TABLE OF CONTENTS

Pages

END OF SECTION

TECHNICAL SPECIFICATIONS

SCOPE OF WORK

PART 1 - SCOPE OF WORK

1.1 DESCRIPTION

A. Work Included: To furnish and deliver all items necessary supplying a VFD REPLACEMENT FOR EFFLUENT PUMP and all necessary appurtenances, testing services, and incidental work to provide a complete and serviceable project identified as:

VFD REPLACEMENT FOR EFFLUENT PUMP

END OF SECTION

SECTION 01 33 00
SUBMITTALS

PART 1 GENERAL

1.01 GENERAL

A. Inquiries: Direct to Engineer regarding procedure, purpose, or extent of Submittal.

B. Timeliness: Schedule and make submissions in accordance with requirements of individual Specification sections and in such sequence as to cause no delay in Work or in Work of other Contractors.

C. Identification of Submittals:

1. Complete, sign, and transmit with each Submittal package, one Transmittal of Contractor's Submittal Form attached at end of this Section.
2. Identify each Submittal with the following numbering and tracking system:
   a. Sequentially number each Submittal.
   b. Resubmission of a Submittal will have original number with sequential alphabetic suffix.
3. Format: Orderly, indexed with labeled tab dividers.
4. Show date of submission.
5. Show Project title and Owner's contract identification and contract number.
6. Show names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
7. Identify, as applicable, Contract Document section and paragraph to which Submittal applies.
8. Identify Submittal type; submit only one type in each Submittal package.
9. Identify and indicate each deviation or variation from Contract Documents.

D. Resubmissions: Clearly identify each correction or change made.

E. Incomplete Submittal Submissions:

1. Engineer will return entire Submittal for Contractor's revision/correction and resubmission.
2. Submittals which do not clearly bear Contractor's specific written indication of Contractor review and approval of Submittal or which are transmitted with an unsigned or uncertified submission form or as may otherwise be required will be returned to Contractor unreviewed.

F. Nonspecified Submissions: Submissions not required under these Contract Documents and not shown on submissions will not be reviewed and will be returned to Contractor.

G. Engineer's Review: Engineer will act upon Contractor's Submittal and transmit response to Contractor not later than 20 working days after receipt, unless otherwise specified. Resubmittals will be subject to same review time.

H. Schedule Delays:

1. No adjustment of Contract Times or Price will be allowed due to Engineer's review of Submittals, unless all of the following criteria are met:
   a. Contractor has notified Engineer in writing that timely review of Submittal in question is critical to progress of Work, and has received Engineer's written acceptance to reflect such on current accepted submissions and progress schedule. Written agreement by the Engineer to reduce Submittal review time will be made only for unusual and Contractor-justified reasons. Acceptance of a progress schedule containing Submittal review times less than specified or less than agreed to in writing by Engineer will not constitute Engineer's acceptance of review times.
   b. Engineer has failed to review and return first submission of a Submittal within agreed time indicated on current accepted schedule of submissions or, if no time is indicated thereon, within 30 days after receipt.
   c. Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return Submittal within time indicated and accepted by Engineer.
2. No adjustment of Contract Times or Price will be allowed due to delays in progress of Work caused by rejection and subsequent resubmission of Submittals, including multiple resubmissions.

1.02 SHOP DRAWINGS AND SAMPLES

A. Copies:

1. Shop Drawings and Product Data: Submit four copies, plus whatever the Manufacturer requires to be returned, maximum eight.
2. Samples: Two, unless otherwise specified in individual Specification sections.

3. Electronic Submittals: Manufacturer may be required to submit all documents electronically. If so the following will be followed:
   a. Each submittal shall be an electronic file in Adobe Acrobat Portable Document Format (PDF). Use the latest version available at the time of execution of the Contract Documents. Electronic files which contain more than ten (10) pages in Adobe Acrobat format shall contain internal book-marking from an index page to major sections of the document. PDF files shall be set to open "Bookmarks and Page" view. General information shall be added to each PDF file, including Title, Subject, Author, and Keywords.
   b. The PDF files shall be set up to print legibly at either 8-1/2-inch by 11-inch, 11-inch by 17-inch or 22-inch by 34-inch.
   c. New electronic files shall be required for each submittal.
   d. Each electronic file shall also include a copy of the Submittal Transmittal Form and completed Submittal Checklist.
   e. Submittals shall be transmitted by uploading the PDF file of the submittal to the project SharePoint site. Submittal review comments will be transmitted back to the Subcontractor electronically via the project SharePoint site as well.
   f. Subcontractor shall provide authorization to reproduce and/or distribute each file as many times as necessary for the Project.
   g. Subcontractor shall include all costs for preparation and transmittal of electronic submittals in its bid, including all resubmittals and final record copies.
   h. Final Record Copies: After all initial and resubmittal information has been approved, consolidate all information and responses to comments into one conformed record copy. Provide one electronic copy of the conformed record copy to CH2M HILL to verify incorporation of previously submitted data. Hard copies, number as required herein, that exactly match the final conformed electronic copy of the submittal will be submitted to CH2M HILL within 30 days of approval of the electronic copy.

B. General: Submit to Engineer as required by individual Specification sections.

C. Identify and Indicate:

   1. Pertinent Drawing sheet(s) and detail number(s), products, units and assemblies, and system or equipment identification or tag numbers.
   2. Critical field dimensions and relationships to other critical features of Work.
   3. Each deviation or variation from Contract Documents.
   4. Proper storage and maintenance requirements.

D. Design Data: When specified, provide Project-specific information as required and as necessary to clearly show calculations, dimensions, logic and assumptions, and referenced standards and codes upon which design is based.

E. Foreign Manufacturers: When proposed, include following additional information:

1. Names and addresses of at least two companies closest to Project that maintain technical service representatives.
2. Complete inventory of spare parts and accessories for each piece of equipment.

F. Preparation:

1. Format: Whenever possible, schedule for and combine Shop Drawings and Samples required for submission in each Specification section or division into a single Submittal package. Also combine product data for like items into a single Submittal package.
2. Present in a clear and thorough manner and of sufficient detail to show kind, size, arrangement, and function of components, materials, and devices and compliance with Contract Documents. Identify details by reference to sheet and detail, and schedule or room numbers shown on Drawings.
3. Reproducible Copy:
   a. Preferred Minimum Sheet Size: 8-1/2- by 11-inch and 11- by 17-inch pages, suitable for photocopying.
   b. Larger than 11- by 17-Inch Sheets: 22-inch by 34-inch preferred, mylar or sepias suitable for copying in a blueprint machine.
4. Product Data: Clearly mark each copy to identify pertinent products or models and show performance characteristics and capacities, dimensions and clearances required, wiring or piping diagrams and controls, and external connections, anchorage, and supports required.
5. Equipment and Component Titles: Identical to title shown on Drawings.
6. Manufacturer's Standard Schematic Drawings and Diagrams as Follows:
   a. Modify to delete information that is not applicable to Work.
   b. Supplement standard information to provide information specifically applicable to Work.

G. Shop Drawing Disposition: Engineer will review, mark, and stamp as appropriate and distribute marked-up copies as noted:

1. Approved as Submitted (for Incorporation in Work):
   a. Two copies furnished Owner.
   b. One copy furnished Resident Project Representative.
   c. One copy retained in Engineer's file.
   d. Remaining copies returned to Manufacturer appropriately annotated.

2. Approved as Noted (for Incorporation in Work):
   a. Two copies furnished Owner.
   b. One copy furnished Resident Project Representative.
   c. One copy retained in Engineer's file.
   d. Remaining copies returned to Manufacturer appropriately annotated.
3. Disapproved:
   a. One copy furnished Resident Project Representative.
   b. One copy retained in Engineer's file.
   c. Remaining copies returned to Contractor appropriately annotated.
   d. Manufacturer shall make corrections or develop replacement and resubmit (in same manner and quantity as specified for original submission).
   e. Submittal is not approved.
4. Incomplete:
   a. One copy furnished Resident Project Representative.
   b. One copy retained in Engineer's file.
   c. Remaining copies returned to Manufacturer appropriately annotated.
   d. Contractor shall complete and resubmit or submit missing portions.
   e. Submittal is not approved.

1.03 SUPPLEMENTS

A. The supplement listed below, following “END OF SECTION,” is part of this Specification.

1. Transmittal of Manufacturer’s Submittal.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

CH2M HILL

TRANSMITTAL OF MANUFACTURER'S SUBMITTAL
(ATTACH TO EACH SUBMITTAL)

DATE:_____

TO:_____

_____

_____

_____

_____

Submittal No.:_____

☐New Submittal ☐Resubmittal

Previous Submittal No.:_____

Project:_____

Project No.:_____

Specification Section No.:_____

(Cover only one section with each transmittal)

Schedule Date of Submittal:

_____

FROM:_____

Manufacturer

_____

_____

_____

SUBMITTAL TYPE:
☐Shop Drawing ☐Administrative ☐Sample
☐Quality Control ☐Contract Closeout ☐"Or-Equal"/Substitute

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Manufacturer hereby certifies that (i) Manufacturer has complied with the requirements of Contract Documents in preparation, review, and submission of designated Submittal and (ii) the Submittal is complete and in accordance with the Contract Documents and requirements of laws and regulations and governing agencies.

By:_____
Manufacturer (Authorized Signature)

SECTION 01 42 13
ABBREVIATIONS

PART 1 GENERAL

1.01 REFERENCE TO STANDARDS AND SPECIFICATIONS OF TECHNICAL SOCIETIES

A. Reference to standards and specifications of technical societies and reporting and resolving discrepancies associated therewith shall be as in the individual Specification sections.

B. Work specified by reference to the published standard or specification of a government agency, technical association, trade association, professional society or institute, testing agency, or other organization shall meet the requirements or surpass the minimum standards of quality for materials and workmanship established by the designated standard or specification.

C. Where so specified, products or workmanship shall also meet or exceed the additional prescriptive or performance requirements included within the Contract Documents to establish a higher or more stringent standard of quality than that required by the referenced standard.

D. Where two or more standards are specified to establish quality, the product and workmanship shall meet or exceed the requirements of the most stringent.

E. Where both a standard and a brand name are specified for a product in the Contract Documents, the proprietary product named shall meet or exceed the requirements of the specified reference standard.

F. Copies of Standards and Specifications of Technical Societies: Copies of applicable referenced standards have not been bound in these Contract Documents.

