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**MAIN WASTEWATER TREATMENT PLANT
OXYGEN PLANT REHABILITATION
(SD-428)**

♦

CONTRACT DOCUMENTS

VOLUME II-B OF IV

TECHNICAL
SPECIFICATIONS
(DIVISIONS 27-40)

JUNE 2024

SPECIFICATION SD-428



EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

Bids will be opened at 1:30 pm, Wednesday, September 11, 2024 in the Board Room,
Second Floor of the District's Administration Building, 375 11th Street, Oakland, California

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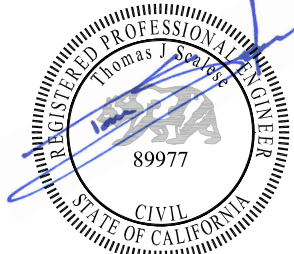
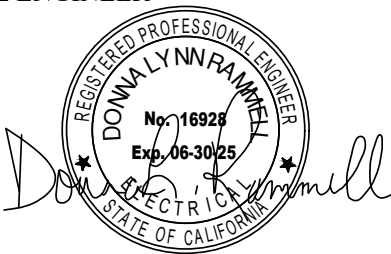
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

SECTION 00 01 07

PROFESSIONAL SEALS AND CERTIFICATIONS

GENERAL

The following design professionals have signed and sealed the original specifications for this project in accordance with the List of Specification Sections.

CIVIL ENGINEER  Dave Richardson (D. Richardson) Woodard & Curran California License: 37097	CIVIL ENGINEER  Thomas Scalese (T. Scalese) Woodard & Curran California License: 89977
ELECTRICAL ENGINEER  Donna Rammell (D. Rammell) Woodard & Curran California License: E16928	CONTROLS ENGINEER  Kyle Tracy (K. Tracy) Woodard & Curran California License: C7556
CIVIL ENGINEER  John Law (J. Law) East Bay Municipal Utility District California License: 95046	FIRE PROTECTION ENGINEER  Christian Ng (C. Ng) Fire & Risk Alliance, California License: 2132

SPECIFICATION SECTION AND TITLE	DESIGN PROFESSIONAL SEAL BY
DIVISION 00 – PROCURMENT AND CONTRACTING DOCUMENTS - ALL SECTIONS	D. Richardson
DIVISION 01 – GENERAL REQUIREMENTS – ALL SECTIONS	D. Richardson
DIVISION 02 - EXISTING CONDITIONS – ALL SECTIONS	D. Richardson
DIVISION 03 – CONCRETE – ALL SECTIONS	T. Scalese
DIVISION 05 – METALS – ALL SECTIONS	T. Scalese
DIVISION 07 – THERMAL AND MOISTURE INSULATION – ALL SECTIONS	D. Richardson
DIVISION 09 – FINISHES – ALL SECTIONS	J. Law
DIVISION 21 – FIRE SUPPRESSION – ALL SECTIONS	C. Ng
DIVISION 22 – PLUMBING	
22 05 00 Air Compressor Motors	D. Richardson
22 05 29 Hangers and Supports for Plumbing Piping and Equipment, 22 05 53.05 Pipe Identification, 22 11 16 Domestic Water Piping, 22 11 19 Domestic Water Piping Specialties	J. Law
DIVISION 26 – ELECTRICAL – ALL SECTIONS	D. Rammell
DIVISION 27 – COMMUNICATIONS – ALL SECTIONS	K. Tracy
DIVISION 28 – ELECTRONIC SAFETY AND SECURITY – ALL SECTIONS	C. Ng
DIVISION 40 – PROCESS INTEGRATION – ALL SECTIONS	K. Tracy

END OF SECTION

SPECIFICATION SD-428

MAIN WASTEWATER TREATMENT PLANT OXYGEN PLANT REHABILITATION

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END OF SECTION

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COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. A single Telecommunications System Supplier (TSS) shall furnish all materials, equipment, labor and services required to achieve a fully integrated and operational communications system which shall be as indicated on the drawings and as specified.
2. The TSS shall supervise and coordinate the installation of the communications system with other related equipment and materials furnished by other suppliers under other sections of this specification.
3. The TSS shall ensure that all equipment of the system is furnished, installed and connected in accordance with the manufacturer's instructions.
4. The requirements of Division 27 in their entirety apply to all communications work and equipment furnished on this project whether furnished or specified under this or other divisions of these specifications.
5. Provide grounding and bonding for communications systems as specified in individual equipment specifications and Section 26 05 26.

B. Under this contract, the terms "communications" and "telecommunications" shall be interchangeable.

C. Related sections:

1. Section 01 33 00 - Submittal Procedures.
2. Section 26 05 00 – Common Work Results for Electrical.
3. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

1.2 QUALITY ASSURANCE

- ###### A.
- The TSS and each subcontractor employed by the TSS to perform communications work under this Contract shall possess a current State of California C-7 Low Voltage Systems Contractor License, and shall be certified by at least one major telecommunications equipment manufacturer such as Ortronics, Lucent Technologies, or Avaya for the installation, splicing, termination, and

testing of copper cables, fiber optic cables, and telecommunications equipment for outside and inside plant wiring.

- B. The TSS and each subcontractor employed by the TSS shall have a minimum of 5 years recent experience in satisfactory completion of jobs of similar size and scope.
- C. The TSS shall compile and submit detailed information relating to licensing, certification, experience, and similar work completed by all telecommunications system subcontractors, including references sufficient to enable the Engineer to evaluate and approve of the TSS and subcontractors responsibility, experience, and capacity to perform the work.
- D. The TSS shall provide complete day-to-day supervision of the construction and testing of the communications system and coordination with other related construction and testing efforts. The TSS shall be available in person, telephone, or pager at all times throughout the duration of this Contract.
- E. Contractor performing fiber installation and testing of the fiber optic cable and associated equipment shall be trained and manufacturer certified within 12 months from the date the work will begin. Contractor shall submit certifications of the individuals performing the test to District for approval prior to performing the work.

1.3 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00.
- B. Furnish submittals for approval as outlined below:
 - 1. Detailed information relating to licensing, certification, experience, and similar work completed by the TSS and all telecommunications system subcontractors, including references.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Unless otherwise indicated, provide all first-quality, new materials and equipment, free from any defects, in first-class condition, and suitable for the space provided. Provide materials and equipment listed by UL wherever standards have been established by that agency.
- B. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer.

2.2 STANDARD PRODUCTS

- A. Unless otherwise indicated, provide materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturers' latest standard design that conforms to these specifications.

2.3 SEISMIC REQUIREMENTS

- A. General: Install all products to be furnished under this contract in conformance with the seismic requirements of Section 01 43 11 Seismic Requirements.
- B. Refer to the detailed technical specifications within Division 27 for specific equipment seismic requirements.

2.4 EQUIPMENT FINISH

- A. Provide materials and equipment with manufacturers' standard finish system. Provide ANSI 61, light grey color or RAL 7035 (light gray) with Electrostatic Powder for all equipment unless otherwise specified in the individual equipment sections. Provide two quarts of touchup paint.

2.5 ENVIRONMENTAL

- A. Provide materials and equipment suitable for installation and operation under rated conditions at 400 feet above sea level and with maximum ambient temperature of 50 degrees Centigrade.

2.6 OUTDOOR EQUIPMENT

- A. Provide equipment and devices to be installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 20 degrees F to 120 degrees F. Equipment must be capable of proper operation at rated output continuously in this ambient temperature range in direct sun. Provide any additional equipment such as enclosures, sunshades, and cooling equipment so that this performance requirement can be met.

2.7 FASTENERS

- A. Fasteners for securing equipment to walls and floors shall be either hot-dip galvanized after fabrication or stainless steel.

2.8 EQUIPMENT ENCLOSURES

- A. General:
 - 1. Equipment enclosures shall have NEMA ratings suitable for the location in which they are installed, as specified in the individual technical sections or as shown on the drawings.

PART 3 - EXECUTION

3.1 GENERAL

- A. Unless specified otherwise, equipment anchoring systems shall be designed to withstand seismic forces as specified in Section 01 43 11.
- B. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance.
- C. Coordinate work with the Engineer and work of other trades to avoid conflicts, errors, delays, and unnecessary interference with operation of the new facilities during construction.
- D. Check the approximate locations of equipment and other system components shown on drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify the Engineer in writing. The Engineer's decision shall govern. Make modifications and changes required to correct conflicts.

3.2 PROTECTION DURING CONSTRUCTION

- A. Throughout the Work, provide protection for materials and equipment against loss or damage in accordance with provisions elsewhere in these Contract Documents. Throughout the Work, follow manufacturers' recommendations for storage. Protect everything from the effects of weather.
- B. Following installation, protect materials and equipment from corrosion, physical damage, and the effects of moisture. When equipment intended for indoor installation is installed at the Contractor's convenience in areas where it is subject to dampness, moisture, dirt, or other adverse atmosphere until completion of construction, ensure that adequate protection from these atmospheres is provided that is acceptable to the Engineer. Keep openings in boxes or equipment closed during construction.

3.3 MATERIAL AND EQUIPMENT INSTALLATION

- A. Follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between the manufacturers' instructions, codes and regulations, and these Contract Documents, follow Engineer's decision. Keep copy of manufacturers' installation instructions on the jobsite available for review at all times.
- B. Use appropriate conduit and conductor entry fittings with enclosures which maintain the specified enclosure environmental capability after proper installation.

3.4 GROUNDING

- A. All network equipment shall be grounded per NEC.

3.5 EQUIPMENT SUPPORTS

- A. Provide equipment supports for all equipment in accordance with Division 01 – General Requirements.

3.6 CUTTING AND PATCHING

- A. Lay out work carefully in advance. Do not cut, drill, or notch any structural member or building surface without specific approval of Engineer. Carefully carry out any cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of materials and equipment. Following such work, restore surfaces neatly to original condition. Use skilled craftsmen of the trades involved.

3.7 CLEANING AND TOUCHUP PAINTING

- A. Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove all materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish. If extensive damage is done to equipment paint surfaces, refinish the entire equipment in a manner that provides a finish equal to or better than the factory finish, that meets the requirements of the specifications, and that is acceptable to the Engineer.
- B. The interior of all equipment shall be vacuumed and wiped free of dust just before final acceptance. De-energization of equipment shall be at times approved in writing by the Engineer.

3.8 INSPECTION

- A. Allow materials, equipment, and workmanship to be inspected at any time by the Engineer or their representatives. Correct work, materials, or equipment not in accordance with these Contract Documents or found to be deficient or defective in a manner satisfactory to the Engineer.

3.9 STANDARDS, CODES, PERMITS, AND REGULATIONS

- A. Perform work; furnish, install, and test materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
 - 1. Local Laws and Ordinances.

2. State and Federal Laws.
 3. California Code of Regulations:
 - a. Title 24, Part 3 – California Electrical Code (CEC).
 4. Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA).
 5. State Fire Marshal.
 6. Underwriters' Laboratories (UL).
 7. National Electrical Safety Code (NESC).
 8. American National Standards Institute (ANSI).
 9. National Electrical Manufacturer's Association (NEMA).
 10. National Electrical Contractor's Association (NECA) Standard of Installation.
 11. Institute of Electrical and Electronics Engineers (IEEE).
 12. Insulated Cable Engineers Association (ICEA).
 13. Occupational Safety and Health Act (OSHA).
 14. American Society for Testing and Materials (ASTM).
- B. Conflicts, if any, that may exist between the above items will be resolved at the discretion of the Engineer.
- C. Wherever the requirements of the specifications or drawings exceed those of the above items, the requirements of the specifications or drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.

3.10 SERVICE CONTINUITY

- A. Maintain continuity of electric service to all functioning portions of the plant. Make no outages without prior written authorization of the Engineer. Include all costs for temporary wiring and overtime work required in the contract price. Remove all temporary wiring at the completion of the work.

3.11 TEMPORARY ELECTRIC POWER

- A. Refer to Section 01 50 00 Temporary Facilities and Controls for necessary provisions for electric power used during construction.

3.12 TESTS

- A. Perform testing as specified in Sections 01 75 17 Field Testing and Startup and 27 08 00 Commissioning of Communications Systems.

END OF SECTION

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SECTION 27 08 00

COMMISSIONING OF COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Work included in this section shall consist of furnishing labor, equipment supplies, materials, and testing equipment, and performing commissioning of communications systems as shown on the drawings and required by these specifications. These include but not limited to providing fiber optical cables, ST Duplex connectors, 19" rack mountable combination connector/splice housings, wall-mount combination connector/splice housings, fiber optic cable and patch cords, 19" rack mountable RJ-45 connector patch panels, wall-mount RJ-45 connector patch panels, CAT 5e Ethernet cable and patch cords, wire ducts, equipment racks, test equipment, etc.
2. The fiber optic cable networks shall be fully tested per the requirements of this Specification.
3. Ethernet cable networks shall be fully tested per the requirements of this Specification.

B. Related sections:

1. Section 27 13 23 – Communications Optical Fiber Backbone Cabling.

1.2 QUALITY ASSURANCE

- A. The Telecommunications System Supplier (TSS) shall have fully qualified technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall conduct the tests. Appropriate training programs include but are not limited to installation certification programs provided by the Building Industry Consulting Service International (BiCSI).
- B. Each technician that will perform testing shall have a minimum of 5 years' recent experience in satisfactory completion of jobs of similar size and scope.
- C. The TSS shall compile and submit detailed information relating to certification, experience, and similar work completed by all technicians performing testing work, including references sufficient to enable the Engineer to evaluate and approve of the technician's responsibility, experience, and capacity to perform the work.
- D. Test Equipment:

1. Test equipment used under this contract shall be from manufacturers that have a minimum of 5 years' experience in producing field test equipment. Manufacturers shall be ISO 9001 certified.
2. All test tools of a given type shall be from the same manufacturer and have compatible electronic results output.
3. All test adapter cables shall be approved by the manufacturer of the test equipment. Adapters from other sources are not acceptable.
4. Baseline accuracy of the test equipment shall exceed ANSI/EIA/TIA TSB67 Level III specified instrument accuracy, as indicated by independent laboratory testing.
5. Test equipment shall have a dynamic range of at least 100 dB to minimize measurement uncertainty.
6. Test equipment shall be capable of storing full frequency sweep data for all tests and printing color graphical reports for all swept measurements.
7. Test equipment shall include S-Band time domain diagnostics for NEXT and return loss (TDNXT and TDRL) for accurate and efficient troubleshooting.
8. Test equipment shall be capable of running individual NEXT and return loss measurements in addition to auto-tests.
9. Test equipment shall include a library of cable types, sorted by a major manufacturer.
10. Test equipment shall store auto-tests in internal memory.
11. Test equipment shall be able to internally group auto-tests and cables in project folders.
12. Test equipment shall include digital signal processing (DSP) technology for support of advanced measurements.
13. The measurement reference plane of the test equipment shall start immediately at the output of the test equipment interface connector. There shall not be a time domain dead zone of any distance that excludes any part of the link from the measurement.

E. Fiber Optic Cable Systems:

1. OTDR (Optical Time Domain Reflectometer) and the use of visual fiber tracers, visual fault locators or OLTS (Optical Loss Test Set) shall be performed by trained testing personnel, using certified equipment designed for the purpose. The technicians performing the tests shall be

trained in the operation of the OTDR equipment and also in the interpretation of OTDR traces. Provide documentation that certifies technicians have been trained in the use of OTDR equipment.

2. All optical fibers in cables lengths of 100 m or greater shall be 100% attenuation tested. The attenuation shall be measured at 850 nm and 1300 nm for multimode fibers.

F. Ethernet Cable Systems

1. Network Cable Verification shall be performed by trained testing personnel, using certified equipment designed for the purpose. The technicians performing the tests shall be trained in the operation of the Network Cable Tester equipment and also in the interpretation of results. Provide documentation that certifies technicians have been trained in the use of the test equipment.
2. All conductors shall be tested for continuity and proper arrangement at each termination point.

1.3 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00.
- B. Submit detailed information relating to certification, experience, and similar work completed by technicians performing testing work, including references.
- C. Submit the following proposed test procedures for the fiber optic cable system as required in this Section for each fiber cable type. Obtain the approval of the Engineer of the proposed test procedure prior to onset of test.
 1. Pre-Installation Test
 2. Installation Test
 3. Final Acceptance Test
- D. Submit the following proposed test procedures for the CAT 6 cable system as required in this Section for each cable type. Obtain the approval of the Engineer of the proposed test procedure prior to onset of test.
 1. Pre-Installation Test
 2. Installation Test
 3. Final Acceptance Test
- E. Submit literature or data sheets on proposed testing equipment, including certification of calibration.

- F. Submit proposed PC software package to be used for OTDR analysis and method of storing test data.
- G. Submit Letter of Certification of Compliance upon successful testing of the fiber optic system. This letter shall state that the installed system meets the criteria based on the link loss budget.
- H. All testing results shall be supplied on printed 8.5" x 11" hard copy as well as on USB flash drive. Test results shall also be uploaded to CMIS if below file size limit.

1.4 REFERENCES

- A. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA):
 - 1. TIA/EIA Technical Systems Bulletin 67 (TSB-67), Link Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems.
 - 2. EIA-310 - Racks, Panels, and Associated Equipment.
 - 3. TIA/EIA-455-86 - FOTP-86 Fiber Optic Cable Jacket Shrinkage.
 - 4. TIA/EIA-455-107 - FOTP-107 Determination of Component Reflectance or Link/System Return Loss Using a Loss Test Set.
 - 5. TIA/EIA-455-171 - FOTP-171 Attenuation by Substitution Measurement--for Short-Length Multimode Graded-Index and Single Mode Optical Fiber Cable Assemblies.
 - 6. EIA/TIA-492AAAB - Detail Specification for 50-m Core Diameter/125-m Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - 7. TIA/EIA-526-14A - Optical Power Loss Measurements on Installed Multimode Fiber Cable Plant.
 - 8. EIA/TIA 568B – Commercial Building Telecommunications Cabling Standard.
 - 9. TIA/EIA-598-B - Optical Fiber Cable Color Coding.
 - 10. TIA/EIA-604 - Fiber Optic Connector Intermateability Standards (FOCIS).
 - 11. EIA/TIA 758 – Customer-Owned Outside Plant Telecommunications Infrastructure Standard.
 - 12. ICEA S-104-696 - Indoor-Outdoor Fiber Optic Cable.

- 13. ANSI/TIA-568-C CAT 5e Field Test Specification
- B. National Electrical Contractors Association (NECA):
 - 1. NECA 301 – Standard for Installing and Testing Fiber Optic Cables.
- C. California Code of Regulations:
 - 1. Title 24, Part 3 – California Electrical Code (CEC).
- D. Underwriters Laboratory:
 - 1. UL 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Fiber Equipment including OTDR, OLTS, jumper cables, etc., required to test fiber optic cables and system shall be provided by the Contractor or Subcontractor providing the testing services.
- B. Copper Equipment including Network Cable Testers, jumper cables, etc., required to test CAT 5e cables and system shall be provided by the Contractor or Subcontractor providing the testing services.

2.2 CLEANING KIT

- A. Fiber optic strands shall be cleaned with a factory approved cleaning kit.

2.3 LUBRICANT

- A. Cable pulling lubricant shall be suitable for polyethylene jacketed fiber optic cables. Lubricant shall be Furnish American Polywater F, Ideal Optic-lube, or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor and each Subcontractor shall be knowledgeable of work to be performed by other trades and take necessary steps to integrate and coordinate their work with other trades.
- B. All work performed in occupied spaces shall be done in a manner that allows the District to operate the existing facilities on a continuous basis.
- C. All fiber optic cable splicing shall be performed using the fusion splice method. Mechanical splice method is not allowed.

3.2 FIELD QUALITY CONTROL

A. Fiber Optic Cable System Field Tests

1. General

- a. Field tests shall be performed on each fiber. All fibers shall be tested for breaks, abnormalities, and overall attenuation characteristics to ensure that the db loss at each splice point and test location is in conformance with the requirements specified herein. Cables shall be tested per Standard NECA 301 where applicable and per the requirements of this Section.
- b. Test jumpers (end-to-end attenuation) or test fiber box (OTDR) are of the same fiber core size and connector type as the cable system.
- c. Optical sources shall be stabilized and have center wavelengths within $\pm 20\text{nm}$ of the 850/1300nm multimode and 1310nm/1550nm single mode nominal wavelengths. In accordance with TIA/EIA-526-14A, multimode LED sources should have spectral widths from 30-60nm at 850nm and 100-140nm at 1300nm.
- d. The power meter shall be calibrated at each of the nominal test wavelengths and traceable to the National Institute of Standards and Technology (NIST) calibration standard.
- e. The power meter and light source shall be set to the same wavelength.
- f. All system connectors, jumpers, and adapters used during the test procedures shall be properly cleaned prior to and during test measurements.
- g. Test technicians shall use the same brand and model of test equipment using the same testing profile. Use of different test equipment and profiles may result in test reports being rejected by the Engineer.
- h. Test the fiber optic cables in the following wavelengths:
 - 1) Multimode fiber: 850nm and 1300nm.
- i. Use LED sources to test multimode fiber.

2. Pre-Installation Test.

- a. After delivery to the site, and before the cable is installed, an end-to-end OTDR bi-directional signature trace for each fiber using

proper index of refraction shall be performed. These traces shall identify the total optical length and any point faults or discontinuities caused by shipping or handling. An average optical attenuation measurement (db/km) shall be made for each fiber at an OTDR. Each measurement shall be captured on a trace and compared to the factory test reports that were attached to the reels. If pre-installation test results differ from factory test report or if the fiber cable shows macro or micro bend damage the fiber cable will be rejected by the Engineer.

- b. Pre-installation test results shall include the signature trace analysis over the length of the fiber optic cable in graphical display indicating attenuation in dB/km. Each test result shall be labeled indicating the cable type and length. The test report shall be submitted to the Engineer for review and approval prior to installation of the fiber optic cable.

3. Installation Test.

- a. Cable shall be tested after the cable is pulled through conduits, cable tray, or on poles prior to splicing to verify that there has been no damage to cable after installation. The cable shall be tested with an OTDR, and signature traces documented indicating the cable type, length and cable number per the Cable Schedule provided in the drawings.
- b. An OTDR measurement shall be completed on each splice and field installed connector. The measurement test shall be done after each splice and field connection to ensure that a clean, low-loss connection was made. Measurement shall be done in both directions.
- c. Acceptable losses are as follows:
 - 1) Splices: ≤ 0.3 dB (single-mode and multimode).
 - 2) Field installed connectors: $\leq .75$ dB.
- d. If the measured splice or connector loss is unacceptable, the splice or connector shall be reworked and retested until the measured loss values are below the acceptable limits as specified.
- e. Provide a Certificate of Compliance for Connector and Splice Loss. Document each splice and field connector measurement. Indicate cable number and location of splice and field connection. Submit documentation to Engineer for review and approval.

4. Final Acceptance Test.

- a. After installation of fiber cables are complete, perform an end-to-end attenuation test from both directions for each fiber cable link or from patch panel to patch panel as shown on the drawings. Test using the wavelengths as specified herein.
 - b. Use an OLTS power meter and source to test for attenuation losses.
 - c. Measured attenuation losses (dB) shall be documented for each fiber cable and compared to the link-loss budget.
 - d. If measured attenuation losses are greater than the maximum link-loss budget values, the fiber cable links in question shall be required to have troubleshooting using an OTDR. The OTDR shall be utilized to locate fault points in the cable system. Once the fault points are located and repaired the link shall be tested again with an OLTS to verify attenuation losses. This process shall be repeated until the attenuation losses are below the maximum link-loss budget for that particular fiber link.
- a. Once the end-to-end attenuation test is completed the results shall be provided in a test report for review and approval by the Engineer. In the report, include the budget link-loss for each link and indicate criteria used for dB loss values. Label each link using the cable number as provided in the Conduit and Cable Schedules as shown on the drawings. Measured test values shall be provided in one section with the budgeted link-loss values provided in another section. Provide a brief explanation at the beginning of the report indicating testing methods used.

B. Certificate of Compliance for Fiber Cable System Network

- 1. After the Engineer has approved the Final Acceptance Test Report, the Contractor shall provide a letter stating that the fiber cable system network has been fully tested and is ready for operation.

C. Unshielded Twisted Pair System Field Tests

- 1. General
 - a. Field tests shall be performed on each conductor. All conductors shall be tested for breaks, abnormalities, and overall continuity to ensure that the cable is in conformance with the requirements specified herein. Cables shall be tested per ANSI/TIA-568-C Cat 5e Field Test Specifications.
 - b. Test technicians shall use the same brand and model of test equipment using the same testing profile. Use of different test equipment and profiles may result in test reports being rejected by the Engineer.

2. Pre-Installation Test.

- a. After delivery to the site, and before the cable is installed, an end-to-end continuity test shall be performed. The test shall identify the total length of the cable. If pre-installation test results differ from factory test report or if the cable shows macro or micro bend damage the cable will be rejected by the Engineer.
- b. Pre-installation test results shall include the cable type and length. The test report shall be submitted to the Engineer for review and approval prior to installation of the cable.

3. Installation Test.

- a. Cable shall be tested after the cable is pulled through conduits, cable tray, or on poles to verify that there has been no damage to cable after installation. The cable shall be tested with a Network Cable Tester and documented indicating the cable type, length and cable number per the Cable Schedule provided in the drawings.
- b. Provide a Certificate of Compliance for Connector termination. Indicate cable number and location of the field connection. Submit documentation to Engineer for review and approval.

4. Final Acceptance Test.

- a. After installation of unshielded twisted pair cables are complete, perform an end-to-end continuity test from both directions from patch panel to patch panel as shown on the drawings.
- b. Once the end-to-end attenuation test is completed the results shall be provided in a test report for review and approval by the Engineer. In the report include the overall length of each cable link. Label each link using the cable number as provided in the Conduit and Cable Schedules as shown on the drawings. Provide a brief explanation at the beginning of the report indicating testing methods used.

D. Certificate of Compliance for Unshielded Twisted Pair Cable System Network

- 1. After the Engineer has approved the Final Acceptance Test Report, the Contractor shall provide a letter stating that the unshielded twisted pair cable system network has been fully tested and is ready for operation.

END OF SECTION

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SECTION 27 11 19

COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Provide fiber optic termination enclosures or patch panels as shown on the drawings and as required to connect the outside fiber optic cable to the indoor fiber optic cable system.
2. Size of the termination enclosures or patch panels shall be based on the number of required fiber cable terminations. Refer the conduit schedule for number of fiber cables.

