum materials shall be used to avoid electrolytic corrosion between dissimilar materials.
- B. Materials shall be sized in accordance with the material requirements of NFPA 780 and UL96A.
- C. Class I materials shall be used for systems on structures under 75 feet in height. Class II materials shall be used on structures for systems on structures exceeding 75 feet in height.

- D. Air terminals shall be 3/8-inch diameter minimum, solid copper, and shall extend at least 24 inches above the device to be protected. The base of this air terminal shall be cast bronze with bolted pressure cable connectors.
- E. Main and down conductors shall consist of UL listed 32 strand of 17-gauge copper wire weighing 215 pounds per 1,000 feet No. 2 AWG minimum and installed in accordance with UL code.
- F. Connecting bonding conductors shall be No. 6 AWG secondary bonding conductor consisting of 14 strands of No. 17 AWG copper wire minimum.
- G. Fasteners for conductors shall be an approved type of non-corrosive metal and have ample strength to support conductors.
- H. Cable connectors shall be cast copper with screw-pressure type stainless steel bolts and nuts.
- I. Ground Terminations:
 - Each down conductor shall have its own ground termination consisting of a 3/4-inch diameter by 10 feet long copper-clad ground rod driven vertically into the earth.
 - 2. Down conductor shall be connected to the ground rod by an exothermic welded connection.
 - 3. Ground rods shall be located 1 foot below final grade and 2 feet from any foundations.
 - 4. Where structural steel building framework is used as the system grounding conductors, perimeter columns shall be grounded at intervals spaced not more than 60 feet apart.
 - 5. Columns shall be grounded using bonding plates with 8 square inches of surface contact area or with an exothermic welded connection.
 - 6. Conductors from columns to the ground terminations shall be Class II copper lightning conductors.

PART 3 EXECUTION

3.01 COORDINATION

A. All services involving excavation, trenching, backfilling, installing ground rods, and ground loops shall be coordinated with other trades to avoid conflicts.

3.02 INSTALLATION

- A. Air Terminals Shall Be:
 - 1. Spaced not to exceed 20 feet apart along the peak of a roof.
 - 2. Within 2 feet of the ends of ridges of gable and hip-roofs.

- 3. Placed at the peak of each cupola.
- 4. Provided for metal stacks, flues, and mechanical equipment having metal thickness of less than 3/16 inch and not within a zone of protection of an air terminal. Equipment with metal thickness 3/16 inch or greater shall be bonded per code requirements.
- 5. Furnished with blunt tops or covers and spring bases or safety cables on roofs with walkways shown on the Drawings or where called for on the Drawings or where specified.

B. Conductors:

- 1. A main conductor cable shall be installed across the entire main roofline to be protected. Each main conductor shall be connected to at least two down leads so as to have at least two paths to ground for each air terminal.
- 2. Ground leads connected to the main conductor shall be spaced not to exceed 100 feet apart.

C. Fasteners:

1. Fasteners for support of conductors shall be spaced not to exceed 36 inches.

D. Roof Penetrations:

1. Roof penetrations shall be made using conduit sleeves passing through a pitch pocket. Pitch pocket shall be purchased, installed, and warranted under applicable Sections of Division 7.

E. Down Conductors:

- 1. Wall bearing structures having reinforced concrete walls shall have any concealed down conductors installed in 1-inch conduit minimum.
- 2. A minimum of two down conductors shall be connected to main conductor cables.
- 3. Spacing of down leads shall not exceed 100 feet.

F. Metal Bonding:

1. All metal materials located within 6 feet of any main or down conductor shall be bonded to the grounding system with appropriate bimetallic connectors.

G. Terminations:

- 1. Ground terminals shall be at the base of the structure.
- 2. Grounding connections shall be made around the perimeter of the structure at a maximum distance of 100 feet apart.
- 3. One ground connection shall be connected to the water system where the water system enters the structure if required by applicable NEC requirements.
- 4. Provide common grounds to the lightning protection system and other services such as telephone and electric entrance wires, cable, and TV/radio antenna systems.
- 5. Ground terminals shall be separate from the building ground system. However, they shall be bonded to it.

3.03 INSPECTION, START-UP, AND TRAINING

- A. The Contractor shall test the ground resistance of the system. Dry Season resistance shall not exceed 5 ohms. Contractor shall be required to provide all testing equipment.
- B. Ground resistance exceeding 5 ohms shall be reduced with additional driven ground rods spaced at 20 feet. Additional ground resistance reduction may require Ground Enhancement Materials (GEM) added to the surrounding soil.
- C. Test results shall be submitted in writing and accepted by the Engineer prior to final payment. Testing shall be repeated until satisfactory results are submitted and accepted by the Engineer.
- D. Upon completion of the installation, the Contractor shall furnish Owner the Master Label issued by UL for this system.

