SP-154013a
(Replaces SP-154013)

SPECIAL PROVISIONS
FOR
ELECTRICAL SYSTEM FOR STORMWATER PUMPS

Dallas County
STP-U-8177(619)--70-25

Effective Date
February 21, 2017

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

154013a.01 GENERAL DESCRIPTION OF ELECTRICAL SYSTEM FOR STORMWATER PUMPS

This section specifies the requirements for supplying and constructing the electrical system and its components for the stormwater pumps to be placed adjacent to the pedestrian box as noted in the plans. The Contractor shall protect surrounding areas, prepare the site, and construct the electrical system in accordance with this specification.

The following shall apply to all articles and sections of this Special Provision.

A. SUBMITTALS

1. Submit shop drawings in accordance with the contract documents.
2. Submit shop drawings for the equipment specified herein as part of the complete, integrated submittal for the process instrumentation & control system and in accordance with the requirements specified under Process Instrumentation & Control.
3. Review of shop drawings constitutes acceptance of general design only and will not release the Contractor for fulfilling the terms and intent of the contract documents.
4. Any additional requirements as listed in this Special Provision.

B. QUALITY ASSURANCE

1. All materials, equipment, and parts shall be new and unused of current manufacture.
2. System supplier shall be responsible for providing all necessary accessories required for a complete and operable system.
3. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than 3 years of documented experience.
4. Products: Listed and classified by UL or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

5. Any additional requirements as listed in this Special Provision.

C. Operation/Maintenance Manuals and Instructions

1. Submit operation & maintenance manuals and instructions in accordance with contract provisions.
2. Submit operation and maintenance manuals for the equipment specified herein in accordance with the requirements that submittals for all motor control equipment be included as part of the submittal for the complete, integrated process instrumentation and control system and in accordance with the requirements specified under Process Instrumentation & Control.
3. Any additional requirements as listed this Special Provision.

D. Warranty

1. See Contract Provisions for additional requirements.
2. Any additional requirements as listed in this Special Provision.

E. Factory Testing

1. Refer to the requirements of Process Instrumentation & Control.
2. Any additional requirements as listed in this Special Provision.

154013a.02 COMMON WORK RESULTS FOR ELECTRICAL

A. DESCRIPTION.

Furnish and install complete and operable electrical systems as indicated on the drawings and as specified herein.

1. Design Requirements
    a. The table included in this section under Hardware Design Requirements specifies the usage requirements for the hardware and equipment specified in the following sections:
        i. Hangers and Supports for Electrical Systems
        ii. Conduit
2. Electrical Work Specified Elsewhere:
    a. Every attempt has been made to indicate in these specifications and drawings all work required under “Electrical.” However, there may be additional specific requirements in the specifications, drawings, or addenda of other trades which pertain to the work of this trade, and any such requirements are hereby made a part of the requirements for this trade.
3. Design Intent:
    a. The Contractor shall furnish and install all the necessary materials, apparatus, and devices to complete the electrical equipment and systems installation herein specified, except such parts as are specifically exempted herein.
    b. If an item is either called for in the specifications or shown on the plans, it shall be considered sufficient for the inclusion of said item in this contract.
    c. The details and drawings are diagrammatic. Verify all dimensions at the site and be responsible for their accuracy.
    d. All sizes as given are minimum except as noted.
    e. Materials and labor shall be new (unless noted or stated otherwise), first class, and workmanlike, and shall be subject at all times to inspections, tests and approval from the commencement until the acceptance of the completed work.
    f. Electrical requirements for equipment are based on design data. It shall be the responsibility of the Contractor to verify actual requirements with the provider of the equipment and adjust electrical installation based upon actual requirements.

4. Substitution of Materials:
   Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the Contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space and for obtaining the specified performance from the system into which these items are placed.
5. Continuity of Existing Services and Systems:
   a. No outages shall be permitted on existing systems except at the time and during the interval specified by the Contracting Authority and the Engineer. Any outage must be scheduled when the interruption causes the least interference with normal schedules and routines. No extra costs will be paid to the Contractor for such outages that must occur outside of regular weekly working hours.
   b. This Contractor shall restore any circuit interrupted as a result of this work to proper operation as soon as possible.
6. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - NFPA 70 - National Electrical Code.
      ii. National Electrical Contractors Association (NECA), current edition.
         - NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
7. Submittals
   a. Shop Drawings shall be prepared and submitted:
      i. Low-Voltage Electrical Power Conductors and Cables (600 V and Less)
      ii. Grounding and Bonding of Electrical Systems
      iii. Hangers and Supports for Electrical Systems
      iv. Conduit
      v. Portable Engine/Generator Set
      vi. Process Instrumentation & Control
8. Operation/Maintenance Manuals and Instructions
   a. Submittal Requirements for Electrical Operation & Maintenance Manuals and Instructions:
   a. Assemble material in three-ring or post binders, using an index at the front of each volume and tabs for each system or type of equipment. In addition to requirements within Division 11 of the Standard Specifications, include the following information:
      i. Copies of as-built submittals.
      ii. Wiring diagrams for electrically powered or controlled equipment
      iii. Records of tests performed to certify compliance with system requirements
      iv. Certificates of inspection by regulatory agencies
      v. Parts lists for manufactured equipment
      vi. Preventive maintenance recommendations
      vii. Warranties
      viii. Additional information as indicated in the technical specification sections
      ix. Test Reports and Demonstration Log:
         - Permanently record checks and tests and demonstrations.
         - Submit copy of complete testing or demonstration report no later than 30 days after testing or demonstration is complete.

9. Quality Assurance
    a. All work and materials shall conform to or exceed in every detail the applicable rules and requirements of the Iowa Electrical Code, the National Electrical Code (ANSI/NFPA 70), other applicable National Fire Protection Association standards, the National Electrical Safety Code, and present manufacturing standards (including NEMA).
    b. All work shall be performed under the direction of a State of Iowa Licensed Master Electrician.
    c. All materials shall be listed by and shall bear the label of an approved electrical testing laboratory. If none of the approved electrical testing laboratories has published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where one of the approved electrical testing laboratories has an applicable system listing and label, the entire system shall be so labeled.
    d. The following laboratories are approved for providing electrical product safety testing and listing services as required in these specifications:
        i. Underwriters Laboratories Inc.
        ii. Electrical Testing Laboratories, Inc.
    e. Certificates And Inspections:
        i. Refer to Division 11 of the Standard Specifications.
        ii. Obtain and pay for all required inspections including but not limited to state or local electrical inspections and fuel tank inspections. Deliver original inspection certificates to the Engineer.
10. Design Requirements
    a. The following table specifies the usage requirements for the hardware and equipment specified in the following sections:
        i. Hangers and Supports for Electrical Systems
        ii. Conduit

HARDWARE USAGE REQUIREMENTS

Area Classification	Voltage	Type	Installation	Use Conduit	Use Box	Use Support	Use Hardware
Hazardous	All	All	Exposed	RMCCS	PCB	SS	SS
Underground	480VAC	Power	Direct-buried in ground	RNC	---	---	---
Underground	120/240V AC	Power	Direct-buried in ground	RNC	---	---	---
Underground	120VAC	Control	Direct-buried in ground	RNC	---	---	---
Underground	24VDC	Signal/ Intrinsically Safe	Direct-buried in ground	RMCCS	---	---	---
Underground	Low	Data/Comm.	Direct-buried in ground	RMCCS	---	---	---
Underground	---	Fiber Optic	Direct-buried in ground	RNC	---	---	---

HARDWARE USAGE REQUIREMENTS

Area Classification	Voltage	Type	Installation	Use Conduit	Use Box	Use Support	Use Hardware
---	All	All	Outdoor Exposed	RMCCS	CB	SS	SS

NOTES:

1. All conduit in new structures shall be concealed.
2. No substitutions shall be allowed unless approved by engineer.
3. Transition to exposed conduit shall comply with specified requirements for exposed conduit, regardless of whether transition is rigid or flexible.
4. Transition from underground or concrete encased conduit shall be RMCCS.
5. Sheet metal boxes are not acceptable for exposed installation.
6. Below grade locations shall be considered damp or wet locations.

ABBREVIATIONS:

RNC: Rigid Non-metallic Conduit	RNB: Rigid Non-metallic Box	RN: Rigid Non-Metallic
RMCS: Galvanized Rigid Metal Conduit	CB: Cast Box	GS: Galvanized Steel
RMCCS: PVC Coated Galvanized Rigid Metal Conduit	PCB: PVC Coated Cast Box	SS: Stainless Steel
EMT: Electrical Metallic Tubing	SB: Steel Box	
AL: Aluminum		

B. MATERIALS.

1. Access Panels and Doors
   a. Lay-in Ceilings:
      i. Removable lay-in ceiling tiles in 2 foot by 2 foot or 2 foot by 4 foot configuration are sufficient; no additional access provisions are required unless specifically indicated.
   b. Drywall and Plaster Walls and Ceilings:
      i. 16 gauge frame with not less than a 20 gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers and similar wet areas, concealed hinges, screwdriver operated cam latch for general application, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needed service; minimum size is 12 inch by 12 inch.
2. Sealing and Fire-Stopping
   i. Refer to Architectural requirements.
   ii. Sealing and fire stopping of sleeves/openings between conduits, cable trays, wire ways, troughs, cable bus, bus duct, etc. and the structural or partition opening shall be the

responsibility of the Contractor whose work penetrates the opening. Individuals skilled in such work shall perform the sealing and fire stopping.

iii. Whenever possible, avoid penetrations of fire and smoke rated partitions. When they cannot be avoided, verify that sufficient space is available for the penetration to be effectively fire and smoke stopped.

iv. Manufacturers:
    i. 3M, STI/SpecSeal, Tremco, or approved equal.
    ii. The same manufacturer shall provide all fire stopping systems.
    iii. The Contractor will be responsible for selecting the appropriate UL tested fire stop system for each application required on the project.

v. Use a product that has a rating not less than the rating of the wall or floor being penetrated. Reference architectural drawings for identification of fire and/or smoke rated walls and floors.

vi. Contractor shall use fire stop putty, caulk sealant, intumescent wrap strips, intumescent fire stop collars, fire stop mortar or a combination of these products to provide a UL listed system for each application required for this project. Provide mineral wool backing where specified in manufacturer's application detail.

3. Non-Rated Penetrations
    a. Conduit Penetrations Through Below Grade Walls:
        iii. In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated conduit and the cored opening or a water-stop type wall sleeve.
    b. Conduit and Cable Tray Penetrations:
        i. At conduit and cable tray penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between conduit and sleeve, or the core drilled opening.

C. CONSTRUCTION.

1. Field Measurements
    a. The Contractor shall obtain from the appropriate trades and review shop drawings for all equipment requiring electrical connections.
    b. Field verify all measurements. Do not base electrical installation or equipment locations on the plans.
    c. Identify conflicts with the work of other trades prior to installation of electrical system.
    d. Electrical installation shall be based upon shop drawing requirements and field verified measurements. Adjust electrical system installation to satisfy field requirements.
2. Delivery, Storage and Handling
    a. Accept electrical equipment on site. Inspect for damage.
    b. Protect electrical equipment from weather, corrosion, and entrance of debris.
3. Installation
    a. Excavation And Backfill:
        i. Perform all excavation and backfill work to accomplish indicated electrical systems installation in accordance with other sections of this specification.
    b. Concrete Work:
        i. Coordinate the quantity and location of all cast-in-place concrete work with the architectural drawings.
        ii. All cast-in-place concrete will be performed by the Contractor unless noted otherwise. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for the support of electrical equipment.
    c. Cutting And Patching:

i. Cutting and patching shall be performed in accordance with the requirements for architectural work. Refer to other sections of these specifications.

d. Building Access:
   i. Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this Contractor, restore any opening to its original condition after the apparatus has been brought into the building.
e. Equipment Access:
   i. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance. Coordinate the exact location of wall and ceiling access panels and doors, making sure that access is available for all equipment and specialties. Where access is required in plaster or drywall walls or ceilings, furnish access doors and arrange for installation with appropriate trades.
f. Working Clearances:
   i. Minimum installed equipment working clearances as required by the NEC shall be maintained.
   ii. Minimum required dedicated electrical equipment space as required by the NEC shall be maintained.
   iii. Coordinate these requirements with the work of other trades.
   iv. Identify conflicts with working space requirements prior to installation of equipment.
g. Coordination:
   i. Cooperate with other trades in locating work in a proper manner. Should it be necessary to raise or lower or move longitudinally any part of the electrical work to better fit the general installation, such work shall be done at no extra cost to the Contracting Authority. The Contractor shall check location of electrical outlets with respect to other installations before installing.
   ii. Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, light fixtures, panel boards, devices, etc. and recessed or semi-recessed heating units installed in/on architectural surfaces.
   iii. Coordinate all work prior to installation. Any installed work that is not coordinated and that interferes with the work of another trade shall be removed or relocated at no additional cost to the Contracting Authority.
   iv. Verify the integrity of fire or smoke ratings where penetrations are required.
h. Sleeves:
   i. Process Equipment Areas:
      - New poured concrete construction: cast in place, Schedule 40, PVC sleeve.
      - All other construction: core drill sleeve openings large enough to insert Schedule 40 PVC sleeve and grout around the sleeve.
      - Floor penetrations:
        - Extend top of sleeve 2 inches above the floor.
        - Where installation of sleeve in floor is not practical, provide 2 inch deep housekeeping pad extending 3 inches around cast in place conduits.
   ii. Non-Process Equipment Areas:
      - Hollow walls: Schedule 40, PVC sleeves, grout around sleeve in masonry construction.
      - All other Areas: core drill sleeve openings large enough to insert Schedule 40 PVC sleeve and utilize the core drilled opening as the sleeve.
   iii. Conduit Support:

- If the pipe penetrating the sleeve is supported by a pipe clamp resting on the sleeve, weld a collar or struts to the sleeve that will transfer weight to the floor structure.

i. Sealing And Firestopping:
   i. Fire and/or Smoke Penetrations:
      - Install approved product in accordance with the manufacturer's instructions where a pipe (i.e. cable tray, bus, cable bus, conduit, wire way, trough, etc.) penetrates a fire rated surface.
      - Where fire stop mortar is used to infill large fire-rated floor openings that could be required to support weight, provide permanent structural forming. Fire stop mortar alone is not adequate to support any substantial weight.
   ii. Non-Rated Surfaces:
      - When the opening is through a non-fire rated wall, floor, ceiling or roof the opening must be sealed using an approved type of material.
      - Install escutcheons or floor/ceiling plates where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces for this paragraph include only those rooms with finished ceilings and the penetration occurs below the ceiling.
      - In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the conduit and tighten in place, in accordance with the manufacturer's instructions.
      - At interior partitions, conduit penetrations are required to be sealed for all areas . Apply sealant to both sides of the penetration in such a manner that the annular space between the conduit sleeve and the conduit is completely filled.

j. Housekeeping and Clean-up
   i. On a daily basis, clean up and remove all debris and rubbish resulting from work and repair all damage to new and existing equipment resulting from work.
   ii. Remove all tools, excess material, and unused equipment from the site when job is complete.

k. General Inspection and Cleaning of Electrical Equipment
   i. Inspect for physical damage and abnormal mechanical or electrical conditions.
   ii. Any item found to be out of tolerance, or in any other way defective as a result of the required testing, shall be reported to the Engineer. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.
   iii. Compare equipment nameplate information with the plans and report any discrepancies.
   iv. Verify proper auxiliary device operation and indicators.
   v. Check tightness of accessible bolted electrical joints. Use torque wrench method.
   vi. Make a close examination of equipment and remove any shipping brackets, insulation, packing, etc. that may not have been removed during original installation.
   vii. Make a close examination of equipment and remove any dirt or other forms of debris that may have collected in existing equipment or in new equipment during installation.
   viii. Vacuum inside of panelboards, switchboards, switchgear, transformer core and coils, horizontal and vertical busducts, MCC's, control panels, and any other similar equipment
   ix. Clean All Equipment:
      - Loosen attached particles and vacuum them away.
      - Remove any remaining packing material adhesives with suitable cleaning solution.
      - Touch-up factory applied finishes damaged during installation using manufacturer approved means to match original finish.

4. Testing and Start-Up Services
    a. Refer to the requirements the individual technical sections.
5. Training
    a. Refer to the requirements the individual technical sections.

154013a.03 UTILITY SERVICES

A. DESCRIPTION.

Provide and install complete and operable utility services as required on the drawings and as specified herein.

1. Summary
    a. Arrange with the Electric Utility for permanent and temporary electric service.
        i. Electric Service:
            - Utility Company: .
                - Mid-American Energy
                - Phone number: 800-329-6261.
            - System Characteristics:
                - Facility type: Storm Water Lift Station.
                - Required service voltage: 277/480V 3-phase, 4-wire.
                - Required service size: 100A.
2. Applicable Publications
    a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the reference thereto.
        i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards
        ii. ANSI/NFPA 70 - National Electrical Code (NEC) and state amendments thereto, Current Edition.
        iii. National Electrical Contractors Association (NECA), Standard of Installation, Current Edition.
        iv. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition.
        v. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition.
3. Related Work Elsewhere
    a. The following divisions may include work which is related to utility services, but which is not included under the scope of this section:
        i. Heating, Ventilating, and Air Conditioning (HVAC)
        ii. Process Integration
        iii. Material Processing and Handling Equipment.
        iv. Process Heating, Cooling, and Drying Equipment.
        v. Industry-specific Manufacturing Equipment.
        vi. Electrical Power Generation.
4. Shop Drawings
    a. Submit shop drawings in accordance with the requirements of Division 11 of the Standard Specifications.
    b. The following information shall be submitted specifically for utility services:
        i. Manufacturer literature sufficient in scope to demonstrate compliance with the requirements of this specification.
        ii. Documentation required by utility company for approval.

5. Quality Assurance
    a. Service entrance and metering equipment provided under this section shall be UL Listed for the service intended and shall be approved by the utility company.

B. CONSTRUCTION.

1. Division of Work
    a. The Contractor shall be responsible for coordinating conductor marking and color coding requirements with control system equipment supplier(s).
2. Field Measurements
    a. Verify existing conditions and dimensions.
    b. Verify that service equipment is ready to be connected and energized.
    c. Make arrangements with utility company and obtain required inspections before energizing service(s).
    d. Coordinate location of utility company facilities to ensure proper access is available.
3. Installation
    a. Install service entrance conduit and conductors in accordance with utility company instructions.
    b. Install metering equipment in accordance with utility company instructions.

154013a.04 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

A. DESCRIPTION.

Furnish and install complete and operable wire and cable systems as indicated on the drawings and as specified herein.

1. Applicable Publications
    a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
        i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
            - NFPA 70 - National Electrical Code.
        ii. ASTM International, originally known as the American Society for Testing and Materials, Specifications and Standards, current edition:
            - ASTM B800-05 Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
            - ASTM B801-99 Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
        iii. National Electrical Contractors Association (NECA), current edition.
            - NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
        iv. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition.
            - U.L. 44 - Rubber-Insulated Wires and Cables.
            - U.L. 50 - Enclosures for Electrical Equipment.
            - U.L. 83 - Thermoplastic-Insulated Wires.
            - U.L. 514B - Conduit, Tubing, and Cable Fittings.
            - U.L. 758 - 220° F Appliance Wiring Materials.
            - U.L. 854 - Service Entrance Cables.
            - U.L. 1063 - Machine-Tool Wires and Cables.

- U.L. 1277 - Type TC Power and Control Tray Cables.
- U.L. 1569 - Metal-Clad Cables
- UL 1581 - Vertical Tray.

2. Submittals
   a. The following information shall be submitted specifically for wire and cable:
      i. Literature sufficient in scope to demonstrate compliance with the requirements of this specification.
      ii. Clearly identify the types of wire and cable proposed.
3. Quality Assurance
   a. Products: Listed and classified by UL or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
   b. Wire and cable manufacturers shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development and production in accordance with ISO 9001.

B. MATERIALS.

1. Wire and Cable – General Purpose (600V, Copper)
   a. Manufacturer: Contractor option.
   b. General:
      i. THWN/THHN general purpose building wire insulated with polyvinyl chloride (PVC) and covered with protective sheath of nylon intended for lighting and power circuits at 600 volts or less, in residential, commercial and industrial buildings.
      ii. The wire shall be suitable for 195°F maximum continuous conductor temperature in dry locations and 170°F in wet locations and listed by Underwriters Laboratories for use in accordance with the National Electrical Code.
   c. Conductors:
      i. Class B or Class C stranded, annealed uncoated copper per UL Standard 83 or 1063.
   d. Insulation:
      i. Each conductor shall be insulated with PVC and sheathed with nylon complying with the requirements of UL Standard 83 for Types THHN/THWN and UL Standard 1063 for Type MTW and CSA C22.2 No. 75 for T90 Nylon.
      ii. Types THWN/THHN shall comply with the optional Gasoline and Oil Resistant rating of UL Standard 83. The insulation shall also comply with UL requirements for 220°F Appliance Wiring Material.
      iii. The average thickness of PVC insulation, for a given conductor size, shall be as specified in UL Standard 83 for Types THWN or THHN. The minimum thickness at any point, of the PVC insulation, shall be not less than 90% of the specified average thickness.
      iv. The minimum thickness at any point of the nylon sheath shall be as specified in UL Standard 83 for Types THWN or THHN.
      v. The PVC insulation shall be applied tightly to the conductor and shall be free-stripping.
   e. Identification:
      i. The wire shall be identified by surface marking indicating manufacturer's identification, conductor size and metal, voltage rating, UL Symbol, type designations and optional ratings. The wire shall also be identified as C(UL) Type T90 Nylon or TWN75, FT1.
   f. Tests:
      i. Wire shall be tested in accordance with the requirements of UL Standard 83 for Types THWN or THHN wire and for the optional Gasoline and Oil Resistant listings; as Type MTW to UL Standard 1063 (stranded items); as AWM to UL Standard 758 (stranded items); and as C(UL) Type T90 Nylon or TWN75.

vii. Usage:
    i. General use power wiring, minimum size No.12 AWG.
    ii. General use control wiring, minimum size No.14 AWG.

2. Shielded Power Cable (600V)
    a. Manufacturer
        i. Contractor option.
    ii. General:
        i. Three conductor type TC Tray Cable insulated with cross linked polyethylene and PVC jacket overall, for use on circuits rated 600 volts and 195°F maximum continuous conductor temperature in wet or dry locations.
        ii. Cables approved for installation in cable trays in accordance with the NEC and for installation in air, in ducts or conduits, in tray or trough, in open wiring or direct buried.
    iii. Conductors:
        i. Shall be Class B stranded uncoated soft copper.
        ii. Suitable separator over the conductor may be used at the option of the manufacturer.
        iii. Three phase conductors shall be cabled together with a Class B stranded, uncoated copper grounding conductor and suitable non-hygroscopic fillers to make round.
        iv. Length of lay shall not exceed 35 times the phase conductor diameter.
        v. The grounding conductor shall comply with the requirements of UL Standard 1277.
        vi. The cable assembly shall be covered with a copper tape shield with drain wire, applied with a 10% minimum lap.
    iv. Insulation:
        i. Each phase conductor shall be insulated with chemically cross linked polyethylene, meeting Type XHHW-2 requirements of Underwriters Laboratories.
        ii. The average thickness of insulation shall be as specified in UL Standard 44 for Type XHHW-2 conductors. The minimum thickness at any point shall be not less than 90% of the specified average thickness.
        iii. The insulated phase conductors shall be black in color and shall be printed with the numerals "1", "2", and "3" on their surface.
        iv. Each cable shall have a PVC protective jacket applied over the taped assembly. The jacket shall meet the Sunlight Resistant requirements of UL Standard 1277.
        v. The average jacket thickness shall be in accordance with UL Standard 1277. The minimum thickness at any point shall be not less than 80% of the specified average thickness.
    v. Identification:
        i. Cables shall be identified by means of surface ink printing indicating manufacturer, number of conductors, size, voltage rating, and required UL information.
    vi. Tests:
        i. Individual conductors and completed cables shall be tested in accordance with UL requirements for Type TC Power Control Tray Cables having XHHW-2 conductors.
        ii. Cables shall be capable of passing the ribbon burner cable tray flame test requirements of UL and IEEE.
    vii. Usage:
        i. Power wiring for motor loads controlled by adjustable frequency drives, where so indicated on the drawings.

3. Shielded Instrumentation Cable (300V)
    a. Manufacturer: Contractor option.
    b. General:

i. Power limited tray cable - two conductor, No.16 AWG (7x24) bare copper, PVC insulation, overall shield with No.18 AWG (7x26) tinned copper drain wire, PVC jacket with nylon ripcord.

c. Electrical Characteristics:
   i. Max. Operating voltage: 300Vrms
   ii. Conductor DC resistance at 70°F: 3.7 ohms per 1000 feet
   iii. Shield DC resistance at 70°F: 5.1 ohms per 1000 feet
   iv. Capacitance between conductors at 1 kHz: 61 picofarads per foot
   v. Capacitance between conductor and shield at 1 kHz: 114 picofarads per foot
   vi. Inductance: 0.19 microhenries per foot
d. Physical Characteristics:
   i. Temperature rating: -20°F to 220°F
   ii. Insulation material: PVC
   iii. Average insulation thickness: 0.016 inches
   iv. Jacket material: Sun resistant PVC.
   v. Jacket thickness: 0.037 inches nominal
   vi. Shield: Aluminum/Polyester, 100% coverage.
   vii. Overall lay length: 2 inches (6 twists per foot)
   viii. Maximum pulling tension: 94 pounds
   ix. Minimum bend radius: 2.6 inches
   x. Flame resistance: UL 1581 vertical tray.
e. Usage:
   i. Instrumentation cable.