B. Related Sections:

1. Section 27 05 00 – Common Work Results for Communications
2. Section 27 08 00 – Commissioning of Communications Systems
3. Section 27 13 23 – Communications Optical Fiber Backbone Cabling
4. Section 27 13 23.13 – Communications Optical Fiber Splicing and Terminations

1.2 QUALITY ASSURANCE

- A. Refer to Section 27 05 00 for quality assurance requirements.
- B. The manufacturer shall be ISO 9001 registered.

1.3 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00.
- B. The Telecommunications System Supplier (TSS) shall furnish submittals for approval as outlined below:
 1. Product data and specifications.
 2. Warranty.
 3. Dimensions (elevations, plan views, sections).
 4. Elevation layout drawings (to scale) and point-to-point interconnection diagrams for each fiber patch panel (FPP) shown on the drawings. Elevation

layout drawings shall show relative locations of all major equipment, including terminal blocks, wiring troughs, protector units, patch panels, grounding bars, intercom ring/loop detectors and multi-outlet assemblies.

1.4 REFERENCES

- A. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA).
 - 1. EIA/TIA 568B – Commercial Building Telecommunications Cabling Standard.
- B. California Code of Regulations:
 - 1. Title 24, Part 3 – 2004 California Electrical Code (CEC).
- C. National Electrical Manufacturer Association (NEMA).
- D. American National Standards Institute (ANSI).
- E. Underwriters Laboratory (UL).
- F. National Electrical Contractor's Association (NECA)
 - 1. NECA – 301 Standard for Installing and Testing Fiber Optic Cables

PART 2 - PRODUCTS

2.1 UNSHIELDED TWISTED PAIR PATCH PANELS

- A. CAT 5e Ethernet Patch Panels located in the DROP 15/65, RIO 15-1, RIO 15-2, RIO 15-3, DROP 23/73, RIO 23-1, RIO 23-2, RIO 23-3, LOX Truck Loadout Panel and O2 Cooling Tower PLC Panel.
 - 1. Wall mounted interconnect panel for terminating and protecting unshielded twisted pair CAT 5e cables.
 - 2. Provide a wall mounted bracket sufficient to fit into a small space.
 - 3. Include routing guides and supports for cable management.
 - 4. Connector jacks shall be grouped in modules of six and shall meet EIA/TIA CAT 5e performance requirements.
 - 5. Provide mounting accessories.
 - 6. Acceptable Manufactures:
 - a. Ortronics Clarity 5e.

b. Or approved equal.

B. CAT 5e Ethernet Patch Panels located in the O2 Electrical Room, 44-NET-006.

1. Patch panel shall be of minimum 1U, 19" rack mounted panel completed with front panel, modular jack housing, and wire management.
2. Patch panel shall be included with six port modular jack connectors and shall meet EIA/TIA CAT 5e performance requirements.
3. Acceptable Manufacturers:
 - a. Ortronics Clarity 5e
 - b. Or approved equal.

2.2 FIBER OPTIC TERMINATION PANELS

A. Fiber optic termination panels (FOTP) shall provide a single location for splicing, terminating, patching, and testing fiber optic cables. The housing for each FOTP shall be designed for use in the corresponding mounting location including, but not limited to, open frame racks, back panels within enclosed panels, and wall-mount enclosures. FOTPs shall have a protective housing for breakout of individual fibers and for splices. The splice area shall support fusion splices and provide strain relief for individual fibers. Provide a swing open front door.

B. FOTPs shall meet the following requirements.

1. Each FOTP shall be sufficiently sized to accommodate the full number of strands in each cable to be terminated plus 50 percent spare capacity.
2. Each fiber strand in each cable shall be terminated so that all strands of all cables are made available at bulkhead-mounted duplex Type LC connectors mounted in connector housing patch panels.
3. Provide patch cord and splice tray storage in the same unit.
4. FOTPs shall be rack-mounted, wall-mounted, or back panel-mounted as indicated on Drawings. FOTPs installed on back panels shall be mounted on DIN rails.
5. FOTPs shall consist of the housing and pigtail cassettes fully loaded with connector housing and factory-terminated pigtails with Type LC duplex connectors.
6. Provide a directory at each FOTP logically identifying each optical fiber within.
7. Furnish and install dust caps on all unused patch panel connectors.

- C. Fiber optic connector assemblies shall meet the following requirements.
1. Installed connectors according to manufacturer assembly instructions.
 2. Only straight connectors shall be used for FOC installations.
 3. Fiber optic connectors shall conform to TIA-604-10A FOCIS-10 - Fiber Optic Connector Intermateability Standard.
 4. Fiber optic connector assemblies shall use high quality connectors factory installed on jacketed pigtailed with dust cap for plug.
 5. Assemblies shall be provided with FOTPs for field splicing to outside plant cables.
 6. Fiber assemblies shall utilize an ultra-physical contact (UPC) finish, or better, on the tip of the fiber connector to provide high yield during splicing and meet EIA and IEC standards for repeatability.
 7. Connectors shall meet the following requirements:
 - a. Connector Type: LC type.
 - b. Insertion Loss: 0.2 dB typical, 0.5 dB maximum
 - c. Return Loss: ≥ 26 Db
- D. Acceptable level of quality for rackmount FOTPs: equivalent to Corning CCH Series closet connector housing. Acceptable level of quality for wall-mount FOTPs: equivalent to Corning WCH Series, Corning ICH Series, with FOTP enclosure rating meeting the installation environment. Acceptable level of quality for FOTPs mounted on back panels: equivalent to Corning SPH Series.
- E. Located in DROP 15/65, RIO 15-1, RIO 15-2, RIO 15-3, DROP 23/73, RIO 23-1, RIO 23-2, RIO 23-3, LOX Truck Loadout Panel and O2 COOLING TOWER PLC Panel.
1. Wall mounted interconnect panel for terminating and protecting fiber cables.
 2. Provide FOTP with splicing provisions or splice trays. Size splice tray for number of cables as indicated on the Conduit Schedule on the drawings.
 3. Include routing guides and support for cable management.
 4. Metal housing and NEMA Type 1.
 5. Connector panels shall be included and be compatible with ST type fiber connectors. Number of fiber connectors as required by cable type.

6. Provide mounting accessories.
7. Acceptable Manufactures:
 - a. Corning, LANscape Solutions WIC Series
 - b. Black Box, BB-JPM400A-R2.
 - c. Or approved equal.

PART 3 - OR EQUAL EXECUTION

3.1 INSTALLATION

- A. Locate patch panels where shown on the drawings.
- B. Splice and connect fiber optic cables per the manufactures installation manual.
- C. Final connections to the equipment shall be made by or under the direct supervision of an authorized representative of the Telecommunications System Supplier.

3.2 FIELD QUALITY CONTROL

- A. Patch panels shall be part of the overall fiber optic system testing as required in Section 27 08 00, Commissioning of Communications Systems.

END OF SECTION

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SECTION 27 13 23

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. Work included:

1. Provide a complete backbone cabling system as shown on the drawings including but not limited to; fiber splice boxes, fiber optic cable, connectors, hardware, patch cords, and accessories as specified herein and in other Sections as noted.
2. The Telecommunications System Supplier (TSS) shall provide the fiber optic cable as shown on the drawings. The fiber optic cable shall be configured as two communications rings as shown on the Drawings:
 - a. Drop 15/65 to RIO-15-1, to RIO 15-2, to RIO 15-3, and back to Drop 15/65
 - b. Drop 23/73 to RIO-23-1, to RIO 23-2, to RIO 23-3, and back to Drop 23/73.
3. The TSS shall be responsible for obtaining all the necessary drawings, implementing site surveys, and locating pull-boxes in order to install and test a complete fiber optic cable system between the facilities as shown on the drawings and as specified herein.
4. The TSS shall develop interconnection diagram and a pulling plan prior to installing the fiber optic cable. The interconnection diagram, pulling plan, including pulling tension calculations, shall be submitted to District for review and approve by the Engineer prior to installation.
5. Provide all equipment required for pulling fiber optic cable through new and existing conduits without exceeding the maximum pulling tension.
6. The TSS shall be responsible for developing a link-loss budget and comparing this information to the Final Acceptance Test as required in Section 27 08 00 Commissioning of Communications Systems. The fiber cable system shall comply with the requirements of the link-loss budget or otherwise will not be approved by the Engineer.

B. Related Sections:

1. Section 26 05 33 – Raceway and Boxes for Electrical Systems
2. Section 26 05 53 – Identification for Electrical Systems

3. Section 27 08 00 – Commissioning of Communication Systems
 4. Section 27 11 19 – Communications Terminal Blocks and Patch Panels
 5. Section 27 13 23.13 – Communications Optical Fiber Splicing and Terminations
- C. Related work installed by others.
1. Refer to the contract drawings for length of conduit routing and location of manholes.

1.2 REFERENCES

- A. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA):
1. EIA/TIA 568B - Commercial Building Telecommunications Cabling Standard.
 2. EIA/TIA 569A - Commercial Building Standard for Telecommunications Pathways and Spaces
 3. EIA/TIA 598A - Optical Fiber Color Coding.
 4. EIA/TIA TSB-72 - Centralized Optical Fiber Cabling Guidelines.
 5. EIA/TIA 455 – Fiber Optic Test Procedures (FOTPs)
- B. Insulated Cable Engineers Association (ICEA)
1. ANSI/ICEA-640 – Standard for Outside Fiber Outside Plant Communications Cable.
- C. National Fire Protection Association (NFPA):
1. California Electrical Code (CEC).
- D. Underwriters Laboratories, Inc. (UL):
1. UL 44 – Thermoset - Insulated Wires and Cables.
- E. United States Department of Agriculture Rural Utility Service (RUS)
1. RUS - 7 CFR 1755.900
- F. National Electrical Contractors Association (NECA)
1. NECA 301 – Standard for Installing and Testing Fiber Optic Cables

1.3 SYSTEM DESCRIPTION

- A. The fiber optic cables shall be tested in accordance with the following procedures per EIA-445 Fiber Optic Test Procedures (FOTP):
 - 1. FOTP-3, Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components.
 - 2. FOTP-25, Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies.
 - 3. FOTP-33, Fiber Optic Cable Tensile Loading and Bending Test.
 - 4. FOTP-37, Low or High Temperature Bend Test for Fiber Optic Cable.
 - 5. FOTP-41, Compressive Loading Resistance of Fiber Optic Cables.
 - 6. FOTP-81, Compound Flow (Drip) Test for Filled Fiber Optic Cable.
 - 7. FOTP-82, Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable.
 - 8. FOTP-85, Fiber Optic Cable Twist Test.
 - 9. FOTP-104, Fiber Optic Cable Cyclic Flexing Test.

1.4 QUALITY ASSURANCE

- A. The materials specified shall be furnished by a single manufacturer wherever possible. The cable manufacturer shall provide installation procedures and technical support concerning the items contained in the specification.
- B. The fiber optic cable installer for fiber optic installations of less than 5 miles in length shall provide proof that the installers are certified fiber optic technicians as approved by the Fiber Optic Association (FOA). The installers shall have a minimum of 5 years of experience in outside plant and indoor applications.
- C. The cable manufacturer shall be ISO 9001 registered.

1.5 SUBMITTALS

- A. Submittals shall be made in accordance with Section 01 33 00, Submittal Procedures.
- B. Furnish submittal information for review and approval for the following:
 - 1. Fiber optic cable descriptive product information and specifications including maximum short term and long term tensile loads.

2. Submit the factory certificate of compliance quality control data sheet with attenuation in dB/km and bandwidth in MHz*km for all fiber strands at:
 - a. 1,310 nm and 1,550 nm wavelengths for single-mode fiber optic cable
 - b. 850 nm and 1,300 nm wavelengths for multimode fiber optic cable
3. Submit a cable pulling plan. The pulling plan shall include the following:
 - a. Considerations noted during the site survey.
 - b. The logistics of cable let-off/pulling equipment.
 - c. The location of intermediate access points, splice points, slack locations, and transition points (from underground to aerial).
 - d. Fiber optic installation and pulling equipment methods proposed.
4. Fiber optic cable pulling tension calculations: Include criteria used for calculations including coefficient of friction for both the fiber optic cable and conduit and lubricant. Provide tensile strength of cable and maximum sidewall pressure of cable. State location of required pull boxes and/or handholes and/or manholes based on tension limitations and calculations.
5. Develop and submit a link-loss budget to determine maximum allowed attenuation losses. The link-loss budget shall be based on the actual installed components of the fiber optic cable system including splice points, connectors and dB/km per cable manufactures specifications. A link-loss budget shall be provided for each fiber optic cable link. If the manufacturer's specifications do not provide dB loss information the following may be used:
 - a. Splices: 0.3 dB (single-mode and multimode)
 - b. Field installed connectors: 0.75 dB
6. Factory Quality Control:
 - a. Cable reel Factory Test Report and Certification where specified.
 - b. Certification letter where specified in Part 3 of this Section.
 - c. Submit testing and certification of all factory connected cables such as patch cords and cable assemblies. Test results shall indicate dB losses.

- d. Test equipment shall be factory authorized calibrated within 12 months of the test date. Certification of the calibration shall be submitted for approval prior to the test.
- 7. Certification and Letters:
 - a. Approved FOA Certification for fiber optic cable installers.
 - b. Letter stating years of experience and applicable projects as indicated in Article 1.4.
 - c. Test equipment calibration certification.
- C. As-Built Documentation:
 - 1. Update conduit schedule and schematic diagram to include as-built conditions including splice points, termination and or patch panels and slack locations.

1.6 INSPECTION OF THE SITE AND EXISTING CONDITIONS

- A. See Article 16 Examination of Drawings, Specifications, and Site of Work in Document 00 21 13 Instructions to Bidders.
- B. Protect all existing aboveground and underground utilities during construction. Pay for all repairs without increase in contract cost should damage to underground utilities occur during construction.

1.7 DELIVERY, STORAGE AND HANDLING

- A. The TSS shall contact the fiber optic cable supplier for any special packaging or delivery requirements.
- B. The TSS shall inspect the reels as they are unloaded from the delivery truck, any visible damage shall be reported by the TSS and the reel returned to the factory.
- C. The TSS shall provide a crane, special lift truck or forklift to unload the cable reels. Reels shall not be rolled off of truck.
- D. Cables shall be packaged on spools or reels. Each package shall contain only one continuous length of cable. The packaging shall be constructed so as to prevent damage to the cable during shipping and handling.
- E. Each cable reel shall be accompanied by a test report and certification that the cable has been tested for continuity at the factory. Cable reels will not be accepted without factory test documentation.
- F. Cable reels shall be covered with a three layer laminated protective material. Cable ends shall be sealed to prevent the ingress of moisture. The outer end of the

cable shall be securely fastened to the reel head so as to prevent the cable from becoming loose in transit. The inner end of the cable shall project into a slot in the side of the reel or into a housing on the inner slot of the drum, in such a manner and with sufficient length to make it available for testing. Test tails shall be at least 2 meters long.

- G. Reels shall be permanently marked with an identification number that can be used by the manufacturer to trace the manufacturing history of the cable and the fiber. Securely attach tags, or clearly and permanently stencil or label each reel, with the following information: customer order number, customer job number, customer reel number, termination, ship date, manufacturer's name, factory reel number, manufacturer's cable code (type and fiber count), length of cable, weight of cable and reel, and defect tag.
- H. Reels shall be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the cable on the reel.
- I. Reels shall be stored upright on their rolling edge. The reels shall never be stored flat or stacked.

PART 2 - PRODUCTS

2.1 SINGLE-MODE FIBER OPTIC CABLE – TYPE 21 – [NOT USED]

A. General

- 1. Use for long distance communication network installed outdoors/indoors in between buildings and structures, underground in an inner duct and conduit as shown on the drawings. Indoor use is allowed where shown on the drawings.
- 2. All dielectric cable construction so that bonding or grounding of the cable is not required.
- 3. The cable shall be listed per CEC Article 770 as type OFN (non-conductive fiber optic general purpose cable).
- 4. The single-mode fiber shall meet ANSI/ICEA S-87-640 for design and testing. The cable shall be designed for outdoor use, water-blocked to prevent water penetration.

B. Fiber characteristics

- 1. The cable shall be non-armored, stranded, loose tube design.
- 2. The cable shall be gel-free design using water-swellaable yarns and tapes for easier cable termination and splicing.

3. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design and include a dielectric central member.
4. The cable shall be approved and listed in accordance with RUS 7 CFR 1755.900.
5. The cable shall include the following specification requirements:
 - a. Core diameter: 8.2 μm
 - b. Cladding diameter: 125.0 $\pm$ 0.7 μm
 - c. Core to cladding concentricity: $\leq$ 0.5 μm
 - d. Wavelength: 1310/1383/1550 nm
 - e. Nominal outside diameter: 10.5 mm (0.41 in)
 - f. Number of tube positions: 6
 - g. Maximum fibers/tube: 12
 - h. Number of fibers: As shown on Drawings
 - i. Operating temperature: -40 to 158 degrees F (-40 to 70 degrees C)
 - j. Maximum attenuation: 0.4/0.4/0.3 dB/km
 - k. Buffer tube size: 2.5-3.0 mm
 - l. Cable jacket: Medium density polyethylene
 - m. Maximum tensile load:
 - 1) Short term: 2700 N (606 lbf)
 - 2) Long term: 890 N (200 lbf)

C. Acceptable products

1. Corning Cable Systems, ALTOS
2. CommScope, TeraSPEED
3. Or equal

2.2 SINGLE-MODE FIBER PATCH CORDS - TYPE 24 –[NOT USED]

A. Single-mode fiber patch cords shall have the following features:

1. Core diameter: 8.2 μm
2. Cladding diameter: 125.0 $\pm$ 0.7 μm
3. Core to cladding concentricity: $\leq$ 0.5 μm
4. Wavelength: 1310/1383/1550 nm Lengths: As required
5. Tight buffered
6. Jacket color: Yellow
7. Jacket rating: UL OFNR
8. Connector types: LC or ST as required, to match equipment specified in this section or as shown on the Drawings
9. Type: duplex, unless otherwise noted on the Drawings
10. Polarity: TIA 568 A-B, unless otherwise noted on the Drawings
11. Polish style: UPC
12. Provided with labeling and identification
13. Insertion loss: Maximum 0.30 dB
14. Return loss: Minimum 55 dB
15. Minimum bend radius: 1 inch
16. Connector intermateability: TIA/EIA-604-2 for ST connectors and TIA/EIA-604-10 for LC connectors
17. Non-contact dust caps on all connector ends

B. Acceptable manufacturers

1. Ortronics Fiber Optic Assemblies.
2. Panduit.
3. Or equal

2.3 MULTIMODE FIBER OPTIC CABLE – TYPE 22

A. General Considerations

1. Use for communication network installed outdoors/indoors in between buildings and structures, underground in an inner duct and/or in conduit as

shown on the drawings. Indoor use is allowed where shown on the drawings.

2. All dielectric cable construction so that bonding or grounding of the cable is not required.
3. The cable shall be listed per CEC Article 770 as type OFN (non-conductive fiber optic general purpose cable).
4. Light source: Light emitting diode (LED).

B. Multimode Fiber Characteristics (TYPE 28)

1. The cable shall have the following characteristics:
 - a. Multimode (850/1300nm).
 - b. Core diameter: 50 μ m. (OM4)
 - c. Wavelength: 850nm/1300nm
 - d. Number of Tube Positions: 6
 - e. Max. Fibers/Tube: 12
 - f. Number of Fibers: As Shown on the drawings
 - g. Operating Temperature: -40 to 158 degrees F (-40 to 70 degrees C).
 - h. Max. Attenuation: ≤ 3.0 dB/km @ 850nm and ≤ 1.0 dB/km @ 1300 nm.
 - i. Buffer tube size: 2.5mm
 - j. Maximum Tensile Load:
 - 1) Short Term: 2700N (606.98lbf)
 - 2) Long Term: 890N (200.08lbf)

C. Acceptable Manufactures:

1. Corning Cable Systems, FREEDM LST
2. CommScope, Arid-Core
3. Or equal.

2.4 MULTI-MODE FIBER OPTIC PATCH CORDS – TYPE 25

A. Multi-mode fiber patch cords shall have the following features:

1. Lengths as required.
2. Multimode (850/1300nm).
3. Core diameter: 50 μ m. (OM4)
4. Bandwidth: 3500 MHz/km @ 850 nm, 500 MHz @ 1300 nm.
5. Jacket rating: Indoor, Outdoor, wet and dry locations.
6. Connector types: LC-LC (both ends) or as required by supplied equipment, ceramic termination.
7. Provided with labeling and identification.
8. Max. Attenuation: ≤ 3.0 dB/km @ 850nm and ≤ 1.0 dB/km @ 1300 nm.
9. Maximum insertion loss: 0.50 dB.
10. Maximum return loss: less than -20 dB.
11. Operating Temperature: -40 to 158 degrees F (-40 to 70 degrees C).
12. Minimum bend radius: 1-inch.
13. Connector intermateability: TIA/EIA-604-2.
14. Non-contact dust caps on all connector ends.

B. Acceptable Manufacturers:

1. Ortronics Fiber Optic Assemblies.
2. Panduit.
3. Or equal.

2.5 OUTDOOR/INDOOR CABLE ASSEMBLY - TYPE 12 [NOT USED]

A. Acceptable manufacturers

1. Corning Cable Systems
2. Or equal as approved by the Engineer

- B. Provide outdoor/indoor cable assembly where indicated on the drawings. One end of cable shall be preconnectorized with type ST connectors. The other end will be connected with a ST connector in the field after being pulled through the underground conduit system.
- C. Cable assembly shall have the following features:
 - 1. Lengths: As required
 - 2. Connector type ST (one end)
 - 3. Gel-Free cable
 - 4. UV Resistant, OFNR and FT-4 rated
 - 5. Multimode, 62.5 μ m
 - 6. Fiber count: 2
 - 7. Color coded fibers

2.6 CABLE CONSTRUCTION

- A. Optical fibers shall be placed inside a loose buffer tube and gel free.
- B. The fibers shall not adhere to the inside of the buffer tube.
- C. Each fiber cable (up to 12 strains) shall be distinguishable by means of color coding according per TIA/EIA-597-A, "Optical Fiber Color Coding."
- D. The fiber optic cable shall have an outer jacket made of polyethylene with a minimum nominal thickness of 1.4mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. The jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8. The fiber optic cable shall be outdoor, wet and dry location rated. The fiber optic cable and patch cord shall be suitable for cable tray and plenum installation.
- E. Cable shall be flame-retardant and UV Resistant.
- F. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
- G. Buffer tubes shall be kink resistant within the specified minimum bend radius.
- H. Fillers may be included in the cable core to lend symmetry to the cable cross section where needed.

- I. The central anti-buckling member shall consist of a dielectric, glass reinforced plastic rod central member. The purpose of the central member is to prevent buckling of the cable.
- J. Buffer tubes shall be stranded around a central member using the reverse oscillation, or “S-Z”, stranding process.
- K. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.
- L. Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.
- M. The cable shall contain at least one ripcord under the sheath for easy sheath removal.
- N. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns.
- O. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
- P. The jacket or sheath shall be free of holes, splits and blisters.
- Q. The cable jacket shall contain no metal elements and shall be of a consistent thickness.
- R. Cable jackets shall be marked with manufacturers’ name, sequential meter or foot markings, the year of manufacture, and a telecommunication handset symbol, as required by Section 350G of the National Electrical Safety Code (NESC). The actual length of the cable shall be within ± 1 percent of the length markings.
- S. The shipping, storage, and operating temperature range of the cable shall be -40 degrees C to +70 degrees C (-40 to 158 degrees F). The installation temperature range of the cable shall be -30 degrees C to +70 degrees C (-22 to 158 degrees F).
- T. When tested in accordance with FOTP-3, “Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components”, the average change in attenuation shall not exceed 0.50 dB/km with 80 percent of the measured fibers not exceeding 0.25 dB/km.

2.7 LUBRICANTS

- A. Provide a water based lubricant or gel that is compatible with fiber optic cable jacket.

B. Acceptable Manufactures

1. Polywater Corp.
2. 3M Corp.
3. Or equal as approved by the Engineer.

2.8 IDENTIFICATION

- A. Label each cable and termination point with the marking equipment specified in Section 26 05 53. The tagging numbering system shall be as shown on the drawings.
- B. Tag each cable in each junction box and enclosure.
- C. Use color coded patch cords and connectors to identify different networks or zones. Assign a unique alphanumeric designator to each patch cord and label each end. Patch cord designators shall be independent of any connected equipment to allow portability and future changes.

2.9 SOURCE QUALITY CONTROL

- A. The optical performance of the fibers in the finished cable shall comply with Table 8.1, Attenuation coefficient performance requirement (dB/k), Table 8.2, Multimode bandwidth coefficient performance requirements (MHz-km) and Table 8.3, Points discontinuity acceptance criteria (dB), of ANSI/ICEA S-87-640.
- B. Perform factory testing of the cable prior to shipment, that at a minimum shall show that the finished cable meets or exceeds the optical performance requirements of ANSI/ICEA S-87-640.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION

- A. Immediately after cable delivery
 1. Perform a pre-installation, on-reel optical time domain reflectometer (OTDR) test to verify that the cable has not been damaged during shipment. Reference Section 27 08 00 – Commissioning of Communication Systems for requirements.

3.2 GENERAL

- A. Install all network cabling in conduit or duct as indicated. Fiber cable Type shall be installed per the conduit and cable schedules provided on the drawings.

- B. Follow cable manufactures recommendations for installation of the fiber optic cables regarding the amount of tension that can be applied to the fiber cable during pulling.