1.02 ABBREVIATIONS

A. Abbreviations for trade organizations and government agencies: Following is a list of construction industry organizations and government agencies to which references may be made in the Contract Documents, with abbreviations used.

1.	AA	Aluminum Association
2.	AFBMA	Anti-Friction Bearing Manufacturers' Association
3.	AGMA	American Gear Manufacturers' Association
4.	ANSI	American National Standards Institute

5.	APWA	American Public Works Association
6.	ASA	American Standards Association
7.	ASCE	American Society of Civil Engineers
8.	ASNT	American Society for Nondestructive Testing
9.	ASME	American Society of Mechanical Engineers
10.	ASTM	American Society for Testing and Materials
11.	AWS	American Welding Society
12.	AWWA	American Water Works Association
13.	BHMA	Builders Hardware Manufacturers' Association
14.	CGA	Compressed Gas Association
15.	CS	Commercial Standard
16.	CSI	Construction Specifications Institute
17.	EJCDC	Engineers Joint Contract Documents' Committee
18.	ETL	Engineering Test Laboratories
19.	FCC	Federal Communications Commission
20.	FM	Factory Mutual
21.	Fed. Spec.	Federal Specifications
22.	FS	Federal Specification
23.	ICBO	International Conference of Building Officials
24.	ICEA	Insulated Cable Engineers' Association
25.	IEEE	Institute of Electrical and Electronics Engineers, Inc.
26.	IES	Illuminating Engineering Society
27.	IFI	Industrial Fasteners Institute
28.	ISA	Instrument Society of America
29.	ISO	Insurance Service Office
30.	Mil. Sp.	Military Specification or MIL
31.	MS	Military Specifications
32.	NEC	National Electrical Code
33.	NECA	National Electrical Contractor's Association
34.	NEMA	National Electrical Manufacturers' Association
35.	NESC	National Electric Safety Code
36.	NFPA	National Fire Protection Association
37.	NSFTL	National Sanitation Foundation Testing Laboratory
38.	NSPE	National Society of Professional Engineers
39.	OSHA	Occupational Safety and Health Act (both Federal and State)
40.	PS	Product Standards Section-U.S. Department of Commerce
41.	UBC	Uniform Building Code
42.	UFC	Uniform Fire Code
43.	UL	Underwriters Laboratories Inc.
44.	UMC	Uniform Mechanical Code
45.	US	U.S. Bureau of Standards
46.	USBR	U.S. Bureau of Reclamation

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 43 33
MANUFACTURERS' FIELD SERVICES

PART 1 GENERAL

1.01 DEFINITIONS

A. Person-Day: One person for 8 hours within regular Contractor working hours.

1.02 SUBMITTALS

A. Informational Submittals:

1. Training Schedule: Submit, in accordance with requirements of this specification, not less than 21 days prior to start of equipment installation and revise as necessary for acceptance.
2. Lesson Plan: Submit, in accordance with requirements of this specification, proposed lesson plan not less than 21 days prior to scheduled training and revise as necessary for acceptance.

1.03 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified elsewhere.

B. Representative subject to acceptance by Owner. No substitute representatives will be allowed unless prior written approval by such has been given.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

A. Furnish manufacturers' services when required by an individual specification section, to meet the requirements of this section.

B. Where time is necessary in excess of that stated in the Specifications for manufacturers' services, or when a minimum time is not specified, the time required to perform the specified services shall be considered incidental.

C. Schedule manufacturer' services to avoid conflict with other onsite testing or other manufacturers' onsite services.

D. Determine, before scheduling services, that all conditions necessary to allow successful testing have been met.

E. Only those days of service approved by Engineer will be credited to fulfill the specified minimum services.

F. When specified in individual specification sections, manufacturer's onsite services shall include:

1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
3. Providing, on a daily basis, copies of all manufacturers' representatives' field notes and data to Owner.
4. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Engineer.
5. Resolution of assembly or installation problems attributable to, or associated with, respective manufacturer's products and systems.
6. Assistance during functional and performance testing, and facility startup and evaluation.
7. Additional requirements may be specified elsewhere.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

A. When so specified, a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by the entity supplying the product, material, or service, and submitted prior to shipment of product or material or the execution of the services.

B. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.

C. Such form shall certify that the proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.

D. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03 MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

A. When so specified, a Manufacturer's Certificate of Proper Installation form, a copy of which is attached to this section, shall be completed and signed by the equipment manufacturer's representative.

B. Such form shall certify that the signing party is a duly authorized representative of the manufacturer, is empowered by the manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to assure that the equipment is complete and operational.

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section", are part of this Specification.

1. Form: Manufacturer's Certificate of Compliance.
2. Form: Manufacturer's Certificate of Proper Installation.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER:

PRODUCT, MATERIAL, OR SERVICE SUBMITTED:

PROJECT NAME:

PROJECT NO:

Comments:_____

_____

_____

_____

_____

_____

I hereby certify that the above-referenced product, material, or service called for by the contract for the named project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the contract requirements, and are in the quantity shown.

Date of Execution: _____, 20___

Manufacturer:_____

Manufacturer's Authorized Representative *(print)*: _____

_____
(Authorized Signature)

MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

OWNER _____ EQPT SERIAL NO: _____

EQPT TAG NO: _____ EQPT/SYSTEM: _____

PROJECT NO: _____ SPEC. SECTION: _____

I hereby certify that the above-referenced equipment/system has been:

(Check Applicable)

- ☐ Installed in accordance with Manufacturer's recommendations.
- ☐ Inspected, checked, and adjusted.
- ☐ Serviced with proper initial lubricants.
- ☐ Electrical and mechanical connections meet quality and safety standards.
- ☐ All applicable safety equipment has been properly installed.
- ☐ Functional tests.
- ☐ System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments: _____

_____

_____

_____

I, the undersigned Manufacturer's Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate his equipment and (iii) authorized to make recommendations required to assure that the equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____, 20___

Manufacturer: _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Detailed information for the preparation, submission, and Engineer's review of Operations and Maintenance (O&M) Data, as required by individual Specification sections.

1.02 DEFINITIONS

A. Preliminary Data: Initial and subsequent submissions for Engineer's review.

B. Final Data: Engineer-accepted data, submitted as specified herein.

C. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations are lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.

1.03 SEQUENCING AND SCHEDULING

A. Equipment and System Data:

1. Preliminary Data:
   a. Do not submit until Shop Drawing for equipment or system has been reviewed and approved by Engineer.
   b. Submit prior to shipment date.
2. Final Data: Submit Instructional Manual Formatted data not less than 30 days prior to equipment or system field functional testing.

B. Materials and Finishes Data:

1. Preliminary Data: Submit at least 15 days prior to request for final inspection.
2. Final Data: Submit within 10 days after final inspection.

1.04 DATA FORMAT

A. Prepare preliminary and final data in the form of an instructional manual.

B. Instructional Manual Format:

1. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.
2. Size: 8-1/2 inches by 11 inches, minimum.
3. Cover: Identify manual with typed or printed title “OPERATION AND MAINTENANCE DATA” and list:
   a. Project title.
   b. Designate applicable system, equipment, material, or finish.
   c. Identity of separate structure as applicable.
   d. Identify volume number if more than one volume.
   e. Identity of general subject matter covered in manual.
4. Spine:
   a. Project title.
   b. Identify volume number if more than one volume.
5. Title Page:
   a. Contractor name, address, and telephone number.
   b. Subcontractor, Supplier, installer, or maintenance contractor’s name, address, and telephone number, as appropriate.
      1) Identify area of responsibility of each.
      2) Provide name and telephone number of local source of supply for parts and replacement.
6. Table of Contents:
   a. Neatly typewritten and arranged in systematic order with consecutive page numbers.
   b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
7. Paper: 20-pound minimum, white for typed pages.
8. Text: Manufacturer’s printed data, or neatly typewritten.
9. Three-hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data.
10. Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.

C. Data Compilation Format:

1. Compile all Engineer-accepted preliminary O&M data into a hard-copy, hard-bound set.

2. Each set shall consist of the following:
   a. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.
   b. Cover: Identify each volume with typed or printed title "OPERATION AND MAINTENANCE DATA, VOLUME NO. ___ OF ___", and list:
      1) Project title.
      2) Contractor's name, address, and telephone number.
      3) If entire volume covers equipment or system provided by one Supplier include the following:
         a) Identity of general subject matter covered in manual.
         b) Identity of equipment number and Specification section.
   c. Provide each volume with title page and typed table of contents with consecutive page numbers. Place contents of entire set, identified by volume number, in each binder.
   d. Table of contents neatly typewritten, arranged in a systematic order:
      1) Include list of each product, indexed to content of each volume.
      2) Designate system or equipment for which it is intended.
      3) Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
   e. Section Dividers:
      1) Heavy, 80 pound cover weight, tabbed with numbered plastic index tabs.
      2) Fly-Leaf:
         a) For each separate product, or each piece of operating equipment, with typed description of product and major component parts of equipment.
         b) List with Each Product:
            (1) Name, address, and telephone number of Subcontractor, Supplier, installer, and maintenance contractor, as appropriate.
            (2) Identify area of responsibility of each.
            (3) Provide local source of supply for parts and replacement.
         c) Identity of separate structure as applicable.
   f. Assemble and bind material, as much as possible, in same order as specified in the Contract Documents.

1.05 SUBMITTALS

A. Informational:

1. Data Outline: Submit two copies of a detailed outline of proposed organization and contents of Final Data prior to preparation of Preliminary Data.
2. Preliminary Data:
   a. Submit two copies for Engineer's review.
   b. If data meets conditions of the Contract:
      1) One copy will be returned to Manufacturer.
      2) One copy will be forwarded to Resident Project Representative.
   c. If data does not meet conditions of the Contract:
      1) All copies will be returned to Manufacturer with Engineer's comments (on separate document) for revision.
      2) Engineer's comments will be retained in Engineer's file.
      3) Resubmit two copies revised in accordance with Engineer's comments.
3. Final Data: Submit two copies in format specified herein and an electronic copy.