PART 4 SPECIAL PROVISIONS

4.01 MASTER LABELER CONTACT INFORMATION

- A. Lightning protection system shall be as designed by:
 - 1. Union Lightning Protection Installers of Dayton, Ohio
 - 2. Michigan Lightning Protection, Inc. of Grand Rapids, Michigan
 - 3. Robbins Lightning, Inc. of Maryville, Missouri
 - 4. Or equal. (Addendum 1, Issued June 21, 2023)

END OF SECTION

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LP-2

MOTOR CONTROL CENTER MCC-1 ONE-LINE DIAGRAM

PANELBOARD DESIGNATION / TAG: LP2 LOCATION:					BOOSTER PUMP STATION												
LECTRI	CAL CHARACTERISTICS: 120/208v - 3p	h - 4w	FEEDER SIZE:				Refer to One-Line diagram(s)					Options:			Options:		
ANELB	OARD CONSTRUCTION:			FED FROM:		EXI	STING 12	0/208V P	ANELBO	ARD		SUB-FEED LU	UGS			MULTIPLE SECTIO	NS
60	AMP MAIN LUGS	A.I.C. (FULI	A.I.C. (FULLY RATED)				SURFACE MOUNTING					SUB-FEED B	REAKER		INTEGRAL	SPD	
	AMP MAIN BREAKER/SWITCH	% NEUTRA	% NEUTRAL (SOLID)			NEMA 12 ENCLOSURE					FEED-THRU LUGS				BOLT-ON	BREAKERS	
24															116		
24						IVII 3C.											00
·Ľ.	After the circuit no. indicates handle locking device.																
		Δ	R R	C			VVIR	JIZE		POLE	Δ	R	C				Г
1			D	C	1	20	#12	#12	20	1	200	D	<u> </u>	RECEPTACIE - BAT			┢
3	EXHAUST FAN EF-1-1		1,176		1	15	#12	#12	15	1	200	66		LIGHTING - BATHE	TING - BATHROOM		┢
5	RECEPTACLES - EAST WING		1,110	800	1	20	#12	#12	15	1			45	XHAUST FAN EF-1-2			┢
7	GENERATOR JACKET WATER HEATER (1"C)	1,125			2	15	#12	#12	15	1	100			IL-1			t
9			1,125		-	15		#12	15	1		100		DISCHARGE FLOW METER			t
11	CHLORINE ANALYZER		-	100	1	15	#12	#12	15	1			1200	GENERATOR BATTERY CHARGER (1"C)			t
13	EXTERIOR RECEPTACLES (1"C)	600			1	20	#10		20	1				SPARE			t
15	SPARE				1	20			20	1				SPARE			T
17	SPACE													SPACE			T
19	SPACE													SPACE			T
21	SPACE													SPACE			T
23	SPACE													SPACE			T
	SUB TOTAL VA	1,725	2, <mark>301</mark>	900							300	166	1,245		SUB TOTAL V	A	_
	PHASE TOTALS	А	В	С													Γ
	TOTAL PHASE VA	2,025	2,467	2,145	ļ						18.4			CONNECTED AMPS (Balanced)			
	TOTAL PHASE AMPS	17	21	18										PHASE DEMAND	AMPS (Balanced)		
	TOTAL CONNECTED KVA		6.637											TOTAL DEMAND N	(VA		

TOL-7766001E05-34 E-5 - ONE-L 6/21/2023 8:35 AM - CLENDER 6/21/2023 8:36 AM



MOTOR CONTROL CENTER MCC-2 ONE-LINE DIAGRAM

NOTES: 1. GENERATOR AND AUTOMATIC TRANSFER SWITCH TO BE PURCHASED BY OWNER AND INSTALLED BY CONTRACTOR



CONDU	JIT AND WIRE SCHEDULE						
NUMBER	CONDUIT AND WIRE						
	3½"C, 3#600KCMIL & 1#2 GND						
2	(2) 3½"C, 3#600KCMIL & 1#2/0 GND						
3	2½"C, VFD RATED 3#4/0 & 3#6 GND						
4	34"C, 3#12 & 1#12 GND						
5	1"C, 2#6 & 1#8 GND						
6	1"C, 3#8 & 1#10 GND						