3.3 INSTALLATION

- A. All fiber runs shall be one continuous cable from source location to destination location. No splicing shall be allowed in manhole, hand hale, above or underground pull box, in conduit, plenum space, cable tray, wireway, etc.
- B. All splicing shall be at the fiber patch panel. All splicing shall utilized fusion splicing method, mechanic splicing shall not be allowed.
- C. Rod and swab out existing ducts prior to installing new cables. Inspect existing raceways and boxes for allowable bending radius prior to installing cable and notify the Engineer of any condition which would prevent the proper installation of the cable.
- D. Lubricate cables with lubricants specially formulated for fiber cabling jackets during installation.
- E. Do not exceed cable manufacturer's specifications for tensile strength and side wall pressure. Provide proper tension monitoring equipment such as dynamometers for measuring tension in the cable during pulling. Use break-away swivels in conjunction with dynamometers to ensure that the maximum pulling tension is not exceeded.
- F. Do not exceed the minimum bending radius of the fiber optic cable as recommended by the manufacture.
- G. Pulleys used to install fiber optic cable must be sized according to the minimum bending radius.
- H. Terminate all cabling per the cable and termination device manufacturer's instructions. Refer to Section 27 13 23.13 for fiber optic cable connectors.
- I. Provide cable slack storage devices in all fiber cable access manholes (new and existing) for storage of slack cable. Provide 50 ft of slack cable without exceeding the cable minimum bend radius per cable manufactures specification data sheet.
- J. Provide Kellems or crimp-on grips for pulling the fiber optic cable. Use correct sized grip for the cable being pulled.
- K. Mid-span cable meets (points where ends of cable reels meet) shall be fusion-spliced and enclosed in a splice box.
- L. When laying loops of fiber on a surface during a pull, use "figure-8" loops to prevent twisting of cable.

- M. For additional installation requirements refer to NECA 301 – Standard for Installing and Testing Fiber Optic Cables.
- N. Provide cable split plugs for conduits with fiber optic cables routed through the access manholes located at the pumping plants and alongside the pipeline.
- O. Contractor shall notify District 10 days prior to performing the ODTR and OLTS tests. District or their representation shall be present to witness the test.

3.4 FIELD QUALITY CONTROL

- A. Refer to Section 27 08 00 for Commissioning of Communication Systems for field testing.

END OF SECTION

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SECTION 27 13 23.13

COMMUNICATIONS OPTICAL FIBER SPLICING AND TERMINATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Provide fiber optic cable splicing as required to attach connectors and terminate at patch panels and or termination enclosures.

B. Related sections:

1. Section 27 05 00 – Common Work Results for Communications
2. Section 27 08 00 – Commissioning of Communications Systems
3. Section 27 11 19 – Communications Termination Blocks and Patch Panels
4. Section 27 13 23 – Communications Optical Fiber Backbone Cabling

1.2 QUALITY ASSURANCE

A. Refer to Section 27 13 23 for quality assurance requirements.

B. The manufacturer shall be ISO 9001 registered.

1.3 SUBMITTALS

A. Make submittals in accordance with Section 01 33 00.

B. The Telecommunications System Supplier (TSS) shall furnish submittals for approval as outlined below:

1. Product Data and specifications.

1.4 REFERENCES

- A. California Electrical Code (CEC).
- B. National Electrical Manufacturer Association (NEMA).
- C. American National Standards Institute (ANSI).
- D. Underwriters Laboratory (UL).
- E. Insulated Cable Engineers Association (ICEA).

- F. National Electrical Contractor's Association (NECA) Standard of Installation.
- G. Fiber Optic Association (FOA)

PART 2 - PRODUCTS

2.1 CONNECTORS

- A. Connectors
 - 1. The fiber optic communications system shall utilize LC type connectors for fiber optic connections. The connectors shall be designed for use with multi-mode cable.
- B. Multi-mode connector specifications shall be as follows:
 - 1. Insertion loss (typical): 0.35 dB
 - 2. Ferrule: Ceramic
 - 3. Construction Housing: Composite
- C. Acceptable Manufacturers:
 - 1. Corning Cable Systems.
 - 2. Lucent Technologies.
 - 3. Or equal.

2.2 PATCH CABLES AND CABLE ASSEMBLIES

- A. Patch cables and or cords and cable assemblies are provided in Section 27 13 23, Communications Optical Fiber Backbone Cabling.

2.3 SPLICING

- A. Field splicing of fiber cables shall be done using the protected single fusion method for multimode fiber cables. Mechanical splicing is not acceptable.
- B. Equipment used for fusion of fiber cables shall be a high precision, micro processor based machine. The machine shall include at a minimum a fiber cleaver, LCD display, maintenance free electrodes and automated functions that align the fibers using profile alignment detection devices. The splicing machine shall offer splice optimization and verification systems providing the operator with accurate splice loss estimations.
- C. The fusion splicing equipment shall be similar to the OptiSplice Premier iLID Fusion Splicer manufactured by Corning.

- D. Splicing shall be noted in the pulling plan with tested dB loss values provided as required by Section 27 08 00.

2.4 SPLICE CASE

- A. Provide a stainless steel splice case including splice trays and organizers for protected single fusion splices of the loose-tube fiber-optic cable specified in Section 27 13 23 and the OPGW cable specified in Section 33 71 49.13.
- B. The splice case shall include the stainless steel shell, section end plates, inserts, sealant, grommets, hardware, and all other necessary items needed for the installation.
- C. The number of splice trays and organizers shall be based on the number of fibers that require splicing. Refer to the cable schedules on the drawings and the products specified in Section 27 13 23 and Section 33 71 49.13 for the fiber count.
- D. Provide transition furcation tubes and a water damming sealant kit for OPGW installations.
- E. Provide one future 3/4" cable entry in each splice case.
- F. Splice cases installed in vault applications shall contain fire-retardant end plates.
- G. Provide accessories required to mount the splice case in a slack box enclosure, on a wall inside a manhole or vault, or in aerial wood pole-mounted applications as shown on the drawings.
- H. Acceptable manufactures
 - 1. Outdoor, aboveground applications
 - a. Preformed Line Products, Coyote Splice Case.
 - b. Or equal.

PART 3 - EXECUTION

3.1 FACTORY QUALITY CONTROL

- A. Connectors and patch cables shall be factory certified for specified dB loss.

3.2 INSTALLATION

- A. Splicing.
 - 1. Fiber cable fusion splicing shall be done per the NECA 301 and per the manufactures instructions.

2. Fiber splicing outdoors shall be protected by a splice enclosure or canister.
 3. Splice canisters shall be located in slack box enclosures in vaults where required by the Fiber Box Schedule included in the drawings. Slack box enclosure are provided by others.
 4. Where necessary due to length of cable, splicing shall be done above grade and not done inside manholes or vaults. Provide enough slack in the fiber cable so that splicing can be done above grade where required.
 5. Splicing shall be done in a clean environment.
- B. Field installed connectors.
1. Field installed connectors shall be done per the manufactures installation instructions.

3.3 FIELD QUALITY CONTROL

- A. All splices and field installed connectors shall be tested for dB losses per the requirements of Section 27 08 00, Commissioning of Communication Systems.

END OF SECTION

SECTION 27 15 13

COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: This section covers the work necessary to furnish and install indoor and outdoor rated data communications horizontal copper cables and data communications copper patch cords, cross connect wires and cables.
- B. Related Sections:
 - 1. Section 26 05 00 – Common Work Results for Electrical.
 - 2. Section 26 05 53 – Identification of Electrical Systems.
 - 3. Section 26 05 19 – Low Voltage Electrical Power Conductors and Cables.
 - 4. Section 27 08 00 – Commissioning of Communications Systems.
 - 5. Section 27 15 43 – Communications Faceplates and Connectors.

1.2 SUBMITTALS

- A. Submittals shall be made in accordance with Section 01 33 00 Submittal Procedures.
- B. The Telecommunications System Supplier (TSS) shall furnish submittals for approval as outlined below:
 - 1. Product data.
 - 2. Warranty.
 - 3. Certified factory test reports.
 - 4. Field test reports.
 - 5. Before installation of cables, submit cable pulling calculations for all outdoor cables showing compliance with all manufacturer's recommended installation requirements and pulling tensions for the Engineers review and approval. Submittal shall include the recommended sequence of cable installations specifically detailing the "from" and "to" points for each cable installation segment.

1.3 REFERENCES

- A. ANSI/TIA/EIA-568-C.2 – Commercial Building Telecommunications Cabling Standard, Category 5e.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. All indoor rated cables, patch cords, and cross connect wires and cables shall be stored indoors in a clean, dry, conditioned location prior to installation.

PART 2 - PRODUCTS

2.1 CATEGORY 5e INDOOR, UNSHIELDED TWISTED PAIR (TYPE 16)

- A. General: Communication cable designed and rated to support high-end Ethernet networking applications, which may have spectral energy that extends up to 550 MHz to support gigabit speed bandwidth data, video, and POE applications. Suitable for installation in conduit, wireway, plenum, and cable trays.
- B. Cable shall be capable of supporting network applications such as Fast Ethernet. The four pair cables are manufactured in an ISO 9001 registered facility and meet and exceed ANSI/TIA/EIA-568-C.2 Category 5e requirements. Cable shall be plenum rated for all in-building horizontal and vertical runs.
- C. Conductors: 4 twisted pairs, 8 conductors total, 24 AWG solid bare copper conductors.
- D. Insulation and Jacket: Each conductor insulated with plenum rated Fluorinated Ethylene Propylene (FEP) insulation, 0.008 inch wall thickness, and nominal diameter of 0.041 inch. The two insulated conductors are twisted together to form a pair and four such pairs laid up to form the cable jacketed with flame retardant PVC. Each pair are color coded as such, white/blue, white/orange, white/green, white/brown.
- E. Nominal cable outside diameter: 0.250 inches.
- F. 10 to +60 degrees C operating temperature.
- G. Applicable Standards & Rating: ANSI/TIA/EIA-568-C.2, Category 5e, C (UL) US listed CEC type CMP, UL Listed.
- H. Acceptable manufacturers:
 - 1. Berk-Tek.
 - 2. Or equal.

2.2 CATEGORY 5e PATCH CORDS (TYPE 17)

A. Category 5e patch cords shall have the following features:

1. Terminations: 8-position.
2. Cable type: UTP plenum.
3. Jacket color: blue.
4. Provided with labeling and identification.
5. Length as required.
6. Resistance: 100 ohms.
7. Jacket rating: CM.
8. Connectors: RJ-45, both ends, polycarbonate material.
9. Pinning: straight (1-1, 2-2, etc.).
10. Conductors: Category 6 cable, four-pairs, 24 AWG, stranded.
11. Minimum bend radius: 1-inch.
12. FCC Standard: Part 68.
13. ETL Standard: TIA/EIA-568C.2 CAT 5e.
14. Insulation and jacket material: PVC.
15. Compatibility: T568B wiring.
16. Acceptable manufacturers:
 - a. Ortronics Clarity 5e Modular Patch Cords.
 - b. Or equal.

2.3 RUS PE-89 OUTDOOR CABLES (TYPE 18) [NOT USED]

- A. General: outdoor voice communications cables designed for installation inside conduits, with moisture protection and additional mechanical and rodent protection.
- B. Average Mutual Capacitance at 1000Hz: 12 pairs or less, B3 +/- 7 nf/mile; over 12 pairs, 83 +/- 4 nf/mile.
- C. Maximum Average Attenuation at 68 degrees F, 772 kHz: 4.5 dB/1000 ft.

- D. Minimum NEXT at 150 kHz: 53 dB.
- E. Minimum NEXT at 772 kHz: 42dB.
- F. Conductors: 24 AWG solid annealed copper.
- G. Insulation: inner layer of foamed natural polyolefin covered by an outer layer of solid colored polyolefin. Individual conductors are twisted into pairs with varying lay lengths to minimize crosstalk and shall have specific color combinations to provide pair identification.
- H. Core assembly: cable pairs shall be assembled into a cylindrical core.
- I. Filling compound: The core assembly shall be filled with an 80 degrees C rated ETPR compound, completely filling the interstices between the pairs and under the core wrap.
- J. Core wrap: a non-hygroscopic, dielectric tape shall be applied over the core assembly to provide protection for the core.
- K. Shielding: the inner shield shall consist of a corrugated, copolymer coated 8-mil aluminum tape applied directly over the core wrap; the aluminum tape shall not butt or overlap at any point along the length of the cable. The outer shield shall consist of a corrugated, copolymer coated 6-mil steel tape applied directly over the aluminum inner shield and overlaps. The shield inner faces shall be flooded.
- L. Jacket: black, linear low density polyethylene.
- M. Number of pairs as shown on the drawings.
- N. Acceptable manufacturers:
 - 1. Superior Essex Caspic FSF (RUS PE-89).
 - 2. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The length of each individual run of horizontal indoor cable from the originating point to the termination point shall not exceed 295 ft (90 m).
- B. Each run of horizontal indoor cable shall be continuous (no splicing allowed) without any joints or splices.
- C. At the end of each horizontal cable run, the outer jacket shall be stripped no more than is necessary for the proper termination of the cable as required by the

manufacturer of the hardware or terminal block to which the cable is being attached.

- D. When terminating a cable, the integrity of the twist for each individual pair shall be maintained up to the point of termination.
- E. Provide sufficient cable at each outlet jack to facilitate removal and inspection of the back of the terminated jacks. Proper bend radius shall be maintained when cable is coiled in outlet boxes.
- F. All horizontal indoor cables installed inside telecommunications equipment racks shall be trained neatly inside rear vertical cable managers. Cables shall not be braided together, but shall lie parallel to each other from the point where they enter the top of the vertical cable managers until they are terminated at the back of patch panels. Cables terminating on the right or left side of patch panels shall be routed via the right or left cable manager. Cables shall not cross the horizontal mid-point of the patch panel. Cables terminated at a patch panel shall be neatly routed from the vertical cable manager to the patch panel. Hook and loop ties shall be used to organize the cables into groups of 12 cables as they exit the cable manager.
- G. Do not exceed manufacturer recommended bending radius or maximum cable pulling tensions.
- H. Install cables as specified in Section 26 05 19.

3.2 FIELD QUALITY CONTROL

- A. Unshielded Twisted Pair cables and connectors shall be part of the overall copper cabling system testing specified in Section 27 08 00.

END OF SECTION

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SECTION 27 15 43

COMMUNICATIONS FACEPLATES AND CONNECTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. This section covers the work necessary to provide complete communications outlet jacks and faceplates for use with voice and data telecommunications circuits.

B. Related sections:

1. Section 26 05 33 – Raceway and Boxes for Electrical.
2. Section 26 05 53 – Identification of Electrical Systems.
3. Section 27 08 00 – Commissioning of Communications Systems.
4. Section 27 15 13 – Communications Copper Horizontal Cabling.

1.2 SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00 Submittal Procedures.

B. The Telecommunications System Supplier (TSS) shall furnish submittals for approval as outlined below:

1. Product data.
2. Warranty.
3. Field test reports.

1.3 DELIVERY, STORAGE, AND HANDLING

A. All equipment shall be stored indoors in a clean, dry, conditioned location prior to installation.

PART 2 - PRODUCTS

2.1 COMMUNICATION OUTLET JACKS

A. Jacks shall have the following features:

1. Colors: white for voice outlet jacks, blue for DCS, dark orange for process control and SCADA outlet jacks, dark green for data outlet jacks.
2. Connector type: RJ-45.
3. Wiring scheme: T568B.
4. Provided with labeling and identification.
5. Wire gauge terminations: 26 to 22 AWG.
6. FCC Standard: Part 68.
7. ETL Standard: TIA/EIA: 568:B 2-1 Category 5e.
8. Category performance/application: Category 5e UTP cable.
9. High impact ABS thermoplastic housing.
10. Gold plated contacts.
11. Front removable.

B. Acceptable manufacturers:

1. Ortronics Clarity.
2. Or equal.

2.2 FACEPLATES

A. Faceplates shall have the following features:

1. Single gang, two to four port, suitable for use with communications outlet jacks specified in this section.
2. Color: white.
3. Provided with labeling and identification.
4. Provided with mounting screws.
5. High impact ABS thermoplastic material.

6. Suitable for use with front removable jacks.
- B. Acceptable manufacturers:
1. Ortronics.
 2. Or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Securely fasten faceplates to outlet or device box or the outlet jack contained within. Install faceplates used with flush mounted boxes with all four edges in continuous contact with the finished wall surfaces without the use of mats or similar materials. Plaster fillings will not be acceptable. Install faceplates vertically or horizontally with an alignment tolerance of 1/16-inch.
- B. Provide nameplates as specified in Section 26 05 53, engraved with telecommunications circuit numbers, and install above each faceplate and outlet jack. The Engineer shall provide circuit numbers after installation of the communications system, prior to field testing of the outlet jacks.
- C. Label each wire as specified in Section 26 05 53.
- D. Final connections to the equipment shall be made by or under the direct supervision of an authorized representative of the TSS.

3.2 FIELD QUALITY CONTROL

- A. Communication outlet jacks shall be part of the overall copper cabling system testing required in Section 27 08 00.

END OF SECTION

SECTION 28 31 00

FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including the General and Supplementary Conditions and other technical specifications and design documents, apply to the work of this Section.

1.2 SUMMARY

- A. Furnish all labor, materials, and equipment for a fully operational fire alarm and emergency notification system in full compliance with the applicable NFPA standards and all other codes, regulations and laws applicable to the work, and in full compliance with the intent of the plans and specifications, including all work inferable from same.
- B. Section Includes:
 - 1. Fire alarm control panel (FACP).
 - 2. Notification appliance circuit (NAC) power supplies (NAC panel).
 - 3. Fire alarm annunciators (FAA).
 - 4. Initiating devices.
 - 5. Notification appliances.
 - 6. Input and output modules.
 - 7. Interface with mechanical systems.
 - 8. Releasing of clean agent systems.
 - 9. System accessories.
 - 10. Wiring and connections.
 - 11. Raceway.

12. System programming.
13. Acceptance Testing and Commissioning.

C. References:

1. National Fire Protection Association (NFPA) – Latest Editions
 - a. NFPA 70, “National Electrical Code (NEC)”
 - b. NFPA 72, “National Fire Alarm and Signaling Code”
2. Underwriter’s Laboratories, Inc. (UL)
 - a. UL Standards
 - 1) UL 50, “Enclosures for Electrical Equipment, Non-Environmental Considerations”
 - 2) UL 268, “Smoke Detectors for Fire Alarm Systems”
 - 3) UL 268A, “Standard for Smoke Detectors for Duct Application”
 - 4) UL 464, “Audible Signaling Devices for Fire Alarm and Signaling Systems”
 - 5) UL 864, “Standard for Control Units and Accessories for Fire Alarm Systems”
3. International Code Council (ICC)
 - a. California Building Code (CBC)
 - b. California Fire Code (CFC)
4. Amendments and Requirements of the Authority or Authorities Having Jurisdiction.

1.3 DEFINITIONS:

- A. Fire Alarm Technician: A qualified fire protection technician certified at Level IV with the National Institute for Certification in Engineering Technologies (NICET) in Fire Alarm Systems.

- B. Fire Alarm Installer: A qualified fire protection technician certified at Level II with the National Institute for Certification in Engineering Technologies (NICET) in Fire Alarm Systems.
- C. Manufacturer's Representative: A certified representative or technician trained by the manufacturer of the fire alarm system, experienced in the installation and operation of the type of system provided.
- D. Abbreviations:
 - 1. AHJ: Authority Having Jurisdiction.
 - 2. HVAC: Heating, Ventilation, and Air Conditioning.
 - 3. IDC: Initiating Device Circuit.
 - 4. NAC: Notification Appliance Circuit.
 - 5. SLC: Signaling Line Circuit.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide an intelligent addressable fire alarm system with audible (horn) and visual (strobe) occupant notification as shown on the drawings and as specified herein.
- B. System shall meet the requirements of the building code, fire code, and NFPA 72, including all local amendments and interpretations.
- C. Fire alarm system design shall be approved by the Engineer and the AHJ.
- D. All materials, wiring, and equipment shall be designed and installed in accordance with the recommended practices of the electrical industry and comply with the latest codes and standards.

1.5 ACTION SUBMITTALS

- A. General:
 - 1. Submittals shall be in full compliance with the requirements of the latest edition of NFPA 72, Chapter 7 and in accordance with 01 33 00, Submittal Procedures.
 - 2. Submit an annotated copy of this specification with the bid to indicate compliance or proposed means of achieving equivalency. If deviating from

the specified product or method, describe equivalent equipment and methods.

3. Provide table of contents.
4. All submittals shall be provided with sufficient clarity to avoid blurred or unreadable text resulting from poorly scanned images.
5. Partial submittals will not be acceptable. Unclear, or partial reproductions of manufacturer's original catalog cuts or descriptive data will not be accepted. Each item supplied shall be clearly identified on each sheet.

B. Product Data: For each type of equipment, device, and material.

1. Annotated to indicate rated capacities, finishes, electrical characteristics, and operating characteristics.
2. Proof of UL Listing
3. Manufacturer's warranty statement

C. Shop Drawings:

1. Complete fire alarm installation drawings showing layout and location of all initiating devices, notification appliances, control panels and electrical supply panels for power connections to the system.
2. Device legend in accordance with NFPA 170.
3. Candela ratings of all visual notification appliances.
4. Location of and connection to all other devices and equipment included in the complete functionality of the system, as specified herein.
5. Layout and location drawings shall show all conduit runs, conduit sizes, wire counts, wire color-coding and device wiring order.
6. Complete point-to-point wiring diagrams showing the points of connection and terminal used for all electrical connections in the system including internal wiring diagrams of all equipment and devices.
7. Clearly show the location and function of all operable switches and lamps.
8. Sequence of operation (SOO) matrix coordinated with all trades.

9. Fire stopping details for penetrations through fire-resistance-rated assemblies.

D. Calculations:

1. Complete battery calculations showing all electrical requirements of the entire fire alarm system including the current draw of all individual devices, both in alarm and supervisory modes. Calculations shall include the battery discharge constant "C".
2. Complete voltage drop calculations for each notification appliance circuit using the following criteria.
 - a. Starting voltage shall be 20.4 VDC.
 - b. The current draw shall be the maximum current draw listed in the manufacturer's literature (current draw at 16 VDC) for the selected candela rating.
 - c. The wire resistance shall be the resistance for single strand, uncoated, copper conductors in Table 8 of the NEC unless the conductor manufacturer's published data indicates a different value.
 - d. The minimum voltage at each visual notification appliance shall be 16 VDC.
 - e. For notification appliances operating at other than 24 VDC, the starting voltage, current draw, and minimum voltage shall comply with the manufacturer's recommendations.

E. HVAC interface:

1. Provide complete documentation and wiring showing connections to HVAC systems for fan shutdown, fire/smoke damper control, and other related controls.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Submit proof of certification in accordance with the Quality Assurance portion of this Section.
1. Fire Alarm Technician.

2. Fire Alarm Installer.
3. Manufacturer's Representative.

1.7 CLOSEOUT SUBMITTALS

- A. Completion documentation shall be in full compliance with the requirements of the latest edition of NFPA 72, Chapter 7.
- B. Operating instructions shall include thorough testing procedures and recommended testing frequency for each item. Maintenance instructions shall include a complete troubleshooting manual. In addition to the operating and maintenance manuals, the Contractor shall supply a complete materials list of the fire alarm system including the addresses and phone numbers of the manufacturer and the local supplier for each item, if applicable.
- C. As-built drawings shall include the following information:
 1. Locations of all installed equipment.
 2. Locations of all initiating devices.
 3. Locations of all notification appliances.
 4. Identities or addresses of all devices and notification appliances.
 5. Conduit routing.
 6. Wiring diagrams.
 7. Identification of color coding.
 8. Terminal designations.
 9. Tag numbers.
- D. Preventive Maintenance (PM) Schedule
 1. Submit recommended preventive maintenance schedule for all equipment and systems.
 2. Include item and system description.
 3. Identify recommended time interval.

1.8 WARRANTY

- A. Contractor-furnished equipment shall be warrantied (guaranteed) for a period of one (1) year from the date of substantial completion. Replacement of components due to either manufacturing or quality type defects shall be provided at no cost to the District during this period.

1.9 QUALITY ASSURANCE

- A. Fire alarm systems shall be designed and installed in accordance with the applicable NFPA standards, locally adopted building code, fire prevention code, and other local policies, interpretations and standards as listed in Part 1 References.
 - 1. If there is a conflict between the reference codes or standards and this SECTION, it is the Contractor's responsibility to notify the Engineer in writing. The most stringent requirement, as determined by the Engineer shall apply.
- B. Installer Qualifications:
 - 1. The Contractor for the fire alarm installation shall be a qualified Fire Alarm Contractor, regularly engaged in the installation of fire alarm systems with a California Electrical (C-10) Contractor License.
 - 2. The Contractor's responsibilities include designing, fabricating, installing and programming the fire alarm system and providing professional design and engineering services needed to assume engineering responsibility.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports shall be by a qualified Fire Alarm Technician.
 - b. The Contractor shall maintain a qualified Fire Alarm Installer on-site during installation.
 - c. The Contractor shall maintain a qualified Fire Alarm Technician on-site during Acceptance Testing.
 - 3. Provide the services of a Manufacturer's Representative. The Manufacturer's Representative shall supervise installation, software documentation, adjustment, preliminary testing, Acceptance Testing and AHJ Acceptance Testing. The Manufacturer's Representative shall provide the required instruction to the District's personnel in the system operation, maintenance and programming.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT

- A. The materials and equipment specified herein shall be new, of a domestic manufacturer, and furnished in accordance with all applicable codes and standards.
- B. All newly installed materials and equipment shall be manufactured within one year of installation.
- C. Individual components and composite systems shall be designed for continuous operation without undue heating or change in rated values and shall be properly fused.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Source Limitations for Fire Alarm Systems and Components:
 - 1. All components of the fire alarm system shall be furnished by the same manufacturer.
 - 2. The contractor shall provide, from the acceptable manufacturer's current product lines, equipment and components which comply with the requirements of these specifications. Equipment or components which do not provide the performance and features required by these specifications are not acceptable, regardless of the manufacturer.

2.2 FIRE ALARM AND DETECTION SYSTEM

- A. General: The system shall include new smoke detectors, manual pull stations, audible and visual notification appliances, annunciators, and control panels. The system shall be electrically supervised against open circuits and grounds in detection circuits, alarm circuits, and coils of the trouble and alarm relays. This supervision shall not require additional wires other than that the line pair terminates in an end-of-line device mounted at the last device on each circuit. The control panel shall continually monitor the status of each individual device connected to a pre-determined address on each addressable loop.
- B. System Wiring and Supervision:
 - 1. Provide Class B initiating device circuits.
 - 2. Provide Class B notification appliance circuits.

3. Provide Class B audio circuits.
4. Provide Class B signaling line circuits.

C. Power Supplies:

1. The system shall be operated from a 120 volt, 60 hertz supply, transformed and rectified to 24V DC. Batteries located in the control panels or adjacent battery boxes shall supply standby power to the fire alarm system adequate for twenty-four (24) hours on standby plus five (5) minutes of alarm and clean agent releasing operation.
2. In case of power interruption, the system shall automatically transfer to standby power. An AC power "ON" lamp on the control panel shall be extinguished to indicate transfer to standby power and will remain extinguished until AC power has been restored. The control panel shall include automatic battery charging equipment.