C. CONSTRUCTION.

1. Field Measurements
   a. Field verify all measurements. Do not base electrical installation or equipment locations on the plans.
   b. Identify conflicts with the work of other trades prior to installation of electrical system.
   c. Adjust electrical system installation to satisfy field requirements.
2. Delivery, Storage and Handling
   a. Accept electrical equipment on site. Inspect for damage.
   b. Protect electrical equipment from weather, corrosion, and entrance of debris.
3. Installation
   a. Pre-Installation:
      i. Verify that interior of building has been protected from weather.
      ii. Verify that mechanical work likely to damage wire has been completed.
      iii. Completely and thoroughly swab raceway prior to installation.
      iv. Verify that field measurements are as shown on drawings.
      v. Wire and cable routing shown on drawings is approximate unless dimensioned. Route wire and cable to satisfy project conditions.
      vi. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.
      vii. Determine required separation between cable and other work.
      viii. Determine cable routing to avoid interference with other work.
      ix. Any single conduit or raceway utilized for a feeder circuit shall contain only power conductors of a single feeder circuit. Do not combine feeder circuits without engineer's written approval.

x. Plans indicate individual homerun equipment connections. Contractor may combine branch circuits of common types in single conduits provided the following conditions are met:
   - NEC requirements for conductor de-rating are satisfied.
   - Conduit fill does not exceed thirty percent. Ten percent fill shall be reserved for future use.

xi. No more than eight 24VDC analog circuits may be combined in a single conduit unless specifically stated otherwise on the drawings.

b. Conductor Sizing:
   i. Conductor sizes are based on copper unless otherwise noted.
   ii. Use conductor not smaller than No.12 AWG for power and lighting circuits.
   iii. Use No.10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet.
   iv. Where circuit wiring length exceeds length identified on the feeder schedule, increase wire size as needed to maintain a maximum voltage drop of three percent.
   v. Use conductor not smaller than No.14 AWG for control circuits.
   vi. Unless shown otherwise on the plans, power wiring shall be No. 12 AWG.

c. Wire Pulling:
   i. Pull all conductors into raceway at same time.
   ii. No. 4 AWG and larger wire and power cables shall lubricated with pulling lubricant to reduce pulling tension and abrasion damage. The lubricant shall be water or wax based containing no oils or greases that may adversely affect cable jackets.
   iii. The minimum bend radius and maximum pulling tension ratings of the wire and cable shall not be exceeded.

d. Splices and Terminations:
   i. Splices and terminations shall not be made within raceways.
   ii. Clean conductor surfaces before splicing or terminating.
   iii. Make splices, taps, and terminations to carry full amp capacity of conductors with no perceptible temperature rise.
   iv. Insulated spring wire connectors may be used to splice 120V power circuits.
   v. Control, communication, and data transmission wire and cable shall not be spliced.
   vi. Use split bolt connectors for copper conductor splices and taps, No. 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150% of insulation rating of conductor.
   vii. Use solderless pressure connectors with insulating covers for copper conductor splices and taps, No. 8 AWG and smaller.
   viii. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, No. 10 AWG and smaller.

e. Motors:
   i. Motor wiring to motors less than 10 horsepower shall be spliced and terminated with fully insulated crimp-on end cap with a layer of self-vulcanizing rubber tape, followed by five layers of vinyl electrical tape. “SkotchLocks” and similar devices shall not be used.
   ii. Motor wiring to motors 10 horsepower or larger shall be spliced and terminated with crimp-on ring terminal lugs, brass nuts, bolts and washers with a layer of self-vulcanizing rubber tape, followed by five layers of vinyl electrical tape. “SkotchLocks” and similar devices shall not be used.

f. Unshielded power cables:
   i. Unshielded power cables shall be spliced and terminated with crimp-on ring terminal lugs, brass nuts, bolts and washers with a layer of self-vulcanizing rubber tape, followed

by five layers of vinyl electrical tape. “SkotchLocks” and similar devices shall not be used.

4. Testing and Start-Up Services
   a. Inspect wire for physical damage and proper connection.
   b. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
   c. Verify continuity of each conductor.
   d. Feeder or branch circuits with ampacity greater than 100 amperes shall be tested after installation to measure insulation resistance of each conductor.
   e. All equipment shall be disconnected and the wire ends shall be cleaned and dried.
   f. Connect Megohmeter between conductor and a grounded point in the enclosure and energize until the reading stabilizes.

154013a.05 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

A. DESCRIPTION.

Furnish and install complete and operable grounding and bonding systems as indicated on the drawings and as specified herein.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - NFPA 70 - National Electrical Code.
         - ANSI/NFPA 99 - Health Care Facilities.
      ii. National Electrical Contractors Association (NECA), current edition.
         - NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
      iii. National Electrical Manufacturers Association (NEMA), Specifications and Standards, Current Edition.
      iv. Underwriters Laboratories, Inc. (UL), Specifications and Standards, Current Edition.
      v. Institute of Electrical and Electronics Engineers (IEEE), Specifications and Standards, current edition:
         - IEEE 837 - Standard for Qualifying Permanent Connections Used in Substation Grounding.
2. Quality Assurance
   a. Measure ground resistance from system neutral connection at service entrance to convenient ground reference point using suitable ground testing equipment. Resistance shall not exceed 2 ohms. Additional grounding electrodes shall be used to satisfy ground resistance requirements where required by earth conditions.

B. MATERIALS.

1. Rod Electrode
   a. Material: Copper-clad steel.
   b. Diameter: 3/4-inch minimum.
   c. Length: 10-feet minimum. Rod shall be driven at least 9.5-feet deep.
   d. Use one or more ground rods to obtain the minimum specified ground resistance. This applies to manholes, padmount switches, transformers, service entrances, and all other equipment requiring a supplemental grounding electrode. Minimum of three ground rods shall be used to ground the service entrance as indicated on plans.

2. Mechanical Connectors
    a. The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper alloy material. Bolts, nuts, washers and lockwashers shall be made of silicon bronze and supplied as a part of the connector body and shall be of the two bolt type.
    b. Split bolt connector types are not allowed.
    c. The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size and manufacturer.
    d. Grounding access wells shall be provided for access to underground mechanical grounding connections. Access well shall be ANSI Tier rated for the area in which it is installed.
3. Compression Connectors
    a. The compression connectors shall be manufactured from pure wrought copper. The conductivity of this material shall be no less than 99%.
    b. The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.
    c. The installation of the connectors shall be made with a compression, tool and die system, as recommended by the manufacturer of the connectors.
    d. The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the required compression tool settings.
    e. Each connector shall be factory filled with an oxide-inhibiting compound.
4. Exothermic Connections
    a. Select the appropriate kit for specific types, sizes, and combinations of conductors and other items to be connected. Field personnel shall be trained in execution of welds.
5. Wire
    a. Material: Stranded copper (aluminum not permitted).
    b. Grounding Electrode Conductor: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger.
    c. Manhole and Vault Bonding: No. 4/0 minimum.
    d. Feeder and Branch Circuit Equipment Ground: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger. Differentiate between the normal ground and the isolated ground when both are used on the same facility.

C. CONSTRUCTION.

1. Field Measurements
    a. Field verify all measurements. Do not base electrical installation or equipment locations on the plans.
    b. Identify conflicts with the work of other trades prior to installation of electrical system.
    c. Adjust electrical system installation to satisfy field requirements.
2. Installation
    a. General:
        i. Verify that final backfill and compaction has been completed before driving rod electrodes.
        ii. Install products in accordance with manufacturer instructions.
        iii. Mechanical connections shall be accessible for inspection and checking. No insulation shall be installed over mechanical ground connections.
        iv. Ground connection surfaces shall be cleaned and all connections shall be made so that it is impossible to move them.
        v. Attach grounds permanently before permanent building service is energized.

vi. Install rod electrodes at locations indicated or as required by local code, whichever requires the most rods. Install additional rod electrodes as required to achieve specified resistance to ground.
vii. Connect grounding electrode conductor and reinforcing steel in foundation footing. Bond steel together.
viii. Bond all conductive components to meet Regulatory Requirements.
ix. Bond together metal siding not attached to grounded structure; bond to ground.
x. All separate ground wires shall be enclosed in rigid galvanized steel conduit and bonded at both ends to the rigid galvanized steel conduit with an approved fitting.

b. Less than 600 volt system grounding:
i. Supplementary Grounding Electrode: Use driven ground rod on exterior of building.
ii. Copper grounding electrode conductor shall be sized as indicated or as required by NEC, whichever is larger and shall be extended from secondary service system neutral to street side of water meter, building steel, ground rod, and any concrete encased electrodes. Bonding jumper shall be installed around water meter. Install conductor in separate rigid conduit. Bond conduit as described above.
iii. Receptacle Grounding: All receptacles installed shall have a separate grounding contact.
iv. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.
v. Bond together each metallic raceway, pipe, duct and other metal objects.
vi. Equipment Grounding Conductor: Separate, insulated green conductor shall be installed within each raceway and cable tray, sized per NEC or as indicated in the contract documents whichever is larger. Terminate each end on suitable lug, bus, enclosure or bushing, per NEC. Install a ground wire from each device to the respective enclosure.

3. Testing and Start-Up Services
a. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

154013a.06 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

A. DESCRIPTION.

Furnish and install supporting devices as indicated on the drawings, scheduled in Common Work Results for Electrical, and as specified herein.

1. Applicable Publications
a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
i. American Iron and Steel Institute (AISI), Specifications and Standards, current edition.
ii. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
- NFPA 70 - National Electrical Code.

iii. American Society for Testing and Materials (ASTM), Specifications and Standards, current edition:
- ASTM A653 - General Requirements for Steel Sheet, Zinc-Coated Galvanized by the Hot-Dip Process.
- ASTM A1011 - Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Ally and High-Strength Low Alloy with Improved Formability (Formerly ASTM A570).

- ASTM F1136 - Standard Specification for Chromium/Zinc Corrosion Protective Coatings for Fasteners.
- ASTM A907 - Standard Specification for Steel, Sheet, and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled, Structural Quality.
- ASTM B633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

iv. National Electrical Contractors Association (NECA), current edition.
- NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
- NECA 101 - Standard for Installing Steel Conduit (Rigid, IMC, EMT).

v. Metal Framing Manufacturers Association (MFMA), Specifications and Standards, current edition.

2. Submittals
   a. The following information shall be submitted specifically for supporting devices:
      i. Submit outline drawings and dimensions for equipment support racks.
3. Quality Assurance
   a. Bolted framing channels and fittings shall have the manufacturers name, part number, and material heat code identification number stamped in the part itself for identification. Material certification sheets and test reports must be made available by the manufacturer upon request
   b. Stainless steel bolted framing parts shall be stamped to identify the material. Material certification sheets and test reports must be made available by the manufacturer upon request.

B. MATERIALS.

1. Strut, Channels, and Connectors
   a. Manufacturers:
      i. Cooper B-Line, Inc.
      ii. Unistrut
      iii. Supertrut
      iv. Or equal
   b. General:
      i. Strut shall be 1 5/8 inches wide in varying heights and welded combinations as required to meet load capacities and designs indicated on the drawings.
   c. Materials and Finish:
      i. Aluminum: Strut shall be manufactured of extruded aluminum alloy 6063-T6. All fittings and hardware shall be zinc plated according to ASTM B633 (SC3 for fittings, SC1 for threaded hardware) for indoor use only. For outdoor use, all fittings and hardware shall be stainless steel Type 304.
      ii. Hot-dip Galvanized Steel: Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS, Grade 33 and shall be hot-dip galvanized after fabrication in accordance with ASTM A123. Fittings shall be manufactured from steel meeting the minimum requirements of ASTM A907 SS, Grade 33, and hot-dip galvanized after fabrication in accordance with ASTM A123. All hardware shall be stainless steel Type 304 or chromium zinc ASTM F1136 Gr. 3. All hot-dip galvanized after fabrication products must be returned to point of manufacture after coating for inspection and removal of all sharp burrs.
      iii. Stainless Steel: All strut, fittings and hardware shall be made of AISI Type 304 stainless steel.

2. Anchors and Fasteners
    i. Concrete and Structural Elements: Use stainless steel precast insert system, expansion anchors and preset inserts.
    ii. Steel Structural Elements: Use stainless steel beam clamps.
    iii. Concrete Surfaces: Use stainless steel self-drilling anchors and expansion anchors.
    iv. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts or hollow wall fasteners.
    v. Solid Masonry Walls: Use stainless steel expansion anchors and preset inserts.
    vi. Sheet Metal: Use stainless steel sheet metal screws.
    vii. Wood: Use stainless steel wood screws.
    viii. All other fasteners: stainless steel screws, suitable for the required usage.
3. Hardware
    a. Conduit and equipment supports, clamps, and other miscellaneous materials shall be constructed of the following materials as scheduled in Common Work Results for Electrical.
        i. Steel.
        ii. Zinc plated steel.
        iii. Galvanized, malleable iron.
        iv. PVC coated, galvanized, malleable iron.
        v. Stainless steel.
        vi. PVC.

C. CONSTRUCTION.

1. Field Measurements
    a. Field verify all measurements. Do not base locations and dimensions on the plans.
    b. Identify conflicts with the work of other trades prior to installation of electrical equipment.
    c. Adjust equipment support rack installation to satisfy field requirements.
2. Delivery, Storage, and Handling
    a. Accept supporting devices on site. Inspect for damage.
    b. Protect supporting devices from corrosion and damage. Do not install damaged materials.
3. Installation
    a. General:
        i. Furnish and install supports and fasteners for all electrical components required for the project, including free standing supports required for those items remotely mounted from the building structure, catwalks, walkways etc.
        ii. Thoroughly clean and remove construction debris from installation.
    b. Strut Channel:
        i. Install strut in accordance with MFMA-102 "Guidelines for the Use of Metal Framing"; in accordance with equipment manufacturer's recommendations, and with recognized industry practices.
        ii. Fabricate supports from channel. Rigidly weld members or use hexagon head bolts to present a neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.
        iii. File and de-bur cut ends of galvanized support channel and spray paint with cold galvanized paint to prevent rusting.
        iv. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.
    c. Anchors and Fasteners:
        i. Provide anchors, fasteners, and supports in accordance with NECA "Standard Practices for Good Workmanship in Electrical Contracting".

ii. Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit.
iii. Do not use spring steel clips and anchors.
iv. Do not use powder-actuated anchors.
v. Obtain permission from Engineer before drilling or cutting structural members.
vi. Install surface-mounted cabinets and panelboards with minimum of four anchors.
vii. Use channel supports to stand cabinets and panelboards 1-5/8-inch off interior or exterior surfaces of exterior walls.
viii. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using anchors and fasteners.
ix. Install free-standing electrical equipment on 3-inch concrete pads unless indicated otherwise on the drawings.
x. Use threaded rod, minimum size 3/8 inch, for supports where indicated on the drawings.
xi. Install products in accordance with manufacturer instructions.

154013a.07 CONDUIT

A. DESCRIPTION.

Furnish and install complete and operable conduit system as indicated on the drawings, scheduled in Common Work Results for Electrical and as specified herein.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - ANSI C80.1 - Electrical Rigid Steel Conduit (ERSC).
         - ANSI C80.3 - Steel Electrical Metallic Tubing (EMT).
         - ANSI C80.5 - Electrical Rigid Aluminum Conduit (ERAC).
         - NFPA 70 - National Electrical Code.
      ii. American Society for Testing and Materials (ASTM), Specifications and Standards, current edition:
         - ASTM F2160 - Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter.
         - ASTM D2239 - Polyethylene (PE) Plastic Pipe (SIDR) Based on Controlled Inside Diameter.
         - ASTM D3035 - Polyethylene (PE) Plastic Pipe (SDR) Based on Controlled Outside Diameter.
         - ASTM D3350 - Polyethylene Plastics Pipe and Fittings Materials.
      iii. National Electrical Contractors Association (NECA), current edition.
         - NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
         - NECA 101 - Standard for Installing Steel Conduit (Rigid, IMC, EMT).
      iv. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition.
         - NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; National Electrical Manufacturers Association.
         - NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit; National Electrical Manufacturers Association.

- NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit; National Electrical Manufacturers Association.
- NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing; National Electrical Manufacturers Association.
- NEMA TC 7 - Smooth Wall Coilable Polyethylene Electrical Plastic Conduit.

v. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition.

- UL 1 - Standard for Flexible Metal Conduit
- UL 6 - Electrical Rigid Metal Conduit - Steel.
- UL 6A - Standard for Electrical Rigid Metal Conduit - Aluminum and Stainless Steel.
- UL 651A Type EB and A Rigid PVC Conduit and HDPE conduit.
- UL 651B Continuous Length HDPE.
- UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit.
- UL 2239 - Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable.

2. Submittals
   a. Submit the following information specifically for conduit:
      i. Manufacturer literature sufficient in scope to demonstrate compliance with the requirements of this specification.
      ii. Clearly identify the types of conduit and fittings proposed.
2. Quality Assurance
   a. Products: Listed and classified by UL or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

B. MATERIALS.

1. Galvanized Rigid Metal Conduit (Type RMCS)
   a. Manufacturer: Contractor option.
   b. Conduit:
      i. Impact and crush resistant mild steel tube with an accurate circular cross section, a uniform wall thickness, a defect free interior surface, and a continuous welded seam.
      ii. Interior and exterior surfaces thoroughly and evenly coated with zinc using the hot-dip galvanizing process.
      iii. Top-coated with a compatible organic layer to inhibit white rust and increase corrosion resistance.
      iv. Factory cut threads, 0.75 inch taper per foot, protected after cutting with an application of molten zinc.
   c. Conduit Bodies:
      i. Ferrous metal construction electro-galvanized inside and out and coated with aluminum acrylic paint.
      ii. Tapered, threaded hubs with integral bushing.
      iii. Stainless steel hardware.
      iv. Cover constructed of same material with solid gasket.
   d. Fittings:
      i. Ferrous metal construction electro-galvanized inside and out.
      ii. Components critical to performance such as set screws, split rings, and locknuts constructed of hardened steel or adequately designed to insure positive bonds.
2. PVC Galvanized Rigid Metal Conduit (Type RMCCS)
   a. Manufacturer:
      i. Perma-Cote Industries.

ii. Robroy.
iii. Ocal
iv. Plasti-Bond
v. Or equal.

b. General:
i. Conduit shall be UL Listed and the coating shall have been investigated by UL as providing the primary corrosion protection for the rigid metal conduit.
ii. Independent certified test results shall be available to confirm coating adhesion under the following conditions:
iii. Conduit immersed in boiling water with a minimum mean time to adhesion failure of 200 hours.
iv. Conduit and condulet exposure to 150°F and 95% relative humidity with a minimum mean time to failure of 30 days.
v. No trace of internal coating shall be visible on a white cloth following six wipes over the coating that has been wetted with acetone.
vi. The exterior coating bond shall be confirmed using the methods described in Section 3.8, NEMA RN1. After these tests the physical properties of the exterior coating shall exceed the minimum requirements specified in Table 3.1, NEMA RN1.

c. Conduit:
i. Impact and crush resistant mild steel tube with an accurate circular cross section, a uniform wall thickness, and a defect free interior surface, and a continuous welded seam.
ii. Interior and exterior surfaces thoroughly and evenly coated with zinc using the hot-dip galvanizing process.
iii. Factory cut threads, 0.75 inch taper per foot, protected after cutting with an application of molten zinc.
iv. Coating:
- External: PVC, 40 mils nominal, free of blisters, bubbles, and pinholes.
- Internal: Urethane, 2 mils minimum.

v. Threaded connections:
- Factory threads: factory coated.
- Field threads: protected by coating sleeve extension on female fitting. Sleeve extension shall be equivalent in length to the nominal conduit size and the inside diameter less than the outside diameter of the coated conduit.

vi. Strength:
- Coating bond to conduit shall be stronger than tensile strength of coating. Field cut, thread, and bent conduit shall not damage conduit.

d. Conduit Bodies:
i. Ferrous metal construction electro-galvanized inside and out and PVC coated to match the conduit.
ii. Tapered, threaded hubs with integral bushing.
iii. Stainless steel or encapsulated stainless steel hardware.
iv. PVC coated cover constructed of same material with solid tongue-in-groove gasket.

e. Fittings:
i. Ferrous metal construction electro-galvanized inside and out and PVC coated to match conduit.

3. Rigid Aluminum Conduit (Type RMCA)
a. Manufacturer:
i. Contractor option.

b. Conduit:
   i. Heavy wall tube manufactured of 6063 aluminum alloy in temper designation T-1 with an accurate circular cross section, a uniform wall thickness and a defect free interior surface.
   ii. Factory cut threads, 0.75 inch taper per foot.
c. Conduit Bodies:
   i. Copper free aluminum construction coated with aluminum acrylic paint.
   ii. Tapered, threaded hubs with integral bushing.
iii. Stainless steel hardware.
iv. Cover constructed of same material with solid gasket.
d. Fittings:
   i. Copper free aluminum construction.
   ii. Components critical to performance such as setscrews, split rings, and locknuts are adequately designed to insure positive bonds.

4. Rigid Non-Metallic Conduit (Type RNC)
   a. Manufacturer:
      i. Carlon.
      ii. Cantex
      iii. Prime Conduit
      iv. Or equal.
   b. Conduit:
      i. Made from polyvinyl chloride compound (recognized by UL), which includes inert modifiers to improve weatherability and heat distortion.
      ii. Rated for use with 195°F conductors. Material shall comply with NEMA Specification TC-2.
      iii. The conduit and fittings shall be homogeneous plastic material free from visible cracks, holes or foreign inclusions. The conduit bore shall be smooth and free of blisters, nicks or other imperfections, which could mar conductors or cables.
      iv. Conduit, fittings and cement shall be produced by the same manufacturer to assure system integrity.
      v. Schedule 80 non-metallic conduit shall be used in locations subject to physical damage. Schedule 40 non-metallic conduit may be used in all other locations.
   c. Conduit Bodies:
      i. Made from polyvinyl chloride compound (recognized by UL), which includes inert modifiers to improve weatherability and heat distortion.
      ii. Rated for use with 105°F conductors. Material shall comply with NEMA Specification TC-3.
      iii. Stainless steel hardware.
      iv. Cover constructed of same material with solid gasket.
   d. Fittings:
      i. Made from polyvinyl chloride compound (recognized by UL), which includes inert modifiers to improve weatherability and heat distortion.
      ii. Rated for use with 105°F conductors. Material shall comply with NEMA Specification TC-3.

C. CONSTRUCTION.

1. Field Measurements
   a. The Contractor shall obtain from the appropriate trades and review shop drawings for all equipment requiring electrical connections. Conduit rough-in shall be based upon shop drawing requirements.

b. The Contractor shall be responsible for coordinating conduit location and rough-in with actual equipment conditions and requirements.
c. Field verify all measurements. Do not base conduit rough-in or equipment locations on the plans.
d. Identify conflicts with the work of other trades prior to installation of electrical equipment and conduit work.
e. Adjust conduit system installation to satisfy field requirements.

2. Delivery, Storage, and Handling
   a. Accept conduit on site. Inspect for damage.
   b. Protect conduit from corrosion and entrance of debris.
   c. Store conduit above grade. Protect from environment with suitable covering.
   d. Protect PVC and PVC coated conduit from sunlight.
3. Installation
   a. General:
      i. Install conduit in accordance with NECA "Standard Practices for Good Workmanship in Electrical Contracting", all requirements of the NEC, and manufacturer recommended practices.
      ii. Arrange conduit to maintain headroom and present neat appearance.
      iii. Design raceway systems to minimize the number of fittings, couplings, kicks, and offsets.
      iv. Raceways located above lowest floor level:
         - Route conduit parallel and perpendicular to walls.
         - All raceways shall be level and straight.
         - Vertical conduits shall be plumb.
      vi. Raceways located in or under lowest level floor:
         - Route conduit in and under slab from point-to-point.
         - Do not cross conduits in slab.
      vii. Do not use flexible conduit in place of bends, conduit bodies, or expansion fittings.
      viii. Flexible conduit shall be used at all equipment terminations. Maximum length of 24-inches unless specifically allowed otherwise by Engineer based upon field conditions.
      ix. Do not use cords for equipment connections unless specifically allowed otherwise by Engineer based upon field conditions.
   b. Raceway sizing:
      i. Size raceways as indicated on drawings.
      ii. Where raceways sizes are not indicated on drawings, size in accordance with NEC requirements. Minimum size 3/4 inch.
      iii. Exposed conduit runs not longer than 10 feet in length and terminating at a single device may be 1/2 inch unless prohibited by NEC.
   c. Raceway Installation:
      i. Maintain adequate clearance between conduit and piping.
      ii. Maintain 12 inch clearance between conduit and surfaces with temperatures exceeding 104°F.
      iii. Cut conduit square using saw or pipe cutter; de-burr cut ends.
      iv. Bring conduit to shoulder of fittings; fasten securely.
      v. Use conduit hubs to fasten conduit to NEMA 4X and NEMA 12 boxes.
      vi. Install no more than equivalent of three 90 degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic factory elbows for bends in metal conduit larger than 2 inch size.
      vii. Avoid moisture traps; install junction box with drain fitting at low points in conduit system.

viii. Suitable pull string shall be installed in each empty conduit, sleeves and nipples excepted.
ix. Use suitable caps to protect installed conduit against entrance of dirt and moisture.
x. Remove all debris and moisture from raceways prior to installing conductors.
xi. Ground and bond conduit under provisions of Grounding And Bonding For Electrical Systems.
xii. Identify conduit under provisions of Identification For Electrical Systems.
xiii. Install plastic coated conduit in accordance with manufacturer's instructions. All 90 degree bends shall be manufactured elbows. Touch-up PVC coating after installation.
xiv. All field cut threads shall be coated with Thomas & Betts Kopr-Shield prior to assembly.

d. Structural Coordination:
   i. Suitable fittings, designed and listed for the purpose, shall be used to accommodate expansion and deflection where conduit crosses seismic, control and expansion joints.
   ii. Install conduit to preserve fire resistance rating of partitions and other elements.
   iii. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate location with roofing installation.
   iv. Where conduit passes between areas subject to variable temperatures, seal conduits to prevent air interchange and condensation formation. Use conduit fitting specifically manufactured for this purpose.
e. Raceway Support:
   i. General:
      - Arrange supports to prevent misalignment during wiring installation.
      - Do not permanently support conduit with wire or perforated pipe straps.
      - Remove wire used for temporary supports.
      - Do not attach conduit to ceiling support wires.
      - Channel, rod, and hardware shall comply with the requirements of Hangers And Supports For Electrical Systems.
   ii. Hardware:
      - Construct conduit support rack with channel and rod to support conduits not supported from structure.
      - Support conduit with channel anchored to structure when conduit offset from structure is required.
      - Secure conduits to channel with pipe straps.
      - Support conduit from structure when conduit offset from structure is not required.
      - Secure conduits directly to structure with one-hole strap and conduit spacer.
e. Conduit Separation:
   i. Separate conduit systems shall be used for the following circuit categories:
      - 120 volt power circuits.
      - 480 volt power circuits. 120 volt control circuits.
      - 24 VDC analog control circuits.
      - Intrinsically safe control circuits.
      - UTP control cables.
      - Manufacturer supplied cables (for example, magnetic flow meter cables).
      - Radio frequency coaxial cables (for example, antenna cables).
   ii. The plans show individual homerun equipment connections. The Contractor may combine circuits of common types (as identified above) into single conduits provided the following conditions are met:
      - NEC requirements for conductor de-rating are satisfied.