1.06 DATA FOR EQUIPMENT AND SYSTEMS

A. Content for Each Unit (or Common Units) and System:

1. Product Data:
   a. Include only those sheets that are pertinent to specific product.
   b. Clearly annotate each sheet to:
      1) Identify specific product or part installed.
      2) Identify data applicable to installation.
      3) Delete references to inapplicable information.
   c. Function, normal operating characteristics, and limiting conditions.
   d. Performance curves, engineering data, nameplate data, and tests.
   e. Complete nomenclature and commercial number of replaceable parts.
   f. Original manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
   g. Spare parts ordering instructions.
   h. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, terminals).

2. Drawings: Supplement product data with Drawings as necessary to clearly illustrate:
   a. Format:
      1) Provide reinforced, punched, binder tab; bind in with text.
      2) Reduced to 8-1/2 inches by 11 inches, or 11 inches by 17 inches folded to 8-1/2 inches by 11 inches.
      3) Where reduction is impractical, fold and place in 8-1/2-inch by 11-inch envelopes bound in text.
      4) Identify Specification section and product on Drawings and envelopes.
   b. Relations of component parts of equipment and systems.
   c. Control and flow diagrams.
   d. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
3. Instructions and Procedures: Within text, as required to supplement product data.
   a. Format:
      1) Organize in consistent format under separate heading for each different procedure.
      2) Provide logical sequence of instructions for each procedure.
      3) Provide information sheet for Owner's personnel, including:
         a) Proper procedures in event of failure.
         b) Instances that might affect validity of guarantee or Bond.
   b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
   c. Operating Procedures:
      1) Startup, break-in, routine, and normal operating instructions.
      2) Test procedures and results of factory tests where required.
      3) Regulation, control, stopping, and emergency instructions.
      4) Description of operation sequence by control manufacturer.
      5) Shutdown instructions for both short and extended duration.
      6) Summer and winter operating instructions, as applicable.
      7) Safety precautions.
      8) Special operating instructions.
   d. Maintenance and Overhaul Procedures:
      1) Routine maintenance.
      2) Guide to troubleshooting.
      3) Disassembly, removal, repair, reinstallation, and re-assembly.
4. Guarantee, Bond, and Service Agreement:

B. Content for Each Electric or Electronic Item or System:

1. Description of Unit and Component Parts:
   a. Function, normal operating characteristics, and limiting conditions.

b. Performance curves, engineering data, nameplate data, and tests.
c. Complete nomenclature and commercial number of replaceable parts.
d. Interconnection wiring diagrams, including control and lighting systems.

2. Circuit Directories of Panelboards.
3. Electrical service.
4. Control requirements and interfaces.
5. Communication requirements and interfaces.
6. List of electrical relay settings, and control and alarm contact settings.
7. Electrical interconnection wiring diagram, including as applicable, single-line, three-line, schematic and internal wiring, and external interconnection wiring.
8. As-installed control diagrams by control manufacturer.
9. Operating Procedures:
   a. Routine and normal operating instructions.
   b. Startup and shutdown sequences, normal and emergency.
   c. Safety precautions.
   d. Special operating instructions.
10. Maintenance Procedures:
    a. Routine maintenance.
    b. Guide to troubleshooting.
    c. Adjustment and checking.
    d. List of relay settings, control and alarm contact settings.
11. Manufacturer’s printed operating and maintenance instructions.
12. List of original manufacturer’s spare parts, manufacturer’s current prices, and recommended quantities to be maintained in storage.

C. Maintenance Summary:

1. Compile individual Maintenance Summary for each applicable equipment item, respective unit or system, and for components or sub-units.
2. Format:
   a. Use Maintenance Summary Form bound with this section or electronic facsimile of such.
   b. Each Maintenance Summary may take as many pages as required.
   c. Use only 8-1/2-inch by 11-inch size paper.
   d. Complete using typewriter or electronic printing.
3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.

4. Recommended Spare Parts:
    a. Data to be consistent with manufacturer's Bill of Materials/Parts List furnished in O&M manuals.
    b. "Unit" is the unit of measure for ordering the part.
    c. "Quantity" is the number of units recommended.
    d. "Unit Cost" is the current purchase price.

1.07 DATA FOR MATERIALS AND FINISHES

A. Content for Architectural Products, Applied Materials, and Finishes:

1. Manufacturer's data, giving full information on products:
    a. Catalog number, size, and composition.
    b. Color and texture designations.
    c. Information required for reordering special-manufactured products.
2. Instructions for Care and Maintenance:
    a. Manufacturer's recommendation for types of cleaning agents and methods.
    b. Cautions against cleaning agents and methods that are detrimental to product.
    c. Recommended schedule for cleaning and maintenance.

B. Content for Moisture Protection and Weather Exposed Products:

1. Manufacturer's data, giving full information on products:
    a. Applicable standards.
    b. Chemical composition.
    c. Details of installation.
2. Instructions for inspection, maintenance, and repair.

1.08 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is part of this Specification.

1. Form: Maintenance Summary Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

MAINTENANCE SUMMARY FORM

PROJECT:_____ CONTRACT NO.:_____

1. EQUIPMENT ITEM_____

2. MANUFACTURER _____

3. EQUIPMENT/TAG NUMBER(S) _____

4. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS)_____

5. NAMEPLATE DATA (hp, voltage, speed, etc.) _____

6. MANUFACTURER'S LOCAL REPRESENTATIVE _____

   a. Name_____ Telephone No. _____

   b. Address _____

7. MAINTENANCE REQUIREMENTS

Maintenance Operation Comments	**Frequency**	**Lubricant (If Applicable)**
List briefly each maintenance operation required and refer to specific information in manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation.	Refer by symbol to lubricant required.

8. LUBRICANT LIST

Reference Symbol	Shell	Exxon Mobile	Chevron Texaco	BP Amoco	Or Equal
List symbols used in No. 7 above.	List equivalent lubricants, as distributed by each manufacturer for the specific use recommended.				

9. RECOMMENDED SPARE PARTS FOR OWNER'S INVENTORY.

Part No.	Description	Unit	Quantity	Unit Cost
Note: Identify parts provided by this Contract with two asterisks.				

SECTION 01 91 14
EQUIPMENT TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.01 DEFINITIONS

A. Facility: Entire Project, or an agreed-upon portion, including all of its unit processes.

B. Functional Test: Test or tests in presence of Engineer and Owner to demonstrate that installed equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements as specified.

C. Performance Test: Test or tests performed after any required functional test in presence of Engineer and Owner to demonstrate and confirm individual equipment meets performance requirements specified in individual sections.

D. Unit Process: As used in this section, a unit process is a portion of the facility that performs a specific process function, such as pump station and generator.

E. Facility Performance Demonstration:

1. A demonstration, conducted by Manufacturer, with assistance of Owner, to demonstrate and document the performance of the entire operating facility, both manually and automatically (if required), based on criteria developed in conjunction with Owner and as accepted by Engineer.
2. Such demonstration is for the purposes of (i) verifying to Owner entire facility performs as a whole, and (ii) documenting performance characteristics of completed facility for Owner's records. Neither the demonstration nor the evaluation is intended in any way to make performance of a unit process or entire facility the responsibility of Manufacturer, unless such performance is otherwise specified.

1.02 SUBMITTALS

A. Informational Submittals:

1. Facility Startup and Performance Demonstration Plan.
2. Functional and performance test results.
3. Completed Unit Process Startup Form for each unit process.
4. Completed Facility Performance Demonstration/Certification Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Contractor's Testing and Startup Representative:

1. Designate and furnish one or more personnel to coordinate and expedite testing and facility startup to discuss test schedule, test methods, materials, facilities operations interface, and Owner's involvement.
2. Representative(s) shall be present during startup meetings and shall be available at all times during testing and startup.

B. Provide test equipment and other materials and equipment required for testing and startup.

C. Owner will: Operate process units and facility with support of Manufacturer.

3.02 EQUIPMENT TESTING

A. Preparation:

1. Complete installation before testing.
2. Furnish qualified manufacturers' representatives, when required by individual Specification sections.
3. Obtain and submit from equipment manufacturer's representative Manufacturer's Certificate of Proper Installation Form, in accordance with Section 01 43 33, Manufacturers' Field Services, when required by individual Specification sections.
4. Equipment Test Report Form: Provide written test report for each item of equipment to be tested, to include the minimum information:
   a. Owner/Project Name.
   b. Equipment or item tested.
   c. Date and time of test.
   d. Type of test performed (Functional or Performance).
   e. Test method.
   f. Test conditions.
   g. Test results.
   h. Signature spaces for Manufacturer and Engineer as witness.
5. Cleaning and Checking: Prior to beginning functional testing:
   a. Calibrate testing equipment in accordance with manufacturer's instructions.
   b. Inspect and clean equipment, and devices, to ensure they are free of foreign material.

c. Check power supply to electric-powered equipment for correct voltage.

6. Ready-to-test determination will be by Engineer based at least on the following:
   a. Acceptable Operation and Maintenance Data.
   b. Notification by Contractor of equipment readiness for testing.
   c. Receipt of Manufacturer's Certificate of Proper Installation, if so specified.
   d. Adequate completion of work adjacent to, or interfacing with, equipment to be tested.
   e. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment.
   f. Satisfactory fulfillment of other specified manufacturer's responsibilities.
   g. Equipment and electrical tagging complete.
   h. Delivery of all spare parts and special tools.

B. Functional Testing:

1. Conduct as specified in individual Specification sections.
2. Notify Owner and Engineer in writing at least 10 days prior to scheduled date of testing.
3. Prepare Equipment Test Report summarizing test method and results.
4. When, in Engineer's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to performance testing phase, if so required by individual Specification sections. Such acceptance will be evidenced by Engineer/Owner's signature as witness on Equipment Test Report.

C. Performance Testing:

1. Conduct as specified in individual Specification sections.
2. Notify Engineer and Owner in writing at least 10 days prior to scheduled date of test.
3. Performance testing shall not commence until equipment has been accepted by Engineer as having satisfied functional test requirements specified.
4. Unless otherwise indicated, furnish labor, materials, and supplies for conducting the test and taking samples and performance measurements.
5. Prepare Equipment Test Report summarizing test method and results.
6. When, in Engineer's opinion, equipment meets performance requirements specified, such equipment will be accepted as to conforming to Contract requirements. Such acceptance will be evidenced by Engineer's signature on Equipment Test Report.

3.03 STARTUP OF UNIT PROCESSES

A. Prior to unit process startup, equipment within unit process shall be accepted by Engineer as having met functional and performance testing requirements specified.