D. Spare circuit capacity:

1. Do not load notification appliance circuits (horn/strobe) beyond 80 percent of their current and voltage capacity.
2. Do not load audio notification appliance circuits beyond 80 percent of their capacity based on tapped speaker load.

2.3 FIRE ALARM CONTROL PANEL (FACP)

A. The FACP shall include, but to not be limited to, the following features:

1. Microprocessor-based; network design; field programmable.
2. Electrical supervision of all initiating, signaling, and AC power input tripping circuits. For ground faults, open circuits, or AC power failure, there shall be a distinctive audible and visual trouble indication. The audible trouble device and visual trouble indicator(s) shall remain on until the system has been restored to normal, except that a silence switch will be provided to silence the trouble condition.
3. Trouble-silencing switch.
4. Automatic locked-in fire alarm initiating signals.

5. Manual, self-restoring-type fire alarm system reset switch.
6. A normally illuminated AC “POWER ON” indicating light.
7. Sufficient auxiliary alarm and trouble relays/contacts to perform all specified functions. The panel shall include normally open and normally closed common alarm and common trouble contacts.
8. Red system common alarm light.
9. Placement supervision of all modules. The removal of any module from the system shall initiate an audible and visual trouble condition.
10. Alarm conditions shall override trouble conditions.
11. Loss of any or all phases of AC power, a break in the standby battery power circuits, or abnormally low battery voltage shall result in the operation of the system’s audible and visual trouble signals.
12. The abnormal position of any system switch shall result in the operation of the system trouble signals.
13. Alarm silence switch which, when activated, will silence all notification appliance circuits.
14. Disconnect switch which, when activated, will disconnect the fire alarm control panel auxiliary power circuits. The systems disconnect switch permits testing or servicing of the alarm system without activating clean agent sprinkler system solenoid valves. The operation of the switch shall cause audible and visual indication at the panel.
15. Battery charging module shall be of the manual and automatic, solid-state type. The module shall manually and automatically vary the charging rate from float trickle or low-rate to equalize high-rate. The module shall use fuses to prevent damage due to overcurrent or reversal of battery polarity. The charger shall be capable of recovery of the batteries from full discharge to full charge in 48 hours or less. The module shall provide low- and high- voltage supervision.
16. Listed for releasing service.

2.4 ADDRESSABLE SMOKE DETECTORS

- A. Detectors shall be tested and listed in accordance with UL 268 or UL 268A. The detectors shall be of a two-part assembly consisting of an addressable twist-lock base with a detector housing. The base shall be the receptacle for the twist-in detector housing. The detector base shall contain screw terminals for making all wiring connections. Installation of the detector shall not require any soldering. Each detector shall contain a visual, red, LED alarm-indicating light which shall remain lit following detector actuation until the fire alarm system is manually reset.
- B. Power for detectors shall be provide through the signaling line circuits. Detectors having independent power circuits (4-wire type) shall have provisions for power supervision. Detector spacing and location shall be in accordance with the contract drawings, manufacturer's recommendations, requirements of NFPA 72. Detectors shall not be placed close to any discharge grille. Detectors shall have RF and transient filtering if these factors affect detector performance. It shall be the contractor's responsibility to take all adverse, ambient, or environmental effects on detector performance into consideration and design the system accordingly to preclude any false alarm problems.
- C. Spot Type Smoke Detectors
 - 1. Addressable, photoelectric, 24 VDC, spot-type, restorable smoke detector with pulsed infrared LED light source.
 - a. Nominal sensitivity shall be 2.5%-3.5% per foot obscuration when tested per UL 268.
 - b. LED indicator to indicate normal and alarm conditions.
- D. Addressable duct smoke detectors (where drawings indicate duct smoke detector provided by fire alarm contractor):
 - 1. Photoelectric type for duct installations.
 - 2. Provide detectors with approved duct-housing mounted exterior to the duct and with perforated sampling tubes extending across the width of the duct.
 - 3. Detector head shall contain amplifier-switching circuitry.
 - 4. The detector shall be mounted in an accessible location and upon activation, shall be capable of activating a remote indicating lamp on a remote annunciator.

5. Remote test switch with alarm indication.

2.5 MANUAL STATIONS

- A. Manual pull stations shall be of durable, molded plastic construction. Stations shall be non-break-glass, non-coded, single or double action, interior and/or weatherproof type, and be semi-flush mounted as indicated on the contract drawings.
- B. Stations shall be addressable. All wires shall be fastened by screws to a terminal block in the device. Contacts shall be switch-type of the proper number and arrangement to perform the functions required. The stations shall not be resettable without the use of a key.

2.6 FIRE PROTECTION SYSTEM INTERFACE

- A. Provide individually addressable modules or zone adapter modules and connections to the waterflow switches, tamper switches, and releasing solenoids of the fire sprinkler systems.
- B. The waterflow switches, tamper switches, and releasing solenoids will be furnished with the sprinkler equipment.

2.7 NOTIFICATION APPLIANCES

- A. General requirements for notification appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated, with screw terminals for system connections.
 1. Combination Notification Appliances: Factory-integrated audible and visual devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections, and mounted in compliance with NFPA 72.
 2. Weatherproof Notification Appliances: Notification appliances installed outdoors, in unconditioned spaces, and at other locations indicated on the drawings shall be weatherproof.
- B. Audible Tone Notification Appliances:
 1. Comply with UL 1480.
 2. Mounting shall be on the wall or ceiling with heights in compliance with NFPA 72.

3. Finish: Factory-finished white indoors. Factory-finished red outdoors.

2.8 ADDRESSABLE INTERFACE MODULE

- A. The addressable interface module shall incorporate a custom, microprocessor-based, integrated circuit that shall provide communication with its compatible control panel. The addressable interface module shall provide the means of interfacing direct shorting devices to the control panel's addressable circuits.
- B. The intelligent interface modules shall be available in three models. The single-point monitoring module shall be designed to monitor a single, normally open or normally closed dry-contact. The interface module shall report the contact's status to the control panel. The single point monitoring module model shall only monitor and report the status of the contact while the single point monitoring module with relay shall incorporate an addressable Form-C relay. The relay and contact device input shall be controlled as separate functions at the same address by the control panel. The dual-input monitoring module shall be designed to supervise and monitor two sets of dry contacts. This interface module shall require two address settings.
- C. The devices shall be capable of and listed for interfacing normally closed security switches to the panel. The addressable interface module shall be dynamically supervised and uniquely identifiable by the control panel.

2.9 REMOTE ANNUNCIATOR

- A. Provide flush mounted annunciator with a recessed, stainless steel faceplate and aluminum frame as indicated on contract drawings.
- B. Annunciators shall operate on power from the control panel source after an initiating device has been activated.

2.10 WIRING

- A. Wiring for the multiplex circuit shall be as recommended by the system manufacturer with polyethylene insulation rated for a minimum of 300 VAC and overall polyvinyl chloride (PVC) jackets.
- B. Wiring for low voltage loops shall be No. 18 AWG minimum and that for 120 VAC circuits shall be No. 12 AWG minimum.
- C. Specific consideration shall be given to voltage drop on the 24 VDC circuits. Where potential problems may exist, conductor sizes shall be changed accordingly.
- D. All wiring shall be color-coded, copper conductors.

- E. Transposing or changing color-coding of wiring within a circuit shall not be permitted even if the wire sizes change.

2.11 RELEASE STATION

- A. Clean agent manual release stations shall be of durable, molded plastic construction. Stations shall be non-break-glass, non-coded, single or double action, interior and/or weatherproof type, and be semi-flush mounted as indicated on the contract drawings.
- B. Stations shall be addressable. All wires shall be fastened by screws to a terminal block in the device. Contacts shall be switch-type of the proper number and arrangement to perform the functions required. The stations shall not be resettable without the use of a key.

2.12 ABORT STATION

- A. Clean agent abort stations shall be of durable, molded plastic construction. Stations shall be non-break-glass, non-coded, single or double action, interior and/or weatherproof type, and be semi-flush mounted as indicated on the contract drawings.
- B. Stations shall be addressable. All wires shall be fastened by screws to a terminal block in the device. Contacts shall be switch-type of the proper number and arrangement to perform the functions required. The stations shall not be resettable without the use of a key.

2.13 EMERGENCY POWER OFF (EPO)

- A. Provide EPO for clean agent system if required by AHJ. Contractor shall be responsible for design of EPO. Coordinate location of EPO with the Engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The installation shall be accomplished by personnel experienced in the installation of the specified type of system. The services of a qualified technician, experienced in the installation and operation of the type of system being installed, shall be provided to supervise the installation, testing, and adjustment of the system.
- B. Wire markers shall be provided for each wire connected to equipment. The markers shall be of the taped band type, of permanent materials, and shall be permanently stamped with the proper identification. The markers shall be attached in a manner

that will not permit accidental detachment. All splices shall be made in a manner that is approved by NFPA 70.

- C. All interior wiring shall be installed in dedicated rigid metal conduit or electrical metallic tubing except where MC cable is permitted by this Section. The sum of the cross-sectional areas of individual conductors shall not exceed 40 percent of the interior cross-sectional area of the conduit. All conduits shall be 1/2-inch minimum. All wiring in damp or wet locations shall have a "W" in the type designation. All underground wiring shall also have a "W" in the type designation and shall be installed in conduits that meet the requirements of NFPA 70 for underground installations. Direct burial installations are not acceptable.
- D. Conduit, boxes, and control panels shall be securely mounted and fastened with proper fittings to assure grounding throughout the system. In finished areas, conduit shall be run concealed. In areas where conduit is run exposed, as much as possible, conduit shall be run high enough so that if a future suspended ceiling is installed, the conduits will become concealed.
 - 1. Flexible conduit shall be used for connecting to devices mounted in suspended lay-in ceiling panels.
 - 2. Maintain continuity of shielding of shielded conductors in outlet and junction boxes. Ground the shields per the manufacturer's recommendations.
- E. Coordinate location and obtain approval for location of all devices and equipment prior to rough-in including, but not limited to, the following:
 - 1. Notification appliances.
 - 2. Manual pull stations.
 - 3. Automatic initiating devices.
 - 4. Remote annunciators.
 - 5. Clean agent fire alarm control panel.
- F. Use of MC cable for fire alarm system wiring is acceptable where work complies with all of the following:
 - 1. Installed in concealed spaces only.
 - 2. Where installed above accessed ceilings: run parallel to building lines plumb and level.

3. Red color coding throughout.
 4. Supports at 6 feet maximum using steel channel or equivalent support. No J-hooks allowed.
 5. Support within 12 inches of any outlet box or junction box.
 6. All work is NEC 330 and 760 compliant. Provide more stringent build including EMT construction where specified or noted above.
 7. Where acceptable to the AHJ.
- G. Install all fire alarm panels, including FACP's, RCP's, NAC panels, and VCC's such that the top of the equipment is not more than 6 feet above finished floor.

3.2 FIELD QUALITY CONTROL

A. Preparation:

1. Pre-test all systems prior to performing Acceptance Testing.
 - a. Pre-testing shall include performing all Acceptance Testing Activities.
 - b. Correct any deficiencies that are found and re-test prior to performing Acceptance Testing.
2. After successful completion of pre-test activities, perform Acceptance Testing.
 - a. The fire alarm system shall be left in service for at least ten (10) days after Acceptance Testing and before AHJ Acceptance Testing to verify continued performance in accordance with this Section. The fire alarm Contractor shall investigate and correct all trouble signals and unwanted alarms that occur during this period and shall provide the District or District's representative with a certified statement of the nature of the failure and the corrective actions.
 - b. Any device found to be inoperative or not in compliance with this Section shall be replaced by the contractor at no additional expense to the District and without undue delay.
3. After successful completion of Acceptance Testing, perform AHJ Acceptance Testing.

- a. Schedule AHJ Acceptance Testing as required by the AHJ. Coordinate schedule with District.
 - b. Any device found to be inoperative or not in compliance with this Section shall be replaced by the contractor at no additional expense to the District and without undue delay.
- B. Equipment:
 - 1. Provide equipment and materials as required to perform system Acceptance Testing. Equipment and materials shall include, but shall not be limited to the following:
 - a. Keys to all control panels, auxiliary panels, and device reset keys.
 - b. Multimeter.
 - c. Testing gas for testing smoke detectors.
 - d. Sound pressure meter.
- C. Complete Acceptance Testing in accordance with NFPA 72, and this Section.
- D. Acceptance Testing:
 - 1. Coordinate with fire protection tests. Operate as required.
 - 2. Coordinate with HVAC systems tests. Operate as required.
 - 3. Coordinate with elevator tests. Operate as required.
 - 4. Perform Acceptance Testing:
 - a. Visual Inspection:
 - 1) Fire alarm systems are complete and installed in accordance with NFPA 72 and this Section.
 - 2) Installation of equipment, devices, raceway, wiring, and interfaces with other systems is in accordance with approved shop drawings.
 - 3) Locations of smoke and heat detectors are in accordance with NFPA 72 regarding ceiling heights, beams, and other building features.

- 4) Detectors are accessible for testing.
- 5) Each notification appliance is installed in the orientations for which it is listed.
- 6) Each wall mounted notification appliance is installed at the correct height.
- 7) Finish work is complete.
- 8) Labels and signs have been installed, are complete and correct, and match approved shop drawings.
- 9) Verify the circuit breaker serving each fire alarm equipment has been provided with a lock and has been marked to indicate the equipment served.
- 10) All electrical connections have been made.
- 11) Connections to other interfaced systems have been made.
- 12) Verify the ratings of fuses in all fire alarm control equipment.

b. Wiring:

- 1) Test all wiring for grounds, opens, and shorts. The minimum resistance between any two conductors, or between any one conductor and ground, shall be ten (10) megohms. Test wiring after conduit, wire, etc. are installed, but before the electronics and detectors are installed.

c. Fire alarm control equipment:

- 1) Perform the following tests and inspections, as applicable, for every FACP, RCP, and NAC panel.
 - a) Test all lamps and LEDs.
 - b) Verify correct receipt of alarm, supervisory, and trouble signals.
 - c) Verify correct operation of occupant notification signals.
 - d) Verify correct operation of auxiliary control functions as described below.

- e) Verify alarm, supervisory, trouble and other signals are transmitted to the supervising station as described in the Sequence of Operations matrix.
- f) Disconnect the fire alarm system from the network connection to other buildings on the campus.
 - i) Verify receipt of trouble signal at the FACP in each building.
 - ii) Verify the fire alarm system within each building continues to perform all required functions independently.
- g) Simulate open circuit on each SLC, IDC, and NAC.
 - i) Verify receipt of trouble signal at the FACP.
 - ii) Verify performance of the circuit in accordance with NFPA 72 for the class of pathway required by this Section.
- h) Simulate ground fault on each SLC, IDC, and NAC.
 - i) Verify receipt of trouble signal at the FACP.
 - ii) Verify performance of the circuit in accordance with NFPA 72 for the class of pathway required by this Section.
- i) Simulate short circuit on each SLC, IDC, and NAC.
 - i) Verify receipt of trouble signal at the FACP.
 - ii) Verify performance of the circuit in accordance with NFPA 72 for the class of pathway required by this Section.
- j) Disconnect primary power. Leave primary power disconnected for twenty-four (24) hours.
 - i) Verify receipt of trouble signal at the associated FACP immediately after the primary power is disconnected.

- ii) Verify power is automatically transferred to battery backup within ten (10) seconds after the primary power is disconnected.
 - iii) After 24 hours, measure activate an initiating device to activate notification appliances.
 - iv) Operate system in alarm including operation of notification appliances for 5 minutes. After 5 minutes of alarm measure the system current. Verify the batteries are capable of supplying the required current used for the battery and voltage drop calculations.
 - v) Restore primary power.
 - vi) Disconnect primary power after 48 hours of battery charging. Verify battery voltage has returned to normal.
- k) Verify clean agent sprinkler system releasing solenoid activation.
 - i) Activate one initiating device in each clean agent sprinkler system zone (two initiating devices where drawings indicate cross-zoning).
 - ii) Verify the solenoid is activated for the correct clean agent sprinkler system.
- d. Remote annunciators: Verify alarm, supervisory, and trouble signals are correctly annunciated.
- e. Spot smoke detectors:
 - 1) Test each spot smoke detector using canned smoke.
 - 2) Verify the alarm signal is received at the FACP or RCP.
 - 3) Verify the smoke detector identity and location are correctly annunciated at the FACP.
 - 4) Where drawings indicate a spot smoke detector is used for fire/smoke damper control, verify the associated fire/smoke damper is closed.

f. Duct smoke detectors:

- 1) Coordinate with the mechanical contractor for air handling equipment operation.
- 2) Test each duct smoke detector using canned smoke. Testing shall include duct smoke detectors provided by the air handling equipment vendor.
- 3) Verify the supervisory signal is received at the FACP.
- 4) Verify the duct smoke detector identity and location are correctly annunciated at the FACP.
- 5) Where the duct smoke detector is used for air handling equipment shutdown, verify the equipment is shutdown.
- 6) Where the duct smoke detector is used for fire/smoke damper control, verify the fire/smoke damper is closed.
- 7) Verify the indicator on the remote test switch is illuminated.
- 8) Verify the duct smoke detector can be reset using the remote test switch.
- 9) Activate the remote test switch and verify the supervisory signal and equipment interface functions operate as when tested with canned smoke.
- 10) Measure the differential pressure between the two sampling tubes with the air handling equipment operating. Verify the differential pressure is within the range specified by the duct smoke detector manufacturer.

g. Manual pull stations:

- 1) Activate each manual pull station.
- 2) Verify the alarm signal is received at the FACP.
- 3) Verify the manual pull station identity and location are correctly annunciated at the FACP.

h. Sprinkler system waterflow switches:

- 1) Coordinate with the fire protection contractor for testing of each waterflow switch.
 - 2) Verify the alarm signal is received at the FACP.
 - 3) Verify the waterflow switch identity and location are correctly annunciated at the FACP.
- i. Sprinkler system valve supervisory switches:
- 1) Coordinate with the fire protection contractor for operation of each supervised valve.
 - 2) Verify the supervisory signal is received at the FACP.
 - 3) Verify the supervisory switch identity and location are correctly annunciated at the FACP.
- j. Visual notification appliances:
- 1) Verify the candela rating on each visual notification appliance matches the approved shop drawings.
 - 2) Verify each visual notification appliance operates.
- k. Audible notification appliances:
- 1) Verify each audible notification appliance operates.
 - 2) Verify audibility.
 - a) Measure the ambient sound level 5 feet above the floor without notification appliances operating.
 - b) Measure the sound pressure level 5 feet above the floor with notification appliances operating.
 - c) Verify the sound pressure level with notification appliances operating is at least 15 dB above the average ambient sound level or 5 dB above the maximum ambient sound level having a duration of at least 60 seconds, whichever is greater.
- l. Air handling equipment shutdown:

- 1) Activate each duct smoke detector associated with air handling equipment. Verify the correct air handling equipment is shut down.
 - 2) Activate each air sampling smoke detector associated with air handling equipment. Verify the correct air handling equipment is shut down.
5. Prepare test and inspection reports and submit to the Authority Having Jurisdiction. Include the following:
 - a. NFPA 72 Record of Completion and Supplemental Records of Completion.

END OF SECTION

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SECTION 40 05 00

COMMON WORK RESULTS FOR PROCESS INTERCONNECTIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Division 40, Process Interconnection covers the work necessary for the complete process control system (PCS). Furnish materials, labor, and equipment in accordance with these specifications and the accompanying Drawings.
2. The requirements of Division 40, Process Interconnections in their entirety applies to all process control system work and equipment furnished on this project whether furnished or specified under this or other divisions of these specifications.
3. See Division 01, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this project.
4. Like items of materials provided hereunder shall be the end products of one manufacturer in order to achieve standardization for appearance, maintenance, and replacement.

1.2 QUALITY ASSURANCE

A. Codes and Standards: The components covered by these specifications shall be designed, tested, assembled, and installed in accordance with the minimum requirements of the latest published standards of the California Electrical Code (CEC), National Electrical Safety Code (NESC), Underwriters Laboratory (UL), American National Standard Institute (ANSI), Institute of Electrical and Electronic Engineers, Inc. (IEEE), and the National Electrical Manufacturers Association (NEMA).

B. Workmanship:

1. Assign a competent representative who shall supervise the work from beginning to completion and final acceptance.
2. All labor shall be performed by skilled workmen who have had a minimum of 5 years of experience on similar projects.
3. Ensure that all equipment and materials fit properly in their installations.

4. All components shall be new and of the best quality, constructed of durable materials, and designed for long life in continuous service with a minimum of maintenance.
5. Any required work to correct improperly fit installations shall be performed by the process control system integrator (PCSS) at no additional expense to the District.
6. All free-standing or floor-mounted equipment shall be front aligned.
7. The PCSS shall ensure that all equipment and materials are installed in accordance with the design and vendor furnished District-approved Drawings.
8. Underwriters Laboratories Inc.: Unless otherwise specified, electrical equipment and material shall be listed and labeled for the purpose for which it is used by the Underwriters, Laboratories Inc. (UL). All control panels provided under this Division shall have a UL stamp and be constructed by a UL approved panel fabrication shop.

1.3 SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00 Submittal Procedures.

1. The PCSS shall furnish submittals for approval as outlined below:
 - a. Product Data.
 - b. Warranty.
 - c. Bill of Materials.
 - d. Control panel dimensions (elevations, plan views, sections).
 - e. Schematic (elementary) diagrams and wiring diagrams.
 - f. Interconnection wiring diagrams for each system showing every wire by number, every junction terminal box or device to which it connects from origination to final destination, and boxes, manholes, handholes, and cabinets through which it passes. These diagrams shall show wiring installed by Contractor between items of manufactured, pre-wired or non-pre-wired equipment.
 - g. Control loop diagrams
 - h. As-built documentation.
 - i. Certified factory test reports.
 - j. Proposed field functional tests.

- k. Field functional test reports.
 - l. Manufacturer's certificate of proper installation.
- B. Submit certified shop drawings and diagrams as follows:
 - 1. Layouts indicating conformity with space requirements.
 - 2. Assembly drawings in sufficient detail to identify every part of the specified equipment including bills of material.
 - 3. Detailed dimension, outline, and panel, and structure layout drawings showing the principal dimensions of the equipment, the location of all devices therein.
 - 4. Connections detailing all internal wiring, and interconnection diagrams detailing all field wiring.
- C. Seismic requirements:
 - 1. Submit seismic requirements in accordance with Sections 01 43 11 Seismic Qualifications and Criteria and 01 81 02 Seismic Design Criteria.

1.4 RESPONSIBILITY

- A. The PCSS shall be responsible for:
 - 1. Complete systems functionally operational in accordance with the intent of these Contract Documents.
 - 2. Coordinating the details of equipment layouts and construction for all specification divisions which affect the work covered under Division 40, Process Interconnections.
 - 3. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.
 - 4. Coordination with Division 26 - Electrical; for installation, wiring and cable requirements.

1.5 INTENT OF DRAWINGS

- A. The Contract Drawings indicate the extent, general location, and arrangement of equipment.

1.6 ENCLOSURE TYPES

- A. Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings:
 - 1. NEMA 1 for dry, non-process indoor locations shown on the Drawings.

2. NEMA 3R for outdoor locations shown on the Drawings.
3. NEMA 12 for locations shown on the Drawings. All supporting hardware shall be galvanized steel.
4. NEMA 4 for rooms below grade (including basements and buried vaults) and locations shown on the Drawings.
5. NEMA 4X for locations shown on the Drawings, typically in areas where corrosive materials are used and stored. Stainless steel NEMA 4X enclosures shall be used in all outdoors locations and indoor wet locations. Fiber glass NEMA 4X enclosures shall be utilized if noted on the Drawings in corrosive areas.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Unless otherwise indicated, provide all first-quality, new materials and equipment, free from any defects, in first-class condition, and suitable for the space provided. Provide materials and equipment listed by UL wherever standards have been established by that agency.
- B. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer.

2.2 STANDARD PRODUCTS

- A. Unless otherwise indicated, provide materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturers' latest standard design that conforms to these specifications.
- B. The control panels shall conform to UL 508A and bearing the label.

2.3 EQUIPMENT FINISH

- A. Provide materials and equipment with manufacturers' standard finish system. Provide ANSI 61, light grey color or RAL 7035 (light gray) with Electrostatic Powder for all equipment unless otherwise specified in the individual equipment sections. Provide two quarts of touchup paint.
- B. Provide standard manufactures brush finish for all stainless steel NEMA 4X enclosures.

2.4 ENVIRONMENTAL

- A. Provide materials and equipment suitable for installation and operation under rated conditions at 200 feet above sea level and with maximum ambient temperature of 39 DEG C.

2.5 OUTDOOR EQUIPMENT

- A. Provide equipment and devices to be installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of -8 degrees C to 60 degrees C. Equipment must be capable of proper operation at rated output continuously in this ambient temperature range in direct sun. Provide any additional equipment such as enclosures, sunshades, and cooling equipment so that this performance requirement can be met.

PART 3 - EXECUTION

3.1 GENERAL

- A. Unless specified otherwise, process interconnections equipment and anchoring systems shall be designed to withstand seismic forces as specified in Sections 01 43 11 Seismic Qualifications and Criteria and 01 81 02 Seismic Design Criteria.
- B. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance. Carry out work in accordance with NECA Standard of Installation unless otherwise specified.

3.2 PROTECTION DURING CONSTRUCTION

- A. Throughout this contract, provide protection for materials and equipment against loss, theft or damage in accordance with provisions elsewhere in these Contract Documents. Throughout this contract, follow manufacturers' recommendations for storage. Protect all equipment from the effects of weather. Prior to installation, store all items in clean, dry, indoor locations
- B. Following installation, protect materials and equipment from corrosion, physical damage, and the effects of moisture. Keep openings in boxes or equipment closed during construction.

3.3 MATERIAL AND EQUIPMENT INSTALLATION

- A. Follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between the manufacturers' instructions, codes and regulations, and these Contract Documents, follow Engineer's decision. Keep copy of manufacturers' installation instructions on the jobsite available for review at all times.

3.4 CLEANING AND TOUCHUP PAINTING

- A. Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove all materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish. If extensive damage is done to equipment paint surfaces, refinish the entire equipment in a manner that provides a finish equal to or better than the factory finish,

that meets the requirements of the specifications, and that is acceptable to the Engineer.