- Conduit fill does not exceed thirty percent. Ten percent fill shall be reserved for future use.
- No more than eight 24VDC analog circuits are combined in a single conduit, unless specifically stated otherwise on the drawings.
- Motor feeder circuits shall not be combined and shall be run in separate conduits.

154013a.08 IDENTIFICATION FOR ELECTRICAL SYSTEMS

A. DESCRIPTION.

Furnish and install electrical identification systems as indicated on the drawings and as specified herein.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - NFPA 70 - National Electrical Code.
         - ANSI Z535.4 - Product Safety Signs and Labels.
      ii. National Electrical Contractors Association (NECA), current edition.
         - NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.

B. MATERIALS.

1. Nameplates
   a. Engraved two-layer laminated plastic, black letters on white background.
   b. Lettering:
      i. 1/4 inch letters for identifying individual equipment and loads.
      ii. 1/2 inch letters for identifying grouped equipment and loads.
2. Conductor Marking
   a. The ends of each conductor shall be marked with circuit number, motor number, wire or terminal number.
   b. Control system wire marking shall be coordinated with control system and equipment shop drawings.
   c. Labels shall be typed in black lettering with indelible ribbons on a white, heat shrink sleeve. Markers shall be shrunk around the wire to ensure a tight, non-slip bond with a compatible heat gun.
   d. Heat shrink wire markers shall be Brady Bradysleeve Type B-321 or B-322.
3. Conductor Color Coding
   a. Conductors No.6 AWG and smaller shall be provided with color coded insulation as described herein. Conductors larger than No.6 AWG may be color coded with appropriately colored Scotch No.35 tape at each end.
   b. Color Coding:
      i. 277/480 vac system shall be colored brown, orange, yellow, and gray for phases A, B, C, and neutral respectively.
      ii. 120/208 vac system shall be colored black, red, blue, and white for phases A, B, C, and neutral respectively.
      iii. 120/240 vac shall be colored black, red, and white for Line 1, Line 2, and neutral respectively.
      iv. 120 vac control wiring shall be colored red.
      v. 24 VDC control wiring shall be colored purple and purple with white stripe for positive and negative conductors respectively.

vi. Intrinsically safe control wiring shall be colored light blue.
vii. Conductors within control cabinets and motor control centers which are supplied from an external source shall be colored yellow.
viii. Grounding conductor and equipment ground conductors shall be colored green.

4. Conduit Marking
   a. Colored band markers shall be field painted.
   b. Color:
      i. 480 Volt System: Yellow.
      ii. 208 Volt and 240 Volt System: White.
      iii. Fire Alarm System: Red.
      iv. Low Voltage Communication System: Black.
      v. Process Instrumentation and Control System: Blue.
5. Equipment, Enclosure, and Cabinet Warning Signs
   a. Electrical Voltage and Shock Hazard Signs
      i. Provide OSHA Voltage and Shock Hazard sign for each electrical enclosure, cabinet, or other piece of equipment that presents an electrical hazard under normal operating circumstances or presents an electrical hazard while the enclosure is open.
   b. Electrical Arc Flash Hazard Signs
      i. Provide Arc Flash Hazard sign for each electrical enclosure, cabinet, or other piece of equipment that presents an arc flash hazard in accordance with NEC and ANSI Z535.4.
   c. Electrical Source Signs
      i. Provide sign indicating voltage level and source for each component of the power distribution system and for all control panels.
      ii. Provide indicating multiple sources where equipment is fed from multiple sources or where signal wiring is present that is powered from a source external to the equipment.

C. CONSTRUCTION.

1. Installation

a. Nameplates:
   i. Provide nameplates for grouped equipment such as panelboards, transformers, motor control centers, and control panels. Nameplate shall identify tag number, voltage, ampere rating, and description.
   ii. Provide nameplates for individual equipment such as motor control center compartments, field instruments, and field control stations. Nameplate shall identify tag number and description.
   iii. Provide nameplates for individual receptacles. Nameplate shall identify panel and circuit number supplying the receptacle.
   iv. Provide nameplates for control cabinets and motor control center compartments which contain wiring supplied from an external source. Nameplate shall state: Multiple power sources within, verify all power supplies are disconnected before servicing equipment.
   v. Nameplates shall be secured to the front of equipment enclosures with stainless steel screws or rivets. Double sided tape will not be acceptable.
   vi. Secure nameplates for flush mounted panelboards behind the panelboard door.
b. Conductor Marking:
   i. Mark conductors at every termination and splice point.
   ii. Mark conductors with wire numbers identified by control system supplier, with panel and circuit identification, or with MCC compartment and wire numbers.
c. Conduit Marking:

i. Furnish colored band markers for each conduit longer than six feet and mark each conduit a minimum of twenty feet on center.

154013a.09 ADJUSTABLE FREQUENCY MOTOR CONTROLLERS

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated process instrumentation and control system, the work specified herein shall be included under the scope of Process Instrumentation & Control. This section specifies the complete ffurnishing and installation and operation of adjustable frequency drive systems as indicated on the drawings and as specified herein. Motor control equipment specified under this section shall be the product of a single manufacturer unless stated otherwise. Adjustable frequency drive systems work may include work in new motor control centers and/or work in existing motor control centers. Refer to the drawings for detailed description of the work.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - NFPA 70 - National Electrical Code.
      ii. Canadian Standards Associates (CSA), Specifications and Standards, Current Edition.
      iii. European Committee for Electrotechnical Standardization (CENELEC), Current Edition.
      - EN 60947 - Low-Voltage Switchgear and Controlgear - Part 4-2: Contactors and Motor-Starters - AC Semiconductor Motor Controllers and Starters
      iv. Electrical and Electronic Manufacturers Association Canada (EEMAC), Specifications and Standards, Current Edition.
      v. Institute of Electrical and Electronics Engineers (IEEE), current edition.
         - IEEE 519-1992 - Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
      vi. International Electrotechnical Association (IEC), Specifications and Standards, Current Edition:
         - IEC-60439 - Low Voltage Switchgear and Control Gear Assemblies.
      vii. National Electrical Contractors Association (NECA), current edition.
         - NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
      viii. National Electrical Manufacturers Association (NEMA), Specifications and Standards, Current Edition:
         - ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
         - ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
         - ICS 4-2000 - Industrial Control and Systems: Terminal Blocks.
         - ICS 5-2000 - Industrial Control and Systems: Control Circuit and Pilot Devices.
         - ICS 6-1993 - Industrial Control and Systems Enclosures
         - ICS 7-1993 - Industrial Control and Systems Adjustable-Speed Drives
         - NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
      ix. Underwriters Laboratories, Inc. (UL), Specifications and Standards, Current Edition:
         - 4.UL 508C - Power Conversion Equipment.

2. Submittals
   a. The following information shall be submitted specifically for adjustable frequency drive systems:
      i. Submit harmonic voltage distortion analysis based upon the minimum three phase bolted fault short circuit current available at the point of service. Submittal data shall not relieve contractor of specified performance requirements. Analysis shall include:
         - Calculate percent voltage distortion, with respect to fundamental voltage, for all harmonics up to the 99th.
         - Comparison with IEEE 519 standards for acceptable voltage distortions on such systems.
3. Operation/Maintenance Manuals and Instructions
   a. The following information shall be provided specifically for adjustable frequency drive systems:
      i. Motor controller data listing identifying the configured values of all adjustable settings and configurable parameters.
4. Quality Assurance
   a. Manufacturer Qualifications:
      i. All equipment provided under this section shall be the products of a single company specializing in manufacturing products specified in this section, with not less than twenty years of documented experience.
      ii. The adjustable frequency drive system manufacturer shall have been engaged in the manufacture of PWM style adjustable frequency drives for a minimum of ten years.
   b. Products: Listed and classified by UL or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
   c. Adjustable frequency drive system manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

B. MATERIALS.

1. Manufacturer
   ~~i. Allen-Bradley, Bulletin Power Flex 753 Series.~~
   ~~ii. Eaton/Cutler-Hammer, DG1 Series.~~
   iii. Asea Brown Boveri (ABB) Model ACQ 800. No substitutions.
   ~~iv. Or equal.~~
2. General
   a. Provide adjustable frequency, drive control systems capable of converting the scheduled voltage, 3-phase, 60 Hz, input power into variable voltage, adjustable frequency, 3-phase output of suitable capacity and waveform to serve as input power to squirrel cage induction motors of the scheduled characteristics (constant or variable torque).
   b. Harmonic Distortion:
      i. The adjustable frequency drive systems shall operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10% total harmonic voltage distortion and commutation notches up to 36,500 volt microseconds, or when operated from the same bus.
      ii. Individual or simultaneous operation of the adjustable frequency drive systems shall not add more than 5% total harmonic voltage distortion to the normal bus, nor more than 10% while operating from the standby generator in accordance with IEEE 519, 1992.
      iii. Maximum total and individual harmonic current distortion limits for each odd harmonic shall not exceed those set forth by IEEE 519, Latest Edition.

iv. If harmonic filters or reactors are needed to meet these requirements, then the manufacturer shall provide and be responsible for the design and manufacture of these items.

3. Ratings
   a. The drive shall accept an input voltage of the nominal three phase voltage indicated on the drawings, +/- 10%.
   b. Displacement power factor: shall range between 1.0 and 0.95, lagging, over the entire speed range.
   c. Efficiency: minimum of 97% at full load and speed.
   d. Environmental Ratings:
      i. Storage ambient temperature range: -40°F to 160°F.
      ii. Operating ambient temperature range: 32°F to 105°F without derating.
      iii. Relative humidity range: 5% to 95% non-condensing.
      iv. Operating elevation: up to 3280 feet without derating.
   e. Provide redundant, thermostatically controlled ventilation fans to maintain interior of drive enclosure within the specified environmental ratings.
   f. Output power Ratings:
      i. The output voltage shall be adjustable from 0 to rated input voltage.
      ii. The output frequency range shall adjustable from 0 to 400Hz.
      iii. The inverter section shall produce a pulse width modulated (PWM) waveform using latest generation IGBTs.
4. Drive Unit Design
   a. Hardware:
      i. Utilize diode or fully gated bridge on the input.
      ii. Utilize DC bus inductor on all drives rated 7.5hp or greater.
      iii. Utilize switching logic power supply operating from the DC bus.
      iv. Incorporate phase to phase and phase to ground MOV protection.
      v. Utilize gold plated plug-in connections on printed circuit boards.
      vi. Microprocessor based inverter logic shall be isolated from power circuits.
      vii. Utilize latest generation IGBT inverter section.
      viii. Inverter section shall not require commutation capacitors.
      ix. Employ interface common for all horsepower ratings. Interface shall include a LCD digital display and programming keypad.
      x. Utilize a main control board with common control connections for all ratings.
   b. Control Design:
      i. The drive design shall be optimized for NEMA Design B motors.
      ii. The drive design shall allow for operation of the drive with the motor disconnected.
      iii. Provide a controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit. Provide annunciation of the fault condition.
      iv. Utilize an adjustable PWM carrier frequency within a range of 2 kHz to 8 kHz to help eliminate audible noise.
      v. Provide either Selectable Sensorless Vector or V/Hz modes.
      vi. The drive shall have the capability of selecting operation for either variable or constant torque loads. Selection of variable torque shall provide 115% of rated VT current for up to 1 minute. Selection of constant torque shall provide 150% of rated CT current for up to 1 minute.
      vii. Provide multiple programmable stop modes including:
         - Ramp

- Coast
- DC-Brake
- Ramp-to-Hold
- S-Curve

viii. Provide multiple acceleration and deceleration rates.
ix. The drive shall have an adjustable output frequency up to 400Hz.
x. The drive shall be capable of sensing a loss of the speed reference.
xi. All adjustments shall be made with the door closed.

c. Power Conditioning:
   i. The drive shall be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion.
   ii. An input isolation transformer shall not be required for protection from normal line transients. If line conditions dictate the use of a transformer, the K factor shall be 4.0 or less.

5. Drive Unit Features
   a. Control Mode:
      i. Selectable sensorless vector or V/Hz mode selectable through programming.
      ii. The sensorless vector mode shall use motor nameplate data plus motor operating data such as IR drop, nominal flux current and flux up time.
      iii. The volts per hertz mode shall be programmable for squared, cubed, straight line, pre-programmed or full custom patterns.
   b. Current Limit:
      i. Programmable current limit from 20% to 160% of constant torque rating.
      ii. Current limit shall be active for all drive states: accelerating, constant speed and decelerating.
      iii. The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit.
   c. Acceleration / Deceleration:
      i. Accel/Decel settings shall provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 seconds.
      ii. A second set of remotely selectable Accel/Decel settings shall be accessible through the control interface.
      iii. An adaptive current limit circuit shall be available and capable of being disabled through programming for fast acceleration of low inertia loads.
   d. Speed Regulation Modes:
      i. Open Loop.
      ii. Slip Compensation with 0.5% speed regulation.
      iii. Droop - Negative Slip Compensation with 0.5% speed regulation.
      iv. Traverse Function.
      v. Closed loop encoder feedback with 0.1% speed regulation.
      vi. Process PI control.
   e. Speed Profiles:
      i. Programming capability shall allow the user to produce speed profiles with linear acceleration/deceleration or "S-Curve" profiles that provide changing accel/decel rates.
      ii. S-Curve profiles shall be selectable for fixed or adjustable values.
   f. Adjustments:
      i. A digital interface shall be used for all set-up, operation and adjustment settings.
      ii. All adjustments shall be stored in nonvolatile memory (EEPROM).

iii. No potentiometer adjustments shall be required.
iv. The drive shall provide EEPROM memory for factory default values.

g. Process PI Control:
   i. The drive shall incorporate an internal process PI regulator with proportional and integral gain adjustments as well as error inversion and output clamping functions.
   ii. The feedback shall be configurable for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator shall adjust the drive output until the feedback equals the reference.
   iii. Process control shall be capable of being enabled or disabled with a hardwire input. Transitioning in and out of process control shall be capable of being tuned for faster response by preloading the integrator.
   iv. Protection shall be provided for a loss of feedback or reference signal.
h. Fault Reset / Run:
   i. The drive shall provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart.
   ii. Ground fault, shorted output faults, and other internal microprocessor faults shall not automatically reset/restart.
   iii. The time between restarts shall be adjustable from 0.5 to 30 seconds.
i. Skip Frequencies:
   i. Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance shall be provided.
   ii. The set points shall have a bandwidth adjustable from 0 Hz to 15 Hz.
j. Run on Power Up:
   i. A user programmable restart function shall be provided to automatically restart the equipment after restoration of power after an outage.
k. Line Loss Restart:
   i. The drive shall have a line loss restart function. This programmable function shall select the reconnect mode of the drive after recovery from a line loss condition.
   ii. The reconnect modes shall be Last Speed, Speed Search, Track Volts, or Use Encoder.
   iii. This feature shall be capable of being disabled thus forcing the drive to start from zero hertz.
l. Fault Memory:
   i. The last four faults as well as operating frequency, drive status and power mode shall be stored at the time of fault.
   ii. Information shall be maintained in the event of a power loss.
m. Overload Protection:
   i. The drive shall provide internal Class 10 motor overload protection investigated by UL to comply with N.E.C. Article 430.
   ii. Overload protection shall be speed sensitive and adjustable for motors with speed ranges of 2:1, 4:1 and 10:1.
   iii. A viewable parameter shall store the overload usage in percent.
   iv. An alarm bit shall be available to adjust a process to eliminate an overload trip.
n. Auto Economizer:
   i. An auto economizer feature shall automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage shall be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage. If the load increases, the drive shall automatically return to normal operation.
o. Flying Start:

i. The drive shall be capable of determining the speed and direction of a spinning motor and adjust its output to "pick-up" the motor at the rotating speed.
ii. The flying start feature shall be operable with or without encoder feedback.

p. Control Logic Ride Through:
i. The control logic shall be capable of "riding through" a power outage of up to 2 seconds in duration.

q. Inertia Ride Through:
i. The drive shall respond to a loss of AC input power by adjusting the output frequency to create a regenerative situation in the motor. The regenerated energy shall be used to power the drive logic during the power outage.
ii. The amount of voltage drop required to trigger inertial ride through and the level at which regulation occurs shall both be adjustable.
iii. Inertia ride through shall be capable of being enable or disable through programming.

r. Input and Output Expansion Cards:
i. The standard Input / Output expansion cards shall consist of both analog and digital I/O.
ii. No jumpers or switches shall be required to configure inputs and outputs. All functions shall be fully programmable.
iii. Analog input card shall have the following as standard:
- One differentially isolated plus or minus 10V (bi-polar) / 20mA, 11 bit plus sign, 10V common mode noise rejection
- One differentially isolated plus or minus 10V (bi-polar) / 20mA, 11 bit plus sign, 160V common mode noise rejection
- Analog inputs shall be user programmable for a variety of uses including frequency command and process loop input. Analog inputs shall be user programmable for function scaling (including invert), offset, signal loss detect and square root.

iv. Analog output card shall have the following as standard:
- One differentially isolated plus or minus 10V (bi-polar) / 20mA, 11 bit plus sign.
- The analog output shall be user programmable to be proportional to one of fourteen process parameters including output frequency, output current, encoder feedback, output power.
- Programming shall be available to select either absolute or signed values of these parameters.

v. Digital input card shall have the following as standard:
- Six digital inputs rated 115Vac
- All inputs shall be individually programmable for functions from a list of twenty-nine (29) that includes Start, Run, Stop, External Fault, Speed Select, Jog and Process PI functions.

vi. Digital output card shall have the following as standard:
- Two relay outputs, form C (1 N.O. - 1 N.C.)
- Contact output ratings shall be 250Vac / 30Vdc (2.0 Amps maximum), resistive or inductive.
- Relays shall be programmable to 26 different conditions including Fault, Alarm, At Speed, Drive Ready and PI Excess Error.
- Timers shall be available for each output to control the amount of time, after the occurring event, that the output relay actually changes state.

s. Reference Signals:
i. The drive shall be capable of using the following input reference signals
- Analog inputs

- Preset speeds
- Remote potentiometer
- Digital MOP
- Human Interface
- Communication module commands

t. Communication:
   i. The drive shall be capable of communicating with an Allen Bradley Ethernet/IP network.

u. Loss of Reference:
   i. In the event of loss of the reference signal, the drive shall be user programmable to the following:
      - Fault the drive
      - Alarm and maintain last reference
      - Alarm and go to preset speed
      - Alarm and go to minimum speed
      - Alarm and go to maximum speed
      - Alarm and maintain last output frequency

v. Metering:
   i. The following parameters shall be accessible through the human interface module:
      - Output Current in Amps
      - Output Voltage in Volts
      - Output Power in kW
      - Elapsed MWh
      - DC Bus Voltage
      - Output Frequency
      - Heatsink Temperature
      - Last eight faults
      - Elapsed Run Time

w. Faults:
   i. Fault information shall be accessible through the human interface module.
   ii. A fault buffer shall store the last four faults in a first-in / first-out manner.
   iii. At a minimum the following faults shall be displayed:
      - Power Loss.
      - Undervoltage.
      - Overvoltage.
      - Overload.
      - Overtemperature (Heat Sink).
      - Overcurrent detected in instantaneous overcurrent trip circuit
      - Maximum retries.
      - Phase-to-phase and phase-to-ground faults.

6. Disconnecting Means
   a. Provide a door interlocked motor circuit protector disconnect
   b. Operator Handles
      i. Provide flange mounted operator handles for free standing units
      ii. Provide through the door operating handles for wall mounted units
      iii. Handles shall be padlockable
   c. The system shall be rated for the available fault current identified on the drawings. The rating shall be shown on the drive label.

7. Drive Input Fuses
    a. Provide drive input fuses to provide branch circuit protection for the drive.
    b. The drive input fuses shall be selected by the manufacturer and mounted in fuse blocks.
8. Control Power Transformer
    a. Provide a control power transformer mounted and wired inside of the drive system enclosure.
    b. The transformer shall be rated for drive power plus 250VA for customer use.
9. Contractors
    a. General:
        i. Contactors shall be IEC or NEMA rated devices suitable for the application intended.
        ii. Provide Isolation and Output contactors.
    b. Isolation:
        i. Input contactor shall provide positive isolation of the controller from line power.
        ii. Input contactor shall close when motor is signaled to start, energizing the controller and allowing adjustable speed control.
        iii. Input contactor shall open after the controller has stopped the motor and de-energize the controller.
        iv. Input contactor shall not switch loaded motor under any circumstances.
    c. Output:
        i. Provide an output contactor between the drive output and the motor. The contactor shall close on power up and open after a drive fault or loss of power.
10. Power Conditioning Equipment
    a. General:
        i. Provide Input Line Reactors, Harmonic Mitigation Filters, or Load-Side Sine Wave Filter where indicated on the drawings.
    b. Common Mode Choke:
        i. Provide a common mode choke at the drive output to help, in conjunction with the proper grounding techniques, reduce or eliminate interference with sensitive electronic equipment or communication devices installed in the same system.
    c. Input Line Reactor:
        a. Provide a drive input line reactor mounted within the drive system enclosure
        b. The line reactor shall meet the following specifications:
            - The construction shall be iron core with an impedance of 3%.
            - The winding shall be copper wound.
            - The insulation shall be Class H with a 240° F rise.
            - The unit shall be rated for system voltage and frequency
11. Pilot Control Devices
    a. Provide front of panel mounted pilot devices as shown on drawings.
12. Enclosures
    a. The enclosure shall be NEMA 1, NEMA 12, NEMA 3R, or NEMA 4X Stainless Steel as indicated on the plans.
    b. Starters shall have an adjustable instantaneous motor circuit protector (HMCP) type disconnect device.

C. CONSTRUCTION.

1. Field Measurements
    a. Field verify all measurements. Do not base exact equipment locations on the plans.
    b. Identify conflicts with the work of other trades prior to installation of electrical equipment.
    c. Identify deviation from physical sizes shown on the plans to Engineer.

d. Contractor shall be responsible for modifications to the installation due to deviations from physical sizes shown on the plans.
e. Identify conflicts with the work of other trades prior to installation of electrical equipment.
f. Record nameplate data for each motor served.

2. Delivery, Storage, and Handling
   a. Accept adjustable frequency motor controllers on site. Inspect for damage.
   b. The Contractor shall be responsible for all equipment necessary to receive, unload, move into building, and install motor control centers.
   c. The Contractor shall be responsible for coordinating specific shipping split requirements with the manufacturer/supplier.
   d. Conform to written instructions of manufacturer.
   e. Protect adjustable frequency motor controllers from corrosion and entrance of debris.
   f. Store adjustable frequency motor controllers above grade. Protect from environment with suitable covering.
3. Installation
   a. Adjust disconnecting means trip settings to satisfy motor nameplate requirements.
   b. Record information for motor data labels and install motor data labels.
   c. Adjust all programmable drive features, including but not limited to auto restart parameters. The drive system must automatically restart after a power fail condition.
   d. Provide typed label inside each unit identifying configured values for all programmable drive parameters.
   e. Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of all connections.
   f. Verify that cooling fans are operating properly.
   g. Thoroughly clean and remove construction debris from filters, enclosure interior, and exterior.
4. Testing and Start-Up Services
   a. Refer to the requirements of Process Instrumentation & Control.
5. Training
   a. Refer to the requirements of Process Instrumentation & Control.

154013a.10 PORTABLE ENGINE/GENERATOR SET

A. DESCRIPTION.

Provide complete factory assembled portable generator set equipment with standard analog controls and satisfying Tier 4 Emissions requirements. Provide factory test, startup by a supplier authorized by the manufacturer, and on-site testing of the system. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
         - NFPA99 – Essential Electrical Systems for Health Care Facilities.

- NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit; component level type tests will not substitute for this requirement.

ii. Canadian Standards Association (CSA), Specifications and Standards, current edition:
- CSA C22.2, No. 14 – M91 Industrial Control Equipment.
- CSA 282, 1989 Emergency Electrical Power Supply for Buildings.

iii. International Electrotechnical Commission (IEC), Specifications and Standards, current edition:
- IEC8528 part 4. Control Systems for Generator Sets.

iv. Institute of Electrical and Electronics Engineers, Specifications and Standards, current edition:
- IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.

v. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition:
- NEMA ICS10-1993 – AC Generator sets.

vi. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition:
- UL2200. The genset shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.

2. Submittals
   a. General requirements specific to this section include:
      i. Submit complete and integrated document containing all equipment included under the scope of this section.
      ii. Submittal shall be complete, neat, orderly, and indexed with tabbed dividers. Partial submittals will not be accepted.
      iii. Include a complete list of proposed exceptions to and deviations from these specifications.
      iv. Clarity and completeness are of prime importance. Acceptability of submittal drawings shall be at the sole discretion of the Engineer in regards to this requirement.
      v. Additional requirements for the various subsystems are specified in the corresponding sections.
   b. Submit the following information:
      i. Manufacturer’s product literature and performance data, sufficient to verify compliance to specification requirements.
      ii. A paragraph-by-paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
      iii. Manufacturer’s certification of prototype testing.
      iv. Manufacturer’s published warranty documents.
      v. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
      vi. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point to point manner.
      vii. Manufacturer's installation instructions.
3. Factory Testing
   a. The generator set supplier shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. Equipment supplied shall be fully tested at the factory for function and performance.

   b. Factory testing may be witnessed by the Contracting Authority and consulting engineer. Costs for travel expenses will be the responsibility of the Contracting Authority and consulting engineer. Supplier is responsible to provide two weeks' notice for testing.
   c. Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady state governing, single step load pickup, and function of safety shutdowns.
4. Operation/Maintenance Manuals and Instructions
   a. Submit final revised shop drawings incorporating any modifications made as a result of installation, start-up, operational testing, or for any other cause. Submit results of all field-testing and corrective actions taken for all operational parameters.
   b. Submit manufacturer's standard operation & maintenance information including installation manuals and safety instructions.
   c. Submit contact list identifying names, addresses, telephone numbers, and any additional contact information for each equipment service organization involved with the Standby Engine/Generator Set.
   d. Submit detailed operation and maintenance procedures for each major equipment item; include description of operation for all modes of operation, routine maintenance procedures, and trouble-shooting guide.
   e. Submit listing spare parts provided under this contract and of recommended additional spare parts not provided under this contract along with costs.
5. Quality Assurance
   a. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
   b. The Standby Engine/Generator Set manufacturer shall have been engaged in the manufacture of generator sets for a minimum of 10 years and shall have a factory trained service and parts organization located within 100 miles of the jobsite.
   c. All control equipment shall be the standard product of the engine/generator set manufacturer. Controls systems that are supplied by a subcontractor of the manufacturer and which are not incorporated into the standard documentation of the manufacturer will not be acceptable.
6. Warranty
   a. The generator set and associated equipment shall be warranted for a period of not less than 5 years from the date of commissioning against defects in materials and workmanship.
   b. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.
   c. The manufacturer of the generator set shall maintain service parts inventory at a central location that is accessible to the service location 24 hours per day, 365 days per year.
   d. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
   e. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

B. MATERIALS.

1. Manufacturer
   a. Acceptable Manufacturers

i. Kohler Power Systems.
ii. Cummins/Onan.
iii. MTU Onsite Energy
iv. Caterpillar/Olympian.
v. Or Equal.

b. These specifications, installation design, and the storage facility design are based upon the first named manufacturer. If the contractor elects to supply a different manufacturer, then the contractor shall be responsible for adjusting the installation of the portable engine/generator set to satisfy the requirements of that manufacturer's equipment.

c. Alternate equipment will only be considered if the following information is submitted ten days prior to the bid date:
i. Certified dimensional data.
ii. Complete interconnecting wiring and piping diagrams.
iii. Manufacturer's certification of prototype testing.
iv. Load study/profile showing non-overloading of genset under steady-state conditions and during motor starting.
v. Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
vi. A paragraph-by-paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
vii. Short circuit study of the load circuits to verify that selective coordination occurs and that thermal-magnetic stresses on components will not exceed the specified ratings.
viii. Listing of similar projects and Contracting Authority contact information for projects completed during the previous 5 years.

2. Generator Set
a. Ratings
i. The generator set shall operate at 1800 rpm, 60 Hz at the following switch-re-connectable voltages. Each supply voltage shall have a dedicated output circuit breaker:
- 200 Amp - 120/240 volts AC, single-phase, three wire.
- 100 Amp - 277/480 volts AC, three-phase wye-configuration, four-wire.

ii. The generator set shall be rated at 55kW, 72kVA at 0.8 PF, standby rating, based on site conditions of: Altitude 1000 feet, ambient temperatures up to 104°F.
iii. The generator set rating shall be based on emergency/standby service.

b. Performance
i. Voltage regulation shall be plus or minus 1.0% for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.
ii. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
iii. The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
iv. Minimum motor starting capability shall be 261kVA at 35% voltage dip.
v. Motor starting capability shall be adequate to start and run two 20 HP pumps (480V,AFD), 5kVA of miscellaneous single phase loads.
vi. The Gen-Set shall be sized to start and run the scheduled loads in three or less steps.

vii. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic.
viii. Telephone influence factor shall be less than 40.

c. Construction
   i. The engine generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a corrosion resistant battery tray with hold-down clamps within the rails.

d. Connections
   i. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations for the number and type cables shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.
   ii. Power connections to auxiliary devices shall be made at the devices, with connectors suitable for plug-in connection as shown on the drawings.
   iii. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

3. Engine and Engine Equipment
   a. The engine shall be diesel fueled, radiator and fan cooled. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories.
   b. Engine accessories and features shall include:
      i. Complete engine fuel system, including all pressure regulators, strainers, and control valves. The fuel system shall be factory plumbed to the generator set.
      ii. An electronic governor system shall provide automatic isochronous frequency regulation.
      iii. Skid mounted radiator and cooling system rated for full load operation in 104°F ambient as measured at the generator air inlet, based on 0.5 in H2O external static head. Radiator shall be sized based on a core temperature that is 20°F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture. Rotating parts shall be guarded against accidental contact.
      iv. Electric starter(s) capable of three complete cranking cycles without overheating.
      v. Positive displacement, mechanical, full pressure, lubrication oil pump.
      vi. Full flow lubrication oil filters with replaceable spin on canister elements and dipstick oil level indicator.
      vii. Fuel filter with replaceable spin on canister element. Fuel cooler, suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.
      viii. Replaceable dry element air cleaner with restriction indicator.
      ix. Flexible supply and return fuel lines.
      x. Engine mounted battery charging alternator, 40 ampere minimum, and solid state voltage regulator.
      xi. Coolant heater
         - Engine mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be 120V as shown on the project drawings and cord connected. The coolant heater shall be UL499 listed and labeled.

- The coolant heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using quick disconnect couplers to isolate the heater for replacement of the heater element. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
- The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power cord connection shall be provided for a single AC power connection to the coolant heater system.
- The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 100°F in a 40°F ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.

xii. Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer.

xiii. Starting and Control Batteries shall be calcium/lead antimony type, 12 or 24 VDC, sized as recommended by the engine manufacturer, complete with battery cables and connectors.

c. Battery Charger

i. A UL listed/CSA certified 10 amp voltage regulated battery charger shall be provided for this engine generator set. The charger shall be mounted on the generator set assembly within the weatherproof enclosure. Input AC voltage and DC output voltage shall be as required. Chargers shall be equipped with float, taper and equalize charge settings. Operational monitors shall provide visual output along with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of:

- Loss of AC power red light.
- Low battery voltage red light.
- High battery voltage red light.
- Power ON green light (no relay contact).

ii. Charger shall include an Analog DC voltmeter and ammeter, 12 hour equalize charge timer, and AC and DC fuses,

iii. Provide cord set for quick connection of battery charger to battery terminals.

iv. Battery Charger shall operate on 120VAC power and shall be cord connected.

4. AC Generator

a. The AC generator shall be synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 260°F.

b. Generator shall be capable of supplying single-phase output at full capacity rating and unity power factor.

c. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5% above or below selected rated voltage.

d. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and

controls shall be capable of sustaining and regulating current supplied to a single-phase or three-phase fault at approximately 300% of rated current for not more than 10 seconds.

e. The subtransient reactance of the alternator shall not exceed 12%, based on the standby rating of the generator set.

5. Engineer Generator Set Control
   a. A NEMA 1 enclosed control panel shall be mounted on the generator set with vibration isolators. The control shall be vibration isolated and prototype tested to verify the durability of all components under the vibration conditions encountered.
   b. The generator set mounted control shall include the following features and functions:
      i. Three-position control switch labeled RUN/OFF/AUTO. In the RUN position the generator set shall automatically start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
      ii. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
      iii. PANEL LAMP switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power.
      iv. Generator Set AC Output Metering: The generator set shall be provided with a metering set with the following features and functions:
         - Analog AC Voltmeter, dual range, 90 degree scale, 2% accuracy; Analog AC Ammeter, dual range, 90 degree scale, 2% accuracy; Analog Frequency/RPM meter, 45 65 Hz, 1350 1950 RPM, 90 degree scale, +/ 0.6 Hz accuracy.
         - Seven position phase selector switch with OFF position to allow meter display of current and voltage in each generator phase. When supplied with reconnectable generators, the meter panel shall be reconnectable for the voltage specified.
      v. Generator Set Alarm and Status Display: The generator set shall be provided with alarm and status indicating lamps to indicate non automatic generator status, and existing alarm and shutdown conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on the display panel:
         - Low oil pressure (alarm).
         - Low oil pressure (shutdown).
         - Low coolant temperature (alarm).
         - High coolant temperature (alarm).
         - High coolant temperature (shutdown).
         - Overcrank (shutdown).
         - Overspeed (shutdown).
         - Low fuel (alarm).
         - In addition, provisions shall be made for indication of two customer specified alarm or shutdown conditions.
      vi. Engine Status Monitoring: The following devices shall be provided on the generator set control:
         - Engine oil pressure gauge.
         - Engine coolant temperature gauge.
         - Engine operation hour gauge.

- Battery voltage (DC volts).

vii. Engine Control Functions. The control system provided shall include a cycle cranking system, which shall be for three cranking periods of 15 seconds each, with 15 second rest period between cranking periods. Fail to start shall be indicated by operation of the overcrank alarm indication lamp. The control system shall also include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification.

viii. Alternator Control Functions:

- The generator set shall include an automatic voltage regulation system that is matched and prototype tested with the governing system provided. It shall be immune from misoperation due to load induced voltage waveform distortion and provide a pulse-width modulated output to the alternator exciter. The system shall include a torque matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of 58 HZ.
- Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/ 5% from rated value.

ix. Voltage Range Select Function:

- The generator set shall be equipped with a full-load rated panel-mounted, rotary switch for de-energized reconnection of alternator leads to provide multiple, individually selectable output voltage levels.

x. The generator set shall be provided with one mounted main line circuit breaker for each selected output voltage, sized as follows:

- For 120/240V 1-phase, 3-wire (wye) connection, 200A
- For 277/480V 3-phase, 4-wire (wye) connection, 100A.

xi. Circuit breakers shall be equipped with shunt trip and shall automatically open on a genset shutdown alarm.

c. Sequence of Operation

i. Generator set shall start on receipt of a manual start signal at the generator control panel.

ii. The generator set control shall initiate the starting sequence for the generator set.

iii. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.

iv. When all start signals have been removed from the generator set, the generator set control shall switch off the excitation system and shall shut down.

v. A start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

6. Portable Engine Exhaust System

a. Exhaust system shall comply with and be factory certified to all applicable regulatory requirements for portable diesel fueled engines in effect at the time of purchase. Install exhaust system according to the engine manufacturer's recommendations and applicable codes and standards.

b. Provide exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer. The mufflers shall be critical grade. Exhaust system shall be installed according to the engine manufacturer’s recommendations and applicable codes and standards.

c. Provide stainless steel, seamless flexible exhaust manifold connector.

7. Portable Diesel Engine Fuel System
    a. Diesel fuel sub-base tank
        i. Manufacturer: Contractor option. Manufacturers shall have a minimum ten years' experience in the design and construction of Underwriters Laboratories (UL) listed sub base tank systems.
        ii. Tank construction:
            - Fuel tank shall be sized based upon the fuel requirements of the genset to provide a minimum of twenty-four hours of genset runtime at full rated standby output capacity.
            - Sub base tank shall be constructed in accordance with Flammable and Combustible Liquids Code, NFPA 30; The Standard for Installation and use of Stationary Combustible Engine and Gas Turbines, NFPA 37; and The Standard for Emergency and Standby Power Systems, NFPA 110.
            - Sub base tank shall be rectangular in shape.
            - Sub base tank shall include reinforced steel box channel for generator support, with load rating of 5000 pounds per genset mounting hole location. Full height gussets shall be provided at genset mounting holes.
            - Sub base tank shall be pressure washed with an iron phosphate solution. Interior shall be coated with a solvent-based film rust preventative, providing inter-operational protection.
            - Sub base tank shall be shipped with a certificate of Structural/Mechanical Integrity, certifying that it has met standards through rigorous testing and has demonstrated specified capabilities.
            - Sub base tank shall include a welded steel containment basin, sized at a minimum of 110% of the tank capacity to prevent escape of fuel into the environment in the event of a tank rupture.
            - Sub base tank shall include a direct-reading fuel level gauge.
            - A fuel containment basin leak detector switch shall be provided.
        iii. Tank fittings:
            - Appropriately sized NPT fuel supply.
            - Fuel return fitting.
            - 1 1/4 inch NPT for normal vent.
            - NPT for emergency vent, sized as appropriate.
            - 2 inch NPT for manual fill with containment and audible fill alarm.
            - NPT for level gauge, sized as appropriate.
            - 3/8 inch NPT basin drain.
            - 2 inch NPT for level alarm.
            - NPT fitting for leak detection alarm.
        iv. Tank venting:
            - Normal venting shall be sized at 1 1/4 inch NPT for tanks through 2499 gallons (1 1/2 inch NPT for 2500 to 3000 gallons; 2 inch NPT for 3001 to 10,000 gallons) in accordance with The American Petroleum Institute Standard No. 2000, for venting atmospheric and low pressure storage tanks. Tank shall be provided with atmospheric (normal) vent cap with screen.
            - The emergency vent NPT fitting shall be sized to accommodate the total capacity of both normal and emergency vents, and is not less than that derived from NFPA 30, Table 2-8, based on wetted surface area of the tank (calculated based on 100% of primary tank). A zinc-plated emergency pressure relief vent cap shall be furnished. The vent shall be spring-pressure operated. Opening pressure shall be 0.5 psig; full

opening pressure shall be 2.5 psig. Limits shall be marked on top of each vent. A second emergency vent fitting shall be provided for the secondary containment portion of the tank if applicable.

v. Testing
- Primary tank sections shall be pressurized at 3 to 5 psi and leak-checked to ensure integrity of sub base weld seams per UL-142 standards. Containment basin shall be leak-checked by means of weld penetrant and ultraviolet light.

b. State of Iowa licensed installer shall install tank.

8. Portable Engine/Generator Set Trailer
   a. Manufacturer: Contractor option. Equal manufacturers shall have a minimum 10 years' experience in the design and construction of Underwriters Laboratories (UL) listed sub base tank systems
   b. Trailer Design and Construction
      i. Trailers shall include integral sub base (generator base) tank.
      ii. Trailer design and construction shall include the following:
      - Tandem axle/single axle.
      - Load rated for the combined weight of the genset, fuel tank, fuel, housing, and accessories.
      - All steel, heavy formed channel construction (tongue and side).
      - Integral cross-members at genset mounting points.
      - Trailer tongue shall be bolt-on extension of side channels with a cross-member providing triangulation support point for standard tongue jack and continuing to an adjustable hitch.
      - Heavy-duty tongue jack.
      - Fenders constructed of formed steel and bolted to side channels. Non-skid material on top surface of fenders.
      - Torflex hydraulic/electric brake axle bolted to trailer frame.
      - 15/16 inch tire and wheel assemblies shall conform to axle.
      - 2 5/16 inch adjustable height ball coupler (or 2 inch ball or 3 inch Pintle eye). Coordinate requirements with Contracting Authority.
      - Heavy-duty safety chains, including slip hook.
      - Two 5000 pound rear stabilizer jack stands bolted to rear cross-member.
      - ICC lighting with six wire connector. Electrical components meet Department of Transportation requirements, including rear taillights, reflectors and wire harness.
      - Tongue mounted, waterproof hinged and gasketed storage box with lockable side-mounted hasp.
      - Trailer and accessories shall be chemically cleaned. Trailer finished with epoxy primer coat and gloss black acrylic enamel paint.

9. Power Connection Cord Sets
   a. Generator set manufacturer shall provide two cord sets, each type W, 50 foot length as follows:
      i. One four-conductor (plus ground) cable rated for 100A at selected voltage of 277/480VAC (three-phase, four-wire).
      ii. One three-conductor (plus ground) cable rated for 200A at selected voltage of 120/240VAC (single-phase, three-wire).
   b. Generator set manufacturer shall provide cord end connectors (plugs) manufactured by Russellstoll for connection to generator and to load-end receptacles, and shall provide matching mating receptacles at generator enclosure and load-end receptacles as noted

below. Load-end receptacles shall be turned over to the Electrical Contractor for installation at service locations indicated. Each cable-end connector shall be selected and installed on its respective cord-set by selected voltage and matched as follows:

i. Voltage: 277/480V (three-phase, four-wire):
   - Source-side cord-end connector (plug): 100A, Style 1, 4-pole, 4-wire, with ground, reverse service, Russellstoll No. JPS1044F.
   - Service (load-side) mating receptacle for installation on control panel: 100A, Style 1, reverse service, 4-pole, 4-wire, with ground, with angle adapter and back-box.

ii. Voltage: 120/240V (single-phase, three-wire):
   - Source-side cord-end connector (plug): 200A, Style 1, 3-pole, 4-wire with ground, reverse service, Russellstoll No. JPS2034H.
   - Field verify cord end connector on existing generator cord.

iii. Cord-end plugs shall be provided with threaded weatherproof covers for protection.

iv. Receptacles shall be provided with threaded weatherproof covers for protection.

v. Plugs and receptacles shall be permanently marked with indicated output voltage and corresponding color band.

10. Outdoor Weather-Protective Sound Attenuating Housing
    a. The generator set shall be provided with a sound-attenuated housing which allows the generator set to operate at full rated load in the ambient conditions previously specified. The enclosure shall reduce the sound pressure level of the generator set while operating at full rated load to a maximum of 69 dBA at any location 20 meters from the generator set in a free field environment. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustical materials used shall be oil and water resistant. No foam materials shall be used unless they can be demonstrated to have the same durability and life as fiberglass.
    b. The enclosure shall include hinged doors for access to both sides of the engine and alternator, and the control equipment. Key-locking and pad-lockable door latches shall be provided for all doors. Door hinges shall be stainless steel.
    c. The enclosure shall be provided with an exhaust silencer that is mounted inside of the enclosure, and allows the generator set package to meet specified sound level requirements. Silencer and exhaust shall include a rain cap and rain shield.
    d. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer's standard color. All surfaces of all metal parts shall be primed and painted.
    e. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.
    f. Enclosure shall protect against entry of rodents, birds, and other wildlife. All openings shall be plugged, sealed, screened or otherwise protected against bird or animal entry.
11. Accessories
    a. Provide supply of consumables (air cleaner, oil filter, etc) in sufficient quantity to last for one year from the date of substantial completion.

C. CONSTRUCTION.

1. Division of Work
   a. The Contractor shall have overall system responsibility and shall provide all materials and labor necessary provide a complete and operable system and comply with all requirements of this section.

   b. The engine/generator set manufacturer shall be responsible for certifying the correctness of installation for all work related to the standby power system regardless of who performs the installation work.
   c. The plans are diagrammatic in nature; it shall be the responsibility of the manufacturer to supplement the plans and complete the final design of the standby power system and to coordinate exact requirements with the installing contractors.

b. Field Measurements
   a. Field verify with exact measurements, the available mounting space for standby power system equipment. Identify deficiencies prior to beginning installation.

c. Delivery Storage and Handling
   a. It shall be the responsibility of the installing contractor to receive all standby power system equipment at the job site. Carefully inspect all equipment for damage prior to accepting from the shipping agency. Do not accept shipment if damage is evident.
   b. Exercise due diligence in storing, protecting, and moving standby power system equipment. Damaged or worn equipment will not be accepted and will be replaced at no additional cost to the Contracting Authority.

d. Installation
   a. Install equipment in locations as indicated on the contract documents. Adjust locations as needed to ensure operability, serviceability, and compliance with all applicable codes and standards.
   b. Installation shall be completely tested prior to start-up. This work includes verification of all field wiring continuity and proper termination of wiring.
   c. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
   d. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
   e. Installation of equipment shall include furnishing and installing all fuel piping and vent piping as required. The tank installer shall perform this work under the supervision of the equipment supplier.
   f. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer’s instructions and seismic requirements of the site
   g. Equipment shall be initially started and operated by representatives of the manufacturer.
   h. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to final testing of the system.

e. Testing and Start-Up Services
   a. Standby power system supplier shall provide installation and start-up services required to place the complete system into operation.
   b. The complete installation shall be tested for compliance with the specification following completion of all site work. Representatives of the manufacturer shall conduct testing, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests.

c. Installation acceptance tests to be conducted on site shall include a "cold start" test and a one step rated load pickup test in accordance with NFPA 110.
d. Test alarm and shutdown circuits by simulating conditions. Adjust output voltage and engine speed.
e. Verify fuel system installation and capacity.
f. Provide for one technician follow-up visit within 1 month of commissioning to consult with Contracting Authority and make any final adjustments, corrections, or repairs.

f. Training
   a. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 2 hours in duration and the class size shall be limited to five persons. Training date shall be coordinated with the facility Contracting Authority.

154013a.11 PROCESS INSTRUMENTATION & CONTROL

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated Process Instrumentation and Control System, the following sections shall be included under the scope of this section: Adjustable Frequency Motor Controllers, Control Panel Construction, Control Panel Components, Instrumentation Devices, Programmable Logic Controllers, Human-Machine Interface Equipment.

The work specified herein shall include the furnishing of all materials, equipment, labor, and supervision necessary to fabricate, install, start-up, and test a complete and operable Process Instrumentation and Control System.

The labor specified herein includes but is not limited to engineering, software development, panel fabrication, equipment calibration and adjustment, testing, training, and documentation.

This section identifies the overall functional requirements for the Process Instrumentation and Control System.

This section includes coordination with the work of other sections. This work includes identification of exact interface requirements with motors, control panels, and field instrumentation provided under other portions of this specification. It shall be the responsibility of the system integrator specified under this section to execute this coordination during the shop drawing submittal phase of the work. Additional costs due to inadequate coordination as required herein shall be borne solely by this contractor.

This section includes coordination with electrical contractor to ensure that the proper number of raceways and conductors are installed. It shall be the responsibility of the system integrator to coordinate this work with the installing electrician. Additional costs due to inadequate coordination as required herein shall be borne solely by this contractor.

This Contractor shall be responsible for all details which may be necessary to properly install, adjust and place in operation the complete installation. The Contractor shall assume full responsibility for additional costs which may result from unauthorized deviation from the Contract Documents.

It shall be the responsibility of the Contractor and supplier to examine all new and existing equipment that is transmitting a signal to, or receiving a signal from equipment specified in the Section. The Contractor shall be responsible for providing signal converters, buffer amplifiers, and isolation devices to make signal levels, reference to ground, etc. compatible between devices specified in the Section and existing equipment.

It shall be the responsibility of the System Integrator to provide the OmniSite Crystal Ball alarm annunciation unit and to coordinate with the City of Waukee to establish service to this unit via the City of Waukee's existing account.