B. Startup sequencing of unit processes shall be as chosen by Manufacturer to meet schedule requirements.

C. Make adjustments, repairs, and corrections necessary to complete unit process startup.

D. Startup shall be considered complete when, in opinion of Engineer, unit process has operated in manner intended for 5 continuous days without significant interruption. This period is in addition to functional or performance test periods specified elsewhere.

E. Significant Interruption: May include any of the following events:

1. Failure of Manufacturer to provide and maintain qualified onsite startup personnel as scheduled.
2. Failure to meet specified functional operation for more than 2 consecutive hours.
3. Failure of any critical equipment or unit process that is not satisfactorily corrected within 5 hours after failure.
4. Failure of any noncritical equipment or unit process that is not satisfactorily corrected within 8 hours after failure.
5. As determined by Engineer.

F. A significant interruption will require startup then in progress to be stopped. After corrections are made, startup test period to start from beginning again.

3.04 SUPPLEMENTS

A. Supplement listed below, following “End of Section,” is a part of this Specification:

1. Unit Process Startup Form.

END OF SECTION

UNIT PROCESS STARTUP FORM

OWNER: _____ **PROJECT:** _____

Unit Process Description: (Include description and equipment number of all equipment and devices):

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves to be opened/closed, order of equipment startup, etc.):

Startup Requirements (Water, power, chemicals, etc.): _____

Evaluation Comments: _____

SECTION 26 05 01
ELECTRICAL

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections. Coordinate all sections and drawings as one contract document.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
   c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
   d. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
2. Electronic Industries Association (EIA/TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
3. Federal Specifications (FS):
   a. W-C-596, Connector, Electrical, Power, General Specification for.
   b. W-S-896, Switch, Toggle (Toggle and Lock), Flush Mounted (General Specification).
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   b. PC62.41.1, Draft Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
   c. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   d. 114, Standard Test Procedures for Single-Phase Induction Motors.
5. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

6. National Electrical Contractor's Association, Inc. (NECA): 1, Standard Practices for Good Workmanship in Electrical Contracting.
7. National Electrical Manufacturers Association (NEMA):
   a. C80.1, Rigid Steel Conduit-Zinc Coated.
   b. C80.3, Electrical Metallic Tubing-Zinc Coated.
   c. C80.6, Intermediate Metal Conduit-Zinc Coated (IMC).
   d. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   e. CC1, Electrical Power Connectors for Substations.
   f. ICS 1, Industrial Control and Systems: General Requirements.
   g. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC.
   h. ICS 2.3, Industrial Control and Systems: Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers.
   i. MG 1, Motors and Generators.
   j. PB 1, Panelboards.
   k. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   l. ST 20, Dry Type Transformers for General Applications.
   m. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
   n. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
   o. WC 57, Instrumentation Cables and Thermocouple Wire.
   p. WC 70, Standard for Non-Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy.
   q. WD 1, General Color Requirements for Wiring Devices.
8. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
9. Underwriters Laboratories, Inc. (UL):
   a. 1, Flexible Metal Conduit.
   b. 6, Electrical Rigid Metal Conduit—Steel.
   c. 13, Power-Limited Circuit Cables.
   d. 44, Thermoset Insulated Wires and Cables.
   e. 62, Flexible Cord and Fixture Wire.
   f. 67, Panelboards.
   g. 98, Enclosed and Dead-Front Switches.
   h. 198C, High Interrupting Capacity Fuses, Current Limiting Types.
   i. 198E, Class R Fuses.
   j. 360, Liquid-Tight Flexible Steel Conduit.
   k. 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   l. 486C, Splicing Wire Connectors.

m. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
n. 508, Industrial Control Equipment.
o. 510, Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
p. 514B, Fittings for Cable and Conduit.
q. 674, Electric Motors And Generators for use in Division 1 Hazardous (Classified) Locations.
r. 854, Service-Entrance Cables.
s. 1059, Terminal Blocks.
t. 1561, Dry-Type General Purpose and Power Transformers.
u. 2111, Overheating Protection for Motors.

1.03 LUMP SUM SCOPE OF WORK

A. The following scope of work shall be included in the lump sum base bid.

1. Supply VFD as specified in Specification Section 26 29 23, Variable-Frequency Motor Controller including all shipping, handling, and storage as needed to transfer the new VFD to Owner for installation by others.

B. General: 1. Perform all electrical testing required to ensure safe and operational system.

1.04 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. MCOV: Maximum Allowable Continuous Operating Voltage.

C. SPD: Surge Protection Device.

1.05 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.06 APPROVAL BY AUTHORITY HAVING JURISDICTION

A. Provide the Work in accordance with current edition of NFPA 70, National Electrical Code (NEC). Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a Nationally Recognized Testing Laboratory (NRTL) or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have the appropriate listing mark or label by a NTRL.

1.07 ENVIRONMENTAL CONDITIONS

A. The room where proposed VFD is to be installed is a conditioned space.

PART 2 PRODUCTS

2.01 GENERAL

A. Products shall comply with all applicable provisions of NFPA 70.

B. Equipment Finish: Manufacturer’s standard finish color, except where specific color is indicated.

C. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

2.02 CONDUCTORS AND CABLES

A. Conductors 600 Volts and Below:

1. Conform to applicable requirements of NEMA WC70, WC 71, WC 72, and WC 74.
2. Conductor Type:
   a. 120- and 277-Volt Lighting, No. 10 AWG and Smaller: Solid copper.
   b. 120-Volt Receptacle Circuits, No. 10 AWG and Smaller: Solid copper.
   c. All Other Circuits: Stranded copper.
3. Insulation:
   a. Type XHHW.
   b. Type THHN/THWN-2, for field wiring.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. No. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

C. Type 3, No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.

5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.

D. CAT6 E Cable, 4 pair:

1. 100 Ohm FTP Fire retardant UL Listed.
2. LSOH outer jacket.
3. Synthetic Water repellent.
4. Shielding Polyester AL tape.
5. Insulation triple coat with 515 mm design.
6. Tinned Copper conductor.
7. IEEE 802 IEEE802.5 performance.
8. Insulation: Fire Retardant IEC.
9. UL 1581 listed as Type THHN/THWN rated VW-1.
10. Conductor group bound with spiral wrap of barrier tape.
11. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.

E. Manufacturers:

1. CAT6 Beldon or equal.
2. South Wire for THHN/THWN.
3. Manufacturers standard for internal control panel.

F. Accessories:

1. Tape:
    a. General Purpose, Flame Retardant: 7 mils, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
    b. Flame Retardant, Cold and Weather Resistant: 8.5 mils, vinyl plastic, Scotch Brand 88.
    c. Arc and Fireproofing:
        1) 30 mils, elastomer.
        2) Manufacturers and Products:
            a) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tape binder.
            b) Plymount; Plyarc 53, with Plyglas 77 glass cloth tape binder.

G. Identification Devices:

1. Sleeve:
    a. Permanent, PVC, yellow or white, with legible machine-printed black markings.

b. Manufacturers and Products:
1) Raychem; Type D-SCE or ZH-SCE.
2) Brady, Type 3PS.

2. Heat Bond Marker:
a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
b. Self-laminating protective shield over text.
c. Machine printed black text.
d. Manufacturer and Product: 3M Co.; Type SCS-HB.

3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.

4. Tie-On Cable Marker Tags:
a. Chemical-resistant white tag.
b. Size: 1/2 inch by 2 inches.
c. Manufacturer and Product: Raychem; Type CM-SCE.

5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

6. Connectors and Terminations:
a. Nylon, Self-Insulated Crimp Connectors:
1) Manufacturers and Products:
a) Thomas & Betts; Sta-Kon.
b) Burndy; Insulug.
c) ILSCO.

7. Self-Insulated, Freespring Wire Connector (Wire Nuts):
a. Plated steel, square wire springs.
b. UL Standard 486C.
c. Manufacturers and Products:
1) Thomas & Betts.
2) Ideal; Twister.

H. Cable Lugs:

a. In accordance with NEMA CC 1.
b. Rated 600 volts of same material as conductor metal.
c. Uninsulated Crimp Connectors and Terminators:
1) Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
2) Manufacturers and Products:
a) Thomas & Betts; Color-Keyed.
b) Burndy; Hydent.
c) ILSCO.
d. Uninsulated, Bolted, Two-Way Connectors and Terminators:
1) Manufacturers and Products:
a) Thomas & Betts; Locktite.
b) Burndy; Quiklug.
c) ILSCO.

I. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

J. Heat Shrinkable Insulation:

1. Thermally stabilized, crosslinked polyolefin.
2. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

2.03 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

A. UL 489 listed for use at location of installation.

B. Minimum Interrupt Rating: 42,000 amps rms symmetrical at 480 volts.

C. Thermal-magnetic, quick-make, quick-break, indicating type showing ON/OFF and TRIPPED indicating positions of operating handle.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Locking: Provisions for padlocking handle.

F. Enclosure: As shown.

G. Interlock: Enclosure and switch shall interlock to prevent opening cover with breaker in the ON position.

2.04 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: White. Engraved to a black core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 1/8 inch.
2. Other Electrical Equipment: ¼ inch.

2.05 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 CONDUCTORS 600 VOLTS AND BELOW

A. Do not splice conductors, unless specifically approved by Engineer.

B. Connections and Terminations:

1. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
2. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
3. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
4. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
5. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
6. Place no more than one conductor in any single-barrel pressure connection.
7. Install crimp connectors with tools approved by connector manufacturer.
8. Install terminals and connectors acceptable for type of material used.
9. Compression Lugs:
    a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
    b. Do not use plier type crimpers.

C. Do not use soldered mechanical joints.

D. Splices and Terminations:

1. Insulate all uninsulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

E. Cap spare conductors with UL listed end caps.

F. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

G. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Cable Protection:
   a. Under Infinite Access Floors: May install without bundling.
   b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
   c. Maintain integrity of shielding of instrumentation cables.
   d. Ensure grounds do not occur because of damage to jacket over the shield.

H. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

I. Communications Tests: Contractor shall coordinate with Plant technicians to ensure proper communications have been established between FP-3-1 and Plant SCADA SYSTEM.

3.02 GROUNDING

A. Grounding shall be in compliance with NFPA 70 and as shown.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

F. Equipment Grounding Conductors: Provide in all conduits containing power conductors and control circuits above 50 volts.

G. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in pump control panel and RTU assemblies for proper connection and tightness.
2. Ground bus connections in pump control panel and RTU assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

3.03 FIELD QUALITY CONTROL

A. Tests shall be performed in accordance with the requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. General:

1. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.
2. Test instrument calibration shall be in accordance with NETA ATS.
3. Perform inspection and electrical tests after equipment has been installed.
4. Perform tests with apparatus de-energized whenever feasible.
5. Inspection and electrical tests on energized equipment are to be:
   a. Scheduled with Owner prior to de-energization.
   b. Minimized to avoid extended period of interruption.

C. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70.

D. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

E. Adjust mechanisms and moving parts for free mechanical movement.

F. Verify nameplate data for conformance to Contract Documents.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

L. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer, door and panel sections having damaged surfaces.
5. Replace missing or damaged hardware.

M. Provide certified test report(s) documenting the successful completion of specified testing. Include field test measurement data.

N. Test the following equipment and materials: Grounding electrodes.

O. Controls:

1. Test control and signal wiring for proper termination and function.
2. Test local control panels and other control devices for proper terminations, configuration and settings, and functions.
3. Demonstrate control, monitoring, and indication functions in presence of Owner and Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Labels shall be 2 in letters laminated plastic white letters black background with stainless steel fasteners.

B. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including terminal junction boxes, switches and control stations.
2. Nameplates required for FP-3-1, FP-3-1A, TJB FP3-1 to SCADA, confirm with Owner prior to procuring or installing labels.

END OF SECTION

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   b. D923, Standard Practice for Sampling Electrical Insulating Liquids.
   c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
   f. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
   h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
   i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
   j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5kV through 500kV.
   c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
   e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.

f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
h. C2, National Electrical Safety Code.
i. C37.20.1, Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
j. C37.20.2, Standard for Metal-Clad Switchgear.
k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
l. C37.23, Standard for Metal-Enclosed Bus.
m. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.

3. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
   b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
   c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
4. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
   c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
5. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.
   d. 101, Life Safety Code.
7. National Institute for Certification in Engineering Technologies (NICET).
8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. List of references to be used for each test.
   c. Sample copy of equipment and materials inspection form(s).
   d. Sample copy of individual device test form.
   e. Sample copy of individual system test form.
2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
   a. Owner’s representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
   b. Staged sequence of initial energization of electrical equipment.
   c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
   d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
4. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
5. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
   a. Protective relays.
   b. Intelligent overload relays.
   c. Variable frequency drives.
   d. Power metering devices.
   e. Uninterruptible power supplies.
   f. Electrical communications modules.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.

2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment shall be:

1. Scheduled with Owner prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Owner at least 48 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Adjust mechanisms and moving parts of equipment for free mechanical movement.

E. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents and approved Submittals.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform Engineer of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.

3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required because of extensive damage, as determined by Engineer, refinish entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
    a. Submit Voltage Field Test Report within 5 days of test.
4. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 6 and larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections For:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables For:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables For:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors and 500-volt dc megohmmeter for 300-volt insulated conductors.
   b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   c. Evaluate ohmic values by comparison with conductors of same length and type.
   d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.04 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristics of adjustable trip breakers shall be within manufacturer’s published time-current characteristic tolerance band, including adjustment factors.
   f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
   g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.05 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer's instructions.
7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.

3.06 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
   a. Tight cover gasket and proper seal.
   b. Unbroken cover glass.
   c. Condition of spiral spring and contacts.
   d. Disc clearance.
   e. Condition of case shorting contacts if present.
2. Mechanically check each relay for:
   a. Freedom of movement.
   b. Proper travel and alignment.
3. Verify each relay:
   a. Complies with Contract Documents, approved Submittal, and application.
   b. Is set in accordance with recommended settings from Coordination Study.

B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.
2. Test on nominal recommended setting for:
   a. Pickup parameters on each operating element.
   b. Timing at three points on time-current curve.
   c. Pickup target and seal-in units.
   d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer’s instruction manual.
3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.

3.07 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.

c. Proper connections.
d. Adequate clearances between primary and secondary circuit wiring.

2. Verify Mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
2. Potential Transformer Tests:
   a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.08 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.09 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, adjustable frequency drive panel, panelboard, switchboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear assemblies for proper termination and tightness.

3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Computer-Based Grounding Multimeter:
   a. In accordance with IEEE 81, Section 8.2.2.7 for measurement of each building's or structure's main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 1 ohm(s).
2. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.2.4 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.10 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.
   c. Neutral ground conductor is solidly grounded.
2. Verify control power has adequate capacity for system.
3. Manually operate monitor panels for:
   a. Trip test.
   b. No trip test.
   c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

END OF SECTION

SECTION 26 29 23
VARIABLE-FREQUENCY MOTOR CONTROLLER

PART 1 GENERAL

1.01 SUMMARY

A. The Variable Frequency Drive (VFD) system shall contain all components required to meet the performance, protection, safety and certification criteria of this specification. All existing control functions shall be retained VFD must contain sufficient power lead connection points sized for existing line and load conductors and buss bars. VFD shall further contain enough input and output (I/O) control points to terminate all existing, and new discrete and analog functions as well as provisions for 20 percent spare capacity.

B. All work in this section shall be under the oversight of Rockwell Automation Field Service Engineer.

1.02 RELATED SECTIONS

A. Section 26 05 01, Electrical.

B. Section 26 08 00, Commissioning of Electrical Systems.

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer’s Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

B. National Fire Protection Association - NFPA 70 - US National Electrical Code.

C. National Electrical Manufacturers Association - NEMA 250 - Enclosures for Electrical Equipment.

D. Underwriters Laboratory Inc. – UL 508.

E. Canadian Standards Association International – CAN/CSA-C22.2 No. 14-05.

F. International Electrical Code - IEC 146.

G. Institute of Electrical and Electronics Engineers, Inc. - IEEE 519 - IEEE Standard Practices and Requirements for Harmonic Control in Electrical Power Systems.

1.04 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source inverter.
4. EMU: Energy monitoring unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.
9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.
13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.
14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor logic.

1.05 SYSTEM DESCRIPTION

A. Performance Requirements:

1. This Specification covers supply, testing and commissioning of AFD. As a minimum drive shall be 18-pulse. Manufacturers may choose to provide higher pulse convertors or harmonic filters as required to meet the current and voltage distortion limits.

2. Composite drive/motor efficiency (CE) is defined as ratio of motor shaft kW to drive input kW. AFD system minimum requirements:
   a. At 60-Hz drive output and 100 percent load, CE equals 92 percent.
   b. At 50-Hz drive output and 60 percent load CE equals 89 percent.
   c. At 40-Hz drive output and 30 percent load CE equals 84 percent.
   d. At 30-Hz drive output and 12.5 percent load CE equals 77 percent.
3. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.
4. Basis for Harmonic Computations: Compute individual and total current and voltage distortion at the incoming line terminals of the drive. Normal source maximum short-circuit current shall match owner branch circuit protection and normal source maximum demand load current of 710A for current and voltage distortion computations, furnish harmonic filters, line reactors, isolation transformers, or higher pulse converter arrangements required to meet current/voltage distortion and line notching limits.
5. Normal Source Current Harmonic Distortion:
   a. Compute normal source individual and total current harmonic distortion at the input terminals to the drive, in accordance with IEEE 519.
   b. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current I_L shall not exceed values specified in Table 1 below:

Table 1

Individual Harmonic Order (Odd Harmonics)	**Harmonic Current Distortion Percent of Max. Demand Load Current IL**
h <11	1.0
11 h <17	0.50
17 h <23	0.375 (2.598 percent for h=17.19)
23 h <35	0.15
35 <h	0.075 (0.520 percent for h=35.37)
Total Demand Distortion (TDD)	5

c. Limits specified in Table 1 are for drives utilizing 18-pulse rectifiers.
d. For harmonic computations, assume both drives running at full load.

6. Standby Source Current Harmonic Distortion:
   a. Compute standby source individual and total current harmonic distortion at the input terminals to the drive, in accordance with IEEE 519. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current IL shall not exceed values specified in Table 2 below.

Table 2

Individual Harmonic Order (Odd Harmonics)	**Harmonic Current Distortion Percent of Max. Demand Load Current IL**
h <11	1.0
11 <h <17	0.5
17 <h <23	0.375 (2.598 percent for h=17.19)
23 <h <35	0.15
35 <h	0.075 (0.520 percent for h=35.37)
Total Demand Distortion (TDD)	5

   b. Limits specified in Table 2 are for drives utilizing 18-pulse rectifiers.
   c. For harmonic computations, assume both drives running at full load.

7. Normal Source Voltage Harmonic Distortion: Compute normal source voltage harmonic distortion at the input terminals of the drive. THD shall not exceed 5 percent, and individual voltage harmonic distortion shall not exceed 3 percent.
8. Standby Source Voltage Harmonic Distortion: Compute standby source voltage harmonic distortion at the input terminals of the 6SWBD, 1A,1B,1C. THD shall not exceed 5 percent, and individual voltage harmonic distortion shall not exceed 3 percent.
9. Furnish isolating transformers or series reactors, harmonic filters, or other devices necessary for proper system operation. Furnish necessary devices and circuits to prevent operation of one drive from adversely affecting operation of other drives supplied from same transformer or same bus.

10. When isolation transformers are used, design to meet K-factor requirements of drive(s) connected.
11. Furnish confirmation statement from the Utility (Keys Energy) that the Total Harmonic Distortion is within their requirements.

B. Design Requirements:

1. Design and provide drive system consisting of adjustable frequency controller, drive motor, auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish AFDs rated on basis of actual motor full load nameplate current rating times 1.15 service factor. (AFD rating = 1.15* full load nameplate motor currents.)
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using pulse-width-modulation (PWM) technique to produce adjustable frequency output.
5. System rated for continuous industrial duty and suitable for use with Standard NEMA MG1, Design B motors
6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for drive system.
7. Incoming Line Reactor: Design to minimize harmonic distortion on incoming power feeder.
8. Output Reactor or dV/Dt Filter: Design to minimize voltage spikes at motor where long motor leads are indicated.
9. The equipment furnished, including filters, transformers, reactors, contactors, and AFD controller must fit within the enclosure dimensions on the Drawings.

1.06 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.