- B. The interior of all panels and enclosures shall be vacuumed and wiped free of dust just prior to final acceptance.

3.5 INSPECTION

- A. Allow materials, equipment, and workmanship to be inspected at any time by the Engineer and District or their representatives. Correct work, materials, or equipment not in accordance with these Contract Documents or found to be deficient or defective in a manner satisfactory to the Engineer.

3.6 STANDARDS, CODES, PERMITS, AND REGULATIONS

- A. Perform work; furnish, install, and test materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
 - 1. Underwriters' Laboratories (UL).
 - 2. National Electrical Safety Code (NESC).
 - 3. American National Standards Institute (ANSI).
 - 4. National Electrical Manufacturer's Association (NEMA).
 - 5. National Electrical Contractors Association (NECA) Standard of Installation.
 - 6. Institute of Electrical and Electronics Engineers (IEEE).
 - 7. California Electrical Code (CEC)
- B. Conflicts, if any that may exist between the above items will be resolved at the discretion of the Engineer.
- C. Wherever the requirements of the specifications or Drawings exceed those of the above items, the requirements of the specifications or Drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.

3.7 MANUFACTURER'S FIELD SERVICES

- A. General
 - 1. Manufacturer's service personnel shall perform all tests, inspections, and adjustments required by the manufacturer and as specified in this section.
 - 2. Manufacturer's service personnel shall report to the job-site with any test equipment and special tools as required and specified.

3. Tests and inspections shall include, but not be limited to, equipment as listed in this section.

3.8 TESTING

- A. Testing shall be performed in accordance with Sections 01 75 17 Field Testing and Startup and 40 80 00 Commissioning of Process Systems.

END OF SECTION

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SECTION 40 05 13

PROCESS PIPE AND FITTINGS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide all labor, materials, equipment, incidentals, and appurtenances required for process pipe and fittings in accordance with this Section and applicable reference standards listed in Article 1.3.
2. Furnish, install, test and make ready for operation all process pipe and fittings of the type(s) and size(s) required as shown on the Drawings and as specified. Provide all related appurtenances, including but not limited to attachments, foundations, anchors, supports, couplings, restraints and all related accessories to provide complete operational piping systems as shown on the Drawings and as specified.
3. Unless otherwise indicated, all fittings and appurtenances shall be of the same type and grade of materials as the connecting pipe. All products provided under this section shall conform to current AWWA and ANSI specifications as appropriate to the type of pipe specified.
4. Furnish one set of all special tools required to completely assemble, disassemble, or maintain the process piping and appurtenances. Special tools shall refer to oversized or specially dimensioned tools, special attachments or fixtures, or any similar items.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

1.3 REFERENCES

A. Reference Standards

1. ASME International (ASME)
 - a. ASME B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
 - b. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
 - c. ASME B16.1 Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
 - d. ASME B16.3 Malleable Iron Threaded Fittings Classes 150 and 300
 - e. ASME B16.9 Factory-Made Wrought Butt welding Fittings
 - f. ASME B16.15 Cast Bronze Threaded Fittings Classes 125 and 250

- g. ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
 - h. ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
 - i. ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - j. ASME B16.26 Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
 - k. ASME B31.1 Power Piping
 - l. ASME B31.9 Building Services Piping
2. ASTM International (ASTM)
- a. ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
 - b. ASTM A269 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
 - c. ASTM A307 Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
 - d. ASTM A479 Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
 - e. ASTM A536 Standard Specification for Ductile Iron Castings
 - f. ASTM A632 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service
 - g. ASTM B32 Standard Specification for Solder Metal
 - h. ASTM B61 Standard Specification for Steam or Valve Bronze Castings
 - i. ASTM B62 Standard Specification for Composition Bronze or Ounce Metal Castings
 - j. ASTM B88 Standard Specification for Seamless Copper Water Tube
 - k. ASTM B124 Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
 - l. ASTM B813 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper
3. American Water Works Association (AWWA)
- a. AWWA C104/A21.4 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
 - b. ANSI/AWWA C110/A21.10 Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in (76 mm through 1219 mm), for Water
 - c. ANSI/AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
 - d. AWWA C115/A21.15 Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
 - e. AWWA C150/A21.50 Thickness Design of Ductile-Iron Pipe
 - f. AWWA C606 Grooved and Shouldered Joints

4. International Organization For Standardization (ISO)

- a. ISO 228-1 Pipe Threads Where Pressure-Tight Joints Are Not Made on the Threads - Part 1: Dimensions, Tolerances and Designation

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination, Sequencing, and Scheduling: per Division 01 General Requirements.

1.5 SUBMITTALS

- A. Submit the following in accordance with Division 01 General Requirements.

B. Shop Drawings

1. Shop Drawings for each type of process pipe shall be identified with the applicable style or series designation. Shop drawings shall show layout and dimensions of equipment, major components, key alignment locations and locations of bolt holes. Drawings shall show critical field dimensions identified by the Manufacturer.
2. Shop Drawings shall show layouts and dimensions of the piping, including actual pipe lengths, diameters, fittings and appurtenances.

C. Product Data

1. Submit sufficient product data to verify compliance with the specifications and to illustrate the construction and assembly of the products. Include compliance of materials and components with applicable standards. Product data shall include manufacturer's descriptive data, technical literature, performance charts, catalog cuts, and installation instructions.
2. Prior to shipment of pipe, submit a certified affidavit of compliance from the pipe manufacturer stating that the pipe, fittings, gaskets, linings and exterior coatings for this Project have been manufactured and tested in accordance with applicable AWWA, ASTM and other standards as well as the requirements specified.

D. Reports

1. Submit field test reports for each section of piping tested for pressure and leakage.

1.6 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.

- B. All welding shall be conducted under qualified welding procedures. All welders and operators shall be certified in accordance with the latest applicable AWS and

ANSI codes for shop and Project Site welding of piping work. Furnish written proof of certifications upon request from the Engineer.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Provide in accordance with Division 01 General Requirements.
- B. All equipment delivered and placed in storage shall be provided with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants in accordance with the Manufacturer's written instructions.
- C. Finished surfaces of all exposed openings shall be protected by caps, wooden blanks or other suitable cover to prevent foreign material and debris from entering the equipment.
- D. Off-load equipment at the installation site using equipment of sufficient size and design to prevent damage to the equipment. Immediately after off-loading, inspect all equipment for shipping damage or missing parts. Any damage or discrepancy shall be noted in a written claim with the shipper prior to accepting delivery. Validate all serial numbers and parts lists with the shipping documentation. Notify the Manufacturer of any unacceptable conditions with the shipper. Pipe which has been rejected after delivery shall be specifically marked for non-use and shall be removed from the Project Site at no additional cost to District. The acceptance of manufacturer's pipe samples prior to shipment shall not guarantee acceptance of all subsequent piping delivered to the job Site.
- E. Where necessary to store outside, enclose with durable, waterproof wrapping. Store rubber products under cover out of direct sunlight. Do not store materials directly on the ground.
- F. Stacking & Unloading
 - 1. Unload all piping in strict accordance with the manufacturer's recommendations. Take care not to damage the pipe during unloading. Utilize padding on all hooks, slings, and pipe tongs used for unloading to prevent damage to the piping including exterior coating and interior lining. Damage to the interior lining of piping shall render it unfit for use. Dropping of pipe during unloading is not acceptable. Care shall be taken to not skid piping against stationary piping during unloading or stacking.
 - 2. All piping shall be stacked in accordance within the limits recommended by its manufacturer. The piping shall be supported off the ground through the use on timbers, rails, or concrete as recommended by the piping manufacturer.
 - 3. Avoid contact between stainless steel piping and ferrous surfaces or materials, which may lead to rusting of particles embedded in the walls of stainless steel piping. All stainless steel piping shall be stored on supports constructed of non-ferrous metal materials. All tools for stainless steel

piping installation shall be specifically designated for use on stainless steel piping to ensure no contamination from ferrous metals occurs. All piping storage and fabrication supports shall be constructed from non-ferrous metal, stainless steel, or provided with a rubber lining.

1.8 WARRANTY

- A. Provide in accordance with Division 01 General Requirements.

1.9 SITE CONDITIONS

- A. Existing Conditions: per Division 01 General Requirements.

PART 2 – PRODUCTS

2.1 COPPER PIPE, TUBING & FITTINGS

- A. See 22 11 16, Domestic Water Piping. Pipe sizes and end connections shall be as shown on the Drawings or as specified. Provide all necessary end connections and appurtenances as required to connect to the end uses.
- B. Press Fittings
 - 1. Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be FKM (Viton). Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer.
 - 2. Press fittings shall be designed to assure leakage of liquids and/or gases from inside the system past the sealing element of an un-pressed connection. The function of this feature is to provide easy identification of connections which have not been pressed prior to putting the system into operation.
 - 3. Press fittings shall be of the same Type and Temper of copper as the connecting pipe.
- C. Flanged Joints
 - 1. Where copper piping is connected to equipment the end connection shall be flanged. Flanges and flanged fittings shall be faced and drilled Class 125/150 in accordance with ASME B16.26. For tie-in to existing flanges, field check existing flanges for non-standard bolt-hole configurations. Provide adaptors and fittings to assure new pipes and flanges mate properly. All flanged joints shall be in alignment with the holes mating with the centerline of the piping.
 - 2. All bolts for flanged connections shall be lubricated with a graphite and oil mixture prior to tightening. All bolts shall be tightened with proper tools to

avoid overstressing the piping, bolts, and sealing gaskets beyond the proper designed limits.

3. Alloy bolts ASTM A193, Grade B7 shall be tightened to obtain a stress of 45,000 psi. Carbon steel bolts ASTM A307, Grade B shall be tightened to obtain a stress of 15,000 psi based on the root thread area. All flange bolts shall be of sufficient length so as to allow a minimum of 2 full threads to extend beyond the fastening nut. Provide dielectric isolation between dissimilar metals.

D. Threaded Joints

1. Threaded joints shall be made with an Engineer approved joint compound applied to the male thread only. The use of caulking on the threaded joint shall not be acceptable. All threaded connections shall be in accordance with ASME B1.20.1. The threaded connections shall be full thread, true taper type, machined accurately to gauge. Size reductions shall be through the use of reducing fittings. All plugs shall be steel or brass with a square head design. Bushings and close nipples shall not be acceptable.

E. Solder & Flux

1. Solder and flux shall conform to ASTM B32. The solder alloy shall be 95 percent tin and 5 percent antimony on all pressure piping and potable water piping. No lead-bearing solder shall be permitted under any circumstances. All soldering shall conform to ASTM B813. Silver solder with 45 percent brazing silver alloy shall be utilized.
2. All tubing shall be square cut with reamed ends to prevent improperly sized ends or burrs prior to soldering. Prior to soldering all surfaces shall be cleaned to a bright metal finish and be free of dirt, grease, or other foreign materials prior to fluxing and soldering. All cleaning shall be conducted using an emery cloth, sandpaper, or steel wool.
3. Both the outside and inside ends of the pipe to be soldered shall be cleaned to a length of at least 3/4 inches greater than the depth of the fitting. All joints shall be assembled using non-corrosive flux. Acid solder or flux shall not be permitted under any circumstances. Any cracks, holes, areas of incomplete penetration, or other related defective connections shall not be acceptable. Peening of defects is not permitted under any circumstances.
4. All soldered joints shall be heated uniformly to the solder melting point to allow a complete draw of the solder into the connecting joint. All excess solder shall be completely removed with a cloth brush. A fillet shall be left around the end of the fitting. All connections shall be required to have full penetration of solder throughout the entire connection joint. The cooling of soldered joints via quenching is not permitted.

F. Brazing

1. All flux shall be applied in strict accordance with the recommendations of the brazing manufacturer. Flux is required when joining copper tubing to cast bronze fittings. Flux is not required when joining copper tubing to wrought copper fittings. Parts to be joined shall be heated 1 inch from the edge of the fitting. Once the flux has become transparent, the heating of the fitting at the base of the cup shall commence. The torch flame shall move continuously throughout the process.
2. Brazing materials shall be applied where the tubing enters the socket or fitting. Direct flames shall not be applied to the brazing material. Capillary action from the heated joint shall draw the brazing material into the joint. A properly made joint shall show a visible fillet completely around the pipe joint. No additional filler shall be added once a fillet has been formed.
3. All flux material shall be removed once the brazing material has solidified. All fittings shall be allowed to cool naturally without the aid of separate quenching. Any cracks, holes, areas of incomplete penetration, or other related defective connections is not acceptable. Peening of defects is not permitted under any circumstances.

G. Grooved Joint Couplings and Fittings

1. Grooved end copper fittings shall be ASME B16.22 wrought copper or ASME B16.18 cast bronze, manufactured to copper tube dimensions. Flaring of tube or fitting ends to accommodate alternate sized couplings shall not be permitted.
 - a. Provide grooved end fittings for copper pipe of the same type, style, and duty. Acceptable level of quality: equivalent to Victaulic – Copper Connection.
2. Grooved joint couplings and associated fittings shall be ASTM A536, Grade 65-45-12 ductile iron, manufactured to copper tube dimensions. Couplings shall have two housing segments. Coupling gaskets shall be pressure responsive elastomer, center-leg type with pipe stop to ensure proper groove engagement, alignment, and pipe insertion depth. Fitting gaskets shall be Nitrile. The coupling system shall be rated to 300 psi (2065 kPa) with Type K or L Copper Tubing.
 - a. Provide grooved joint couplings for copper pipe of the same type, style, and duty. Acceptable level of quality: equivalent to Victaulic - Style 607.

H. Copper Tubing

1. All seamless copper alloy tubing shall conform to ASTM B88, alloy C12200, Type L, with an O60 annealed temper. Copper tubing shall only be used where specified or specifically indicated on the Drawings.

I. Copper Joints

1. If the joint type is not specified elsewhere, use soldered joints or joining as directed by the Engineer. Dielectric fittings or isolation joints and materials shall be provided between all dissimilar metals.
2. Unions shall be installed to allow for ease of disassembly for any future piping alterations or repairs. All unions shall be installed as shown on the Drawings and as directed by the Engineer. Unions shall also be installed in long piping runs, equipment bypasses, connections to equipment, pumps, tanks and between shutoff valves.
3. Unions or flanges for servicing and disconnect are not required in installations using grooved joint couplings.

J. Copper Fittings - General

1. All component castings of flanges and fittings shall be copper alloy and shall conform to ASTM B61 or ASTM B62. Solder joint fittings shall conform to ASME B16.22 and ASME B16.18. Fittings for flared copper tube shall conform to ASME B16.26. Cast bronze threaded fittings shall conform to ASME B16.15 and be threaded in accordance with ASME B1.20.1. Tubing compression fittings shall be forged brass alloy C37700, conforming to ASTM B124.
2. Flared fittings shall not be used without prior written approval from the Engineer.
3. Fittings shall match the type and grade of the connecting piping.

K. Bolting for Copper Piping

1. All bolting materials shall meet the requirements of ASME B31.1. Bolts shall be provided with washers of the same material as the bolts. Provide flange bolt isolators for all dissimilar metals.

L. Pipe Bending

1. All bending of copper piping shall be in accordance with the recommendations of the pipe manufacturer. All bends shall be free from damage including, but not limited to, holes, cracks, or buckles.

2.2 STAINLESS STEEL TUBING

- A. All stainless steel tubing shall meet the requirements of ASTM A269 and ASTM A632. All tubing shall be seamless or welded, Type 316 with nominal size and wall thickness. Provide tubing sizes indicated on Drawings.

- B. Fittings shall be compression style, constructed of ASTM A479 stainless steel, Type 316. All nuts, ferrules, and bodies shall be rated to a minimum 150 psi pressure. Threads shall be straight conforming to ISO 228-1 and ASME B1.1.
- C. All tubing of the same type, style, and duty shall be supplied by a single manufacturer. Stainless steel tubing to be a product of one of the following manufacturers.
 - 1. Eagle Stainless Tube & Fabrication, Inc.
 - 2. Swagelok Company
 - 3. Plymouth Tube Company
 - 4. Or equal

2.3 GASKETS

- A. Gaskets shall conform to ANSI/AWWA C111/A21.11. Gaskets shall be provided by the pipe manufacturer unless otherwise noted. Unless otherwise noted, all gaskets 12 inches in diameter or less shall be a minimum of 1/8 inches thick. All gaskets larger than 12 inches in diameter shall be a minimum of 3/32 inches thick.
- B. Gaskets to have a smooth finish, be designed for use in plastic, metal or plastic-lined metal piping systems as applicable and be compatible with the associated process fluid. Gaskets for use in potable water service shall have an NSF 61 listing. Gaskets for low pressure air piping shall be suitable for use at temperatures to 250 degrees F.
- C. Gaskets for use on flanged piping shall be low torque, flat ring type, full face to ANSI B16.5 dimensions for 125/150-pound flanges and rated for a minimum pressure of 150 psi. Gaskets shall have two concentric, convex, molded rings between the center hole and bolt hole circle. For flanged CPVC piping, when the mating flange has a raised face an additional filler gasket shall be provided between the outer diameter of the raised face and outer diameter of the flange to protect the flange from bolting moments.
- D. Gaskets for use on mechanical joint and push-on joint piping shall meet or exceed the minimum requirements of AWWA C111/A21.11 for styrene-butadiene rubber (SBR) gaskets. Gaskets for use on bell and spigot joint FRP piping shall be EPDM.
- E. Gaskets for use with grooved end joints shall be pressure responsive elastomer. Gaskets for carbon steel grooved end piping shall be EHP and suitable for water service to 250 deg F. Gaskets for HDPE grooved end piping to be pre-lubricated.
- F. If for a specific application a pipe or valve manufacturer recommends a different type of gasket than that specified, submit gasket information Engineer the for review and approval.

- G. Gaskets of the same type and material to be provided by a single manufacturer. Gaskets to be a product of one of the following manufacturers.

1. Asahi America, Inc.
2. Allstate Gasket & Packing, Inc.
3. Metro Industries, Inc.
4. Or equal

2.4 UNIONS

- A. When joining pipe segments, provide unions where called for on the Drawings and as specified. Provide additional unions to allow for disassembly of piping segments. Provide unions at pumps, equipment and valves to allow for removal without disassembly of the piping systems.
- B. Unions or flanges for servicing and disconnect are not required in installations using grooved joint couplings.

2.5 ATTACHMENT HARDWARE

- A. Unless otherwise indicated, all attachment hardware, including but not limited to nuts, bolts, washers and all related fastening devices shall be 316 stainless steel. Threads shall be coated with mineral oil or another anti-seize compound prior to installation. Hardware for submerged applications shall be 316 stainless steel.

PART 3 – EXECUTION

3.1 INSTALLATION - GENERAL

- A. Piping systems shall be fabricated and installed in accordance with ASME B31.1. Install each run of piping with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance or replacement of valves and equipment. Reduce sizes, where indicated on the Drawings, by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerances.
- B. Locate piping runs, except as indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown, or, if not otherwise indicated, run piping in the shortest route which does not obstruct usable space or block access for servicing the building and its equipment. Hold piping close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of buildings.
- C. Provide unions in piping as shown on the Drawings and as specified. Unions shall be provided in locations, including but not limited to the following: equipment, pumps, tanks, valves, long piping runs, piping bypasses around equipment, or any

other location as directed by the Engineer or District. Unions shall be located to allow for piping disassembly, alterations, and repairs.

- D. Provide all field routing and coordination of process piping routing as required to accommodate all necessary coordination with other Work of the Contract, including, but not limited to heating, ventilating, and air-conditioning (HVAC), electrical, structural, architectural, plumbing, and civil work.

3.2 COPPER PIPE & TUBING INSTALLATION

- A. All threaded connections shall conform to ANSI B2 and ASME B1.20.1. All threaded connections shall be true, accurate, and of full thread. All threaded plugs shall be brass with a square head. All threaded joints shall be made with a joint compound approved by the piping manufacturer. The joint compound shall be applied to the male thread only. Caulking of threaded joints is not acceptable. All reductions and expansions in piping diameters shall be through the use of reducers and expansion fittings. Bushings or close nipples are not acceptable.
- B. Soldering
 - 1. Unless otherwise indicated all joints for copper pipe 2 inches and smaller shall be soldered. Prior to soldering, all surfaces shall be thoroughly cleaned and polished, and free from dirt, grease, grime or other foreign materials before fluxing and soldering. The cleaning shall be performed by using an emery cloth, sandpaper, or steel wool. Clean the outside end of the copper tubing for a length of at least 1/2 inch greater than the depth of the fitting. The inside of the fittings shall be cleaned in a similar manner. Apply non-corrosive flux and assemble the joint. Insert ends of tubes into fittings to the full depth of the sockets. Acid solder and acid flux are not acceptable.
 - 2. The copper piping and tubing surfaces to be joined shall be heated up slowly and uniformly. The surface being soldered shall be heated to the melting point of the solder. Apply heating to draw the solder completely into the joint. Form continuous solder beads around the entire circumferences of the joints. Once solder is plasticized, remove all excess with a brush or other suitable cleaning device. Excess solder shall be removed from the interior and exterior of the piping. Provide a fillet around the end of all fittings and joints. Allow soldered joints to cool slowly in the air. The use of water for quenching is not acceptable. Provide full penetration of solder within all joints.
- C. All cutting of copper tubing shall be square. The ends of all-cut piping shall be reamed or filed to remove burrs. The use of piping with out-of-round ends is not acceptable. Any type of defects, including but not limited to, cracks, holes, and incomplete solder penetration is not acceptable. Peening for the closing of defects is not acceptable under any circumstances.

- D. Utilize heating torches of sufficient size based on the size of the piping to be joined. Utilize combination torches with ring burners or multiple tips for heating of copper fittings 1-3/4 inches and larger.
- E. Brazing
1. All joints for interior copper pipe larger than 2 inches shall be brazed. Apply all flux in strict accordance with the recommendations of the manufacturer of brazing filler material. Apply flux to the outside of fittings and avoid allowing the flux to enter the inside of the tubing. Apply heat to the brazed sections of piping beginning 1 inch from the edge of each fitting.
 2. Once the flux becomes transparent, heat the fitting at the base of the cup. All heating shall be conducted while continuously moving the torch flame. Continuously maintain heating along the joint between the fitting and tubing connection axis.
 3. Apply the brazing material at the joint where the tubing enters the socket of a fitting. Heat the joint to melt the brazing material. Do not apply the torch flame directly on the brazing material. A properly assembled joint shall consist of a fillet of filler being visible around the complete circumference of the joint. Once a complete fillet is visible, stop adding filler metal. Remove any excess flux residue.
 4. Allow all joints to cool slowly via the surrounding air. The use of water for quenching is not acceptable. Any type of defects, including but not limited to, cracks, holes, and incomplete filler material penetration is not acceptable. Peening for the closing of defects is not acceptable under any circumstances.
- F. Flanges
1. Install flanged connections as required as shown on the Drawings and as approved by the Engineer. Install all flange faces in perfect alignment. The flange holes shall straddle the vertical center line of the piping.
 2. Flange bolts shall be alloy steel, ASTM A193 Grade B7, or commercial grade carbon steel, ASTM A307, Grade B. Alloy steel bolts shall be tightened to obtain a stress of 45,000 psi and carbon steel bolts shall be tightened to obtain approximately 15,000 psi of stress. The stress shall be based on the root area of the bolt thread. Provide flange bolt isolators for dissimilar metals.
 3. Lubricate all bolts over the entire thread length with a heavy graphite and oil mixture prior to tightening. Tighten bolts with proper wrenches. Secure flanges with uniform pressure on the bolts and gaskets. Flanged joints with flange dishing and over-compression of the gaskets due to overstressing of the bolts is not acceptable. Utilize bolts of adequate length to allow for a minimum of 2 full thread lengths to extend beyond the fastening nut.

3.3 STAINLESS STEEL PIPE INSTALLATION

- A. Install all pipe and fittings in strict accordance with the recommendations of the pipe manufacturer. All piping shall be pitched to low points and shall be provided with condensate drains. All pipe supports and restraints shall be provided as recommended by the pipe Manufacturer.
- B. If pipe cutting is required for installation, a machine shall be used. All cuts shall be neat, true, and smooth at 90-degree angles to the pipe longitudinal axis or center line.
- C. Prior to assembly in the field, clean all flanges, gaskets or threads with a soap and warm water solution. All flanged bolts shall be tightened alternately and evenly to the manufacturer's required torque. Take care not to over-tighten any flange bolts. Do not utilize extension or pipe ratchet wrenches, which may cause over-torque of flange bolts. All flange joints shall be assembled with gaskets, bolts and nuts, bolt studs with a nut on each end, or studs and nuts when the pipe is tapped. Ensure all flange holes are provided with connectors.
- D. Cut threads full and clean using sharp dies. Ream all threaded ends to remove burrs and restore the full inside pipe diameter. Apply pipe joint compound or Teflon pipe joint tape as recommended by the pipe and fitting manufacturer on male threads at each joint, and tighten the joint to leave not more than 3 threads exposed.
- E. All pipe and fittings shall be cleaned of all dust, oil, grease, water, dirt or any other foreign matter prior to installation. Ensure no foreign matter, tools, or other construction materials are left in the piping. All stainless steel piping shall be washed clean with steam or warm water to remove any other remaining foreign matter or debris.
- F. Stainless steel piping used in low pressure air or other associated hot applications to be designed to account for thermal expansion and contraction over a temperature range of 0 degrees F to 200 degrees F.
- G. Welding in the field shall only be conducted with prior written approved by the Engineer. All welds shall be made by welders certified under ASME Section IX and be equal or exceed shop welds in all respects. Field welding shall only be conducted after a demonstration weld is successfully completed by each welder, at no additional cost to the District or Engineer. All field-welded joints shall be thoroughly cleaned and buffed using deburring and finishing wheels.
- H. Provide certifications that on-Site welders are qualified in accordance with ANSI B31.1, Paragraph 127.5 for shop and Project Site welding of pipe work. Provide certified copies of current welding certificates for welders on Site to Engineer and District.
- I. If rusting of stainless steel piping occurs after installation, remove at no additional cost to District or Engineer. Pickle the affected surface area of the piping with a deoxidizer as recommended by the pipe manufacturer and approved by Engineer.

Scrub affected areas of the piping with stainless steel brushes and then thoroughly rinse the affected area.