1. Applicable Publications
    a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
        i. American National Standards Institute/Instrument Society of America (ANSI/ISA), Specifications and Standards, current edition:
            - PLC fail
            - ANSI/ISA-5.1-1984 - Instrumentation Symbols and Identification.
            - ANSI/ISA-5.3-1983 - Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.
            - ANSI/ISA-95.00.01-2000 - Enterprise Control System Integration, Part 1: Models and Terminology.
            - ANSI/ISA-TR99.00.01-2004, Security Technologies for Manufacturing and Control Systems.
            - ANSI/ISA-TR99.00.02-2004, Integrating Electronic Security into the Manufacturing and Control Systems Environment.
        ii. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
            - NFPA 70 - National Electrical Code.
        iii. European Community, Applicable Directives.
            - EN50005 - for Terminal Markings.
            - EN50081-1- Generic Emission Standard.
            - EN50082-1 - Generic Immunity Standard.
            - EN61000-4-4 - Electromagnetic compatibility (EMC). Testing and measurement techniques.
            - EN61000-4-5 - Electromagnetic compatibility (EMC). Testing and measurement techniques. Surge immunity test.
        iv. Canadian Standards Association (CSA), Specifications and Standards, current edition:
            - CSA C22.2, Industrial Control Equipment.
        v. CUL - Underwriter's Laboratories of Canada.
        vi. International Electrotechnical Commission (IEC), Specifications and Standards, current edition:
            - IEC 60529 - Classification of Degrees of Protection Provided by Enclosures
        vii. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition:
            - NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
            - NEMA ICS 3 - Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC.
        viii. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition:
            - UL508 - Industrial Control Equipment.
            - UL508A - Industrial Control Panels.
            - UL 913 - Intrinsically Safe Specification.
            - UL94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

2. Submittals
    a. Submit the following information specifically for hardware alarm notification system:
        i. General requirements specific to this section include:
            - Submit complete and integrated document containing all equipment included under the scope of this section.
            - Submittal shall be complete, neat, orderly, and indexed with tabbed dividers. Partial submittals will not be accepted.
            - Include a complete list of proposed exceptions to and deviations from these specifications.
            - Clarity and completeness are of prime importance. Acceptability of submittal drawings shall be at the sole discretion of the Engineer in regards to this requirement.
            - Additional requirements for the various subsystems are specified in the corresponding sections.
        ii. Submit the following information:
            - Bill of Materials:
                - Complete listing of all components identifying exact make and model, quantity, and description.
            - Component Data Sheets:
                - Detailed listing for each type of device, identifying Engineer's tag number, manufacturer, model, options, ranges, and other information necessary to supplement component catalog cut sheets and clearly show compliance with these specifications.
            - Component Catalog Cut sheets:
                - Manufacturer's standard catalog information.
            - Control Panel Construction Drawings:
                - Scaled drawings of all control panels and enclosures.
                - Front panel elevation complete with nameplate legend.
                - Back panel elevation complete with schedule of devices.
            - Control Panel Schematic Wiring Diagrams:
                - Ladder type schematic diagrams.
                - Show all devices requiring electrical connections.
                - Identify all wire and terminal numbers.
                - Identify PLC I/O addresses.
                - Reference Engineer's tag number where assigned.
                - Cross-reference all relay contacts and coils.
                - Identify switching action on all switching devices.
                - Common diagrams will not be accepted.
            - Analog Loop Diagrams:
                - Show all devices requiring electrical connections.
                - Identify all wire and terminal numbers.
                - Identify PLC I/O addresses.
                - Identify location of loop power supply.
                - Identify field devices, back-of-panel devices, and front-of panel devices.
                - Show tabular summary of transmitter output capability, input impedance of each receiver, total loop impedance, and reserve output capacity.
                - Reference Engineer's tag number where assigned.
                - Common diagrams will not be accepted.
            - Control Panel Plumbing Diagrams:

- Show all devices requiring plumbing connections (air or liquid).
- Show pipe/tube sizing.
- Show all control devices (valves, regulators, filters, etc.).

- Control Panel Power and Environmental Requirements:
  - Identify voltage and ampacity requirements.
  - Show sizing calculations for environmental controls (ventilation, heat, air conditioning).
- Interconnecting Wiring Diagrams:
  - Show all interconnections between control panels.
  - Show all interconnections between control panels and motor control centers.
  - Show all interconnections between control panels and field devices.
  - Show all interconnections between motor control centers and field devices.
  - Identify all wire and terminal numbers, including field terminal junction box terminals.
- Control Device Installation Details:
  - Supplement contract documents with additional details necessary for proper installation of control devices.
- Configuration Documentation:
  - Submit complete, documented configuration data for all configurable controllers.
  - Additional requirements for PLC systems and PC based SCADA systems are identified in the individual subsystem sections.

3. Factory Testing
   a. The entire Process Instrumentation and Control System shall be assembled at the manufacturer's facility and tested to the greatest extent possible. This test shall include simulation of all I/O points and demonstration of proper system operation. Document the results of this test in writing and submit to the Engineer.
   b. The Engineer and Contracting Authority may witness the factory acceptance test. Schedule test date a minimum of 2 weeks in advance to allow attendance by the Engineer and the Contracting Authority. Contractor shall provide actual screens, outline of sequence operation and agenda for preliminary review by the Contracting Authority and Engineer one week prior to meeting. Contractor shall supply overnight lodging and meals for four representatives from the Contracting Authority for the factory test.
   c. Correct any deficiencies identified during the test prior to shipping the control system to the job site.
4. Operation/Maintenance Manuals and Instructions
   a. Submit the following information specifically for Lift Station Control system:
      i. Submit final revised shop drawings incorporating any modifications made as a result of factory test, installation, start-up, operational testing, or for any other cause. Submit results of all field-testing and corrective actions taken for all discrete control devices and for all analog control devices. Submit analog device calibration data sheets.
      ii. Submit manufacturers' standard operation & maintenance information including installation manuals and safety instructions.
      iii. Submit contact list identifying names, addresses, telephone numbers, and any additional contact information for each equipment service organization involved with the Process Instrumentation and Control System.
      iv. Submit detailed operation and maintenance procedures for each major equipment item; include description of operation for all modes of operation, routine maintenance procedures, and trouble-shooting guide.

v. Submit listing spare parts provided under this contract and of recommended additional spare parts not provided under this contract along with costs.
vi. Provide an operating manual for all graphic interface panels. The manual shall consist of:
- Color screen print-outs of all graphic screens organized in a logical manner.
- Narrative description of what is shown on the screen.
- Description of all operator adjustable values, including the permissible range and start-up values.
- Suitable Binder.
- Table of Contents and index tabs.
- Both hard copy and electronic format (Word or pdf).

5. Quality Assurance
   a. Products: Listed and classified by UL or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

B. MATERIALS

1. System Integrator
   a. The system integrator shall be a firm specializing in the integration of control systems with documented experience in the detailed design, construction, configuration, and maintenance of PLC based control systems and motor control centers for the water/wastewater utility market. This experience must include a minimum of five projects similar in nature to this project during the last 5 years.
   b. Acceptable System Integrators are as follows:
      i. Automatic Systems, contact Travis Moran, telephone number (515) 232-4770.
      ii. Electric Pump, telephone number 515-265-2222.
      ~~ii~~ iii. IPS, contact Eric Fisher, telephone number 608-849-4375.
      ~~iii~~ iv. Jetco, Inc., contact John Whitacre, telephone number 515-967-5874.
      ~~iv~~ v. PRIMEX, contact Dan Origer, telephone number 515-450-7652.
2. General Functional Description
   a. Summary of System Improvements:
      i. New PLC based control system shall be provided at the following locations:
         - Lift Station Local Control Panel:
           - Provide new LCP in new enclosure, which shall consist of:
           - Motor controllers and components
           - Intrinsically safe barriers for level control
           - Allen-Bradley MicroLogix 1400 Ethernet processor, associated chassis, power supply and scheduled I/O modules
           - Industrial Ethernet switch (N-Tron or Hirschmann.
           - High-brightness Operator Interface
           - Uninterruptible Power Supply
           - Alarm Dialer/System Monitor - Omni-Site Crystal Ball
   b. General Requirements:
      i. The process instrumentation and control system consists of the following functional divisions which will be defined in detail for each loop under Detailed Functional Description:
         - Local Control Functions: includes local control panels, pilot control devices, instruments, and sensors.
         - Motor Control Functions: includes hardwired MCCs, Ethernet networked MCCs, and pilot control devices located within these MCCs.

- SCADA System Control Functions: includes PLC hardware, interface devices, and PLC logic.
- SCADA System Monitoring Functions: includes graphical user interface hardware and configuration, event monitoring and logging functions, analog parameter trending, and alarm handling.
- SCADA System Historical Data Functions: includes historical database, report configuration, and interface with the existing maintenance management software system, if applicable.

ii. The process instrumentation and control system includes SCADA system workstations and network infrastructure. It shall be the responsibility of the system integrator to coordinate all efforts specified herein with these existing systems so as to minimize impact on facility operations.

iii. SCADA/HMI Graphical Interface

- All SCADA/HMI functions shall be shall be configured on the control panel mounted touch screen(s) in a consistent manner in accordance with industry conventions and standards. Screens shall display information in a logical, hierarchical fashion that allows simple navigation and operator understanding of the interface. The Contracting Authority and Engineer shall determine the acceptability of all proposed interface screens; refer to the submittal requirements for this section and to the operator interface functional requirements shown on the drawings.
- In the event of a localized or complete network failure, the operator interface touch screens shall operate a local application that provides interface only to the associated PLC.
- The HMI display systems for this project include hardware of varying screen resolutions. Provide HMI display images sized for the display hardware. Distorted display images due to the lack of coordination between display image and display hardware resolutions will not be acceptable.
- Configure a facility overview display that graphically displays all plant processes. Areas of the facility which are being incorporated into the SCADA system at this time shall be included in this overview. The intent is that this screen will serve as the main portal to the various process display screens. The overview shall include links to the processes presently incorporated into the SCADA system and may be expanded in the future to include additional processes.
- Operator interface functions shall include an event/alarm log which will time and date stamp each event and alarm occurrence and will also indicate the time an alarm was acknowledged and the time an alarm was cleared. Alarm handling shall be configured such that acknowledgment will only be required in a single location in order to acknowledge a cleared alarm. Refer to the detailed functional descriptions for alarm system interface with the existing plant paging system.
- Operator interface functions shall include an equipment runtime/starts-per-day log, analog signal trends, and totalization for the signals indicated. Provide a non-resettable totalizer for each runtime and flow total.

iv. Historical Data

- The historical data shall also be available in tabular format for manipulation and analysis by operations and engineering personnel. Data format and process reporting and graphing shall be coordinated and verified with the Contracting Authority and Engineer.

c. Typical Motor Control Functions:

i. Type IV Motor Control - Ethernet capable, adjustable frequency drive.
   - Local Control Functions:
     - Any additional sensors or functions are specified in the detailed functional description.
   - Motor Control Center Functions:
     - Panel HAND-OFF-AUTO selector switch shall control motor operation in HAND position. Motor will run at local HMI selected speed.
     - In OFF position, the motor shall not run.
     - In AUTO position, the motor shall start and stop in response to the Ethernet I-O REQUIRED.
     - Provide time delays on hardwired protective interlock circuits to prevent nuisance tripping.
   - AFD shall be configured with a starting ramp.
     - AFD input contactor shall disconnect the AFD from line power when not required to run.
     - Pilot control circuitry shall be designed such that HAND position control and any additional interlock circuitry identified in the detailed functional descriptions will be functional regardless of the status of the Ethernet network.
     - Adjustable frequency drive shall provide motor protection. Adjustable frequency drive shall monitor the following motor data functions: AFD READY, OVERLOAD, AFD ALARM, AFD FAULT, RUN, OUTPUT CURRENT, and PERCENT SPEED.
     - RUN condition shall activate corresponding panel pilot light.
     - Provide auxiliary contacts to allow Ethernet monitoring of the following conditions: DISCONNECT OPEN and IN AUTO conditions.
     - Provide additional functions as specified in the detailed functional description.
   - SCADA System Control Functions:
     - Graphical display MANUAL-OFF-AUTO selector (unless specified otherwise) shall control the REQUIRED signal. In MANUAL, the signal shall be active and the SPEED COMMAND shall be manually input. In OFF, the signal shall be inactive. In AUTO, the signal and the SPEED COMMAND shall be controlled by the automatic control strategy specified in the detailed functional description.
     - Generate FAIL-TO-RUN alarm based on a discrepancy between RUN and REQUIRED signals after an adjustable FAIL DELAY time has elapsed. FAIL-TO-RUN condition shall prevent motor operation until cleared and reset.
     - Generate ABNORMAL CURRENT signal when motor average current falls below or rises above adjustable MINIMUM/MAXIMUM set points.
     - Provide additional functions as specified in the detailed functional description.
   - SCADA System Monitoring Functions:
     - Display the following status conditions: MCC DISCONNECT OPEN, MCC IN AUTO, REQUIRED, RUN, ABNORMAL CURRENT, PHASE LOSS, GROUND FAULT and MOTOR OVERLOAD.
     - Display, trend, and record the following parameters: AVERAGE CURRENT, PERCENT CURRENT IMBALANCE, and PERCENT THERMAL CAPACITY USED.
     - Incorporate into the plant alarm paging system and display the following alarm conditions: FAIL-TO-RUN.
     - Provide additional functions as specified in the detailed functional description.

- SCADA System Historical Data Functions:
  - Display non-resettable runtime total.
  - Calculate, display, and record daily runtime total.
  - Calculate, display, and record number of daily starts.
  - Provide additional functions as specified in the detailed functional description.

3. Unit Process 1: Lift Station Pumping
   a. Loop 1-1: Influent Pump Control
      i. Motor Control Scheme
         - Provide Type IV motor control.
      ii. Local Control Functions:
         - Provide pump motor high temperature discrete signal to SCADA.
         - Provide pump high moisture signal for seal fail indication.
      iii. Motor Controller Functions (Local Panel):
         - Interlock motor high temperature switch with shutdown of pump at Control panel.
         - Provide hardwired adjustable pump back-spin re-start delay after pump stop.
         - Provide hardwired backup operation scheme which shall become active whenever PLC or submersible level sensor fail, evidenced by alarm float switch being triggered. High and low alarm float switches shall sense and alarm on abnormal level conditions.
         - Provide a discrete, hardwired alternator for back-up float operation, powered off a control power circuit separate from the PLC control system. The back-up hardwired float system shall provide full back-up operating capability independent of PLC control. Pumps shall run until the wetwell level reaches the Pumps Off float, and shall then be started automatically by floats as indicated below. Pumps shall have staggered, time-delayed starts to prevent simultaneous starts on high level. Activate pumps and alarms based upon the following wet well level conditions:
           - High Level Alarm/Back-Up Mode Enable.
           - Lead Pump On. Lag pump on after adjustable time delay
           - Low Level Alarm/Pumps Off.
         - Provide adjustable time delays to prevent simultaneous pump starts.
         - Pump speed in Back-up float control mode shall be pre-set at the VFD via a hard-wired input and shall be set at 100% at start-up.
      iv. SCADA System Control Functions
         - Provide alternation entry field for operator to selected pump to operate: manual or automatic alternation.
           - Manual selection of lead pump, Pump 1-Pump 2.
           - Automatic alternation of lead pump when lead pump has been called to run for an operator adjustable time period.
           - Automatic fail-over to start next pump on lead pump fail.
         - Provide operator set minimum pump speed.
         - Operator adjustable parameters to the automatic level control system are as follows:
           - Level set point values: L1, L2, L3, L4, and L5.
           - Delay Time: T
           - Minimum pump speed for operation of one VFD driven pump: Speed 1
           - Minimum pump speed for multiple pump operation: Speed 2
         - Two Pump Automatic Operation shall be as follows:

- L1 – low level alarm/redundant pumps off
- L2 – pumps off
- L3 – lead pump on. Pump speed is adjusted with rising and falling level with minimum pump speed Speed1.
- With falling level to L2, and after delay time T, Lead pump is deactivated.
- L4 – lag pump on. Speed of both pumps varies with rising and falling water level with minimum pump speed Speed2.
- With falling level to L2, and after delay time T, both pumps are deactivated.
- L5 – high level alarm

- Alarm and Back-up Level Control
  - Provide back-up mode On-Off-Auto switch to control enabling of back-up mode. In Off position back-up mode shall not be enabled, in On position back-up mode shall be continuously enabled, in Auto position back-up mode shall be enabled by high-level alarm float switch.
  - At L5, activate high level alarm.
  - At L5, activate float switch control.

v. SCADA System Monitoring Functions
- Monitor back-up mode enabled signal.

vi. SCADA System Alarming
- Provide pump fail alarm.
- Provide seal fail alarm.
- Provide “backup system active” alarm.

vii. SCADA System Historical Data Functions
- Provide daily flow calculation based pump runtimes.
- Incorporate influent wetwell pumping in overall station graphic

b. Loop 1-2: Wetwell Level Monitoring

i. Local Control Functions:
- Provide analog wetwell level signal from submersible level sensors.
- Provide discrete high level alarm/back-up enable signal from ~~float~~ level switch.
- Provide discrete high level/lead pump on signal from ~~float~~ level switch.
- Provide discrete pump on signal from ~~float~~ level switch.
- Provide discrete pumps off/ low level alarm signal from ~~float~~ level switch.

ii. Motor Controller Functions (Local Panel):
- None additional.

iii. SCADA System Control Functions
- Initiate backup control on operator adjustable high level signal.

iv. SCADA System Monitoring Functions
- Provide wetwell level indication.
- Monitor wetwell high level.
- Monitor wetwell low level.

v. SCADA System Alarming
- Provide wetwell high level alarm.
- Provide wetwell low level alarm.

vi. Historical Data Functions
- Display, log and trend data per P&ID.
- Trend wetwell level and incorporate influent pumping and wetwell level in overall plant graphic display and daily process reports.

4. Unit Process 2: Station Power Monitoring
    a. Loop 2-1: Power Fail Monitoring
        i. SCADA System Monitoring Functions:
            - Monitor per P&IDs
                - Station Power Fail
        ii. SCADA System Alarming
            - Station Power Fail
    b. Loop 2-2: Phase Fail Monitoring
        i. SCADA System Monitoring Functions:
            - Monitor per P&IDs
                - Station Phase Fail
        ii. SCADA System Alarming
            - Station Power Fail
5. Unit Process 3: Station Temperature Monitoring
    a. Loop 3: Panel Temperature Monitoring
        i. SCADA System Monitoring Functions:
            - Monitor per P&IDs
                - Panel temperature
        ii. SCADA System Alarming
            - Panel high temperature (adjustable set-point)
            - Panel low temperature (adjustable set-point)
6. Unit Process 4: Control System Monitoring
    a. Loops 4-1, 4-2 and 4-3: Control System Power Monitoring
        i. SCADA System Monitoring Functions:
            - Monitor per P&IDs
                - 120V control panel power
                - ~~PLC~~ Controller health
                - UPS. Interface all available status signals to ~~PLC~~ controller and log events.
                    - Line Fail
                    - UPS Fault
                    - UPS Charging
                    - UPS On Battery
                    - Replace UPS Battery
        ii. SCADA System Alarming
            - ~~PLC~~ Controller fail
            - Control Power Fail
            - UPS Fail
7. Unit Process 5: Intrusion Monitoring
    a. Loop 5: Intrusion Monitoring
        i. SCADA System Control
            - Provide unlabeled deadfront panel lighted pushbutton to disable intrusion alarm.
            - Provide operator adjustable time delay to automatically re-arm intrusion monitoring and annunciation.
        ii. SCADA System Monitoring Functions:
            - Monitor per P&IDs
                - Door Open Signal
                - Intrusion defeat signal
        iii. SCADA System Alarming

- Intrusion

8. Unit Process 6: Station Alarm and Monitoring
    a. Loop 6: Alarming
        i. Local Panel Functions
            - Provide front of panel alarm silence pushbutton to silence alarm horn and turn off alarm strobe.
            - Provide local alarm annunciation via alarm horn and alarm strobe.
        ii. SCADA System Monitoring
            - Provide the following Alarm/Monitoring points to station alarm dialer/monitor.
                - Pump No.1 Fail
                - Pump No.2 Fail
                - Pump No.1 Run time accumulation
                - Pump No.2 Run time accumulation
                - High alarm level (Hard-wired from float relay to alarm annunciator)
                - Back-up control active (Hard-wired from float relay to alarm annunciator)
                - Station Power Fail
                - Control power fail
                - UPS fail
                - High/Low panel temperature
                - Wetwell level trending
                - Pump speed pacing
                - Pump 1 full load amps
                - Pump 2 full load amps
        iii. SCADA System Alarming
            - Provide common alarm on front of panel.
            - Alarm on following alarm points to station alarm dialer/monitor. Provide OmniSite Crystal Ball unit for remote alarm annunciation. Operator interface/keypad be provided with extension cable and shall be deadfront accessible. Include one year of subscription service. Final determination of alarm configuration shall be done during the shop drawing review phase:
                - Pump No.1 Fail
                - Pump No.2 Fail
                - High alarm level (Hard-wired from float relay to alarm annunciator)
                - Low alarm level (Hard-wired from float relay to alarm annunciator)
                - Back-up control active
                - Station Power Fail
                - Control power fail
                - UPS fail
                - High/Low panel temperature

C. CONSTRUCTION.

1. Software Configuration Services
    a. General Graphic Screen Design Requirements:
        i. Present displays in a consistent manner in accordance with industry conventions and standards.
        ii. Screens shall display information in a logical, hierarchical fashion that allows simple navigation and operator understanding of the interface.

iii. Provide a minimum of one screen for each unit process as defined in above, and on the Process and Instrumentation Drawings (P&IDs). The exact number of screens and detail will be dictated by the scope and complexity of the project.
iv. The System Integrator is encouraged to solicit feedback throughout the development of the graphic screens. Formal feedback will be provided at the point of the pre-submittal coordination conference, shop drawing submittal, and factory witness test.

b. Graphic Overview Screens:
   i. Process Trending
      - Provide pre-configured trend screens for all analog process variables. In addition, provide two trend screens with operator assignable pens that may be reconfigured as specific trending needs arise. Trend screens shall be quickly accessible through a menu button which allows navigation to the trend screen keyed to that respective process screen. In addition, provide a means to navigate to a selected trend screen from the main menu system. Typical analog process variable trend screens would include the following:
        - Pump Station Parameters (Levels, Pump On/Off, Pump Speed where VFD Controlled).
   ii. Totalized Information Display:
      - Equipment Totals:
        - Display cumulative, non-resettable runtime.
        - Display daily runtime total for yesterday and today.
        - Display number of starts for yesterday and today.
   iii. User Security Levels:
      - Configure the following user name and password controlled security levels for each utility (water, wastewater, etc.):
        - Operator Standard - Display Only
        - Operator Advanced - Display, Control, and Reporting Only
        - Supervisor - Display, Control, Reporting, and Set Point Adjustment
        - Engineering - Display and Reporting Only
        - Coordinate additional security levels with Contracting Authority and Engineer during shop drawing review.
   iv. Process Setpoint Capture:
      - Display all current values for operator adjustable process control set-points; provide print out or screen capture capability.
   v. Facility Management Screens:
      - Provide screens to facilitate monitoring and control of the following when included on the project:
        - Standby Power Systems and Load Control
        - Alarm Channel Assignment and Control
        - Alarm History
        - Event History
        - Environmental monitoring
        - Access monitoring and control
        - Surveillance monitoring
   vi. Alarm Management Screens:
      - Provide screens which depict active and historical alarm lists.
      - Alarms shall be grouped in a logical manner, generally in alignment with the Loop sequence.

- Provide Alarm Dialer set-up screens which provide the following alarm management control.
- Alarm event assignment to a specified dialer channel. Where so equipped with both a software based dialer and a hardwired dialer, channel assignments for both shall be made from the same screen.
- Enable/Disable toggle for local audio-visual alarm devices for each alarm point.
- Enable/Disable dial-out toggle for each alarm point.
- On each alarm window provide a Pareto Chart via an ActiveX control in which one can quickly analyze which alarms and events occur most frequently in a given (by filter) time period, area of plant, piece of equipment, etc. The Alarm Pareto ActiveX shall automatically update every time the alarm display query is updated or changed. Further, the Alarm Pareto should allow for adjustment of number of bars being displayed in the Pareto chart, whether the orientation is horizontal or vertical and colors of bar charts.

vii. Additional Screens:

- Provide up to five additional screens as directed by the Contracting Authority. The need for these screens will be determined during the shop drawing review, witness testing, and start-up phases.

c. Display Conventions:

i. Colors, Screen layout, computer resolution should be consistent among all vendors and shall be coordinated by the System Integrator.

ii. Graphic Detail:

- 3-D only for equipment, process piping represented by lines in a P&ID style.

iii. Screen Layout:

- Main Menu:
  - X=0, Y=-38
  - Width = 1280, Height = 136

iv. Main Window:

- X=0, Y=100
- Width = 1280, Height = 779

v. Alarm Window:

- X=0, Y=879
- Width = 1280, Height = 105

vi. Indicator Colors:

- Green:
  - HOA (Hand-Off-Auto) in Auto
  - Pump Run
  - Valve is Open
- Yellow:
  - Required/Called to Run
  - Valve Traveling
  - HOA in Hand
  - Float for control is activated
- Light Blue:
  - Valve is closed
  - OCA in Close
- Red or Blinking Red:

- In Alarm
- Failed
- Float for alarm is activated

- White
  - Pump/Equipment is Off
  - HOA in Off
- Grey:
  - Pump/Equipment is Off
  - Inactive state
  - Unacknowledged, Cleared Alarm
- Blinking Grey:
  - HOA or OCA at MCC not in Auto. Pump/Valve is unavailable for automatic control from PLC.

vii. Numeric Display and Data Entry Colors:
- Black background with green text displays a value from field devices such as flow meters and level sensors.
  - White background with black text is a numeric entry for entering setpoints.
  - White background with red text is a numeric entry for entering alarm setpoints.
  - Gray background with black text is a calculated number or accumulator value, such as runtimes, flow totals, and other elapsed timer values.

viii. Alarm and Event Text Colors:
- Red text signifies a current unacknowledged alarm.
- Blue text signifies a current acknowledged alarm.
- Green text signifies an alarm that has returned to normal.
- Black text signifies and event such as pump run, setpoint change, or valve closed.

ix. Alarming:
- Method of alarm acknowledgement and silencing (horn & dialer) standard set by System Integrator after discussion with Engineer and all involved vendors.

x. Communication:
- Networked Microprocessors and Computers
  - IP addressing shall be coordinated and controlled by the System Integrator.
  - Naming convention standards shall be coordinated and controlled by the System Integrator.
- Control system equipment failure and communication failure procedures shall be discussed and confirmed with all vendors that communicate I/O requests.
- Setup parameters for I/O communications between PLC's will be coordinated and controlled by the System Integrator.

xi. Security
- Create users and security levels for on screen access, and control and setpoint access.

2. Field Measurements
   a. Field verify with exact measurements, the available mounting space for control system equipment. Identify deficiencies prior to beginning installation.
   b. Where ranges are indicated on the contract documents, they are to be considered preliminary. Field verify the exact ranges required based on field conditions.