2. Individual and total harmonic content (voltage and current) reflected in system normal source supply at driven equipment actual load at 70 percent and 100 percent of rated speed at incoming line terminals of power panel PP-1 for the load conditions specified. Normal source system short-circuit available at drive shall be calculated from data furnished by the Utility. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.
3. Individual and total current and voltage harmonic content reflected in standby power source, at locations specified, at driven equipment actual load at 70 percent and 100 percent of rated speed determined by using actual size and subtransient reactance of standby system obtained from standby source manufacturer. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.
4. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer's certification motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.
5. Data on shelf life of "dc link" capacitor.
6. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
7. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
8. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.
9. Maximum heat dissipation from enclosure.
10. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
11. Complete system operating description.
12. Complete system schematic (elementary) wiring diagrams.
13. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.
14. One-line diagram of system, including component ratings.
15. Description of diagnostic features being provided.
16. Descriptive literature for control devices such as relays and timers.
17. Itemized bill-of-materials listing system components.

18. Specific description of provisions, such as filtering and harmonic suppression, being made to ensure proper system operation when system is supplied from standby engine generator specified in these Documents.
19. Description of MPR being furnished or how these functions are accomplished within drive system.
20. Elevation Drawings: Include dimensional information and conduit routing locations.
21. Unit Descriptions: Include amperage ratings, enclosure ratings, fault ratings, nameplate information, etc. as required for approval.
22. Wiring Diagrams:
    a. Power Diagram: Include amperage ratings, circuit breaker frame sizes, circuit breaker continuous amp ratings, etc. as required for approval.
    b. Control Diagram: Include disconnect devices, pilot devices, etc.
23. Major components list.

B. Product Data Sheets:

1. VFD and Operator Interface publications.
2. Data sheets and publications on all major components including but not limited to the following:
    a. Contactors.
    b. Circuit breaker and fuse (power and control).
    c. Control power transformers.
    d. Pilot devices.
    e. Relays/Timers.

C. Test procedures shall be per the manufacturer’s standards.

1.07 CLOSEOUT SUBMITTALS (OPERATION AND MAINTENANCE MANUALS)

A. Shop Drawings – Final as shipped.

1. Elevation Drawings: Include dimensional information and conduit routing locations.
2. Unit Descriptions: Include amperage ratings, enclosure ratings, fault ratings, nameplate information, etc. as required for approval.
3. Wiring Diagrams:
    a. Power Diagram: Include amperage ratings, circuit breaker frame sizes, circuit breaker continuous amp ratings, etc. as required for approval.
    b. Control Diagram: Include disconnect devices, pilot devices, etc.
4. Major components list.

B. Product Data Sheets:

1. VFD and Operator Interface publications.
2. Data sheets and publications on all major components including but not limited to the following:
   a. Contactors.
   b. Circuit breaker and fuse (power and control).
   c. Control power transformers.
   d. Pilot devices.
   e. Relays/Timers.

C. Test procedures shall be per the manufacturer's standards.

D. Operation and Maintenance Data:

1. Service and Contact information.
2. VFD and Operator Interface User Manuals.
3. Troubleshooting / Service Manuals.

1.08 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturers:
   a. The VFD and all associated optional equipment shall be UL listed or recognized.
   b. The VFD shall contain a UL label attached on the inside of the enclosure cabinet.
2. Suppliers:
   a. All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system and must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.
   b. The VFD shall be factory pre-wired, assembled and tested as a complete package.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer is responsible for the shipping of equipment.

B. Owner shall store the equipment in a clean and dry space at an ambient temperature range of -25 °C to 55 °C (-13 °F to 130 °F).

1.10 WARRANTY

A. The manufacturer shall provide their standard parts warranty for 18 months from the date of shipment or 12 months from the date of being energized, whichever occurs first.

B. This warranty applies to variable frequency drive systems.

1.11 EXTRA MATERIALS

A. Furnish a spare Variable Frequency Drive Power Flex 755.

B. Furnish for each drive unit.

1. Complete set of components likely to fail in normal service.
2. Printed circuit boards.
3. One complete power bridge and one spare printed circuit card for each modular, plug-in type card in controller.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Allen-Bradley – PowerFlex 755 VFD (No substitutions).

2.02 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 to 104 degrees F.

B. Storage Temperature: Minus 40 to 158 degrees F.

C. Humidity: 0 to 95 percent relative (noncondensing).

D. Altitude: 0 foot to 3,300 feet.

E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.03 VARIABLE FREQUENCY DRIVE UNIT

A. Features:

1. Certifications:
   a. Listed to UL508C and CAN/CSA-C22.2 No. 14-05.
   b. In conformity with EMC Directive (2004/108/EC) and Low Voltage Directive (2006/95/EC). Standards applied; EN 61800-3:2004, EN 61800-5-1:2007

c. TÜV Rheinland - standards applied: EN 61800-3:2004, EN 61800-5-1:2007, EN ISO 13849-1:2008, EN ISO 13849-2:2003, EN 61800-5-2:2007, EN 61508 PARTS 1-7:2000, EN 62061:2005, and EN 60204-1:2006.
d. Australian Communications and Media Authority. In conformity with Radiocommunications Act: 1992, Radiocommunications Standard: 2008, and Radiocommunications Labeling Notice: 2008. Standards applied: EN 61800-3:2004.
e. Electric Power Research Institute. Certified compliant with standards SEMI F47 and IEC 61000-4-34.
f. Russian GOST-R Certificate No. POCC US.ME92.H00040
g. Compliant with the European “Restriction of Hazardous Substances” Directive.

2. Hardware:
   a. Utilize diode bridge or SCR bridge on the input rectifier.
   b. Utilize dc bus inductor on all six-pulse VFDs only.
   c. Utilize switching logic power supply operating from the dc bus.
   d. Incorporate phase to phase and phase to ground MOV protection on the ac input line.
   e. Microprocessor based inverter logic shall be isolated from power circuits.
   f. Utilize latest generation IGBT inverter section.
   g. Battery receptacle for Lithium battery power to the Real Time Clock.
   h. Additional DPI port for handheld and remote HIM options.
   i. Dedicated Digital Input for hardware enable.
   j. Conformal coated printed circuit boards.
   k. Optional onboard 24V dc Auxiliary Control Power Supply.
3. Control Logic:
   a. Ability to operate with motor disconnected.
   b. Provide a controlled shut down, when properly protected, 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.
   c. Provide multiple programmable stop modes including Ramp, Coast, DC-Brake, Ramp-to-Hold, Fast Braking, and Current Limit Stop.
   d. Provide multiple acceleration and deceleration rates.
   e. Adjustable output frequency up to 650Hz.
4. DeviceLogix Control:
   a. Ability to control outputs and manage status information locally within the VFD.
   b. Ability to function stand-alone or complimentary to supervisory control.
   c. Ability to speed reaction time by processing in the VFD.

d. Ability to provide scaling, selector switches, or other data manipulations not already built into the VFD.
e. Ability to read inputs/write outputs and exclusively control the VFD.
f. Ability to provide an option for decision making if communication is lost with main controller.
g. Ability to control other VFDs via a peer-to-peer EtherNet/IP network.
h. Ability to write programs off-line.

5. Motor Control Modes:
   a. Selectable Sensorless Vector, Flux Vector, V/Hz, and Adjustable Voltage Control modes selectable through programming.
   b. The drive shall be supplied with a Start-up and Auto-tune mode.
   c. The V/Hz mode shall be programmable for fan curve or full custom patterns.
   d. Capable of Open Loop V/Hz.
6. Current Limit:
   a. Programmable current limit from 20 to 160 percent of rated output current.
   b. Current limit shall be active for all drive states: accelerating, constant speed and decelerating.
   c. The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit.
7. Acceleration / Deceleration:
   a. Accel/Decel settings shall provide separate adjustments to allow either setting to be adjusted from 0 to 3600 seconds.
   b. A second set of remotely selectable accel/decel settings shall be accessible through digital inputs.
8. Speed Profiles:
   a. Programming capability shall allow the user to produce speed profiles with linear acceleration/deceleration or "S Curve" profiles that provide changing accel/decel rates.
   b. S Curve profiles shall be adjustable.
9. Adjustments:
   a. A digital interface can be used for all set-up, operation and adjustment settings.
   b. All adjustments shall be stored in nonvolatile memory (EEPROM).
   c. No potentiometer adjustments shall be required.
   d. EEPROM memory for factory default values shall be provided.
   e. Software must be available for trending and diagnostics, as well as online and offline programming functionality.

10. Process PID Control:
    a. The drive shall incorporate an internal process PI regulator with proportional and integral gain adjustments as well as error inversion and output clamping functions.
    b. The feedback shall be configurable for normal or square root functions. If the feedback indicates that the process is moving away from the set-point, the regulator shall adjust the drive output until the feedback equals the reference.
    c. 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.
    d. Protection shall be provided for a loss of feedback or reference signal.
11. Skip Frequencies:
    a. Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance shall be provided.
    b. The set points shall have a bandwidth adjustable from Maximum Reverse Speed to Maximum Forward Speed.
12. Fault Reset / Run:
    a. The drive shall provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart.
    b. The automatic mode shall not be applicable to a ground fault, shorted output faults and other internal microprocessor faults.
    c. The time between restarts shall be adjustable from 0.5 seconds to 30 seconds.
13. Run on Power Up: A user programmable restart function shall be provided to allow restart of the equipment after restoration of power after long duration power outages. Restart time dependent on presence of incoming signal.
14. Fault Memory:
    a. The last 32 fault codes shall be stored and time stamped in a fault buffer.
    b. Information about the drive’s condition at the time of the last fault such as operating frequency, output current, dc bus voltage and twenty-seven other status conditions shall be stored.
    c. A power-up marker shall be provided at each power-up time to aid in analyzing fault data.
    d. The last 32 alarm codes shall be stored and time stamped for additional troubleshooting reference.