3.4 INSTALLATION OF SLEEVES AND SEALS

- A. Install pipe sleeves of types as indicated on the Drawings where piping passes through walls, floors, ceilings, and roofs. Do not install sleeves through structural members of Work, except as detailed on the Drawings, or as approved by the Engineer. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation will have free movement in the sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than the piping run. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface, except floor sleeves. Extend floor sleeves 4 inches above the level floor finish, and 4 inches above floor finishes sloped to drain. Provide temporary support of sleeves and provide temporary closure to prevent concrete and other materials from entering sleeves.
- B. Sleeve Seals shall be installed in accordance with the following:
 - 1. Mechanical Seals: Loosely assemble rubber links around the pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form a watertight seal.
 - 2. Wall Pipe: Install wall pipe where indicated on Drawings. Joints shall be as indicated for connection to adjacent piping.

3.5 CLEANING

- A. Thoroughly clean the interior and exterior of all piping prior to testing. Provide removal of all dirt, dust, oil, grease and other foreign materials from the piping. Exercise care while cleaning piping to avoid damage to linings and coatings. Clean all piping in strict accordance with the recommendation of the piping manufacturer.
- B. Flush out piping systems, except odor control piping, with clean water prior to proceeding with the required tests. Inspect each run of piping for completion of joints, supports, accessory items, and appurtenances prior to testing.

3.6 PIPE TESTING - GENERAL

- A. Test all piping in the presence of the Engineer and the plumbing or building inspector if required by the State of the Project location or by the District. All testing shall be in accordance with the requirements of the local and state plumbing codes and the appropriate sections of these Specifications. All testing shall be conducted at no additional cost to the District or Engineer. Provide all labor, equipment, materials, taps, water, gauges, pumps, and appurtenances to conduct all piping tests.
- B. When requested by the Engineer or local plumbing inspector, building gravity drains shall be tested prior to backfilling or concealing. All other piping may be tested after backfilling. Any deficiencies found during testing shall be repaired and

retested at no additional cost to the Engineer or District. Provide lawful disposal of all waste after the testing.

- C. Test all piping systems before insulation is installed. Remove all control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where the test pressure exceeds the valve pressure rating. Test each section with water or other fluids as directed by the Engineer and District. Pressurize the pipe to the specified level for the required time period.

3.7 HYDROSTATIC PRESSURE TESTING

- A. All liquid service pipe and fittings shall be pressure tested using water to the test pressures specified or as directed by the Engineer. All pipe and fittings shall be pressure tested with water at the maximum service temperature specified or as directed by the Engineer. Test pressures for designations and systems not listed shall be as directed by the Engineer prior to testing. All testing shall be in accordance with the procedures of ASME B31.1.
- B. Provide water or other test fluid as directed by the Engineer, of sufficient capacity to deliver the required test pressure specified. Provide all valves on the suction and discharge side of the pump as well as a strainer on the inlet side of the pump to prevent foreign matter from entering the system. Provide pressure gauges capable of reading 50 percent higher than the specified test pressure. The pressure gauges shall be located at the pump discharge and any other place as directed by the Engineer. Provide a pressure relief valve set at a pressure 20 to 25 percent above the specified test pressure. Provide heaters, if required, to heat the test water to the specified test temperature.
- C. Preparation For Testing
 - 1. Coordinate the testing fluid to be used with Engineer and District. When the fluid test temperature is not ambient, consult with Engineer for the appropriate test temperature. All testing equipment shall be compatible with the piping and test fluid. Provide vents at all high points of the system if not already installed. Provide drains in locations where venting or draining devices do not exist.
 - 2. Remove all discs, pistons, and balls from check valves if they prohibit testing of the piping system. Ensure all valves and appurtenances are fully open within the section of piping to be tested. Remove all control instruments and alarms prior to testing. Block off or remove all pressure relief valves prior to testing and temporarily close all external openings of the piping section to be tested. All closures shall be specifically designed for the test pressure. All joints in the piping section to be tested shall be left exposed for examination and inspection during the test period. Pipe insulation shall not be installed prior to conducting pipe testing.

3. Provide temporary supports for vapor or gas piping to support the weight of the test fluid if the vapor or gas piping is directed to be hydrostatically tested.
4. Provide temporary support, restraint or isolation for all expansion joints.

D. Hydrostatic Test

1. Slowly fill the piping system, expelling entrapped air from all high points. The fill rate shall be controlled so that the fluid velocity within the pipe system is less than 2 feet per second. Once the filling process has been completed the piping system shall be brought up to the specified test temperature, if required or directed by the Engineer. The pressure shall be held at 20 percent less than the test pressure until the temperature has been stabilized. Once the temperature has stabilized, raise the pressure to the test level as specified or as directed by the Engineer.
2. The pipe system shall be slowly brought up to the test pressure. Take care not to create shock, surge, or water hammer in the pipe system.
3. For pressure piping, test each piping system at 150 percent of the design operating pressure, but not less than 25 psig test pressure, whichever is greater. Pressure piping shall be defined as piping systems in which the process fluid does not flow via gravity. The minimum test pressure for all gravity piping shall be 10 psig. Provide the Engineer and District with a minimum 24-hour notice prior to the testing. Tests which are not witnessed by Engineer are not acceptable. In the absence of specified test pressures, consult the Engineer for determining the test pressure for each system. The required test period shall be a minimum of 2 hours.
4. The test duration time limit shall not begin until the full pressure specified or indicated by the Engineer has been reached and the system has been stabilized to within plus or minus 5 percent of the test temperature. The system temperature shall be maintained to within plus or minus 5 percent of the specified or Engineer indicated value for the entire duration of the test. The test pressure shall be maintained at plus or minus 5 psi of the specified or Engineer indicated test pressure for the entire duration of the test.
5. The pressure test to be monitored by a recording type pressure gauge. When temperature and pressure control is required, use a combination temperature and pressure recording gauge. Record the entire test process. The records shall include, but are not limited to, the date of testing, piping section tested, test pressure, testing equipment, testing results, test fluid, test temperature, and signatures of Engineer, Contractor, and District.

E. Inspection of Testing

1. Observe each test section for leakage during the test period. The hydrostatic test shall be deemed acceptable if no visible leaks are detected and the pipe

system pressure can be maintained within plus or minus 1 percent but no more than 5 psi of the specified value.

2. Upon completion of the test, the pressure shall be slowly removed by opening a valve or other pressure-relieving device at a location remote to the location of the pressure and temperature monitoring equipment. The pressure shall be reduced to approximately 20 percent of the specified or Engineer indicated test pressure. Stabilize the system pressure at that point while the entire system is inspected for leaks, cracks, or other piping system defects. If any defects are found, alleviate pressure in the piping system, drain the test fluid, correct all defects, and retest the piping system.
3. Repair all piping system sections which fail the hydrostatic pressure piping test, by disassembly and re-installation using new materials to the extent required to overcome leakage or pressure drop. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods. Repair and retest all defective piping sections at no additional cost to the District or Engineer. Drain and dispose of all fluids from the piping systems after testing and repair Work has been completed.

3.8 PNEUMATIC PRESSURE TESTING

- A. All low-pressure air service pipe and fittings shall be pneumatically pressure tested using air to the test pressures specified or as directed by the Engineer. All pipe and fittings shall be pressure tested with air at the maximum service temperature specified or as directed by the Engineer. Test pressures for designations and systems not listed shall be as approved by the Engineer prior to testing. All testing shall be in accordance with the procedures of ASME B31.1.
- B. Preparation For Testing
 1. Coordinate testing pressure with Engineer. When the air test temperature is not ambient, consult the Engineer for the appropriate test temperature. All testing equipment shall be compatible with the piping. Provide vents at all high points of the system if not already installed.
 2. Remove all discs, pistons and balls from check valves if they prohibit testing of the piping system. Ensure all valves and appurtenances are fully open within the section of piping to be tested. Remove all control instruments and alarms prior to testing. Block off or remove all pressure relief valves prior to testing and temporarily close all external openings of the piping section to be tested. All closures shall be specifically designed for the test pressure. All joints in the piping section to be tested shall be left exposed for examination and inspection during the test period. Insulation shall not be installed prior to conducting tests. Provide a soapy water solution and test all fittings, joints, couplings and valves for air leakage.
 3. Personnel not directly involved in pneumatic pressure testing of piping shall be evacuated from the area. The maximum length of piping to be tested at

1 time shall be 400 feet. Examine all connections prior to testing to ensure proper fit and tightness. Determine the pressure rating for all connected devices and appurtenances to ensure they are rated for the required test pressure. Isolate all equipment and appurtenances, which may be damaged by testing. Plug all test, drain, and vent ports, which are not required for the test. If the section of pipe being tested is isolated from other sections by in-line valves, ensure that the portion not being tested is open to the atmosphere. Protect expansion joints against system pressures by suitable movement-limiting devices.

C. Pneumatic Pressure Test

1. Slowly fill the piping system. Each piping system shall be brought up to the specified test temperature. The pressure shall be held at 20 percent less than the required test pressure until the temperature has been stabilized. Once the temperature has stabilized, raise the pressure to the test level as specified or as directed by the Engineer.
2. Test each piping system at 150 percent of the design operating pressure, but not less than 25 psi test pressure, whichever is greater. Provide the Engineer and District with a minimum of 24-hour notice prior to the testing. Tests which are not witnessed by Engineer are not acceptable. In the absence of specified test pressures, consult Engineer for determining the test pressure for each system. The required test period shall be 2 hours.
3. The test duration time limit shall not begin until the full pressure specified or indicated by the Engineer has been reached and the system has been stabilized to within plus or minus 5 percent of the test temperature. The system temperature shall be maintained to within plus or minus 5 percent of the specified or Engineer indicated value for the entire duration of the test. The test pressure shall be maintained at plus or minus 0.5 psi of the specified or Engineer indicated test pressure for the entire duration of the test.
4. The pressure test shall be monitored by a recording type pressure gauge. When temperature and pressure control is required, use a combination temperature and pressure recording gauge. Record the entire test process. The records shall include, but are not limited to, the date of testing, piping section tested, test pressure, testing equipment, testing results, test temperature, and signatures of the Engineer, Contractor, and District.

D. Inspection

1. Observe each test section for leakage during the test period. Once the test segment has been pressurized to the specified levels, the source of pressurization shall be isolated and all piping, connections shall be tested for leaks by swabbing with standard high film soap solution while also observing for the formation of air bubbles. Each pneumatic pressure test shall be deemed acceptable if no visible leaks (air bubbles) are detected and

the pipe system pressure can be maintained to within plus or minus 1/2 percent but no more than 0.5 psi of the specified value.

2. Upon completion of the test, the pressure shall be slowly removed by opening a valve or other pressure-relieving device at a location remote to the location of the pressure/temperature monitoring equipment. If any defects are found, alleviate all pressure in the piping system, correct all defects, and retest the piping system.
3. Repair all piping system sections which fail the pneumatic pressure-piping test, by disassembly and re-installation, using new materials to the extent required to overcome leakage or pressure drop. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods. Repair and retest defective piping sections at no additional cost to District or Engineer.

END OF SECTION

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PROCESS PIPE SUPPORTS

PART 1 – GENERAL

1.1 SUMMARY

- A. Provide all labor, materials, equipment, incidentals, hardware and appurtenances to install a complete system of pipe hangers, pipe supports, concrete inserts, anchor bolts and related appurtenances for supporting non-buried piping as shown on the Drawings and as specified herein. All pipe hanger and support systems shall be designed and constructed to resist the seismic forces as specified herein or as indicated on the Drawings.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

1.3 REFERENCES

- A. Reference Standards
 - 1. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
 - a. MSS SP-58 Standard for Pipe Hangers and Supports - Materials, Design and Manufacture
 - b. MSS SP-69 Standard for Pipe Hangers and Supports – Selection and Application
 - c. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports
 - 2. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - a. Seismic Restraints Manual

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination, sequencing, and scheduling: Per Division 01 General Requirements.

1.5 SUBMITTALS

- A. Submit in accordance with Division 01 General Requirements.
- B. Shop Drawings

1. Submit complete piping layout Drawings for each piping system. Indicate the type and locations of hangers, supports, anchors, guides, anchor bolts, and any other pipe supporting appurtenances.
2. Where standard hangers and/or supports are not suitable, submit detailed Drawings showing materials and methods of construction for each type of custom hanger and support.
3. Submit detailed Drawings any construction-related deviations in piping layouts, materials or routing. The review of construction-related deviation submittals shall only be for conformance to the Specifications and Drawings.

C. Product Data

1. Submit catalog cuts, Specifications and dimensioned Drawings for each type of pipe hanger and support.
2. Indicate materials of construction, important dimensions and range of pipe sizes for which each hanger is suitable.
3. Submit detailed information on anchor bolts, hardware, anti-seize compounds, and any other appurtenant materials.
4. The product data shall include a representative catalog cut for each different type of pipe hanger or support indicating the materials of construction, important dimensions and range of pipe sizes for which that hanger is suitable. Where standard hangers and/or supports are not suitable, submit detailed drawings showing materials and methods of construction for each type of special hanger and/or support.
5. Include design calculations of support reactions transmitted to the structure and type of anchor, guide and other pipe supporting appurtenances including structural fasteners.

D. Certifications

1. Submit design calculations and drawings for all pipe support systems stamped by an independent licensed Professional Engineer in the State of California who is engaged in the business of pipe support system analysis and design. Pipe support design engineer shall certify that the pipe support design meets the specified project site and loading requirements and the design is in accordance with all applicable codes specified herein.
2. Independent pipe support design Engineer shall submit experience record in design and fabrication of pipe hangers and supports as specified herein. The support design Engineer shall have not less than 3 years of experience within the last 5 years in the analysis and design of pipe support design.

3. Stamped calculations shall not be required prior to installation. All layout and support detail submittals shall bear the stamp of the independent licensed professional engineer.
 4. Stamped "Record" drawings and calculations shall be submitted after final installation for Project Records.
- E. Closeout and Maintenance Material Submittals: per Division 01 General Requirements.

1.6 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.
- B. The fabricator of pipe hangers, supports and related appurtenances shall have not less than 5 years of current experience in the design and fabrication of the pipe hangers and supports as specified in this section.
- C. Provide pipe hangers and supports which comply with the Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), MSS SP-58 standards. Select and apply pipe hangers and supports, complying with MSS SP-69 standards. Terminology in this Specification is defined in MSS SP-90 standards.
- D. All piping hangers, supports and appurtenances shall conform to the latest applicable requirements of the State Building Code of the Project location and ANSI B31.1, except as supplemented or modified by the requirements of this Specification.
- E. Coordinate process piping hangers, supports, and appurtenances to eliminate interference with similar support systems to be installed for plumbing, heating, ventilating, and air conditioning (HVAC), electrical, and other disciplines of Work. The piping support systems shall account for structural expansion joints and co-located piping expansion joints. The piping hanger and support system shall provide and maintain unhindered access to all equipment for both operation and removal. No material handling equipment supports shall be used for piping supports. Do not attach piping hangers, supports, and appurtenances from structural struts or braces unless approved in writing by the Engineer.
- F. All process piping and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain or force from being imposed on the equipment. When the equipment manufacturers have indicated that piping loads shall not be transmitted to their equipment, submit a written certification stating that such requirements have been complied with.
- G. The Contractor shall engage the services of an independent Licensed Professional Engineer in the State of California with specific experience in the structural design and configuration of pipe supporting systems, including any non-standard supports that need to be designed and certified.

- H. The independent pipe support design Engineer shall have not less than 3 years of experience within the last 5 years in the analysis and design of pipe supports.
- I. The independent pipe support design Engineer shall be responsible for work within the Contract Documents and within the design configuration. Any construction-related deviations shall be submitted to the Engineer. These submittals will be reviewed for conformance to the specifications.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 01 General Requirements.

1.8 SITE CONDITIONS

- A. Existing Conditions: per Division 01 General Requirements.

1.9 SEISMIC RESTRAINTS

- A. Provide seismic restraints for all piping systems including but not limited to free standing, suspended or wall mounted piping. Seismic restraints shall be sized for the Seismic Hazard Exposure Group and Seismic Performance Category as indicated in Section 01 33 12.
- B. Use the restraints defined in the manual when the seismic criteria, and size of piping, are within the limits of the latest edition of the SMACNA Seismic Restraints Manual. Select restraints from the Tables that represent the highest seismic hazard class or level possible within the State in which the project resides. Provide members of material of equal strength to those in the standards where materials other than carbon steel are specified.
- C. Materials of construction for seismic restraints shall be same as those specified in subsequent articles of this specification.

1.10 WARRANTY

- A. Provide in accordance with Division 01 General Requirements.

PART 2 – PRODUCTS

2.1 PIPING SUPPORTS - GENERAL

- A. The products specified are intended to support the various types of process piping systems shown on the Drawings. The Contractor shall be responsible for developing the final details associated with the specific installation conditions. The details include, but are not limited to, piping system temperatures and pressures associated with each application.
- B. The Contractor may propose minor adjustments to the piping arrangements to simplify the supports and to adjust the layout of process piping systems. An

example of an adjustment shall be a minor change to a pipe centerline elevation so that a single trapeze support may be used for a process piping system.

- C. Unless otherwise indicated, process piping hangers and supports shall be a manufacturer's standard product. All products specified or otherwise shall conform to the requirements of MSS SP-58 and MSS SP-69 standards. Any reference to specific catalog or figure numbers from a specific manufacturer shall be for establishing the type, design, and quality of a piping support product. Any references contained in this Specification section shall not be considered as proprietary.
- D. All piping supports and hangers of the same type, style, and duty shall be supplied by a single manufacturer. All process piping supports and hangers shall be a product of the following manufacturer:
 - 1. Gulf States Hangers & Supports Manufacturers, Inc.
 - 2. Anvil International, Inc.
 - 3. Carpenter & Paterson, Inc.
 - 4. Eaton B-Line (Formerly Cooper B-Line)
 - 5. PHD Manufacturing, Inc.
 - 6. Unistrut Corporation (For Pipe Support Framework)
 - 7. Globe Strut (For Pipe Support Framework)
 - 8. Power-Strut (For Pipe Support Framework)
 - 9. MP Husky (For Pipe Support Framework)
 - 10. Engineer Approved Equal

2.2 PIPING FORCES

- A. Provide ridged support of all piping systems. Provide supports to prevent significant stresses in the material, valves, fittings and other connected pipe appurtenances. All supports and anchors shall be designed to secure the pipe in the intended position and alignment.
- B. All supports and anchors shall be designed to accommodate thermal expansion and contraction.
- C. Pipe supports and anchor design shall specifically account for internal flow forces, all probable external forces from equipment connection, human contact, and all seismic forces. Provide structural steel members to brace any piping system from excessive dislocation. All pipe fittings and appurtenances connected to equipment shall be supported in a manner to prevent any strain from being imposed on the

equipment or piping systems. All pipe supports shall be installed such that they do not induce point loadings on the piping. All supports shall distribute pipe loads evenly along the pipe circumference.

- D. All piping hangers, supports and appurtenances shall be adequate to maintain the supported load in proper position under all operating conditions. The minimum working factor of safety for all supporting equipment, except for springs, shall be 1/5 the ultimate tensile strength of the material, assuming a minimum 10 feet of water filled pipe being supported.

2.3 DISSIMILAR METALS

- A. All stainless steel piping shall be isolated from all ferrous metals including galvanized steel. Provide a neoprene sheet or stainless steel protection shields to prevent direct contact when installed.
- B. Copper piping shall be protected from galvanic corrosion from contact with ferrous metals. Provide corrosion protection by wrapping the copper pipe with 1/16-inch thick neoprene, sheet metal and a galvanized protection shield with isolators. Copper plated or polyvinyl chloride (PVC) coated hangers and supports may also be used to provide dielectric isolation.

2.4 NON-METALLIC PIPING

- A. Uninsulated non-metallic piping, shall be protected from local stress concentrations at each support point. Protection from local stresses shall be provided by PVC coated steel or 304 stainless steel protection shields.
- B. Pipes which are bottom supported for 180 degrees shall be provided with arc shields. Pipes which are supported for 360 degrees shall be provided with protection shields for the entire exterior pipe circumference. Protection shields shall have an 18-gauge minimum thickness. Protection shields shall be a minimum of 12 inches in length. Securely fasten each protection shield to the pipe with 304 stainless steel straps not less than 1/2 inches in width.

2.5 INSULATED PIPE

- A. Insulated piping shall be provided with a rigid insulating saddle at each pipe support location. Provide protection shields at each support location.

2.6 VERTICAL PIPING

- A. Whenever possible, support vertical piping using floor supports rather than wall supports. Concrete supports, base elbows, and base tees shall be used when possible and as shown on the Drawings.
- B. Support vertical piping by pipe collars, clamps, brackets, or wall rests. Spacing as indicated under "Support Spacing" in this Specification.
- C. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

2.7 MATERIALS OF CONSTRUCTION

- A. All piping support systems shall be constructed of the following materials based on location unless otherwise specified or indicated on the Drawings
 - 1. All outdoor piping: 316 stainless steel
 - 2. All interior building piping: 304 Stainless Steel
- B. All pipe clamps on plastic pipe shall be provided with a plastic coating or neoprene isolator.
- C. All supports for copper pipe shall be copper plated or shall have a minimum 1/16-inch plastic coating.
- D. All fasteners and related hardware for supports, including, but not limited to nuts, bolts, anchors, and washers shall be 316 stainless steel regardless of location.
- E. All stainless steel components shall be passivated after fabrication.

2.8 HORIZONTAL PIPING HANGERS AND SUPPORTS

- A. Unless otherwise specified or indicated on the Drawings, provide factory fabricated horizontal piping hangers and supports conforming to MSS SP-58 standards. Horizontal piping supports and hangers shall be one of the following MSS types listed below.
 - 1. The specific type of support shall be selected by the Contractor to suit the horizontal piping system layout in accordance with MSS SP-69 standards as well as the piping manufacturer's published support requirements. Whenever possible, use only one type of support system by one manufacturer for each piping service. Select the size of hangers and supports to exactly fit the nominal pipe outside diameter for bare piping, and to exactly fit around piping insulation with a saddle or shield for all insulated piping.
 - 2. Type 5 - Pipe Hangers, Type 12 - Pipe Clamps, and Type 26 - Pipe Clips shall not be used. Type 3 - Three Bolt Pipe Clamps shall not be used on insulated piping systems. Type 24 - U-Bolts shall only be used in conjunction with other supports types including trapeze hanger systems or fabricated frames.

2.9 SINGLE PIPE CLEVIS HANGERS

- A. Whenever possible, single process piping runs shall be supported by single pipe adjustable clevis type hangers (MSS Type 1), suspended by hanger rods from structural steel members, concrete ceilings, or the bottom of trapeze hangers. The clevis type hanger shall be specifically designed for the process piping type being supported as follows
 - 1. Adjustable Clevis Hangers

- a. Anvil International, Inc. - Figure No. 260
 - b. Carpenter & Paterson, Inc. - Figure No. 100
 - c. PHD Manufacturing, Inc. - Figure No. 425
 - d. Engineer Approved Equal
2. Adjustable Clevis Hangers (Insulated Pipe)
- a. Anvil International, Inc. - Figure No. 300
 - b. Carpenter & Paterson, Inc. - Figure No. 100EL
 - c. PHD Manufacturing, Inc. - Figure No. 430
 - d. Engineer Approved Equal
3. Adjustable Clevis Hangers (Cast Iron or Ductile Iron Pipe)
- a. Anvil International, Inc. - Figure No. 590
 - b. Carpenter & Paterson, Inc. - Figure No. 100DI
 - c. PHD Manufacturing, Inc. - Figure No. 420
 - d. Engineer Approved Equal

2.10 PIPE CLAMPS

- A. Single process piping runs supported by pipe clamps, (MSS Type 4), shall be in accordance with the following
- 1. Anvil International, Inc. - Figure No. 212
 - 2. Carpenter & Paterson, Inc. - Figure No. 175
 - 3. PHD Manufacturing, Inc. - Figure No. 520/521
 - 4. Engineer Approved Equal

2.11 ADJUSTABLE BAND HANGERS

- A. Single process piping runs supported by adjustable band hangers, (MSS Type 7), shall be in accordance with the following
- 1. Carpenter & Paterson, Inc. - Figure No. 1A
 - 2. PHD Manufacturing, Inc. - Figure No. 180, 181, & 183
 - 3. Engineer Approved Equal

2.12 PIPE SADDLE SUPPORTS

- A. Single process piping runs supported by pipe saddle supports, (MSS Type 36), shall be in accordance with the following
 - 1. Anvil International, Inc. - Figure No. 258
 - 2. PHD Manufacturing, Inc. - Figure No. 880
 - 3. Or Equal
- B. Provide pipe base supports and cast floor flanges for all pipe saddle supports. Refer to the details on the Drawings for additional requirements.

2.13 PIPE STANCHION SADDLES

- A. Single process piping runs supported by pipe stanchion saddles, (MSS Type 37), shall be in accordance with the following
 - 1. Anvil International, Inc. - Figure No. 259
 - 2. Carpenter & Paterson, Inc. - Figure No. 125
 - 3. PHD Manufacturing, Inc. - Figure No. 882
 - 4. Or Equal
- B. Provide pipe base supports and floor flanges for all pipe stanchion saddles. Refer to the details on the Drawings for additional requirements.

2.14 ADJUSTABLE ROLLER HANGERS

- A. Single process piping runs supported by adjustable roller hangers (MSS Type 43), shall be in accordance with the following
 - 1. Anvil International, Inc. - Figure No. 181
 - 2. Carpenter & Paterson, Inc. - Figure No. 140
 - 3. PHD Manufacturing, Inc. - Figure No. 470 & 475
 - 4. Or Equal

2.15 PIPE ROLL STANDS

- A. Single process piping runs supported by pipe roll stands, (MSS Type 44), shall be in accordance with the following:
 - 1. Anvil International, Inc. - Figure No. 271
 - 2. Carpenter & Paterson, Inc. - Figure No. 54

3. PHD Manufacturing, Inc. - Figure No. 486

4. Or Equal

2.16 PIPE ROLLS & PLATES

A. Single process piping runs supported by pipe rolls and plates, (MSS Type 45), shall be in accordance with the following:

1. Anvil International, Inc. - Figure No. 277

2. Carpenter & Paterson, Inc. - Figure No. 63

3. Or Equal

2.17 PIPE GUIDES & SLIDE PLATES

A. Provide structural slide assemblies and guides (MSS Type 35) using reinforced polytetrafluoroethylene (PTFE) or graphite slides to allow for longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where slides do not require provisions for lateral restraint the following methods may be used

1. For piping systems 4 inches and larger, when the temperature of the medium is 60 degrees F or higher, a pipe covering protective saddle (MSS Type 39) which is welded to the pipe may freely rest on the support.