3. Delivery, Storage, and Handling
    a. It shall be the responsibility of the installing contractor to receive all process instrumentation and control equipment at the job site. Carefully inspect all equipment for damage prior to accepting from the shipping agency. Do not accept shipment if damage is evident.
    b. Exercise due diligence in storing, protecting, and moving process instrumentation and control equipment. Damaged or worn equipment will not be accepted and will be replaced at no additional cost to the Contracting Authority.
4. Installation
    a. Install equipment in locations as indicated on the contract documents. Adjust locations as needed to ensure operability, serviceability, and compliance with all applicable codes and standards.
    b. Installation shall be completely tested prior to start-up. This work includes verification of all field wiring continuity and proper termination of wiring.
5. Testing and Start-Up Services
    a. System Integrator shall provide installation and start-up services required to place the complete system into operation.
    b. Each signal and function shall be fully tested. These tests shall be based on actual operation of primary elements and verification of proper control system response. Submit test results as part of Operations and Maintenance Manual.
    c. Record calibrations of all analog devices.
    d. Demonstrate proper operation of the process and instrumentation control system to the Contracting Authority and in the presence of the Engineer.
6. Training
    a. Training shall be suitable for plant operations personnel with limited knowledge of electrical components.
    b. Provide two instructor days of operator training at the job site. Training shall consist of operations instruction and maintenance/trouble-shooting instruction.
        i. Operations instruction shall identify all control loops with description of all interlocks, interface with other loops, and operational input requirements. Describe procedures for re-starting the system.
        ii. Maintenance instruction shall identify periodic maintenance that can be performed by the operator. Provide description of procedures and locations for replacement of consumable devices such as fuses and for checking the calibration or operation of devices.
        iii. Trouble-shooting instruction shall identify simple procedures and methods for identifying potential causes in the event of failures. For example, instruct operator on correlation of input signals and PLC I/O module indicator lights.

154013a.12 CONTROL PANEL CONSTRUCTION

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated process instrumentation and control system, the work specified herein shall be included under the scope of Process Instrumentation & Control.

1. Application Publications
    a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
        i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards:
            - ANSI/NFPA 70 - National Electrical Code and state amendments thereto.

- ANSI/NFPA 79 - Electrical Standard for Industrial Machinery.

ii. American National Standards Institute/Instrument Society of America (ANSI/ISA), Specifications and Standards, current edition.

iii. Canadian Standards Associates (CSA), Specifications and Standards, Current Edition.
- CSA Standard C22.2 No. 0 - General Requirements - Canadian Electrical Code, Part II
- CSA Standard C22.2 No. 0.4 - Bonding and Grounding of Electrical Equipment (Protective Equipment)
- CSA Standard C22.2 No. 14 - Industrial Control Equipment for Use in Ordinary (Non-Hazardous) Locations
- CSA Standard C22.2 No. 40 - Cutout, Junction, and Pull boxes
- CSA Standard C22.2 No. 94 - Special Purpose Enclosures

iv. Electrical and Electronic Manufacturers Association Canada (EEMAC), Specifications and Standards, Current Edition.

v. International Electrotechnical Association (IEC), Specifications and Standards, Current Edition.
- IEC 60529 - Classification of Degrees of Protection Provided by Enclosures
- IEC 60204 - Safety of Machinery - Electrical Equipment of Machines
- IEC 60079 - Electrical Apparatus for Explosive Gas Atmospheres

vi. National Electrical Manufacturers Association (NEMA), Specifications and Standards, Current Edition.
- NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- NEMA ICS6 - Enclosures for Industrial Controls and Systems

vii. Underwriters Laboratories, Inc. (UL), Specifications and Standards, Current Edition.
- UL50 - Cabinets and Boxes
- UL508 - Industrial Control Equipment
- UL508A - Industrial Control Panels
- UL94 - Flammability of Plastic Materials

2. Quality Assurance
   a. All control panels shall be constructed in accordance with UL 508 standards and shall bear the UL 508 listing.
3. Extra Materials
   a. See Iowa DOT Standard Specifications Division 11 for additional requirements.
   b. Provide one spare vapor phase corrosion inhibiting capsule for each control panel.
   c. Provide a ten or twenty percent of the total number of terminals as installed spares in each control panel.
4. Design Requirements

CONTROL PANEL CONSTRUCTION REQUIREMENTS

TAG NUMBER	DESCRIPTION	TYPE	SIZE	UPS	NOTES
LCP-1	Storm Water Lift Station Local Control Panel	F	60”Wx42”Hx12” D	X	1, 2

Notes:
1. Specified size indicates the physical size anticipated by the ENGINEER. CONTRACTOR shall verify actual size with SYSTEM INTEGRATOR and adjust installation accordingly.
2. Provide 18 inch legs and ventilated front/rear removable panels per “ventilated skirt” lift station panel design.

B. MATERIALS.

1. General Requirements
   a. Fabricate, install instruments, plumb and wire in factory.
   b. Test wiring and plumbing prior to shipment.
   c. Make external connections by way of numbered terminal blocks.
   d. Separate electrical components from pneumatic and hydraulic components by metal barriers.
   e. Conform to ISA standards.
2. Type F – Control Panel Enclosure, Free-Standing, Stainless Steel, Heated, Air Conditioned, and Insulated
   a. Manufacturer:
      i. Hoffman Enclosures, Inc. Stainless Steel Two-Door Floor-Mount Type 12 Enclosures
      ii. Stahlin
      iii. Hammond
      iv. Or equal
   b. Environmental Rating:
      i. NEMA Type 3R/12, stainless steel
   c. Construction
      i. 12 or 14 gauge Type 304 stainless steel, 12 gauge enclosures have 10 gauge backs
      ii. Seams continuously welded and ground smooth, no holes or knockouts
      iii. Strong, rigid construction with body stiffeners
      iv. Gasketed overlapping doors eliminate need for center post
      v. Plated steel three point latching mechanism and key-locking handle
      vi. Latch rods have rollers for easier door closing
      vii. Heavy gauge continuous hinges support each door
      viii. Data pocket, provided on door with three point latches, is high-impact thermoplastic
      ix. Floor stands are welded to enclosure
      x. Heavy duty lifting eyes are Type 316 stainless steel
      xi. Panel supports
      xii. Oil-resistant gasket attached with oil resistant adhesive and held in place with steel retaining clips
      xiii. Insulate interior of enclosure and door
      xiv. Thermostatically controlled panel heater sized to maintain internal panel temperature within operational parameters of all internal components
      xv. Collar studs for mounting optional panel
      xvi. Ground studs in body of enclosure
      xvii. Bonding provision on doors
      xviii. Drip shield kit
      xix. Provide air conditioning unit to thermostatically control internal panel temperatures during warm weather. Size unit accommodate heat generated by control power transformer and VFD operation.
      xx. Finish:
         - Enclosures are unpainted. Front, sides, top, and back have smooth No.4 brushed finish
         - Steel sub-panels are painted white
      xxi. Provide hinged dead front inner panels; Right hand door shall be 480V section, Left had door shall be 120VAC/24VDC control section. Right had deadfront shall be interlocked to Utility/Generator Main Disconnect circuit breakers.
      xxii. Mount OmniSite Crystal Ball unit to back pan, with extension cable to deadfront accessible operator interface.

C. CONSTRUCTION.

1. Field Measurements
   a. Refer to the requirements of Process Instrumentation & Control.
2. Delivery Storage and Handling
   a. Refer to the requirements of Process Instrumentation & Control.
3. Installation
   a. Refer to the requirements of Process Instrumentation & Control.
4. Control Panel Fabrication and Environmental Protection Requirements
   a. Instrument Mounting:
      i. Locate instruments designated for back-of-panel mounting in manner to allow for maintenance and adjustment.
      ii. Instrument mounting height shall not exceed 6 feet 6 inches. Minimum height shall be 4 feet 0 inches.
      iii. Panel cutouts for instruments and other devices, such as lights and switches, shall be cut, punched, or drilled and smoothly finished with rounded edges.
      iv. Provide steel angle stiffeners on back of panel face to prevent panel deflection under instrument loading or operation.
      v. Provide internal structural steel framework for instrument support purposes and panel bracing. Internal framework shall permit lifting of panel without racking or distortion.
      vi. Provide shelf or bracket support for any equipment not secured to panel, such as UPS or router. Shelf placement shall allow for bending space for wiring entering panel.
   b. Corrosion Protection:
      i. Provide vapor phase corrosion inhibiting capsules in each control panel to protect all exposed metal surfaces for a period of at least two years. Corrosion inhibiting modules shall be Northern Instrument Corporation, Zerust vapor capsules Model VC-2-2 or Hoffman Engineering Corporation corrosion inhibitor Model A-HCI-5.
      ii. Provide thermostatically controlled condensation heater in panels located high humidity areas and in areas in which ambient temperature will vary. Heater shall be sized to prevent condensation within panel.
   c. Heating, Ventilating, and Air Conditioning:
      i. Provide heating equipment as specified under Part 2.
      ii. Provide filtered ventilation fan(s) where needed and sized to dissipate heat generated by components located within control panel.
      iii. Provide filtered air conditioning equipment and insulate panel where needed to maintain internal panel temperature within operating parameters of internal panel components.
   c. Coordination:
      i. Clearly mark and coordinate with installation Contractor areas dedicated to intrinsically safe circuits.
5. Control Panel Electrical Requirements
   a. Electric Service:
      i. Design control panel to operate on electrical supply indicated on the drawings.
         - Three phase service:
           - Provide main circuit breaker.
           - Provide branch circuit breakers for distribution of three phase and single phase power at voltages above 120VAC.
           - Control panel and internal components shall be rated to interrupt the available fault current.

- Main circuit breaker and branch circuit breakers shall be coordinated such that a fault in a branch circuit will trip only the branch circuit breaker and not the main circuit breaker.
- Separate 480VAC wiring from control voltage wiring.
- Provide appropriately sized control power transformer.
- Provide miniature circuit breakers for distribution of 120VAC control power in accordance with the following:
  - No more than 20 devices on any single circuit.
  - Where multiple units perform parallel operations, do not group all devices on the same branch circuit. The purpose is to prevent the failure of any single branch circuit from shutting down at entire operation.
  - Do not exceed the ampacity of the branch circuit.
  - Panel service outlet shall be protected by separate branch circuit breakers
  - Power supplies shall be protected by separate branch circuit breakers.
- Provide 20 amp, 120VAC deadfront mounted GFCI convenience outlet.
- Control power transformer fuses and branch circuit breakers shall be coordinated such that a fault in a branch circuit will trip only the branch circuit breaker and not the control power transformer fuses.
- Branch circuit breakers shall be rated for 15A and 250VAC.
- Fuses shall not be substituted for circuit breakers.

- Single phase service:
  - Provide main circuit breaker.
  - Provide miniature circuit breakers for distribution of 120VAC control power in accordance with the following:
    - No more than 20 devices on any single circuit.
    - Where multiple units perform parallel operations, do not group all devices on the same branch circuit. The purpose is to prevent the failure of any single branch circuit from shutting down at entire operation.
    - Do not exceed the ampacity of the branch circuit.
    - Panel service outlet shall be protected by separate branch circuit breakers
    - Power supplies shall be protected by separate branch circuit breakers.
  - Provide 20A, 120VAC service outlet circuit within back-of-panel area.
  - Main circuit breaker and branch circuit breakers shall be coordinated such that a fault in a branch circuit will trip only the branch circuit breaker and not the main circuit breaker.
  - Branch circuit breakers shall be rated for 15A and 250VAC.
  - Fuses shall not be substituted for circuit breakers.
- Uninterruptible power supply:
  - Provide a DIN rail mounted uninterruptible power supply (UPS); provide distribution of 120VAC power on the line and load sides of the UPS.
  - Panel service outlet and other non-critical loads shall be powered from the line side of the UPS. Critical loads, including but not limited to all digital control equipment, shall be powered from the load side of the UPS.
  - Provide UPS bypass circuitry to minimize heating of control panel and unnecessary wear of the UPS battery.

b. Output Signal Fusing:
   i. Provide appropriately sized fuses for all output signals to devices located external to the panel in accordance with the following requirements:

- Maximum fuse size: 5A
- Separate fuse for each device
- Fuses shall be installed in indicating type fuse holder terminal blocks.

c. Control Panel Wiring:
   i. Wiring within panels, consoles, racks, and cabinets shall meet the following requirements:
      - Wires for ac circuits shall be 300V or 600V, Type MTW stranded copper and shall be sized for the current to be carried but not smaller than No.16 AWG.
      - Wires for analog signal circuits shall be 300V stranded copper and shall be twisted shielded pairs not smaller than No.18 AWG.
      - Wires for other dc circuits shall be 300V, Type MTW stranded copper not smaller than No.18 AWG.
      - Wiring for special signals such as communications, digital data, and multiplexed signals shall use manufacturers standard cables.
   ii. Terminal blocks for panels, consoles, racks, and cabinets shall meet the following requirements:
      - Wire all spare or unused panel mounted elements, including PLC input/output points, to terminal blocks.
      - Provide open construction terminal blocks for wiring that is entirely internal to the panel.
      - Provide isolation switch terminal blocks for all wiring that is not entirely internal to the panel.
      - Rail-mount individual terminals to create a complete assembly. Provide terminals constructed such that jumpers can be installed with no loss of space on terminal or rail.
      - Size all terminal block components to allow insertion of all necessary wire sizes and types.
      - Provide power distribution blocks for distribution of control panel power at voltages exceeding 120VAC.
   iii. Grounding:
      - Panels, consoles, racks, and cabinets shall be provided with an isolated copper grounding bus for all signal and shield ground connections. This ground bus shall be grounded at a common single ground point. The signal grounding system shall meet National Electrical Code requirements.
      - Each analog loop shall only be grounded at a single point for the loop. This single point shall be at the location of the dc power supply for the loop.

d. Power Supplies:
   i. Provide dc power supplies as required to power instruments requiring external dc power, including two-wire transmitters and dc relays.
   ii. Power supplies shall be suitable for intrinsically safe circuits where two-wire transmitters are located in a hazardous area.

d. Electrical Transient Protection:
   i. All electrical and electronic elements of the control system shall be protected against damage due to electrical transients induced in interconnecting lines from lighting discharges and nearby electrical systems.
   ii. Surge Suppressor Locations:
      - As a minimum, provide surge suppressors at the following locations:

- Provide 480VAC, panel mounted surge suppressor on the load side of each 480VAC main circuit breaker in each panel.
- Provide 120VAC, panel mounted surge suppressor on the load side of each 120VAC main circuit breaker in each panel.
- Provide 24VDC, panel mounted surge suppressor at the panel connections of all analog signal circuits that have any portion of the circuit extending outside of a protecting building.
- Provide 24VDC, field mounted surge suppressor at the field connection of each analog signal transmitter located outside of a protecting building.

5. Standard Signal Interfaces
   a. Unless otherwise specified discrete input and output signals shall conform to the following:
      i. Isolated unpowered (dry) contact closures.
      ii. Power contact from panel receiving signal or device receiving signal.
   b. Unless otherwise specified input and output analog signals shall conform to following:
      i. External to panel: isolated, 4-20 mA DC.
      ii. Internal to panel: 1 to 5VDC signals.
      iii. For two wire transmitter provide isolated type and power with 24VDC from panel or device receiving signal.
      iv. Where isolation is required to interface with particular equipment or because of loop impedance, provide isolated, DC-to-DC transmitter.
6. Testing and Start-Up Services
   a. Refer to the requirements of Process Instrumentation & Control.
7. Training
   a. Refer to the requirements of Process Instrumentation & Control.

154013a.13 CONTROL PANEL COMPONENTS

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated process instrumentation and control system, the work specified herein shall be included under the scope of Process Instrumentation & Control

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - ANSI/NFPA 70 - National Electrical Code and state amendments thereto.
         - ANSI/IEEE C37.90 - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
         - ANSI/IEEE C62.11- IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits.
         - ANSI/IEEE C62.34 - IEEE Standard for Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters).
         - ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
      ii. CE - European Community, Applicable Directives.
         - EN50005 - for Terminal Markings.
         - EN50081-1- Generic Emission Standard.
         - EN50082-1 - Generic Immunity Standard.

- EN61000-4-4 - Electromagnetic compatibility (EMC). Testing and measurement techniques.
- EN61000-4-5 - Electromagnetic compatibility (EMC). Testing and measurement techniques. Surge immunity test.

iii. Canadian Standards Association (CSA), Specifications and Standards, current edition:
- CSA C22.2, Industrial Control Equipment.

iv. CUL - Underwriter's Laboratories of Canada.

v. International Electrotechnical Commission (IEC), Specifications and Standards, current edition:
- IEC 60529 - Classification of Degrees of Protection Provided by Enclosures

vi. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition:
- NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
- NEMA ICS 3 - Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC.

vii. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition:
- UL508 - Industrial Control Equipment.
- UL508A - Industrial Control Panels.
- UL 913 - Intrinsically Safe Specification.
- UL94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

3. Quality Assurance
   a. Products: Listed and classified by UL or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
4. Extra Materials
   a. Supply five spare control power transformer fuses of each type supplied for this project
   b. Supply five spare lamps of each type supplied for this project.
   c. Supply two spare relays of each type supplied for this project.

B. MATERIALS.

1. Alarm Signal – Audible
   a. Manufacturer:
      i. Mallory Sonalert
      ii. Wolf Automation
      iii. Jameco
      iv. Or equal
   b. Agency Approvals:
      i. UL listed
   c. Signal:
      i. Mechanism:
         - Solid-state, piezoelectric transducer
         - Low power consumption
         - No mechanical wear from moving parts
      ii. Power Supply:
         - 120VAC, 60 Hz, input power
         - 21 mA typical operating current
      iii. Intermittent Tone:

- Frequency: 2900 + 500 Hz
- Pulse Rate: 2 to 10 pulses per second

iv. Sound Pressure Level:

- Process Equipment Area: 80-95 dBA at 2 feet
- Non-Process Equipment Area: 55-65 dBA at 2 feet

d. Mounting:
   i. Screw-neck, panel-mount
   ii. Maintain environmental integrity of panel

2. Circuit Breaker - Miniature
   a. Manufacturer:
      i. Square D QOU Unit Mount Class 720
      ii. Eaton
      iii. ABB
      iv. Or equal
   b. Agency Approvals:
      i. UL Listed
   c. General:
      i. Surface, flush or DIN rail mounting in one-, two- and three-pole construction.
      ii. Used for overcurrent protection and switching on both ac and dc systems.
   d. Construction:
      i. Terminal lug wire size: 1- No.14 - No.2 AWG Cu or Al
      ii. Reversible line and load lugs for convenient flush or surface mount wiring
      iii. DIN mounted (symmetrical rail 35 x 7.5 DIN/EN 50 022)
      iv. UL Listed as HACR type -- 15A to 70A
      v. Field installable quick connectors
      vi. Single handle with internal common trip
      vii. UL Listed 48VDC (5,000 AIR)
3. Control Power Transformer
   a. Manufacturer:
      i. Cutler Hammer, Type MTE
      ii. Square D
      iii. Acme
      iv. Or equal
   b. Agency Approvals:
      i. UL Listed
      ii. CSA Certified
   c. Construction:
      ii. Epoxy encapsulated coils
      iii. High quality silicon steel laminations
      iv. Copper magnet wire
      v. 130° F rise, Class 105 insulation system
      vi. Molded terminals
   d. Electrical:
      i. Capacity:
         - Select transformer VA rating based upon connected load with an additional 25 percent spare capacity.
      ii. Primary terminals:
         - 240 x 480VAC

- 230 x 460VAC
- 220 x 440VAC
- Finger-safe terminal covers

iii. Secondary terminals:
- 120VAC
- 115VAC
- 110VAC
- Finger-safe terminal covers

iv. Fusing:
- Dual primary fuse block
- Single secondary fuse block
- Finger-safe fuse block covers
- Class CC fuses, sized for VA rating of transformer

v. Mounting:
- Back panel

4. Intrinsically Safe Barrier
   a. Manufacturer:
      i. R. Stahl, Intrinsipak Series 9001/9002
      ii. PR Electronics
      iii. Pepperl-Fuchs
      iv. Or equal
   b. Certificates:
      i. Zone 1: PTB 01 ATEX 2088
      ii. Zone 2: PTB 01 ATEX 2135
   c. Explosion protection:
      i. Zone 1: E II (1/2)G [EEx ia/ib] IIC/IIB
      ii. Zone 2: E II 3G EEx nA II T4
   d. Enclosure material: Polyamide 6 GF
   e. Degree of Protection
      i. According to IEC 60529
         - Terminal enclosure: IP 20
         - Housing: IP 40
   f. Connection:
      i. Four cage terminals, each maximum 1.5 sq-mm flexible/solid
      ii. Two PA-terminals, each maximum 4 sq-mm flexible / solid
      iii. Replaceable back-up fuse
   g. Environmental:
      i. Temperature:
         - Ambient: -5°F to 140°F
         - Storage: -5°F to 170°F
      ii. Maximum relative humidity 95%, non-condensing
   h. Leakage current: less than 1 mA
   i. Installation:
      i. Panel mounted in accordance with ANSI/NFPA 70.
   j. Hazardous Location Switch:
      i. Maximum lead length: 1000 feet
   ii. Non-energy storing or generating
   iii. Contains no capacitance or inductance, resistive switch only

iv. Installed in accordance with ANSI/NFPA 70.

5. Intrinsically Safe Relay
   a. Manufacturer:
      i. Diversified Electronics, Inc. - Model ISO-120-xx
      ii. PR Electronics
      iii. Idec
      iv. Or equal
   b. Agency Approvals:
      i. UL 913
      ii. Class I, Groups A, B, C, D
      iii. Class II, Groups, E, F, G
      iv. Class III
   c. Construction:
      i. Surface mount enclosure
      ii. Life expectancy:
         - Mechanical: 20 million operations
         - Electrical: 50,000 operations at rated load
         - Duty Cycle: continuous
      iii. Operating Temperature: -4°F to 131°F
   d. Electrical:
      i. Control Voltage: 120VAC, 60 Hz, nominal
      ii. Control Switch:
         - Open circuit voltage: 6.2VDC
         - Short circuit current: 10uA
      iii. Isolation: 2500VAC, input to output
      iv. Power Consumption: 2.5VA
      v. Contact rating:
         - SPST - N.O.
         - 5A per channel, 120VAC, resistive
         - 278VA, inductive
      vi. Channels: 2, 3, or 4
      vii. Status LED: One per channel
   e. Installation:
      i. Panel mounted in accordance with ANSI/NFPA 70
   f. Hazardous Location Switch:
      i. Maximum lead length: 1000 feet
      ii. Non-energy storing or generating
      iii. Contains no capacitance or inductance, resistive switch only
      iv. Installed in accordance with ANSI/NFPA 70
6. Pilot Device – Indicating Light
   a. Manufacturer:
      i. Allen Bradley Bulletin 800T/800H
      ii. Cutler-Hammer
      iii. Square D.
      iv. Or equal
   b. Agency Approvals:
      i. UL Listed
      ii. CSA Certified

iii. CE Compliant

c. Mechanical:
   i. Size: 30.5 mm
   ii. Environmental rating:
      - NEMA 4/13 watertight/oiltight: NEMA 1, 12, 3R, 4 control panels
      - NEMA 4/4X corrosion resistant: NEMA 4X control panels and remote control stations
   iii. Life expectancy: 200,000 operations
   iv. Push-to-test, transformer type, dual input
d. Electrical:
   i. Input power: 120VAC
   ii. Lamp:
      - High visibility, 28 chip cluster LED
      - Color: red, green, amber, as scheduled
   iii. Lens: High impact plastic, colored to match lamp
e. Nameplate
   i. Standard or jumbo with engraved service legend
f. Field Mounted Control Stations:
   i. Type I Enclosure: NEMA 4X polycarbonate enclosure
   ii. Type II Enclosure: NEMA 4X stainless steel enclosure
   iii. Type III Enclosure: NEMA 7 hazardous location enclosure

7. Pilot Device – Push Button
   a. Manufacturer:
      i. Allen Bradley Bulletin 800T/800H
      ii. Cutler-Hammer
      iii. Square D
      iv. Or equal
   b. Agency Approvals:
      i. UL Listed
      ii. CSA Certified
      iii. CE Compliant
   c. Mechanical:
      i. Size: 30.5 mm
      ii. Environmental rating:
         - NEMA 4/13 watertight/oiltight: NEMA 1, 12, 3R, 4 control panels
         - NEMA 4/4X corrosion resistant: NEMA 4X control panels and remote control stations
      iii. Life expectancy: 10,000,000 operations
      iv. Momentary contact, non-illuminated
   d. Electrical:
      i. Rated Voltage: 120VAC
      ii. Continuous current rating:
         - AC: 10A
         - DC: 2.5A
      iii. Operational current:
         - Make: 7200VA
         - Break: 720VA
      iv. Operator:
         - Mushroom head: Emergency stop service
         - Flush-head: All other services

8. Nameplate: Standard or jumbo with engraved service legend
9. Field Mounted Control Stations:
    i. Type I Enclosure: NEMA 4X polycarbonate enclosure
    ii. Type II Enclosure: NEMA 4X stainless steel enclosure
    iii. Type III Enclosure: NEMA 7 hazardous location enclosure