15. Overload Protection:
    a. The drive shall provide internal class 10 adjustable overload protection.
    b. Overload protection shall be speed sensitive and adjustable.
    c. A viewable parameter shall store the overload usage.
16. Auto Economizer:
    a. An auto economizer feature shall be available to 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.
    b. When the load increases, the drive shall automatically return to normal operation.
17. Terminal Blocks:
    a. Separate terminal blocks shall be provided for control and power wiring.
    b. I/O terminal blocks shall be removable with wiring in place.
18. Flying Start: 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. This feature is disabled by default.
19. Inputs and Outputs:
    a. The Input / Output option modules shall consist of both analog and digital I/O.
    b. No jumpers or switches shall be required to configure digital inputs and outputs.
    c. All digital input and output functions shall be fully programmable.
    d. The control terminal blocks shall be rated for 115V ac.
    e. Inputs shall be optically isolated from the drive control logic.
    f. The control interface card shall provide input terminals for access to fixed drive functions that include start, stop, external fault, speed, and enable.
    g. The VFD shall be capable of supporting up to 7 analog inputs, 7 analog outputs, 21 digital inputs, 7 relay outputs, 7 transistor outputs, and 3 positive temperature coefficient (PTC) inputs.
    h. The Input / Output option modules shall have the following features:
    i. Analog Inputs:
        1) Quantity two (2) differentially isolated, ±10V (bi-polar), 88k ohm input impedance, 11 bit plus sign.
        2) 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.

j. Analog Outputs: Furnish three 4 to 20 mA dc signals for actual frequency, actual load, motor current.

k. Digital Inputs:
   1) Quantity of six (6) digital inputs rated 24V DC/115V AC.
   2) All inputs shall be individually programmable for multiple functions including: Start, Run, Stop, Auxiliary Fault, Speed Select, Jog and Process PI functions.

l. Digital Outputs:
   1) At least one (1) relay output (N.O. or N.C.).
   2) For 240V ac or 24V dc, N.O. contact output ratings shall be 2 amp max., general purpose (inductive)/resistive. N.C. contact output ratings shall be 2 amp max., resistive only.
   3) Relays shall be programmable to multiple conditions including: Fault, Alarm, At Speed, Drive Ready and PI Excess Error.
   4) Timers shall be available for each output to control the amount of time, after the occurring event, that the output relay actually changes state.
   5) At least 1 transistor output.
   6) For 24V dc, transistor output rating shall be 1 amp max, Resistive.

20. Reference Signals:
    a. The drive shall be capable of using the following input reference signals:
       1) Analog inputs.
       2) Preset speeds.
       3) Remote potentiometer.
       4) Digital MOP.
       5) Human Interface Module.
       6) Communication modules.
21. Loss of Reference:
    a. The drive shall be capable of sensing reference loss conditions.
    b. In the event of loss of the reference signal, the drive shall be user programmable to the following:
       1) Fault the drive and coast to stop.
       2) Issue a minor fault - allows the drive to continue running while some types of faults are present.
       3) Alarm and maintain last reference.

4) When using a communications network to control the drive, the communications adapter shall have these configurable responses to network disruptions and controller idle (fault or program) conditions:
   a) Fault.
   b) Stop.
   c) Zero Data.
   d) Hold Last State.
   e) Send Fault Configuration.

22. Metering:
    a. At a minimum, the following parameters shall be accessible through the Human Interface Module, if installed:
       1) Output Current in Amps.
       2) Output Voltage in Volts.
       3) Output Power in kW.
       4) Elapsed MWh.
       5) DC Bus Voltage.
       6) Frequency.
       7) Heatsink Temperature.
       8) Last eight (32) faults.
       9) Elapsed Run Time.
       10) IGBT Temperature.
23. Faults:
    a. At a minimum, the following faults shall be accessible through the Human Interface Module:
       1) Power Loss.
       2) Undervoltage.
       3) Overvoltage.
       4) Motor Overload.
       5) Heat Sink Over-temperature.
       6) Maximum Retries.
       7) Phase to Phase and Phase to Ground Faults.
24. Predictive Diagnostics:
    a. At a minimum, the following predictive diagnostic features shall be provided:
       1) Relay Output Life Cycles based on load type and amps.
       2) Hours of Fan Life based on load and ambient temperature.
       3) Motor Bearing life based on expected hours of use.
       4) Motor Lubrication schedule based on hours of use.
       5) Machine Bearing life based on expected hours of use.
25. Real-Time Clock:
    a. Shall be capable of providing time stamped events.
    b. Shall have the ability to be set locally or via a remote controller.
    c. Shall provide the ability to be programmable for month, day, year and local time zones in HH:MM: SS.

B. Conformal Coating Requirements: All electronic circuit boards and components shall have a UL recognized conformal coating that meets the Military's MIL-I-46058C specification The coating shall provide for moisture and environmental protection All electronic circuit boards shall be impervious to moisture, fungus, dust, and corrosive atmospheres such as Hydrogen Sulfide, salt, and other environmental contaminants Terminal pins and connectors shall be masked off such that the coating shall not impede operation The coating shall be applied to both sides and all edges of the electronic circuit boards

C. Enclosure:

1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator's controls.
3. Wire drive from below and above for power and control wiring.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5. Wiring:
    a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
    b. Label each terminal for permanent identification of leads.
    c. Identify each wire at each end with imprinted Mylar adhesive-back wire markers.
    d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
    e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
    f. Wire connections internal to panels by crimp-on terminal types.
    g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
    h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.
6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

2.04 VFD PACKAGED SYSTEM

A. Features:

1. Ratings:
   a. Voltage.
      1) Capable of accepting nominal plant power of 480V ac at 60Hz.
      2) The supply input voltage tolerance shall be plus or minus 10 percent of nominal line voltage.
   b. Displacement Power Factor: Eighteen-pulse VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. X Distortion P.F.) of 0.98 or better at rated load and nominal line voltage, over the entire speed range.
   c. Efficiency:
      1) A minimum of 96.5 percent (+/- 1%) at 100 percent speed and 100 percent motor load at nominal line voltage.
      2) Control power supplies, control circuits, and cooling fans shall be included in all loss calculations.
      3) Operating ambient temperature range without derating: 0 °C to 40 °C (32 °F to 104 °F).
      4) Operating relative humidity range shall be 5 to 95 percent non-condensing.
      5) Operating elevation shall be up to 1000 Meters (3,300 ft) without derating.
2. Sizing:
   a. Systems rated at Normal Duty loads shall provide 110 percent overload capability for up to one minute and 150 percent for up to 3 seconds.
   b. Systems rated at Heavy Duty loads shall provide 150 percent overload capability for up to one minute and 180 percent for up to 3 seconds.
3. Auto Reset/Run: For faults other than those caused by a loss of power or any other non-critical fault, the drive system shall provide a means to automatically clear the fault and resume operation.
4. Ride-Through:
   a. The VFD system shall attempt to ride through power dips up to 20 percent of nominal. The duration of ride-through shall be inversely proportional to load. For outages greater than 20 percent, the drive shall stop the motor and issue a power loss alarm signal to a process controller, which may be forwarded to an external alarm signaling device.

5. Run on Power Up: The VFD system shall provide circuitry to allow for remote restart of equipment after a power outage. Unless indicated in the contact drawings, faults due to power outages shall be remotely resettable. The VFD system shall indicate a loss of power to a process controller, which may be forwarded to an external alarm signaling device. Upon indication of power restoration the process controller will attempt to clear any faults and issue a run command, if desired.
6. Communications:
    a. VFD shall be capable of communicating on multiple networks.
    b. VFD shall be capable of supporting the following network options:
        1) EtherNet/IP.
7. Enclosure Door Mounted Human Interface Module (HIM):
    a. VFD shall provide a HIM with integral LCD display, operating keys and programming keys.
    b. An enclosure door-mounted HIM, rated NEMA/UL Type 1.
    c. An optional VFD-mounted HIM, rated NEMA/UL Type 1, may be provided and shall be capable of connecting via a separate cable for use as a handheld terminal.
    d. The HIM shall have the following features:
        1) A seven (7) line by twenty-one (21) character backlit LCD display with graphics capability.
        2) Shall indicate drive operating conditions, adjustments and fault indications.
        3) Shall be configured to display in the following three distinct zones:
    e. The top zone shall display the status of direction, drive condition, fault / alarm conditions and Auto / Manual mode.
    f. The middle zone shall display drive output frequency.
    g. The bottom zone shall be configurable as a display for either programming menus / information or as a two-line user display for two additional values utilizing scaled units.
        1) Shall provide digital speed control.
        2) The keypad shall include programming keys, drive operating keys (Start, Stop, Direction, Jog and Speed Control), and numeric keys for direct entry.

B. Control Power Transformer:

1. Provide a control power transformer mounted and wired inside of the drive system enclosure.
2. The transformer shall be rated for the VFD power requirements.

3. Provide VFD with a single 18-pulse converter.
   a. The converter bridge shall be a parallel 18-pulse diode bridge assembly with DC snubber (board or assembly). Diodes shall be rated (devices) with a blocking voltage minimum of 1600V.
   b. The converter shall incorporate 1000V three phase block style MOV protection rated 85 °C. The drive system shall incorporate an 18-pulse phase shifting auto transformer with line reactor as an assembly. The 18-pulse assembly shall be wired into the VFD System enclosure where possible. The auto transformer shall have the following minimum features:
      1) Rated for input rectifier duty and matched to VFD overload capability.
      2) Copper or aluminum wound.
      3) Class 180 or 220 insulation.
      4) Power factor of 0.98 or better at rated load and nominal line voltage.
      5) Open core construction.
      6) One normally closed thermoswitch contact in each coil wired into a VFD control circuit.
   c. The drive system shall be compliant with IEEE519-1992 standards at the input VFD terminals based upon the input power phase imbalance within 0.5 percent of nominal line voltage and under full VFD output current ratings.

C. Output Filtering: 3 percent output line reactor.

2.05 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
   a. Interior: One coat white enamel.
   b. Exterior: One coat manufacturer’s standard gray enamel or EIA 359-A-1, No. 61.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all control panels furnished.

C. Record test data for report.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install by Contractor in accordance with manufacturer's printed instructions.

3.02 FIELD QUALITY CONTROL

A. Functional Test (by manufacturer):

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
   a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
   b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test (by manufacturer):

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 24-hour period without malfunction.
4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.
5. With load connected to normal utility source, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion, up to and including 35th harmonic, at the input terminals of pump control panel, under following load conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
   b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
   c. THD at the input terminals of pump control panel under following conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.

6. With load connected to standby power source, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion, up to and including 35th harmonic, at the input terminals of pump control panel CP-1 with drives running at:
      1) Full load.
      2) Half load.
   b. THD at location at the input terminals of pump control panel with drives running at:
      1) Full load.
      2) Half load.
7. Record test data for report.