2. For piping systems less than 4 inches, a pipe protection shield (MSS Type 40) attached to the pipe or insulation, may freely rest on the support.

3. For piping systems 4 inches and larger carrying medium less than 60 degrees F, a pipe protection shield (MSS Type 40) attached to the pipe or insulation, may freely rest on the support.

B. In cases where there are high system temperatures and welding to piping is not desirable, pipe slide assemblies and guides shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

C. Except as otherwise indicated, provide factory fabricated pipe guides and slide plate systems. Provide pipe guides and slide plates (MSS Type 35) in accordance with the following:

1. Anvil International, Inc. - Figure No. 439

2. PHD Manufacturing, Inc. - Figure No. 690

3. Carpenter & Paterson, Inc. - Figure No. 1010

4. Engineer Approved Equal

2.18 EXTENDED VERTICAL PIPING CLAMPS

- A. Except as otherwise indicated, provide factory-fabricated extended vertical piping clamps. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping. Provide larger diameter clamps to accommodate insulated piping and shields. Provide vertical piping two-bolt extended riser clamps in accordance with the following
1. Anvil International, Inc. - Figure No. 100
 2. Carpenter & Paterson, Inc. - Figure No. 267
 3. PHD Manufacturing, Inc. - Figure No. 545
 4. Engineer Approved Equal

2.19 OFFSET PIPE CLAMPS

- A. Except as otherwise indicated, provide factory fabricated offset vertical piping clamps. Provide vertical piping 2-bolt offset riser clamps in accordance with the following
1. Anvil International, Inc. - Figure No. 103
 2. Carpenter & Paterson, Inc. - Figure No. 179
 3. PHD Manufacturing, Inc. - Figure No. 535
 4. Engineer Approved Equal

2.20 PIPE RISER CLAMPS

- A. Pipe riser clamps (MSS Type 8) shall be used to support vertical piping runs extending through floor slabs. Insulation shall be provided for the entire diameter of insulated pipes prior to installing riser clamps. Insulation shall not be damaged by clamp installation. Provide pipe riser clamps in accordance with the following:
1. Anvil International, Inc. - Figure No. 261
 2. Carpenter & Paterson, Inc. - Figure No. 126
 3. PHD Manufacturing, Inc. - Figure No. 550, 551, or 553
 4. Engineer Approved Equal

2.21 WALL PIPE SUPPORTS

- A. Where pipe runs are near supports, including, but not limited to walls, beams, and columns, and are also located an excessive distance from ceilings or the underside

of beams, welded stainless steel wall pipe supports shall be used for hanging pipe. In cases where single pipes rest on top of bracket pipe supports, all attachments shall meet requirements as specified under multiple pipe hangers. Provide structural wall pipe supports in accordance with the following

- B. Light duty applications (MSS Type 31) shall be defined as small diameter piping less than 2 inches nominal pipe size.
 - 1. PHD Manufacturing, Inc. - Figure No. 850
 - 2. Carpenter & Paterson, Inc. - Figure No. 69
 - 3. Engineer Approved Equal
- C. Medium duty applications (MSS Type 32) shall be defined as 3 inch through 6 inch PVC or Stainless Steel piping.
 - 1. PHD Manufacturing, Inc. - Figure No. 855
 - 2. Carpenter & Paterson, Inc. - Figure No. 84
 - 3. Engineer Approved Equal
- D. Heavy duty applications (MSS Type 33) shall be used for all Type DI/1 & Type CS/1 piping and all piping materials larger than 6 inch nominal pipe size.
 - 1. PHD Manufacturing, Inc. - Figure No. 860
 - 2. Carpenter & Paterson, Inc. - Figure No. 139
 - 3. Engineer Approved Equal
- E. Where applicable and approved by the Engineer, the use of C-channels with stainless steel brackets and pipe clamps shall be provided. All members shall be securely fastened to walls, columns, or other Engineer approved structural members. Attachment shall utilize double expansion shields or other methods as approved by the Engineer. Additional wall bearing plates shall be provided where required.

2.22 MULTIPLE PIPE HANGERS

- A. Suspended multiple pipes, running parallel in the same horizontal plane, which are adjacent to each other shall be suspended by trapeze type hangers or wall brackets. Trapeze hangers shall consist of stainless steel or aluminum structural channels supported from stainless steel threaded rods.
- B. Provide all other necessary accessories, including, but not limited to rods, concrete inserts, C-clamps, beam clamps, welded beam attachments, and expansion shields, as required and as specified for a complete piping support system.

- C. Unless otherwise specified or indicated on the Drawings, pipe anchors used for attaching pipe to trapeze or multiple pipe wall brackets shall be anchor or pipe chairs.
- D. All chair U-bolts shall be tightened to allow freedom of movement for normal expansion and contraction of piping runs except where pipe shall be anchored to control direction of movement or act as a thrust anchor.

2.23 HANGER ROD ATTACHMENTS & BEAM CLAMPS

- A. Hanger rod attachments shall be machine threaded. The strength of the rod shall be based on its root diameter. Threaded rods shall not be formed or bent in the field.
- B. Hanger rods shall be attached to concrete structures using concrete inserts. Beam clamps, C-clamps, or welded beam attachments shall be used for attaching hanger rods to structural steel members.
- C. Where required and as approved by the Engineer, expansion or epoxy anchors shall be used for attaching to concrete structures.
- D. Provide a bituminous coating for all iron or steel in direct contact with concrete.
- E. Both locknuts and retaining devices shall be furnished by the piping support manufacturer.
- F. Field fabricated clamp bodies and retaining devices are not acceptable. Side beam or channel clamps (MSS Type 20) shall be provided with an added iron heel plate or adaptor. Whenever possible utilize center beam clamps (MSS Type 21).

2.24 ANCHORS

- A. Anchor piping at locations indicated on the Drawings or required per the Specifications. The anchor design and materials shall be in accordance with ANSI/ASME B.31 standards. Additional anchoring shall be provided as approved by the Engineer. All anchors shall be 316 stainless steel regardless of installation location.
- B. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1 inch behind the steel reinforcement. Concrete anchors for ceiling mounted pipe supports and appurtenances shall be adhesive or expansion type.
- C. Anchors for wall supports, floor supports and all related appurtenances shall be in accordance with the following. Size all supports as required for proper support as well as to provide compatibility with the associated pipe support.
- D. Anchor bolts shall be a product of the following Manufacturer:
 - 1. Hilti – Kwik-Bolt

2. Simpson Strong-Tie – Wedge-All
3. Powers – Power-Stud
4. Engineer Approved Equal

2.25 INSULATION SHIELDS & SADDLES

- A. Provide pipe covering protective saddles (MSS Type 39) on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher.
- B. Provide pipe protection shields (MSS Type 40) for use on insulated piping systems less than 4 inches. Shields may be used on piping systems larger than 4 inches when the temperature of the medium is 60 degrees F or less. All shields shall be constructed of materials as previously indicated in this Section.
- C. All protective shields shall be in accordance with the following:
 1. Anvil International, Inc. - Figure No. 167
 2. Carpenter & Paterson, Inc. - Figure No. 265
 3. PHD Manufacturing, Inc. - Figure No. 170
 4. Engineer Approved Equal

2.26 HORIZONTAL SMALL DIAMETER PIPE SUPPORTS

- A. Horizontal piping runs less than 3 inches in diameter shall be held in position by supports fabricated from 304 stainless steel or aluminum C-channels, welded post bases and pipe clamps.
- B. To assure adequate support, fabricate supports using two vertical members and post bases connected by a horizontal member of sufficient load capacity to support the piping run. Wherever possible, supports shall be anchored to nearby walls or other structural members to provide horizontal rigidity. More than 1 pipe may be supported from a common fabricated support as approved by the Engineer.

2.27 SMALL DIAMETER PLASTIC PIPE SUPPORT

- A. Provide all pipe supports for closely spaced vertical plastic piping systems 3 inches and smaller to provide a rigid support system. The interval of vertical support spacing shall be as required by the pipe manufacturer, but in no case, shall the vertical spacing interval exceed 6 feet between supports. The support system shall consist of a framework suitably anchored to floors, ceilings, roofs or other Engineer approved structural members.
- B. Vertical and horizontal supporting members shall be 304 stainless steel or aluminum U-shaped channels. The assemblies shall be furnished complete with all

nuts, bolts and fittings for a complete assembly including end caps for all support members.

- C. Vertical piping shall be secured to the horizontal members by pipe clamps or pipe straps.
- D. The design of each individual framing system for small diameter plastic pipe support systems shall be the responsibility of the Contractor. Shop Drawings, shall be submitted and shall show all details of the installation, including dimensions and types of supports. In all instances the completed frame shall be adequately braced to provide a complete rigid structure when all the piping has been attached.
- E. Size all supports for proper support as well as to provide compatibility with the associated piping material. Use only 1 type by 1 manufacturer for each piping service.

2.28 CUSTOM FABRICATED PIPE SUPPORTS

- A. Whenever possible utilize standard piping supports and appurtenances. If standard supports are not suitable for an application, provide custom fabricated structural shapes, concrete, and anchor hardware for support of process piping systems.
- B. All custom fabricated supports and hardware shall be of approved materials of construction like items previously specified, and shall meet all applicable requirements of this specification section.
- C. Submit complete design details of the pipe support system and system components. Do not install custom fabricated pipe supports without the written approval of the Engineer.

2.29 THIN-WALLED PIPE SUPPORTS

- A. Supports for thin walled pipe shall be provided per the requirements of this Specification, and shall include saddle bracing to avoid damaging the pipe at the point of contact with the associated support.

2.30 CONCRETE INSERTS

- A. Provide inserts (MSS Type 18) to allow a connection point for hanger rods in concrete. Inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for (MSS Type 18) inserts. Provide a bituminous coating for all metallic inserts in direct contact with concrete. All concrete inserts shall be in accordance with the following:
 - 1. Anvil International, Inc. - Figure No. 282
 - 2. Carpenter & Paterson, Inc. - Figure No. 650
 - 3. PHD Manufacturing, Inc. - Figure No. 951

4. Engineer Approved Equal

2.31 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

PART 3 – EXECUTION

3.1 GENERAL

- A. Hangers, supports, and guides shown on the Drawings are for coordination purposes and represent recommendations based on assumed pipe routing. Provide routing and installation of all hangers, supports and guides for complete piping systems.
- B. The installation of pipe support systems shall in no way interfere with the operation of monorails, access hatches, building systems, overhead doors, etc. The installed systems shall not interfere with maintenance and operational access to equipment.
- C. All pipe supports shall be designed with liberal strength and stiffness to support the respective pipes under the maximum combination of peak loading conditions including pipe weight, liquid weight, liquid movement and pressure forces, thermal expansion and contraction, vibrations and all probable externally applied forces, including seismic forces. Prior to installation, all pipe support systems shall be approved by the Engineer.
- D. Design and adjust pipe support systems to allow for drainage of pipe.

3.2 SEISMIC CONDITIONS

- A. Design process piping supports in accordance with Section 01 33 12.
- B. Provide seismic restraints for all piping systems, including, but not limited to free standing, suspended or wall mounted piping. Use the restraints defined in the SMACNA Seismic Restraints Manual when the seismic criteria, and size of piping, are within the limits of the SMACNA Manual. Provide members of material of equal strength to those in the standards where materials other than carbon steel are specified.

3.3 SUPPORT LOCATIONS

- A. Support piping such that piping live and dead loading, and stresses from movement, will not be transmitted to connected equipment, valves, tanks, couplings, and any other appurtenances that are not designed to support piping loads. Equipment shall not be used to support piping.
- B. Support piping immediately adjacent to each change of direction and where installation of inline equipment produces concentrated loads. Provide support at offsets in piping as necessary to prevent deflection of the pipe axis due to expansion

or pressure forces, except where right angle bends are utilized to compensate for expansion.

- C. Provide independent support on either side of each valve and in-line instrument. Support shall permit removal and replacement of valve or instrument without affecting support of adjacent piping. Support of valves by connected piping is not acceptable. All electric and hydraulic valve actuators shall be independently supported.
- D. Couplings: Support all couplings shown on the Drawings and as specified for connection to tanks, pumps, equipment, and appurtenances. All such couplings shall be rigidly supported, to prevent transfer of force to the equipment. Fixed or restraining supports shall not be installed between a flexible coupling and the connected piece of equipment/appurtenance. The supports shall be located at the end opposite the tank, pump, equipment, and appurtenance.

3.4 SUPPORT SPACING, GENERAL

- A. Distance between pipe supports shall be the minimum of pipe manufacturer requirements, location requirements defined above, and spacing defined below.
- B. Space supports so that the sag of the pipe (if any) is within the limits of the piping manufacturer. The support design and layout shall minimize bending stresses on the supported piping from concentrated loads between supports. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for the smallest pipe size or install intermediate supports for smaller diameter pipe.

3.5 SUPPORT SPACING, METALLIC PIPING

- A. Minimum Spacing for Rigid Metallic Piping (including cast iron, ductile iron, steel and stainless steel) shall be per the following table:

Pipe Size (Inches)	Maximum Span (feet)
1½ inches & smaller	5 feet
2 inches to 4 inches	10 feet
5 inches to 8 inches	15 feet
10 inches & larger	20 feet

3.6 SUPPORT SPACING, PLASIC PIPING

- A. Provide continuous support for plastic piping (including PVC and HDPE) whenever possible. Continuous support shall consist of v-troughs or ladder type cable trays.

- B. All ladder type cable trays shall be constructed of PVC coated aluminum, aluminum or stainless steel. The ladder rung spacing shall be a maximum of 12 inches. The tray width shall be a minimum of 6 inches for single piping runs and 12 inches for double piping runs.
- C. Secure plastic pipes to v-trough or ladder trays by clamps or fasteners. The spacing between clamps and fasteners shall not be greater than 10 feet.
- D. Minimum Spacing for Rigid Plastic Piping (including PVC and HDPE) shall be per the following table:

Pipe Size (Inches)	Maximum Span (feet)
1½ inches & smaller	4.5 feet
2 inches to 4 inches	6 feet
5 inches to 8 inches	9 feet
10 inches & larger	10 feet

3.7 INSTALLATION

- A. Install hangers, supports, clamps, and attachments to support piping properly from building structures in accordance with MSS SP-69.
- B. Attach pipe supports to concrete walls, columns, structural steel, and other Engineer approved support members. The pipe support system shall not impose loads on the supporting structures in excess of the loads for which the supporting structure was designed.
- C. Do not support piping from existing precast concrete tees, metal stairs, ladders, concrete columns or concrete beams or walkways unless specifically directed or authorized in writing by the Engineer. Do not use wire or perforated metal to support piping. Do not support piping from other piping.
- D. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
- E. Torque all Top Beam C-Clamps (MSS Type 19), C-Clamps (MSS Type 23), and any other hardware with specific torque requirements in accordance with MSS SP-69 standards and manufacturer requirements.
- F. Except as otherwise permitted, make provisions for vertical adjustment of all hangers after installation.
- G. Where temporary supports are used, provide sufficiently rigid support to prevent shifting or distortion of pipe.

- H. Apply anti-seize compound to all nuts, bolts, and other associated fasteners. Supports installed without the approved anti-seize compound shall be dismantled and correctly installed, at no additional cost to the District or Engineer.

3.8 CONCRETE INSERTS

- A. Install concrete inserts on forms before concrete is placed. Before setting these items, all Drawings and figures shall be checked which have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports shall be the responsibility of the installing Contractor. Continuous metal inserts shall be embedded flush with the concrete surface. Provide a bituminous coating for all metallic concrete inserts in contact with concrete.

3.9 FINISHING

- A. All sharp edges and comers within 7 feet of the floor or walking surfaces shall be ground down and/or protected with plastic protective covers.
- B. All ferrous metal surfaces shall be finished in accordance with Section 09 90 00. Stainless steel, galvanized steel, plastic, brass, bronze, copper and fiber-reinforced plastic (FRP) components shall not be painted unless otherwise indicated in the Contract Documents.

3.10 TESTING

- A. All pipe support systems shall be tested for compliance with this Specification and referenced standards. After installation, each pipe support system shall be tested in conjunction with the respective piping pressure tests as specified in Section 40 05 13. If any part of the pipe support system proves to be defective or inadequate, it shall be repaired and/or augmented to the satisfaction of the Engineer, at no additional cost to the District or Engineer.

3.11 FIELD QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

3.12 STARTUP & COMMISSIONING

- A. Provide in accordance with Division 01 General Requirements.

3.13 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Division 01 General Requirements.

END OF SECTION

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SECTION 40 05 23

PROCESS VALVES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work Included

1. Provide all labor, materials, equipment, incidentals, and appurtenances required for process valves in accordance with this Section and applicable reference standards listed in Article 1.3.
2. The following sections reference the process valve type and specification reference numbers shown in the valve tag symbols on the Contract Drawings. Provide all valves that are specified, indicated on the Drawings and/or are required to complete the work indicated in the Contract Documents.
3. Furnish, install, test and make ready for operation all process valves of the type(s) and size(s) required and as shown on the Drawings and as specified herein. Provide all related valve accessories including but not limited to extension stems, stem guides, operating wrenches, floor stands, and valve tags. The valves and appurtenances shall be of sizes and connection types as shown on the Drawings and as specified herein.
 - a. The requirements of this Specification Section shall apply to Sections 40 05 23a Control Valve Purchase Specifications and 40 05 23b Cooling Water Relief Valve Purchase Specifications. Contractor shall provide all valves listed in 40 05 23a and 40 05 23b. Contractor shall provide submittals as required by this Section for all valves listed in 40 05 23a and 40 05 23b.
4. Provide gear operated hand wheel actuators for all valves which are located adjacent to walls or structural supporting members to allow unobstructed actuation.
5. Furnish one set of all special tools required to completely assemble, disassemble, or maintain the valves and strainers. Special tools shall refer to oversized or specially dimensioned tools, special attachments or fixtures, or any similar items.

B. Related Sections

1. Section 01 33 00 – Submittal Procedures.
2. Section 01 75 17 – Field Testing and Startup.
3. Section 01 91 13.10 – Asset Identification Tags.

4. Section 40 61 01 – Instrumentation and Controls General Requirements.

1.2 REFERENCES

A. Reference Standards

1. American National Standards Institute (ANSI)
 - a. ANSI B16.1 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
 - b. ANSI B16.104 Control Valve Seat Leaking
2. American Society of Mechanical Engineers (ASME)
 - a. ASME B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24
ASME B16.10 Face-to-Face and End-to-End Dimensions of Valves
 - b. ASME Section IV: Rules for the Construction of Heating Boilers
3. ASSE International (ASSE)
 - a. ASSE 1013 Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers
4. ASTM International (ASTM)
 - a. ASTM A 126 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - b. ASTM A 216/A 216M Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
 - c. ASTM A 240/A 240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
 - d. ASTM A 276/A 276M Standard Specification for Stainless Steel Bars and Shapes
 - e. ASTM A 351/A 351M Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
 - f. ASTM A 436 Standard Specification for Austenitic Gray Iron Castings
 - g. ASTM A 48/A 48M Standard Specification for Gray Iron Castings
 - h. ASTM A 536 Standard Specification for Ductile Iron Castings

- i. ASTM B 584 Standard Specification for Copper Alloy Sand Castings for General Applications
- j. ASTM B 16/B 16M Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
- k. ASTM B 30 Standard Specification for Copper Alloys in Ingot Form
- l. ASTM B 36/B 36M Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
- m. ASTM B 61 Standard Specification for Steam or Valve Bronze Castings
- n. ASTM B 62 Standard Specification for Composition Bronze or Ounce Metal Castings
- o. ASTM B 124/B 124M Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
- p. ASTM B 138/B 138M Standard Specification for Manganese Bronze Rod, Bar, and Shapes
- q. ASTM B 150/B 150M Standard Specification for Aluminum Bronze Rod, Bar, and Shapes
- r. ASTM B 505/B 505M Standard Specification for Copper Alloy Continuous Castings
- s. ASTM D 1599 Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings
- t. ASTM D 2000 Standard Classification System for Rubber Products in Automotive Applications
- u. ASTM D 3222 Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials
- v. ASTM D 4024 Standard Specification for Machine Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
- w. ASTM D 429 Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates
- x. ASTM D 1056 Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber
- y. ASTM D 1784 Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

- z. ASTM F 593 Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
 - aa. ASTM F 1476 Standard for Performance of Gasketed Mechanical Couplings in Piping Applications
 - bb. ASTM F 1970 Standard Specification for Special Engineered Fittings, Appurtenances or Valves for Use in Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Systems
 - cc. ATSM G93-03-2011 Standard Practice for Cleaning Methods and Cleanliness Levels for material and Equipment Used in Oxygen-Enriched Environments
5. American Water Works Association (AWWA)
- a. AWWA C500 Metal-Seated Gate Valves for Water Supply Service
 - b. AWWA C504 Rubber-Seated Butterfly Valves
 - c. AWWA C508 Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In. (600 mm) NPS
 - d. AWWA C509 Resilient-Seated Gate Valves for Water Supply Service
 - e. AWWA C511 Reduced-Pressure Principle Backflow-Prevention Assembly
 - f. AWWA C512 Air Release, Air/Vacuum, and Combination Air Valves for Waterwork and Wastewater Service
 - g. AWWA C515 Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
 - h. AWWA C517 Resilient-Seated Cast-Iron Eccentric Plug Valves
 - i. AWWA C550 Protective Interior Coatings for Valves and Hydrants
 - j. AWWA C606 Grooved and Shouldered Joints
 - k. AWWA D102 Coating Steel Water-Storage Tanks

1.3 SUBMITTALS

A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

- 1. Shop drawings for each valve shall be identified with the applicable style or series designation. Shop Drawings shall show layout and dimensions of

equipment, major components, key alignment locations and locations of bolt holes. Drawings shall show all critical field dimensions identified by the Manufacturer.

C. Product Data

1. Submit sufficient product data to verify compliance with the specifications and to illustrate the construction and assembly of the products. Include compliance of materials and components with applicable standards. Product data shall include manufacturer's descriptive data, technical literature, performance charts, catalog cuts, and installation instructions. The type, thickness, application procedure, and test for coatings, and non-metallic and metallic linings shall also be included.

D. Reports

1. Submit test reports for each valve tested for pressure and leakage.

E. Closeout and Maintenance Material Submittals: per Division 01 General Requirements.

1.4 QUALIFICATIONS OF MANUFACTURER

- A. Materials and equipment shall be the standard products of a Manufacturer regularly engaged in the production of such products and shall essentially duplicate items that have been in satisfactory use in identical applications in other cryogenic oxygen facilities. The Manufacturer shall have a minimum of five (5) years of documented experience in the design and production of process valves or strainers of "all types", and not less than five (5) years of experience in the production of equal or larger sized models of the exact equipment as specified herein.
- F. The Manufacturer shall provide a list of at least five (5) similar installations, including contact names and phone numbers. Equipment shall be supported by a service organization that is, in the opinion of the Engineer, reasonably convenient to the site to ensure parts and service can be acquired in a timely fashion.

1.5 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.
- B. All valves of the same type shall be the product of a single Manufacturer. Unless otherwise indicated, floor stands, associated adapters, extension stems, extension stem brackets, and all associated appurtenances shall be provided by the valve Manufacturer.
- G. All valves shall be suitable for the services specified and intended. The pressure ratings and materials specified represent minimum acceptable standards for valves and strainers. All valves and strainers shall have a pressure rating no less than that required for the system in which they are installed.

- H. All piping systems, components, and appurtenances in contact with potable water, including potable water during any stage of treatment or conditioning, shall be certified to meet the requirements of ANSI/NSF 61 for water service.
- I. All grooved valves shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. All castings used for valve shall be date stamped for quality assurance and traceability.

1.6 DELIVERY, STORAGE & HANDLING

- A. Provide in accordance with Division 01 General Requirements.
- B. All equipment delivered and placed in storage shall be provided with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants in accordance with the Manufacturer's written instructions.
- C. Finished surfaces of all exposed openings shall be protected by wooden blanks or other suitable cover to prevent foreign material and debris from entering the equipment.
- D. Off-load equipment at the installation site using equipment of sufficient size and design to prevent damage to the equipment. Immediately after off-loading, inspect all equipment for shipping damage or missing parts. Any damage or discrepancy shall be noted in a written claim with the shipper prior to accepting delivery. Validate all serial numbers and parts lists with the shipping documentation. Notify the Manufacturer of any unacceptable conditions with the shipper.
- E. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping. Store rubber products under cover out of direct sunlight. Do not store materials directly on the ground.

1.7 WARRANTY

- A. Provide in accordance with Division 01 General Requirements.

PART 2 – PRODUCTS

2.1 PROCESS VALVES - GENERAL

- A. The use of a Manufacturer's and/or identification catalog number in the following sections shall be for the purpose of establishing a standard of quality and/or the valve configuration/assembly desired for the application specified or shown on the Drawings. The reference to specific product catalog, model, or figure numbers shall not be considered as "Proprietary".
- J. Valve sizes shall be equal to line sizes as shown on the Drawings, unless otherwise indicated. Provide all necessary reducers and/or expansion fittings for connection of valves to pipelines that are not of equal size. All flanged valves shall conform to ANSI B16.1 standards unless otherwise noted. Grooved end valves shall be of the same manufacturer as the adjoining couplings, with ends compliant to AWWA C606.

- K. Valves shall include all required operator(s), actuator(s), handwheel(s), chain wheel(s), extension stem(s), floor stand(s), floor box(es) worm and gear operator(s), operating nut(s), chain(s), wrenches, and all other appurtenances required for a properly installed and operational valve assembly as shown on the Drawings and as specified herein. The installation shall form a complete workable system as shown on the Drawings.
- L. Cast marking(s) shall be provided on all valves and strainers. The marking(s) shall include size, working pressure, a cast arrow to indicate direction of flow, name of Manufacturer, and year of Manufacture. The marking shall be located on an appropriate part of the valve in a clearly visible location. All valves and strainers shall be suitable for the intended service shown on the Drawings and specified herein. Renewable parts shall not be of a lower quality than those specified and provided with the initially specified and installed valve or strainer assembly.
- M. All valves shall open by turning/rotating the valve actuator Counterclockwise ("Left"), unless otherwise specified or shown on the Drawings. Provide all special adaptors to ensure compatibility between valves, appurtenances, and adjacent piping.
- N. All valves shall be oxygen cleaned in accordance with ATSM-G93-03-2011 Standard Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments
- O. All valves shall be assembled with components that are suitable for their listed temperature and pressure ranges.
- P. All valves shall be assembled with components that are suitable for oxygen service.
- Q. The first manufacturer presented and the valves specified in the valve data sheets are intended as the easiest replacement option. All other manufacturers may or may not require piping modification for proper dimensional fit.
- R. Valves inside the cold box or turbine duct will require a new valve boot to be installed and sealed against the cold box.