8. Pilot Device – Selector Switch
    a. Manufacturer:
        i. Allen Bradley Bulletin 800T/800H
        ii. Cutler-Hammer
        iii. Square D.
        iv. Or equal
    b. Agency Approvals:
        i. UL Listed
        ii. CSA Certified
        iii. CE Compliant
    c. Mechanical:
        i. Size: 30.5 mm
        ii. Environmental rating:
            - NEMA 4/13 watertight/oiltight: NEMA 1, 12, 3R, 4 control panels
            - NEMA 4/4X corrosion resistant: NEMA 4X control panels and remote control stations
        iii. Life expectancy: 1,000,000 operations
        iv. Maintained contact, non-illuminated (spring return from right or left where scheduled)
    d. Electrical:
        i. Rated Voltage: 120VAC
        ii. Continuous current rating:
            - AC: 10A
            - DC: 2.5A
        iii. Operational current:
            - Make: 7200VA
            - Break: 720VA
        iv. Operator:
            - Standard knob operator, two-position, or three-position
            - Keyed operator: where scheduled
        e. Nameplate: Standard or jumbo with engraved service legend
        f. Field Mounted Control Stations:
            i. Type I Enclosure: NEMA 4X polycarbonate enclosure
        ii. Type II Enclosure: NEMA 4X stainless steel enclosure
        iii. Type III Enclosure: NEMA 7 hazardous location enclosure
9. Power Supply – 12/24VDC
    a. Manufacturer:
        i. IDEC PS5R Series
        ii. Sola/Hevi-Duty Series SDP
        iii. Allen-Bradley
        iv. Or equal
    b. Agency Approvals:
        i. UL Listed
        ii. CE Marked
    c. Mechanical:

i. Enclosure:
- IP20
- Sealed plastic
- Fine ventilation grid

ii. Mounting: DIN rail

d. Electrical:
i. Capacity:
- Size to power connected loads. Reserve 25% of capacity for future use.
- Provide multiple power supplies where needed to accommodate load.

ii. Input:
- Voltage: 85-264VAC
- Frequency: 43-67Hz
- Efficiency: 88.5%
- Current: 1.0A at 100VAC

iii. Output:
- Voltage: 24-28VDC or 10-12VDC
- Voltage regulation: 2%
- Overvoltage protection: 40VDC
- Noise suppression: EMI values below EN50081-1
- Current: 2.1A at 24VDC or 2.5A at 12VDC

iv. Monitoring:
- LED Indicator
- Output power good status contact

10. Power Supply – 120VAC, Uninterruptible
a. Manufacturer:
i. Eaton/Powerware 9130
ii. CyberPower
iii. APC
iv. Or equal

b. Agency Approvals:
i. UL Listed
ii. CE Marked
iii. FCC Approved

c. General:
i. Topology: True online, double-conversion
ii. Diagnostics: Full system self-test on power up
iii. UPS Bypass Automatic: on Overload or UPS failure less than 4 ms
iv. Transfer Time to battery: 0 ms
v. Overload Capacity:
- 125% for 10 minutes before transfer to bypass
- 150% for 10 seconds before transfer to bypass

d. Input:
i. Input voltage: 80-144VAC, single phase, 60 Hz
ii. Input power factor: greater than 95%
iii. Input Line: NEMA 5-15 plug and cord
iv. Protection: fuse or circuit breaker

e. Electrical Output:
i. Voltage Regulation:

- On Utility: +/-2% of nominal
- On Battery: +/-3% of nominal

ii. Nominal Output Voltage: Same as selected input voltage
iii. Output Voltage Waveform: Sine Wave
iv. Output Voltage Distortion: less than 3% THD
v. Output Line: Four NEMA 5-15 receptacles, minimum
vi. Output protection: Electronic overload sensing, and circuit breaker protection
vii. Efficiency:
- Online Mode: greater than 86%
- Hi-Efficiency Mode: greater than 90%

f. Battery:
i. Internal Battery type: Sealed, lead-acid; maintenance free
ii. On Battery Runtime: 10 minutes
iii. Battery Replacement: Hot-swappable internal batteries
iv. Recharge Time: less than 4 hours to 90% capacity
v. Start-On-Battery: Allows start of UPS without utility input

g. Environmental:
i. Temperature:
- Operating: 32°F to 104°F
- Storage: 5°F to 122°F

ii. Relative Humidity: 0 to 95% non-condensing
iii. Audible Noise at 1 meter: less than 52dB
iv. Altitude: 10,000 feet without deteriorating

h. Communications:
i. Relay Output:
- Common Alarm

ii. User Interface: LCD status screen
iii. Audible Alarms UPS alarm conditions, including:
- On-Battery
- Low Battery
- Overload
- UPS Fault

iv. Communications: One RS232 Serial Port; One Communications Slot; One USB Port
v. Communications cable: 6-foot communications cable included
vi. Power Management Software: Powerware Software Suite CD

i. Manufacturers Warranty:
i. Warranty: 2 year comprehensive, including battery
ii. Equipment Protection Policy: $25,000 lifetime protection including lightning damage

11. Power Supply – 120VAC, Uninterruptible, DIN-Rail Mounted
a. Manufacturer:
i. Allen-Bradley 1609-D
ii. Sola
iii. IDEC
iv. Or equal

b. Agency Approvals:
i. Safety: UL 1778, CSA C22.2 No. 107.3, EN/IEC62040-1
ii. EMC: FCC & CE (EN 62040-2)
iii. Markings: UL, cULus, FCC, CE, C-Tick

c. General:
    i. Topology: True sine wave AC output.
    ii. Remote Enable/Disable selector switch
d. Input:
    i. Input voltage: 90-145VAC, single phase, 60 Hz
    ii. Capacity frequency: 50/60Hz +/- 3 Hz
    iii. Input Line: Hardwired
e. Electrical Output:
    i. Online:
        - Nominal Output Voltage: 108-132V
        - Transfer Point Accuracy: +/-3%
    ii. On Battery:
        - Nominal Output Voltage: 120V (sine wave)
        - Frequency: 50/60Hz +/- 3 Hz
        - THD: 10% Full Linear Load
f. Short Circuit Protection
    i. Crest Factor: 2.2:1
g. Efficiency
    i. On Battery (typical with resistive load): 75%
    ii. Online (typical with resistive load excluding AVR mode)
        - 600VA: 86%
        - 1000VA: 94%
        - 1500VA: 95%
h. Protection
    i. Surge: 380 Joules
    ii. Overload (Shutdown after 10s): > 110…130%
    iii. Overload (Shutdown immediately): >130%
    iv. Output Short Online/Battery: Premises branch circuit over-current protection/Shutdown
    v. Thermal Protection: UPS inside temperature 140°F
i. Battery Pack:
    i. Internal Battery type:
        - Sealed, lead-acid; maintenance free
        - 12V/5Ah (for 0°F to 105°F B.B. BP5-12) 12V/5.5Ah (for 0°F to 125°F B.B. HRL5.5-12)
    ii. On Battery Runtime:
        - 600VA: >5 min (at 80°F, full R load)
        - 1000VA: >3.5 min (at 80°F, full R load)
        - 1500VA: >2.5 min (at 80°F, full R load)
    iii. Voltage: 36V
    iv. Recharge Time: less than 8 hours to 90% capacity after discharge with full load
    v. Charger: Current limited, constant voltage charger
    vi. Lifetime: 2 to 3 years at 80°F ambient temperature
    vii. Additional battery connection to extend run-time or capacity
j. Environmental:
    i. Temperature:
        - Operating: 32°F to 104°F
        - Storage: 5°F to 113 F
    ii. Relative Humidity: 5% to 95% non-condensing

iii. Audible Noise at 3 feet, front Side: less than 50dB
iv. Heat Ouput:
- 600VA:
  - On Line, Full load: 217 BTU per hour
  - On Line, Full load, Charging: 296 BTU per hour
  - On Battery: Full Load: 1331 BTU per hour
- 1000VA:
  - On Line, Full load: 142 BTU per hour
  - On Line, Full load, Charging: 221 BTU per hour
  - On Battery: Full Load: 2218 BTU per hour
- 1500VA:
  - On Line, Full load: 176 BTU per hour
  - On Line, Full load, Charging: 256 BTU per hour
  - On Battery: Full Load: 3344 BTU per hour

k. Communications:
i. User Interface:
- LED Status lights
  - Output short circuit
  - Output overload
  - Over temperature from heat sink
  - Over temperature ambient
  - Over voltage from Inverter DC/DC Converter
  - Over voltage from Inverter
  - Under voltage from Inverter
  - Over voltage from AVR output
  - Under voltage from AVR output
  - Fan Failure
  - Charger Failure
  - TMOV failure
  - Missing Battery
  - Replace Batteries

ii. Audible Alarm, UPS alarm condition
iii. Dry Contacts
- Remote On/Off
- Three Dry I/O, 1A/24VDC
  - On Battery
  - Low Battery
  - Fault

iv. Communications:
- One USB Port

v. Power Management Software
vi. Monitoring through SCADA:
- Line Fail
- Low Battery
- UPS Fault
- Bypass

l. Physical
i. UPS: Overall dimensions 375mm long by 200mm high by 220mm deep

ii. DIN-rail mounting brackets for heavy-duty DIN rail for both UPS and additional batteries.

m. Manufacturer's Warranty:
   i. Warranty: 2 year comprehensive, including battery

12. Relay – 120V General Purpose
   a. Manufacturer:
      i. Allen Bradley Bulletin 700-HB
      ii. IDEC RU Series
      iii. Schneider
      iv. Or equal
   b. Agency Approvals:
      i. UL Listed
      ii. CE Marked
   c. Mechanical:
      i. Enclosure: Transparent dust cover
      ii. Contacts: Silver cadmium oxide
      iii. Insulating Material: Molded, high dielectric
      iv. Terminal Markings: In accordance with EN50-0005
      v. Life expectancy: 10,000,000 operations
      vi. Operations:
         - Pickup: 20 mS
         - Dropout: 4 mS
         - Maximum Rate: Four operations per second
      vii. Blade style, quick connect terminals
   d. Electrical:
      i. Contacts:
         - Double-pole, double throw
         - Rated thermal current: 15A
         - Make: 60A
         - Break: 6A
      ii. Coil:
         - 120 VAC + 10, -20%
         - Consumption.
            - Inrush: 2.85 VA
            - Sealed: 1.9 VA
      iii. Voltage:
         - Rated Insulation Voltage: 250V IEC-300V UL/CSA
         - Dielectric Withstand Voltage:
            - Pole-to-Pole: 1500V
            - Contact to Coil: 6000V
            - Contact to Frame: 4000V
      iv. Push-to-Test Operator
      v. Pilot light
   e. Relay Socket:
      i. 11-blade
      ii. Finger-safe terminal
      iii. DIN rail mounted
      iv. Double tier
      v. Retainer clip

vi. Relay identification snap-in markers

13. Relay – Solid State
    a. Manufacturer:
        i. Allen Bradley Bulletin 700-SH
        ii. IDEC RSS Series
        iii. Eaton
        iv. Or equal
    b. Agency Approvals:
        i. UL Recognized
        ii. CE Marked
    c. Electrical:
        i. Input:
            - Voltage: 4-32VDC
            - Impedance: 15mA, maximum, voltage dependent
            - Pick-up voltage: 4VDC
            - Drop-out Voltage: 1VDC
            - Dielectric Strength: 2500VACrms
            - Reverse voltage protection
        ii. Output:
            - Continuous current: 10A
            - Voltage range: 19-264VAC
            - Contact: SPST - N.O.
            - Off State leakage: 5 mA max (at 100VAC)
            - Turn-On/Turn-Off time; 0.5 cycle
        iii. Features:
            - Photo isolation
            - Dual SCR output
            - Built-in snubber
14. Relay – Time Delay
    a. Manufacturer:
        i. Allen Bradley Bulletin 700-HS
        ii. IDEC, RTE Series
        iii. Schneider
        iv. Or equal
    b. Agency Approvals:
        i. UL Listed
        ii. CE Marked
    c. Mechanical:
        i. Insulation resistance: 100 Mohms, minimum
        ii. Dielectric strength: 1500VAC, 1 minute
        iii. Vibration resistance: 6N
        iv. Shock resistance: 500N
        v. Operating temperature: 0 to 150° F
        vi. Operating humidity: 45 to 85%, relative
        vii. Blade style: quick-connect terminals
    d. Electrical:
        i. Contacts:
            - Two Form C double-pole, double-throw

- 10A, 240VAC, resistive

ii. Timing functions:
- Delay on make/interval
- Delay on break/single shot
- Range: 0.1 seconds - 10 minutes, or 0.1 minutes - 10 hours

iii. Accuracy:
- Repeat: + 0.25%
- Voltage: + 1.0%
- Temperature error: + 2.0%
- Setting error: + 10.0%

e. Relay Socket:
i. 11-blade
ii. Finger-safe terminal
iii. DIN rail mounted
iv. Double tier
v. Retainer clip
vi. Relay identification snap-in markers

15. Surge Suppressor – 24VDC, Field Mounted
a. Manufacturer:
i. EDCO/Emerson SS65 Series
ii. Joslyn
iii. Pepperl-Fuchs
iv. Or equal
b. Agency Approvals:
i. UL Listed
c. General Description:
i. Transient Protection for Low-Voltage Signal Lines
ii. Sneak/Fault Current Protection
iii. Resettable Fusing-PTCs
iv. Differential and Common Mode Protection
v. Automatic Recovery
vi. Encapsulated in Stainless Steel Pipe Nipples
vii. Silicon Avalanche Hybrid Technology
viii. UL 497B Listed
ix. Protection for One Pair (Two Wires & Shield on SS65)
d. Electrical:
i. Response Time: less than 1 nanosecond
ii. Maximum Signal Voltage: 28VDC
iii. DC Clamping Level:
- Line-to-Ground: 36V +/-l0%
- Line-to-Line: 72V +/-l0%

iv. Maximum Let-Thru Voltage:
- Line-to-Ground (10x700 microseconds): 44V at 400A
- Line-to-Line (10x700 microseconds): 90V at 400A

v. Series Resistance (per conductor): 5 Ohms (typical)
vi. Capacitance (zero volts bias):
- Line-to-Line: 600pf typical
- Line-to-Ground: 1200pf typical

vii. Number of Occurrences: 400 at 500 Amps (10x1000 microseconds)

16. Surge Suppressor – 24VDC/120VAC Signal, Panel Mounted
    a. Manufacturer:
        i. Circuit Components Incorporated, Surge Control SPU Series
            - Base Module: SPU-xx-LM
            - Daughter Module: SPU-xx-CD-30/120
        ii. Allen-Bradley
        iii. Phoenix Contact
        iv. Or equal
    b. Agency Approvals:
        i. UL Listed
    c. General Description:
        i. Performance exceeds highest class severity level of IEC/EN 61000-4-4 and 61000-4-5
        ii. Enhanced filtering to attenuate high frequency and bring equipment into compliance with IEEE /ANSI C37.90.1
        iii. Universal hardwired version for all I/O modules including AC, DC, contact output, current output and signal input
        iv. Multi-stage design provides the most effective suppression and filtering available, and requires no additional secondary protection
        v. Sub-nano second response time stops failures due to lightning, spikes and over-voltage surges while filtering all other electrical noise
        vi. Plug-in replaceable daughter card modules contain all active surge suppression
        vii. Space efficient protector is hermetically sealed and suitable for the most harsh industrial environments
        viii. Universal DIN-Rail mounting allows easy installation on any standard DIN-Rail configuration
        ix. Automatic reset and fail safe design requires no maintenance. Eliminates “Out of Service” downtime and repair/replacement costs caused by damaging electrical surges
        x. Protection for current loop instrumentation and low frequency signal/data lines
        xi. UL-497B listed for Data Models (60 VDC or less) UL file E205158
    d. Electrical:
        i. Signal Channels: 5, 10, 15, or 20
        ii. Operating: +/-30VDC
        iii. Maximum Operating Voltage: 33VDC
        iv. Maximum Operating Current: 0.5A
        v. Clamping Action Turn-On: 37.1V
        vi. Maximum Clamping (8x20 micro-seconds): 52V
        vii. Maximum Surge Voltage: 6kV
        viii. Maximum Surge Current (8x20 micro-seconds): 2.5kA
        ix. Response Time: Less than 1 nanosecond
        x. Operating & Storage Temperature: -40°F to 185°F.
    17. Surge Suppressor – 120VAC/208VAC/480VAC Power, Panel Mounted
        a. Manufacturer:
            i. Intermatic Model AG2401C-IND/AGC6503-IND
            ii. Schneider
            iii. Easton
            iv. Or equal
        b. Agency Approvals:
            i. UL Listed
        c. General Description:

i. ANSI/IEEE C62.11 for Category 'C' locations. The arrester shall provide protection between each phase conductor and ground. The Secondary Surge Arrester shall employ parallel MOV's and provide protection from Category 'C' level transient surges as defined in ANSI/IEEE C62.11, C62.34, C62.41.1 and C62.41.2 without degradation of components.
ii. The Maximum Continuous Operating Voltage (MCOV) shall be comply with the following:
- 120VAC, single phase system: 150VAC
- 120/240VAC, single phase system: 150VAC
- 120/208VAC, three phase system: 150VAC
- 240VAC, three phase system: 275VAC
- 480VAC, three phase system: 550VAC

iii. The arrester housing shall be constructed of UV resistant polycarbonate or material of equal strength and UV resistance. All electrical connections shall be sealed in a UL component recognized epoxy to exclude moisture, dirt and corrosion. The encapsulation shall have a minimum UL Flame Class rating of 94V-0. A 0.5 or 1/2 inch threaded nipple and locknut shall be provided. Leads shall be a minimum of 12 gauge and 18 inches in length.
iv. When subjected to a 8 x 20 micro-second test impulse, the Peak Clamping Voltage shall comply with the following: be no greater than 480V for 1500A, 710V for 5000A or 1,110V for 10,000A (4 x 10 micro-second).
- 120VAC, or 120/240VAC, single phase systems:
  - 480VAC for 1500A (4 x 10 micro-second)
  - 710V for 5000A (4 x 10 micro-second)
  - 1110V for 10,000A (4 x 10 micro-second)
- 120/208VAC, 240VAC, or 277/480VAC, three phase systems:
  - 1850VAC for 1500A (4 x 10 micro-second)
  - 2320V for 5000A (4 x 10 micro-second)
  - 2660V for 10,000A (4 x 10 micro-second)

d. Electrical:
i. Technology: Parallel Metal Oxide Varistors (40 kA Line to Ground)
ii. Configuration: Each line to ground/neutral
iii. Enclosure: Weatherproof and UV resistant NEMA 4 molded polycarbonate with metal threaded nipple
iv. Operational indicators: Monitoring circuits supervise components in each phase. Individual green LED for each phase indicates proper operation. LED's will turn OFF on failure of protection
v. Encapsulation: UL component recognized epoxy potting compound. UL Flame class 94V-0; Relative Temperature Index: Electric - 90, Mechanical – 90
vi. Mounting: 1/2 inch x 20 threaded nipple
vii. Mounting bracket: Right angle aluminum bracket
viii. Wiring: 18 inches of 12 gauge stranded copper wire is pre-connected for each phase, neutral and ground
ix. Wire color code: Black - phase leads, White - ground/neutral lead
x. Ambient operating temperature: -40°F to 185°F

e. Manufacturer's Warranty:
i. 10 year limited

18. Terminal Block – Indicating Fused
a. Manufacturer:

i. Allen Bradley Bulletin 1492-H4 (AC) or 1492-H5 (DC)
ii. Phoenix Contact
iii. Schneider
iv. Or equal

b. Agency Approvals:
a. UL
b. CSA
c. IEC

c. Specifications:
i. Voltage Rating: 300VAC/VDC
ii. Maximum Current: 12A
iii. Wire Range (Rated Cross Section): No. 30 to No. 12 AWG
iv. Leakage Current:
- 2 mA at 300VAC
- 2 mA at 24VDC

v. Working Voltage:
- 100 to 300VAC
- 10 to 57VAC/VDC

vi. Fuse Size: 1/4 inch by 1 1/4 inch
vii. Wire Strip Length 0.38 inch
viii. Tightening Torque: 3 to 7 pound-inch
ix. Density: 33 pieces per foot
x. Insulation Temperature Range: -40 to 221° F
xi. Accessories:
xii. Aluminum DIN Rail with Standoff Brackets
- End Barrier and End Anchors
- Side Jumper Insulating Sleeve
- Marking Systems

19. Terminal Block – Isolating Switch
a. Manufacturer:
i. Allen Bradley Bulletin 1492-H7
ii. Phoenix Contact
iii. Schneider
iv. Or equal

b. Agency Approvals:
i. UL
ii. CSA
iii. IEC

c. Specifications:
i. Voltage Rating: 300VAC/VDC
ii. Maximum Current: 15A
iii. Wire Range (Rated Cross Section): No. 30 to No. 12 AWG
iv. Leakage Current:
- 2 mA at 300VAC
- 2 mA at 24VDC

v. Working Voltage:
- 100 to 300VAC
- 10 to 57VAC/VDC

vi. Dummy Fuse Size: 1/4 inch by 1 1/4 inch
vii. Wire Strip Length 0.38 inch
viii. Tightening Torque: 3 to 7 pound-inch
ix. Density: 33 pieces per foot
x. Insulation Temperature Range: -40°F to 221°F
xi. Accessories:
- Aluminum DIN Rail with Standoff Brackets
- End Barrier and End Anchors
- Side Jumper Insulating Sleeve
- Marking Systems

20. Terminal Block – Open Style
    a. Manufacturer:
        i. Allen Bradley Bulletin 1492-CAM1
        ii. Phoenix Contact
        iii. Schneider
        iv. Or equal
    b. Agency Approvals:
        i. UL
        ii. CSA
        iii. IEC
    c. Specifications:
        i. Voltage Rating: 600VAC/VDC
        ii. Maximum Current: 65A
        iii. Wire Range (Rated Cross Section): No. 22 to No. 8 AWG
        iv. Wire Strip Length 0.38 inch
        v. Tightening Torque: 10 to 16 pound-inch
        vi. Density: 30 pieces per foot
        vii. Insulation Temperature Range: -40°F to 221°F
        viii. Accessories:
            - Aluminum DIN Rail with Standoff Brackets
            - End Barrier and End Anchors
            - Side Jumper Insulating Sleeve
            - Marking Systems
21. Transmitter – Isolated DC to DC
    a. Manufacturer:
        i. Wilkerson Instrument Co., Model MM4300A
        ii. Omron
        iii. PR Electronics
        iv. Or equal
    b. Agency Approvals:
        i. UL Listed
    c. Construction:
        i. 8-pin, relay socket
        ii. Operating temperature: 15°F to 140°F
    d. Electrical:
        i. Input: 4-20 mADC or 0-10VDC
        ii. Input impedance:
            - Voltage: 200 kOhms

- Current 50 Ohms

iii. Output range:
- Voltage: 0 - 10 VDC, 2 kOhm minimum load
- Current: 4-20 mADC, 24VDC compliance (1200 ohms/20 mADC)

iv. Response time: Less than 100 ms
v. Accuracy: + 0.1% of span
vi. Linearity: + 0.05% of span
vii. Common mode rejection: 120 dB
viii. Isolation:
- 500 megohms
- 1000VAC

e. Manufacturer's Warranty:
i. 10 year limited

C. CONSTRUCTION

1. Field Measurements
   a. Refer to the requirements of Process Instrumentation & Control.
2. Delivery, Storage, and Handling
   a. Refer to the requirements of Process Instrumentation & Control.
3. Installation
   a. Refer to the requirements of Process Instrumentation & Control.
4. Testing and Start-Up Services
   a. Refer to the requirements of Process Instrumentation & Control.
5. Training
   a. Refer to the requirements of Process Instrumentation & Control.

154013a.14 INSTRUMENTATION DEVICES

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated process instrumentation and control system, the work specified herein shall be included under the scope of Process Instrumentation & Control.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - ANSI/NFPA 70 - National Electrical Code and state amendments thereto.
         - ANSI/IEEE C37.90 - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
         - ANSI/IEEE C62.11- IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits.
         - ANSI/IEEE C62.34 - IEEE Standard for Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters).
         - ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
      ii. CE - European Community, Applicable Directives.
         - EN50005 - for Terminal Markings.
         - EN50081-1- Generic Emission Standard.