C. Test Equipment (provided by manufacturer):

1. Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

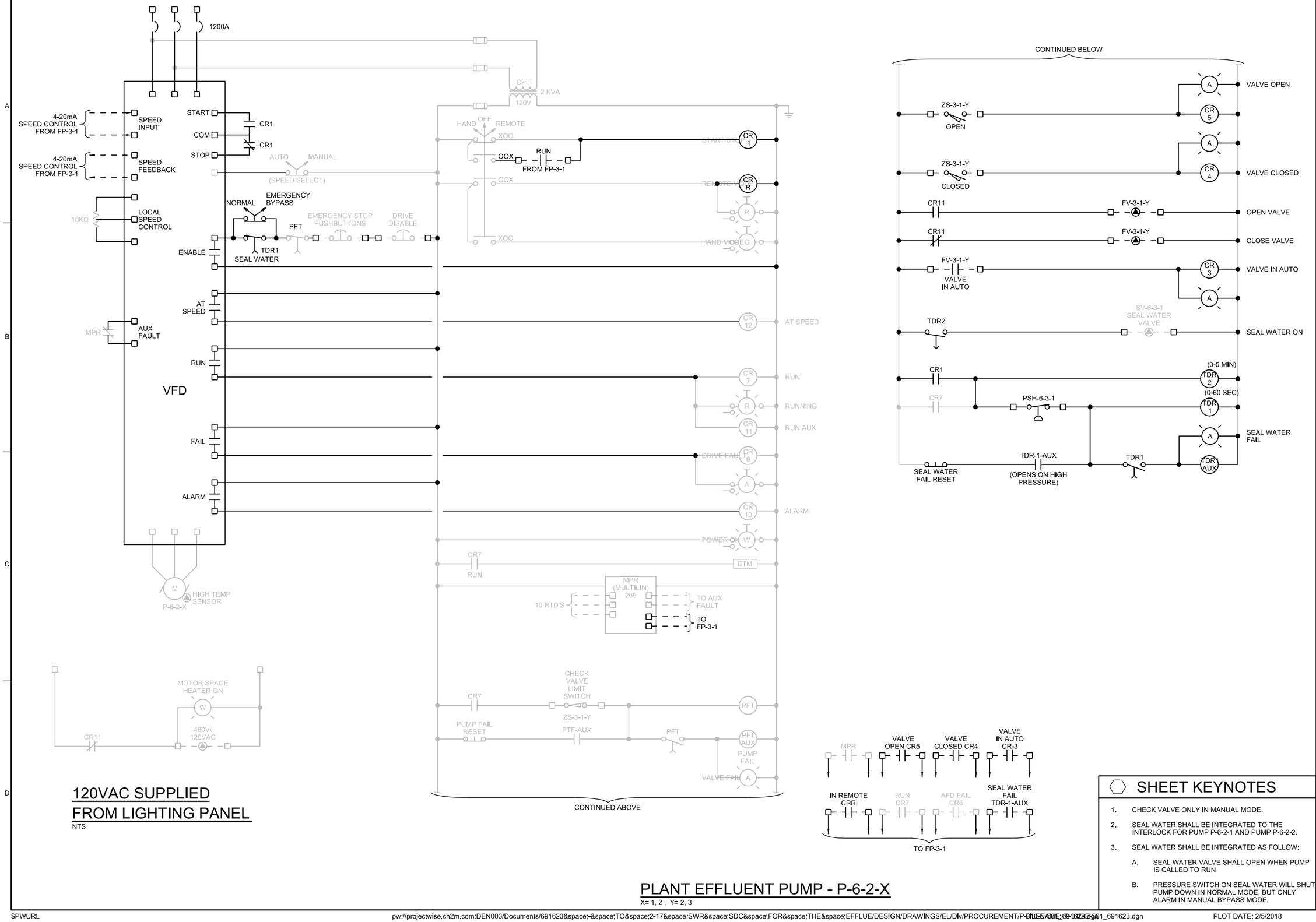
3.03 MANUFACTURERS' SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for prestartup classroom or Site training.
4. 1 person-day for facility startup.
5. 1 person-day for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

END OF SECTION

DRAWINGS



PLANT EFFLUENT PUMP - P-6-2-X

X= 1, 2 , Y= 2, 3

SHEET KEYNOTES

1. CHECK VALVE ONLY IN MANUAL MODE.
2. SEAL WATER SHALL BE INTEGRATED TO THE INTERLOCK FOR PUMP P-6-2-1 AND PUMP P-6-2-2.
3. SEAL WATER SHALL BE INTEGRATED AS FOLLOW:
   - A. SEAL WATER VALVE SHALL OPEN WHEN PUMP IS CALLED TO RUN
   - B. PRESSURE SWITCH ON SEAL WATER WILL SHUT PUMP DOWN IN NORMAL MODE, BUT ONLY ALARM IN MANUAL BYPASS MODE.

NO.	DATE	DSGN	DR	CHK	BY
		E CARRASCO	A PASTRANA	D NICHOLSON	APVD
			REVISION		D NICHOLSON

3011 S.W. WILLISTON ROAD
GAINESVILLE, FLORIDA 32608
EB0000072 AAC001992
DAVID C. NICHOLSON PE 60201

SWR SDC
FOR THE EFFLUENT
CITY OF KEY WEST
KEY WEST, FLORIDA

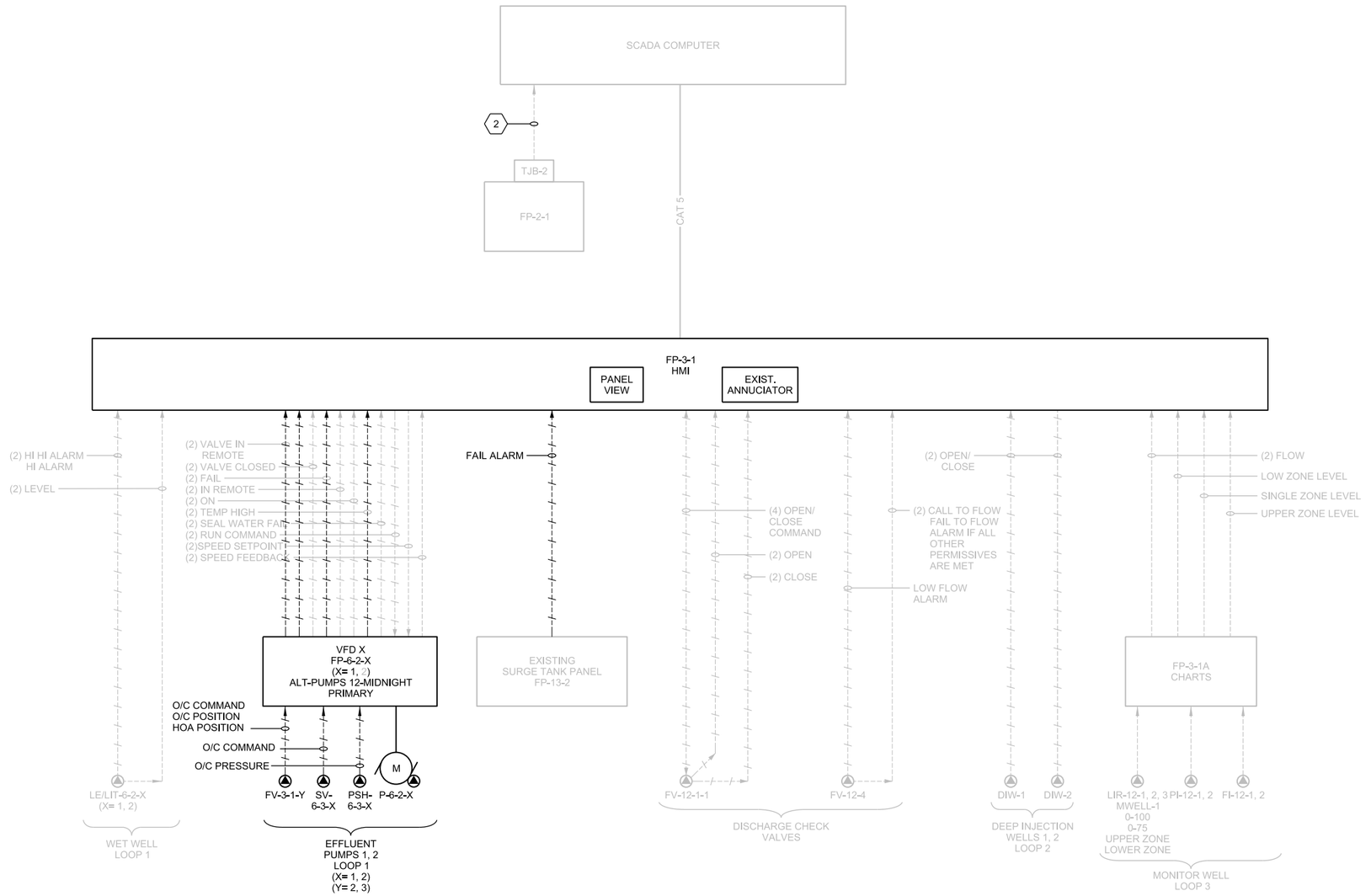
ELECTRICAL
CONTROL DIAGRAMS

BID DOCUMENTS

NTS	
VERIFY SCALE	
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"	
DATE	FEBRUARY 2018
PROJ	691623
DWG	010-E-501
SHEET	of

SHEET KEYNOTES

1. PUMPS P-6-2-1 & P-6-2-2 ARE EXISTING. FP-6-3 IS FUTURE. PROVIDE ALL LOGIC IN TRIPLICATE WITH FUTURE FP-6-2-3 OUT OF SEQUENCE BUT READY TO ENABLE.
2. NO INTERLOCK IN MANUAL.



NO.	DATE	DSGN	DR	CHK	APVD	BY	REVISION
		E CARRASCO	A PASTRANA	D NICHOLSON	APVD	D NICHOLSON	

3011 S.W. WILLISTON ROAD
GAINESVILLE, FLORIDA 32608
EB0000072 · AAC001992
DAVID C. NICHOLSON, PE 60201

SWR SDC
FOR THE EFFLUENT
CITY OF KEY WEST
KEY WEST, FLORIDA

ELECTRICAL
RISER DIAGRAM

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	FEBRUARY 2018
PROJ	691623
DWG	010-E-502
SHEET	of

BID DOCUMENTS