- EN50082-1 - Generic Immunity Standard.
- EN61000-4-4 - Electromagnetic compatibility (EMC). Testing and measurement techniques.
- EN61000-4-5 - Electromagnetic compatibility (EMC). Testing and measurement techniques. Surge immunity test.

iii. Canadian Standards Association (CSA), Specifications and Standards, current edition:
- CSA C22.2, Industrial Control Equipment.

iv. CUL - Underwriter's Laboratories of Canada.

v. International Electrotechnical Commission (IEC), Specifications and Standards, current edition:
- IEC 60529 - Classification of Degrees of Protection Provided by Enclosures

vi. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition:
- NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
- NEMA ICS 3 - Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC.

vii. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition:
- UL508 - Industrial Control Equipment.
- UL508A - Industrial Control Panels.
- UL 913 - Intrinsically Safe Specification.
- UL94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

2. Design Requirements

INSTRUMENTATION AND CONTROL COMPONENTS				
LOCATION	**TAG**	**DESCRIPTION**	**TYPE**	**NOTES**
Lift Station	LT-1-2	SUBMERSIBLE LEVEL TRANSDUCER, STORM WATER WETWELL	L1	
Lift Station	LSHH/LSH/LSL-1-2	LEVEL SWITCH, HIGH ALARM, LAG-LAG ON, INFLUENT PUMP STATION	~~L6~~ L1	
~~Lift Station~~	~~LSH-1-2~~	~~LEVEL SWITCH, PUMPS ON, STORM WATER WETWELL~~	~~L6~~	
~~Lift Station~~	~~LSL-1-2~~	~~LEVEL SWITCH, PUMPS OFF, STORM WATER WETWELL~~	~~L6~~	
~~Lift Station~~	~~LSLL-1-2~~	~~LEVEL SWITCH, LOW ALARM, STORM WATER WETWELL~~	~~L6~~	

B. MATERIALS.

1. L1 – Level Element and Transmitter, Submersible
   a. Manufacturer
      i. ~~Sigma Controls and shall be Model 6100~~ Flygt DuoProbe, Do Not Substitute.
      ~~ii. Siemens Model A1000i~~
      ~~iii. Contegra Model SLX 130~~
      ~~iv. KPSI Model 750~~
      ~~v. Or equal.~~
   b. The transducer shall be of the solid-state head-pressure sensing type, suitable for continuous submergence and operation and shall be installed in accordance with manufacturer's

instructions. The sensor shall be mounted using a stainless steel cable system in a location and as shown on the plans.

c. The transducer housing shall be fabricated of Type 316 stainless steel with a bottom diaphragm 2 1/2 inch diameter of heavy-duty, limp, foul-free, molded Teflon bonded to a synthetic rubber back/seal.

d. A hydraulic fill liquid shall transmit the sensed pressure to a solid-state variable capacitance or piezo-resistive transducer element. Unit shall produce output signal proportional to level with an accuracy of 1.0% of span.

e. The transducer shall incorporate laser-trimmed, temperature compensation and high quality components and construction to provide a precise, reliable, stable output signal pressure over a factory-calibrated range.

f. The transducer element shall incorporate high over-pressure protection and be designed to withstand intermittent over-pressures five times the full scale range being sensed. Metallic diaphragms shall not be acceptable in that they are subject to damage or distortion. Sensing principles employing LVDT's, resistive or pneumatic elements shall not be acceptable.

g. The transducers shall be a two-wire type, operating from a loop power supply of 12 to 40 VDC, and producing a 4-20 mADC signal in direct proportion to the measured level excursion over a factory-calibrated range as indicated.

h. MultiTrode Multi-element probe shall be incorporated into the DuoProbe and in conjunction with MultiTrode MTR Level Relay shall provide fixed set-points for back-up pump operation in dependant of the MultiSmart pump controller.

~~h~~ i. Provide intrinsically safe barriers and relays for the level transducer and the multi-element probe, in accordance with Class I, Division 1 requirements of the National Electric Code.

~~2. L6 - Level Switch, Wet Well Float~~

~~a. Manufacturer~~

~~i. Anchor Roto-Float P100NO/NC-SSHT Non-Mercury Float~~

~~ii. US Filter/Consolidated Electric Company Model 9G~~

~~iii. Siemens~~

~~iv. Or equal.~~

~~b. The wetwell float level switch shall be a Type 316 stainless steel, Teflon coated, watertight float enclosing a 20A/115 vac switch. The switch shall contain no mercury. The switch shall have a maximum activation/deactivation level differential of one inch. Float switches identified as detecting high level alarm conditions shall be equipped with normally closed contacts.~~

~~c. The level switch cable shall be provided by the manufacturer and it shall consist of a No.14 AWG copper, three conductor, PVC jacketed, heavy duty SO cord with a maximum O.D. of 5/8 inch. The cable shall include a ground conductor for bonding the float body to the conduit system. The cable length shall be selected to accommodate locations of float and associated junction box. Contractor shall be responsible for selecting length of cable to accommodate initial mounting elevation with enough slack cable to allow 2 foot lower elevation. Excess cable shall be coiled and secured above the maximum water level.~~

~~d. The entire float switch assembly, including cable shall be rated for process fluid temperatures of 150°F, minimum.~~

~~e. Float switch shall be provided with clamps and accessories suitable for fixed pipe mounting.~~

~~f. Where float switch is located in hazardous location, installation shall be intrinsically safe, suitable for use in Class I Division I atmospheres in accordance with the National Electrical Code. Installation shall include an intrinsically safe relay located in the control panel receiving the float signal.~~

~~3~~ 2. T1 – Temperature Transmitter

a. Manufacturer:
   i. ACI A/TT100-0-4X
   ii. PR Electronics
   iii. Allen-Bradley
   iv. Or equal.
b. Equipment Description
   i. Two-wire temperature transmitter with local RTD.
c. References
   i. National Electrical Manufacturer's Association (NEMA).
   ii. Factory Mutual (FM).
d. Environmental Conditions
   i. Humidity: 0 to 100% relative humidity.
   ii. Ambient Temperature Limits: -45°F to 185°F.
e. Process Conditions
   i. Measurement of exterior ambient temperature
f. Electrical
   i. UL Listed.
g. Conduit connections: 1/2 inch NPT conduit connection.
h. Power Supply
   i. 12 to 45 V dc with no load for 4-20 mA dc output.
   ii. 8 to 12 V dc for 1 to 5 dc low power output.
   iii. 5 to 12 V dc for 0.8 to 3.2 V dc low power output.
i. Outputs
   i. Zero and Span adjustment
   ii. Analog Output: 4-20 mA output, 700 max at 24 VDC, field scalable, 2:1
   iii. Turndown. Various faults are indicated at 0 mA, 3.5 mA, 22 mA, and 24 mA (2WLP, 2XLP, 8W2D, 8X2D models only)
   iv. Outputs shall be a 4-20 mA analog signal, linear with temperature for RTD inputs, linear with input signal for thermocouple or millivolt inputs.
   v. Low power output option.
j. Performance
   i. Accuracy: +/- 0.5% of full range span at room temperature
   ii. Repeatability: +/- 0.1% full range span
   iii. Stability: +/- 0.25% of calibrated span per year max
   iv. Temperature drive: 0.3% full scale/°F.
k. Enclosure
   i. Type 4X/IP66 certified epoxy coated aluminum; Explosion-proof models only: Epoxy-coated aluminum cover, tempered glass insert; Conduit, 1/2 inch NPTF stainless steel fitting; 3/4 inchNPTF aluminum casting
   ii. Faceplate: UV-resistant pressure sensitive keypad and display overlay

~~4~~ 3. Y1 – Alarm Beacons

a. Provide LED-type flashing alarm beacons
b. Powered by the transmitter
c. 65 flashes per minute
d. Wall mounted vertically with wall mounting bracket
e. Weatherproof NEMA 4x for outdoor locations; Explosion Proof corrosion resistant NEMA 7 construction for indoor Class I, Division 1 locations; NEMA 4X for all other indoor locations.

f. UL listed.
g. Red, or as shown on plans

C. CONSTRUCTION.

1. Field Measurements
   a. Refer to the requirements of Process Instrumentation & Control.
2. Delivery Storage and Handling
   a. Refer to the requirements of Process Instrumentation & Control.
3. Installation
   a. Refer to the requirements of Process Instrumentation & Control.
4. Testing and Start-Up Services
   a. Refer to the requirements of Process Instrumentation & Control.
5. Training
   a. Refer to the requirements of Process Instrumentation & Control.

154013a.15 ~~PROGRAMMABLE LOGIC~~ PUMP STATION CONTROLLERS

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated process instrumentation and control system, the work specified herein shall be included under the scope of Process Instrumentation & Control. Equip programmable logic controllers with memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points. Equip programmable logic controller systems with I/O as scheduled on the drawings. Provide modification to existing programmable logic controller systems as specified. The software configuration files shall become the property of the City of Waukee. Identify all protection methods and turn over all keys and passwords to the City of Waukee. System supplier shall draft an agreement with the City of Waukee, to be reviewed by the engineer, identifying any consequences arising from modifications to the configuration files not authorized in writing by the system supplier during the specified warranty period. This agreement will be signed by the City of Waukee and supplier and copies of the document distributed to all parties. Unauthorized modifications to software configuration during the warranty period will result in a void warranty.

1. Applicable Publications
   a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.
      i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
         - ANSI/NFPA 70 - National Electrical Code and state amendments thereto.
         - ANSI/IEEE C37.90 - IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
      ii. CE - European Community, Applicable Directives:
         - EN50005 - for Terminal Markings.
         - EN50081-1- Generic Emission Standard.
         - EN50082-1 - Generic Immunity Standard.
         - EN61000-4-4 - Electromagnetic compatibility (EMC). Testing and measurement techniques.
         - EN61000-4-5 - Electromagnetic compatibility (EMC). Testing and measurement techniques. Surge immunity test.
      iii. Canadian Standards Association (CSA), Specifications and Standards, current edition
         - CSA C22.2, Industrial Control Equipment.
      iv. CUL - Underwriter's Laboratories of Canada.
      v. International Electrotechnical Commission (IEC), Specifications and Standards, current edition:

- IEC1131-1. Programmable Controllers - Part 1: General Information.
- IEC1131-2. Programmable Controllers - Part 2: Equipment Requirements and Tests.
- IEC1131-3. Programmable Controllers - Part 3: Programming Languages.
- IEC1131-4. Programmable Controllers - Part 4: User Guidelines.
- IEC1131-5. Programmable Controllers - Part 5: Communications.
- IEC 60529 - Classification of Degrees of Protection Provided by Enclosures

vi. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition:
- NEMA ICS 2- Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
- NEMA ICS 3- Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC.

vii. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition:
- UL508 - Industrial Control Equipment.
- UL508A - Industrial Control Panels.
- UL94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

2. Submittals
   a. Submit the following information specifically for programmable logic controllers:
      i. Software configuration consisting of data tables, ladder logic, and other parameters.
      ii. Identify coordination requirements with other sections.
3. Operation/Maintenance Manuals and Instructions
   a. Submit the following information specifically for programmable logic controllers:
      i. As-built printout of all software configuration including data tables, ladder logic, passwords, and other parameters. Document software with English language descriptions and tag numbers where appropriate.
      ii. Electronic documentation shall include fully annotated electronic copies of all PLC programs . As-built documentation shall include all changes made during the first year of operation.
      iii. Software configuration files shall be included in the manual in two forms:
         - CD ROM.
         - Paper.
   b. Submit software license certificates, manufacturer provided software documentation, and software installation media.
4. Extra Materials
   a. Supply one spare 120VAC discrete input/output module of each type supplied for this project
   b. Supply one spare 24VDC analog input/output module of each type supplied for this project
   c. Supply one spare communication module of each type supplied for this project
   d. Supply one spare processor of each type supplied for this project

B. MATERIALS.

1. Manufacturer
   a. Manufacturers:
      i. ~~Allen-Bradley/Rockwell Automation~~ Multi-trode/Flygt
      ii. The Contracting Authority will consider products of another manufacturer only as alternate bid equipment in accordance with Iowa DOT Standard Specifications Division 11.
2. General System Requirements
   a. Common Hardware Specifications

i. Environmental
- Ambient Temperature Rating:
  - Operating: 32°F to 140°F
  - Storage: -40°F to 185°F
- Humidity: 5 to 95% non-condensing
- Shock:
  - Operating: 30 Gs (three pulses, 11 mS)
  - Non-operating: 50.0 Gs (three pulses, 11 mS)
- Vibration:
  - Vibration Operating: 1.0 G at 5 to 2000 Hz
  - Non-operating: 2.5 Gs at 5 to 2000 Hz
- Free Fall (drop test):
  - Portable, 5 pounds or less at 2.5 feet (Six drops)
  - Portable, 5 pounds or more at 0.33 (Three flat drops)
- Electromagnetic Compatibility:
  - Showering Arc: 1.5 kV Per NEMA ICS 2/NEMA ICS 3
  - Surge Withstand Capability: 3 kV per ANSI/IEEE C37.90
  - Fast Transient Burst (impulse): 2 kV for power supplies, 1 kV for I/O and communication lines over 10m, 5 nS rise time
  - Electrostatic Discharge: 15 kV, 100 pF/1.5 kohm model
  - Radiated Electromagnetic Susceptibility: 5W walkie-talkie at 464.5 MHz and 153.05 MHz
  - Noise Immunity: NEMA Standard ICS 2

ii. Safety:
- Dielectric Withstand: 1500VAC per UL 508, CSA C22.2
- Isolation between communication circuits: 500VDC
- Isolation between backplane and I/O: 1500VAC
- Flammability and Electrical Ignition: UL94V-0
- Certification:
  - UL listed
  - CSA certified
  - CUL listed
  - Class 1, Groups A, B, C or D, Division 2
  - CE compliant for all applicable directives

~~b. Configuration~~

~~i. The programmable controller, associated I/O, chassis, and power supplies shall be of a modular design. The programmable controller and I/O modules shall mount into the chassis~~

~~ii. Processor Systems shall include processor, power supply, input/output modules, communication modules, and remote interface modules as required to meet system requirements.~~

~~iii. Remote Input/Output Units shall include input/output modules, interface modules, communication modules, and power supply to meet system input and output requirements.~~

~~iv. Modules are to be supplied as specified unless system requirements dictate the use of alternative modules.~~

~~c. Selection~~

~~i. The programmable controller shall be selected from a family of programmable controllers with memory capability ranging up to 7.5Mbytes.~~

~~ii. All system and signal power to the controller and support modules shall be distributed on a single motherboard or backplane.~~

~~iii. All system modules including the processor shall be removable from the chassis or inserted in to the chassis while power is being supplied to the chassis without faulting the processor or damaging the modules.~~

~~iv. All system modules and chassis shall be designed to provide for free airflow convection cooling.~~

~~v. Modules shall be designed to plug into a chassis and to be keyed to allow installation in only one direction. The design must prohibit upside down insertion of the modules as well as safeguard against the insertion of a module into the wrong slot or chassis via an electronic method for identifying a module. Electronic keying shall perform an electronic check to insure that the physical module is consistent with what was configured for the corresponding slot.~~

~~d. Programming:~~

~~i. Minimum Programming Instruction Set:~~

- ~~Language Characteristics: Ladder diagram~~
- ~~Logic Operations: AND, OR, XOR, NOT~~
- ~~Register Operations: Store, recall~~
- ~~Math Operations: Addition, subtraction, multiplication, division, square root, matrix operations~~
- ~~Process Control: Proportional-Integral-Derivative~~

3. ~~Programmable Logic~~ Pump Station Controller System, ~~Micrologix Platform (Expandable)~~ Multi-Smart (Do Not Substitute)

a. Processor Unit

i. Manufacturer:

- ~~Allen-Bradley Micrologix 1400, 1766-L32AWWA~~ Flygt
- The Contracting Authority will consider products of another manufacturer only as alternate bid equipment in accordance with Iowa DOT Standard Specifications Division 11.

ii. Processor requirements:

- Input Power: 120/240VAC
- Memory:
  - Non-volatile battery backed RAM
  - User Program / User Data Space: 10 Kbytes / 10 Kbytes
  - Data Logging / Recipe Storage: Up to 128 Kbytes for data logging and up to 64 Kbytes for recipe (recipe memory subtracted from available data logging)
  - Battery Back-up: Yes
  - Back-up Memory Module: Yes
  - Battery-backed RAM: 20Kbytes
  - Throughput: 0.7 ms
- Communication Ports:
  - Two RS-232~~: One 8-pin mini-DIN; One 9-pin D-shell~~

- Two RS485
- Two Ethernet
- USB device port
- SD card port

- Communication Types:
  - TCP/IP
  - UDP
  - RS232
  - RS485
  - Private radio over RS232
  - PSTN
  - Wireless LAN
  - Cellular data (via integral pppm module)
  - Cellular voice
- Communication Protocols
  - DNP3 (master & slave, level 2 compliant)
    - Change of state reporting
    - Native date/time and quality stamps for each data point
    - Event buffering for different classes of data
    - Support for multiple masters and slaves to be configured on the unit.
    - DNP Security (for securing communications between master station and RTU) Modbus (master & slave)
  - Modbus TCP
  - Modbus RTU
  - Modbus ASCII
  - Support for multiple masters and slaves.
    - ~~Ethernet TCP/IP~~
    - ~~Web Server Capability~~
    - ~~DF1 Full Duplex~~
    - ~~DF1 Half Duplex Master/Slave~~
    - ~~DF1 Radio Modem~~
    - ~~DH-485~~
    - ~~Modbus RTU Master/Slave~~
    - ~~ASCII Read/Write~~
    - ~~NP3 over IP~~
    - ~~Modbus TCP/IP~~
    - ~~DNP3 Slave~~
  - ~~One 10/100 Mbps Ethernet Port~~
    - ~~EtherNet/IP messaging only~~

iii. Embedded Input/Output:
- Digital Inputs: ~~Twenty 120VAC~~ voltage free input, also configurable as sounters
- Analog Inputs: ~~Four 24VDC~~ (10 bit)
- Digital Outputs: ~~Twelve relay~~ 240V, 5A resistive
- Analog Outputs: ~~Two 24VDC~~ (10 bit)

~~b. Expansion I/O:~~

~~i. Analog input module:~~
- ~~Manufacturer: Allen-Bradley Model 1762-IF4~~
- ~~Input points: four differential, individually selectable as current or voltage~~

ii. Analog output module:
- Manufacturer: Allen-Bradley Model 1762-OF4
- Input points: four single-ended, individually selectable as current or voltage

iii. Digital input:
- Manufacturer: Allen-Bradley Model 1762-IA8
- Voltage Category/Type: 100 to 120VAC
- Operating Voltage: 79 to 132VACSignal Delay, Max.: On: 20.0 ms, Off: 20.0 ms
- Off-State Current, Max.: 2.5 mA
- IEC Input Compatibility: Type 3
- Number of Inputs: Eight
- Bus Current Load, Max.: 115 mADC at 5VDC

iv. Digital output:
- Manufacturer: Allen-Bradley Model 1762-OW8
- Operating Voltage: 85 to 265VAC
- Continuous Current per Output, Max: 0.5 at 140°F; 1.0A at 86°F
- Continuous Current per Module, Max: 16A
- Number of Outputs: Eight (individually isolated)
- Type of Contact Outputs: Normally open
- Bus Current Load, Max.: 125 mADC at 5VDC; 100 mADC at 24VDC

C. CONSTRUCTION.

1. Field Measurements
   a. Refer to the requirements of Process Instrumentation & Control.
2. Delivery Storage and Handling
   a. Refer to the requirements of Process Instrumentation & Control.
3. Installation
   a. Refer to the requirements of Process Instrumentation & Control.
   b. Provide interconnect cables of the appropriate type as needed.
4. Testing and Start-Up Services
   a. Refer to the requirements of Process Instrumentation & Control.
5. Training
   a. Refer to the requirements of Process Instrumentation & Control.

154013a.16 HUMAN-MACHINE INTERFACE EQUIPMENT

A. DESCRIPTION.

For the purpose of obtaining a complete and integrated process instrumentation and control system, the work specified herein shall be included under the scope of Process Instrumentation & Control. Equip human machine interface systems with memory and functional capacity to perform the specified interface, display, and data recording functions specified. Provide a minimum of 25% tag capacity reserved for future use for software licensed on a tag basis. The software configuration files shall become the property of the City of Waukee. Identify all protection methods and turn over all keys and passwords to the City of Waukee. System supplier shall draft an agreement with the City of Waukee, to be reviewed by the engineer, identifying any consequences arising from modifications to the configuration files not authorized in writing by the system supplier during the specified warranty period. This agreement will be signed by the City of Waukee and supplier and copies of the document distributed to all parties. Unauthorized modifications to software configuration during the warranty period will result in a void warranty.

1. Applicable Publications

a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent applicable.

i. American National Standards Institute/National Fire Protection Agency (ANSI/NFPA), Specifications and Standards, current edition:
- ANSI/NFPA 70 - National Electrical Code and state amendments thereto.
- ANSI/IEEE C37.90 - IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

ii. CE - European Community, Applicable Directives.
- EN50005 - for Terminal Markings.
- EN50081-1- Generic Emission Standard.
- EN50082-1 - Generic Immunity Standard.
- EN61000-4-4 - Electromagnetic compatibility (EMC). Testing and measurement techniques.
- EN61000-4-5 - Electromagnetic compatibility (EMC). Testing and measurement techniques. Surge immunity test

iii. Canadian Standards Association (CSA), Specifications and Standards, current edition:
- SA C22.2, Industrial Control Equipment.

iv. CUL - Underwriter's Laboratories of Canada.

v. International Electrotechnical Commission (IEC), Specifications and Standards, current edition:
- IEC1131-1. Programmable Controllers - Part 1: General Information.
  - IEC1131-2. Programmable Controllers - Part 2: Equipment Requirements and Tests.
  - IEC1131-3. Programmable Controllers - Part 3: Programming Languages.
  - IEC1131-4. Programmable Controllers - Part 4: User Guidelines.
  - IEC1131-5. Programmable Controllers - Part 5: Communications.
- IEC 60529 - Classification of Degrees of Protection Provided by Enclosures

vi. National Electrical Manufacturers Association (NEMA), Specifications and Standards, current edition:
- NEMA ICS 2- Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
- NEMA ICS 3- Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC.

vii. Underwriters Laboratories, Inc. (UL), Specifications and Standards, current edition:
- UL508 - Industrial Control Equipment.
- UL508A - Industrial Control Panels.
- UL94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

2. Submittals
   a. Submit the following information specifically for human-machine interface equipment:
      i. Provide copies of all graphic screens. Each screen shall be formatted on a single page which shall include a narrative description of the parameters displayed, ranges for adjustable parameters and recommended or typical values. The screens shall be organized in a logical fashion. An Index or Table of Contents shall be provided with a page numbering system or tabs which permit ready access to the information contained therein.
      ii. Software configuration consisting of data tables and other parameters.
3. Operation/Maintenance Manuals and Instructions

a. Submit the following information specifically for human-machine interface equipment:
   i. Provide copies of all graphic screens. Each screen shall be formatted on a single page which shall include a narrative description of the parameters displayed, ranges for adjustable parameters and recommended or typical values. The screens shall be organized in a logical fashion. An Index or Table of Contents shall be provided with a page numbering system or tabs which permit ready access to the information contained therein.
   ii. As-built printout of all software configuration including data tables, passwords, and other parameters. Document software with English language descriptions and tag numbers where appropriate.
   iii. Electronic documentation shall include fully annotated electronic copies of all HMI programming. As-built documentation shall include all changes made during the first year of operation.
   iv. Software configuration files shall be included in the manual in two forms:
      - CD ROM.
      - Paper.
b. Submit software license certificates, manufacturer provided software documentation, and software installation media.

B. MATERIALS.

1. Operator Interface Terminal – ~~High Brightness~~ Integral to Multi-Smart Pump Controller
   a. Manufacturer:
      i. ~~Pro-Face America AGP-3300U~~ Flygt - Do Not Substitute.
      ~~ii. Beijer~~
      ~~iii. Advantech~~
      ~~iv. Or equal~~
      ~~ii. Agency approvals:~~
         - ~~C-UL certified~~
         - ~~UL listed~~
         - ~~CE marked~~
      ~~iii. Environmental:~~
         - ~~Temperature:~~
            - ~~Operating: 32°F to 122°F~~
            - ~~Storage: -4°F to 140°F~~
         - ~~Relative Humidity: 10% to 90% non-condensing~~
         - ~~Shock: IEC/EN61131-2 compliant, 147 m/s², X, Y, Z directions for 3 times~~
         - ~~Vibration: IEC/EN61131-2 compliant, 5 Hz to 9 Hz Single amplitude 3.5 mm [0.14 in.], 9 to 150 Hz Fixed acceleration: 9.8 m/s², X, Y, Z directions for 10 cycles (100 min)~~
         - ~~Ratings: IP65f NEMA #250 TYPE 1 (on the front panel when properly installed in an enclosure)~~
      ~~iv. Electrical:~~
         - ~~Input Voltage:~~
            - ~~85 to 264VAC~~
            - ~~47 to 63 Hz~~
         - ~~Power Consumption: 60 VA maximum~~
      ~~v. Display:~~
         - ~~Type: TFT Color LCD (Ultra luminance)~~
         - ~~Size 5.7 inch display~~

- Resolution: 320 x 240 pixels
- Dot Pitch: W0.01 x H0.01 inch
- Effective Display Area: W4.54 x H3.40 inch
- Display Colors: 65,536 Colors (No blink)/16,384 Colors (Blink)
- Backlight: CCFL (User nonreplaceable parts. Factory replacement required.)
- Brightness Control: 8 Levels (Adjusted with the touch panel)

b. Character sizes: Standard font: 8 x 8, 8 x 16, 16 x 16 and 32 x 32 pixel fonts, Stroke font: 6 to 127 pixel fonts, Image font: 8 to 72 pixel fonts

i. Font Sizes: Standard font: Width can be expanded up to 8 times., Height can be expanded up to eight times.

- Program Area: 132KB FLASH EPROM
- Variable Area: SRAM 64 KB (uses lithium battery)

ii. Touchscreen:

- Analog resistive

iii. Memory:

- FLASH EPROM 6 MB
- Data Backup: SRAM 320KB (uses lithium battery)

iv. Communications Ports:

- Ethernet
- RS-232 (two)
- USB
- Compact Flash Card Slot

C. CONSTRUCTION.

1. Field Measurements
   a. Refer to the requirements of Process Instrumentation & Control.
2. Delivery Storage and Handling
   a. Refer to the requirements of Process Instrumentation & Control.
3. Installation
   a. Refer to the requirements of Process Instrumentation & Control.
4. Software Configuration Services
   a. Refer to the requirements of Process Instrumentation & Control.
5. Testing and Start-Up Services
   a. Refer to the requirements of Process Instrumentation & Control.
6. Training
   a. Refer to the requirements of Process Instrumentation & Control.

154013a.17 METHOD OF MEASUREMENT.

Lump sum item; no measurement will be made.

154013a.18 BASIS OF PAYMENT.

This item will be included in and paid for at the lump sum bid item price for Electrical System for Stormwater Pumps; price shall be full compensation for furnishing all equipment, materials, and all other work necessary or incidental to the construction of the complete installation and for all equipment, tools, labor, and incidentals necessary to complete the work.