2.2 VALVES

- A. Provide as specified in the Valve Index and Data Sheets and as specified.

B. ATTACHMENTS

- 1. Valve index
- 2. Data sheets

2.3 HIGH PERFORMANCE BUTTERFLY VALVES 14 INCH AND 20 INCH

- A. General

1. High performance butterfly valves shall be furnished and installed in place of the Dezurik switch valves. All parts shall be suitable for high oxygen purity service.
2. Sizes
 - a. Wafer style
 - b. 14 inch
 - c. 20 inch
3. Design Working Pressure
 - a. ASME Class 150
4. Gas Temperature
 - a. Minus 25 to 200 degrees Fahrenheit
5. Valves shall be equipped with a retaining ring at the top of the shaft to prevent movement of the top portion of the shaft past the compression ring.
6. Valves shall be equipped with a high cycle option seat and shaft to maintain high reliability.
7. Valves shall have an offset shaft and eccentric disc to extend seat life and reduce wear.

B. Materials of Construction

1. Body: 316 Stainless Steel
2. Shaft: 316 Stainless Steel
3. Disc: Double Eccentric 316 Stainless Steel Disc
4. Seat: Xtreme seat material
5. Bearings: Filled PEEK thrust bearings and excluder ring (High Cycle)
6. Shaft Seals: 316 SS/Woven PTFE shaft bearings

C. Packing: PTFE Actuator

1. Application Criteria:
 - a. Ambient Temperature rating: 0 to 100 degrees Fahrenheit
 - b. Pneumatic Supply: Minimum 40 PSIG
 - c. Torque: Minimum torque determined by valve manufacturers application data
 - d. Duty Cycle: 60 cycles per hour

- e. Type: Double acting piston
- 2. General
 - a. Actuator must have adjustable open and closed stops.
 - b. Actuator must have high cycle options for high reliability in high frequency and fast cycles.
- 3. Materials of construction
 - a. Aluminum cylinder
 - b. PTFE piston seals
 - c. Nitrile rubber O-ring
 - d. Steel and PTFE bearings
 - e. Stainless Steel Stop Screw
 - f. Aluminum Allow Piston
- D. Positioner Monitor
 - 1. 2 SPDT Mechanical switches to monitor both open and closed stop positions.
 - 2. ¾ Inch FNPT conduit entry
 - 3. Yellow and Black indicating beacon
 - 4. Namur mount to fit with specified actuator and valve
 - 5. Position Monitor provided shall match those specified in the valve specification. Additional detail on position monitors can be found in 40 70 00 Instrumentation for Process Systems.
- E. Solenoids
 - 1. General
 - a. 4 Way piston/popover solenoid valve compatible with air.
 - b. One inlet, two outlet, and one exhaust port.
 - c. Brass body
 - d. ½" Port size
 - e. Flow from 1 to 2 Cv
 - f. 120 V AC
 - g. Outdoor Operating environment

2.4 HIGH PERFORMANCE BUTTERFLY VALVES 4 INCH AND 6 INCH

A. General

1. High performance butterfly valves shall be furnished and installed in place of the Dezurik switch valves. All parts shall be suitable for high oxygen purity service.
2. Sizes
 - a. Wafer style
 - b. 4 Inch
 - c. 6 Inch
3. Design Working Pressure
 - a. ASME Class 150
4. Gas Temperature
 - a. Minus 25 to 200 degrees Fahrenheit
5. Valves shall be equipped with a retaining ring at the top of the shaft to prevent movement of the top portion of the shaft past the compression ring.
6. Valves shall be equipped with a high cycle option seat and shaft to maintain high reliability.
7. Valves shall have an offset shaft and eccentric disc to extend seat life and reduce wear.

B. Materials of Construction

1. Body: 316 Stainless Steel
2. Shaft: 316 Stainless Steel
3. Disc: Double Eccentric 316 Stainless Steel Disc
4. Seat: Xtreme seat material
5. Bearings: Filled PEEK thrust bearings and excluder ring (High Cycle)
6. Shaft Seals: 316 SS/Woven PTFE shaft bearings
7. Packing: PTFE

C. Actuators

1. Actuators will comply with manufacturers written specification for operation, stroke, and torque data.

2. Actuators shall be pneumatic diaphragm spring return type actuators with action in the direction indicated on the valve data sheets.
3. Actuators shall be suitable for outdoor service with an anti-corrosion coating, aluminum, or stainless steel construction.
4. Actuators shall be suitable for service with temperatures ranging from -40 degrees Fahrenheit up to 120 degrees Fahrenheit.
5. Actuators shall have consistent supply instrument air pressure of 40 PSIG or more to operate.

D. Positioners

1. Positioners shall conform to valve and actuator written specifications
2. Positioners shall contain an integral I/P transducer pre-set to the range and action on the valve data sheets.
3. Positioners shall be suitable for outdoor service with an anti-corrosion coating, stainless steel, or aluminum construction.
4. Positioner provided shall match the positioner specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

E. Solenoids

1. Solenoids shall be 3-way solenoid with consistent branding across all valves. 1/4 Inch NPT entry and 120 VAC.

2.5 ROTARY CONTROL VALVE

A. General

1. Eccentrically rotating, double offset plug with extremely linear flow characteristics at higher turndown shall be installed as all compressor vent valves.
2. Sizes
 - a. 4 Inches
3. Design Working Pressure
 - a. ASME Class 150
4. Gas Temperature
 - a. Minus 50 to 200 degrees Fahrenheit
5. Flangeless connection

6. Valve shall be of a spring opposed rolling diaphragm type.
7. Valve shall have a CV ratio of 100:1 and provide stable operation over a wide range of conditions.
8. Valve shall make no contact with the sealing seat until it is moved into a fully closed position.

B. Materials of Construction

1. 316 Stainless Steel body
2. 316 Stainless Steel plug with hardened seating surface
3. 316 Stainless Steel with PCTFE insert seat
4. 316 Stainless Steel Retainer

C. Actuators

1. Appropriately sized and selected based on the valve manufacturers written instructions.
2. Spring-Opposed Rolling Diaphragm Actuator
3. ¼ Inch NPT air connection
4. Cast Iron Yoke
5. Sealed Radial Bearing

D. Positioners

1. Direct mounted positioner with built in I/P
2. 4-20 ma signal range
3. Supply and output gauges included
4. Reverse Acting
5. Positioner provided shall match the positioner specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

E. Solenoids

1. ¼ Inch Stainless Steel Solenoid
2. 3 Way solenoid valve
3. 120 VAC

2.6 CRYOGENIC PROPORTIONAL TRIM GLOBE VALVE

A. General

1. All cryogenic Proportional Trim Globe Valves shall be suitable for their environment and temperature ranges according to the manufacturers written specifications.
2. Valves inside the coldbox require custom stem length which are stipulated in the valve data sheets.
3. Valves must be capable of being rebuilt through the extended valve stem without requiring the removal of perlite.
4. Valves requiring boots are noted on the provided data sheets. Boots should be made of Gylon or Hypalon and seal tightly against both the cold box and the valve stem.

B. Materials of Construction

1. Valve Body: 316 Stainless Steel
2. Bonnet: 316 Stainless Steel
3. Stem: 316 Stainless steel
4. Flanges: 316 Stainless Steel

C. Actuators

1. Actuators will comply with manufacturers written specification for operation, stroke, and torque data.
2. Actuators shall be pneumatic diaphragm spring return type actuators with action in the direction indicated on the valve data sheets.
3. Actuators shall be suitable for outdoor service with an anti-corrosion coating or stainless steel construction.
4. Actuators shall be suitable for service with temperatures ranging from -40 degrees Fahrenheit up to 120 degrees Fahrenheit.
5. Actuators shall have consistent supply instrument air pressure of 40 PSIG or more to operate.

D. Positioners

1. Positioners shall conform to valve and actuator written specifications

2. Positioners shall contain an integral I/P transducer pre-set to the range and action on the valve data sheets.
3. Positioners shall be suitable for outdoor service with an anti-corrosion coating, stainless steel, or aluminum construction.
4. Positioner provided shall match the positioner specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

E. Solenoids

1. Solenoids shall be 3 way solenoid with consistent branding across all valves. 1/4 Inch NPT entry and 120 VAC.

2.7 CRYOGENIC BUTTERFLY VALVE

A. General

1. Cryogenic butterfly valves shall be able to operate effectively in temperatures ranging from -320 degrees Fahrenheit to 350 degrees Fahrenheit.
2. Cryogenic butterfly valves shall have extended bonnets and stems as detailed in the valve data sheets allowing protrusion from the cold box. A suitable valve boot shall be procured and installed in order to seal the cold box and valve stem.
3. Cryogenic butterfly valves shall have an ANSI pressure rating of 150 PSIG.
4. Valve Sizes:
 - a. 4 Inch
 - b. 6 Inch
5. Wafer style construction
6. Cryogenic butterfly valves shall have an eccentric disc and offset shaft allowing for minimal wear points along the seat for higher cycle life.

B. Materials of Construction

1. Body: 316 Stainless Steel
2. Disc: 316 Stainless Steel
3. Shaft: 17-pH Stainless Steel
4. Seat: PTFE/316 Stainless Steel

5. Shaft Seal: PTFE
6. Materials suitable for oxygen service

C. Actuators

1. Actuators will comply with manufacturers written specifications for operation, stroke, and torque data.
2. Actuators shall be pneumatic diaphragm spring return type actuators with action in the direction indicated on the valve data sheets.
3. Actuators shall be suitable for outdoor service with a anti-corrosion coating, aluminum, or stainless steel construction.
4. Actuators shall be suitable to operate at a minimum of 40 PSIG instrument air pressure.

D. Positioners

1. Positioners shall conform to valve and actuator written specifications
2. Positioners shall contain an integral I/P transducer pre-set to the range and action on the valve data sheets.
3. Positioners shall be suitable for outdoor service with an anti-corrosion coating, stainless steel, or aluminum construction.
4. Positioner provided shall match the positioner specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

E. Solenoids

1. Solenoids shall be 3 way solenoid with consistent branding across all valves. 1/4 Inch NPT entry and 120 VAC.

2.8 BUTTERFLY VALVES

A. General

1. High performance butterfly valves shall be furnished and installed in place of the Dezurik switch valves. All parts shall be suitable for high oxygen purity service.
2. Sizes
 - a. Wafer style
 - b. 6 Inch
 - c. 4 Inch

3. Design Working Pressure
 - a. ASME Class 150
 4. Gas Temperature
 - a. Minus 20 to 200 degrees Fahrenheit
 5. Valves shall be equipped with a retaining ring at the top of the shaft to prevent movement of the top portion of the shaft past the compression ring.
 6. Valves shall be equipped with a high cycle option seat and shaft to maintain high reliability.
 7. Valves shall have an offset shaft and eccentric disc to extend seat life and reduce wear.
- B. Materials of Construction
1. Body: 316 Stainless Steel
 2. Shaft: 316 Stainless Steel
 3. Disc: Double Eccentric 316 Stainless Steel Disc
 4. Seat: Xtreme seat material
 5. Bearings: Filled PEEK thrust bearings and excluder ring (High Cycle)
 6. Shaft Seals: 316 SS/Woven PTFE shaft bearings
 7. Packing: PTFE
- C. Actuators
1. Actuators will comply with manufacturers written specifications for operation, stroke, and torque data.
 2. Actuators shall be pneumatic diaphragm spring return type actuators with action in the direction indicated on the valve data sheets.
 3. Actuators shall be suitable for outdoor service with a anti-corrosion coating, aluminum, or stainless steel construction.
 4. Actuators shall be suitable to operate at a minimum of 40 PSIG instrument air pressure.
- D. Positioners
1. Positioners shall conform to valve and actuator written specifications.

2. Positioners shall contain an integral I/P transducer pre-set to the range and action on the valve data sheets.
3. Positioners shall be suitable for outdoor service with an anti-corrosion coating, stainless steel, or aluminum construction.
4. Positioner provided shall match the positioner specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

E. Solenoids

1. Solenoids shall be 3 way solenoid with consistent branding across all valves. 1/4 Inch NPT entry and 120 VAC.

2.9 BALL VALVES

A. General

1. All sample valves shall be replaced with the ball valves suitable for oxygen service and temperatures ranging from -60 Degrees Celsius to 110 Degrees Celsius.
2. Ball valves shall have both connections be ½ Inch female NPT.
3. Ball valves shall have a handle with locking mechanism which must be adjusted to open or close the valve.

B. Materials of Construction:

1. Body: 316 Stainless Steel
2. Stem: 316 Stainless Steel
3. Fluorocarbon FKM Flange Seal
4. Seat: Alloy X-750 Reinforced PTFE
5. Ball: 316 Stainless Steel
6. Handle: 316 Stainless steel with Vinyl cover

2.10 TURBINE INLET GUIDE VANE ACTUATOR

A. General

1. The actuator, solenoid, and positioner are being replaced on the turbine inlet guide vane. All new mounting hardware and linkages shall be provided to the existing valve.

2. Actuator, Positioner, and Solenoid shall be supplied based on the information presented in the valve data sheets.
3. Positioner provided shall match the positioner specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

2.11 MAIN AIR COMPRESSOR INLET GUIDE VANE ACTUATOR

A. General

1. The actuator, solenoid, and positioner are being replaced on the turbine inlet guide vane. All new mounting hardware and linkages shall be provided to the existing valve.
2. Actuator, Positioner, and Solenoid shall be supplied based on the information presented in the valve data sheets.
3. Positioner provided shall match the positioners specified in the valve specification. Additional detail on positioners can be found in 40 70 00 Instrumentation for Process Systems.

2.12 GASKETS

- A. Gaskets shall be compatible with the associated process fluid. Coupling gasket material shall match the piping system gasket material. Gaskets for use in potable water service shall have an NSF 61 listing. All gaskets shall be rated for a temperature range appropriate with the process or as indicated on the drawings.
- B. If a different type of gasket than that specified for a specific application is recommended by the manufacturer, the gasket information shall be submitted to the Engineer for review and approval.

2.13 SPARE PARTS

- A. Concurrent with delivery and installation of the specified valves, spare parts for each different item of material and equipment specified that is recommended by the Manufacturer to be replaced any time up to three (3) years of service shall be provided. For each type and size of valve, the following extra materials shall be provided: lubricator, lubricant (with appropriate temperature rating), lubricator/isolating valve; galvanized operating wrench, 4 feet long, for T-handled operators; galvanized operating key for cross handled valves.
- B. Extra materials shall include two (2) of the following spare parts for each type and size of valve: gaskets; O-ring seals; diaphragms (molded); all elastomer parts; stem packing; seat rings and seat ring pulling tool.

2.14 VALVE ACTUATORS AND OPERATORS

- A. Unless otherwise specified or shown on the Drawings, all valves shall be manually actuated. All valves shall have an operating hand wheel or a handle/lever mounted

on the operator. Valves with operating nuts shall be non-rising stem design with an AWWA 2 inch square operating nut. Provide at least six (6) two (2) foot long steel operating bars for all operating nuts. All valves shall be provided with hand wheel actuators on all manually actuated valves larger than six (6) inches in size unless otherwise specified or shown on the Drawings.

- B. The valve Manufacturer shall supply and factory mount all actuators; including any type of manual or powered actuators. The valves and actuators shall be shipped as a single unit. All valve actuators shall be sized to operate the associated valve for the full range of pressures and velocities. Position indicators shall be provided for interior NRS valves.
- C. The force in a manual operator shall not exceed 40 pounds of rim-pull under any operating condition, including initial breakaway. The operator shall be equipped with gear reduction when force exceeds 40 pounds of rim-pull. All manual operators shall be self-locking type or shall be equipped with a self-locking device. The actuators shall be capable of moving the valves from a fully open to a fully closed position and a fully closed position to a fully open position. The actuator shall be capable of holding the valve at any position in between the fully open and fully closed positions. A position indicator shall be supplied on quarter-turn valves. Each operating device shall have the word "OPEN" permanently cast as well as an arrow indicating the direction of operation.

2.15 CHAINWHEEL OPERATORS

- A. Unless otherwise specified or shown on the Drawings, chain wheel actuators shall be provided for all valves when the valve center line is located **six (6) feet** or greater above the operating floor. All chain wheel actuators shall be provided complete with chain guides. The operator chain shall loop within a minimum of **four (4) feet** from the operating floor level. Provide 316 stainless steel "L" type tie-back anchors shall be to allow for chain attachment. All chain shall be weldless single loop lock type.
- B. All chain wheel actuators and chain guides shall be specifically sized for the diameter of the valve hand wheel. All chain wheel actuators shall be designed to allow for field adjustment and detachment. All chain wheel actuators shall be designed and constructed in accordance with the following criteria:
 - 1. Size: Match to Valve Hand wheel Diameter
 - 2. Chain Wheel: Cast Iron or Ductile Iron - Epoxy Coated
 - 3. Chain Guide: Malleable Iron
 - 4. Attachment Hardware: 316 Stainless Steel
 - 5. Chain: 304 Stainless Steel
 - 6. Chain: Spark-Resistant Brass (Explosion Proof Environments Only)

- C. The chain wheel rim shall contain a groove into which the chain guide attaches. The groove shall be an integral part of the casting. All ferrous metallic surfaces of the chain wheel actuators shall be provided with a two-part epoxy paint coating. The coating color system shall be matched to the valve piping system color coding. All chain wheel actuators which are located in Class 1, Division 1 & 2 "Explosion Proof" electrical hazard areas shall be equipped with a spark-resistant brass chain.
- D. All chain wheel actuators of the same type, style, and duty shall be supplied by a single Manufacturer. Where applicable, chain wheel actuators shall be provided by the Manufacturer of the valve being served. The chain wheel actuators shall be a product of the following Manufacturer:
 - 1. M&H Valve Company
 - 2. Kennedy Valve Company
 - 3. Babbitt Steam Specialty Company
 - 4. Or Equal.

2.16 GEAR OPERATORS

- A. Unless otherwise specified or shown on the Drawings, all valves larger than eight (8) inches shall be provided with gear operators. All manually operated valves with a rim pull greater than 40 ft-lbs shall also be provided with gear operators. Worm and gear operators shall be a one-piece design with worm-gears of bronze or machine cut steel material. Worm shall be hardened alloy steel with the thread ground and polished. Traveling nut type operators shall have threaded steel reach rods with an internally threaded bronze or ductile iron nut.
- B. The output shaft shall be perpendicular to the valve shaft and be provided with a removable hand wheel. Unless otherwise noted or specified all gear actuators shall conform to AWWA C504 standards. All butterfly valve actuators shall provide proof of certification. All gear actuators shall be removable from the valve without removing the valve from the line or dismantling the valve.
- C. All gear operators shall indicate the valve position and have adjustable stops. The maximum hand wheel size shall be 24 inches in diameter. All position indicators shall be of the embossed, stamped, engraved, etched, or raised types.
- D. Unless otherwise specified or shown on the Drawings, all gear operated valves three (3) inches & larger shall be provided with position indication at the point of operation. Valves smaller than three (3) inches shall have position indication on the respective hand wheel's or lever actuators.

2.17 FINISHINGS & COATINGS

- A. Unless otherwise specified, all iron body valves shall be exterior primed with a shop coat of an Engineer approved rust-inhibitive primer. The primer shall be applied in accordance with the instructions of the paint Manufacturer. The primer shall be

compatible with the finish coat provided. Unless otherwise specified, the finish coat shall match the coating of connecting pipe in type and color. All field painting shall be in accordance with Section 09 90 00 PAINTING & COATING. Stainless steel, brass, bronze, and plastic body valves shall not require coating.

- B. Unless otherwise specified or noted, all interior ferrous surfaces shall be given a shop finish of an asphalt varnish or epoxy coating in accordance with AWWA C550 and AWWA C509 standards.
- C. The epoxy paint shall be either a two-part liquid material or a heat-activated (fusion) material except that only a heat-activated material shall apply if a valve coating is specified as "fusion" or "fusion bonded" epoxy. The epoxy lining and coating shall have a minimum 4.0 mils dry film thickness except where it is limited by valve operating tolerances. Safety isolation valves and lockout valves with handles, hand wheel's, or chain wheels shall be painted "Safety Yellow."
- D. Ferrous surfaces obviously not intended to be painted shall be given a shop coat of grease or other acceptable rust-inhibitive coating.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install valves as shown on the Drawings and in strict accordance with the Manufacturer's recommendations. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward of the horizontal plane. Allow sufficient room for maintenance, removal and proper operation. All valves shall be located and oriented to permit easy access to the valve operator, and to avoid interferences.
- B. All valves shall be independently supported. Valves shall not be supported by the connecting piping.
- C. Flanged valve bolt holes shall be installed to straddle the vertical centerline of the pipe. Flanged faces shall be cleaned prior to inserting the gasket and bolts. All nuts shall be tightened progressively and uniformly. Threaded ends shall have the threads cleaned by wire brushing or swabbing prior to installation.
- D. Where any valve or appurtenance installation is covered by a standard, the Contractor shall install such equipment in accordance with the standard unless otherwise specified or indicated on the Drawings. The Contractor shall certify any such installations are in accordance with all applicable standards.
- E. Unless otherwise specified or shown on the Drawings, all valve connections/joints shall be installed in accordance with the specified and applicable standards. The Contractor shall be responsible for all verification of Manufacturer's torque requirements.

3.2 VALVE ORIENTATION

- A. The operating stem of a manual valve shall be installed in a vertical position when the valve is installed in horizontal runs of pipe having centerline elevations of 4.5 feet or less above the finished floor, unless otherwise specified or indicated on the Drawings. The operating stem of a manual valve shall be installed in a horizontal position in horizontal runs of pipe having centerline elevations greater than 4.5 feet above the finish floor, unless otherwise specified or indicated on the Drawings.
- F. All manually actuated valves three (3) inches and smaller shall have the valve indicators and operators located to display toward the normal operational locations.

3.3 BUTTERFLY VALVES

- A. Orientation of butterfly valves shall take into account changes in pipe direction. Valve shafts shall be oriented so that unbalanced flows caused by pipe direction changes or other disturbances are equally divided to each half of the disc.

3.4 PLUG VALVES

- A. If a plug valve seat position is not shown in the contract Drawings, locate the seat position as follows: for horizontal flow, the flow shall produce an "unseating" pressure, and the plug shall open into the top half of valve; and for vertical flow, the seat shall be installed in the highest portion of the valve.

3.5 VALVE TESTING

- A. Test all valves visually for leaks and proper operation under pressure. Test valves to ensure proper valve function and actuation. All valves shall be tested as part of the respective piping system or segment in accordance with Section 40 05 13 PROCESS PIPE AND FITTINGS.
- G. Valves may either be tested while testing pipelines, or as a separate test. It shall be demonstrated that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, and in both directions for two-way valve applications. Count and record the number of turns required to open and close each valve, and account for any discrepancies with the Manufacturer's data.
- H. Air and vacuum relief valves shall be examined as the associated pipe is being filled to verify venting and seating is fully functional. Set, verify, and record set pressures for all relief and regulating valves. Self-contained automatic valves shall be tested at both maximum and minimum operating ranges, and reset upon completion of test to the design value.
- I. Take care not to overpressure any valve and appurtenances during testing.

3.6 RETESTING

- A. If the equipment does not successfully pass the tests listed above, the Manufacturer/Contractor shall repair the equipment and perform the tests again until

passing the tests successfully. If any deficiencies are revealed during any test, such deficiencies shall be corrected and the tests shall be re-conducted at no additional cost to the District or Engineer.

3.7 CLEANING

- A. All items, including but not limited to all valves & valve interiors, shall be thoroughly cleaned prior to installation, testing, and final acceptance. All dirt, debris, and other foreign materials shall be removed.

(continued on next page)

VALVE INDEX	
Valve Tag*	Valve Description
FV-111A, 112A	Air Control Valve
FV-113A, 114A	Nitrogen Control Valve
LV-330A	Crude LOX Control Valve
FV-340N	Liquid Nitrogen
FV-601X	GOX Control Valve
FV-214A	Air Control Valve
FV-215A	Air Control Valve
FV-213A	Air Control Valve
FV-220A	Air Control Valve
FV-600X	GOX Control Valve
X600X-1, X600X-2	GOX Control Valve
FV-635	GOX Control Valve
PV-615, 625	GOX Control Valve
PV-616, 626	LOX Control Valve
PSV-817, 818	Cooling Water Relief Valve
PSV-819, PSV-820	Water Relief Valve
PSV-821, 822	Water Relief Valve
PSV-823, 824	Water Relief Valve
Multiple	Sample Taps and Instrument Valves

*Valve tags may be abridged. Contractor shall refer to plans for quantity of valves and full tag name.

END OF SECTION

SECTION 40 05 23a
CONTROL VALVE PURCHASE SPECIFICATIONS

PURCHASE SPECIFICATIONS																																																																
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 EQUIPMENT AND SERVICES FOR THE INDUSTRIAL GASES INDUSTRY 74 Sail Away Lane Moneta, VA 24121 Tel. (513)939-9380			<table><thead><tr><th>Revision</th><th>No.</th><th>Date</th><th>By</th></tr></thead><tbody><tr><td>30% Design</td><td></td><td>12/2/21</td><td>D. Boggs</td></tr><tr><td>90% Design</td><td></td><td>1/25/23</td><td>D. Boggs</td></tr><tr><td>100% Design</td><td></td><td>11/29/23</td><td>D. Boggs</td></tr><tr><td>100% Design</td><td>1</td><td>3/26/24</td><td>D. Boggs</td></tr><tr><td>100% Design</td><td>2</td><td>4/12/2024</td><td>D. Boggs</td></tr></tbody></table>		Revision	No.	Date	By	30% Design		12/2/21	D. Boggs	90% Design		1/25/23	D. Boggs	100% Design		11/29/23	D. Boggs	100% Design	1	3/26/24	D. Boggs	100% Design	2	4/12/2024	D. Boggs																																				
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PURCHASE SPECIFICATIONS
CONTROL VALVES



74 Sail Away Lane
Moneta, VA 24121
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Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
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100% Design		3/26/24	D. Boggs

Tag No.		FV-113N & FV-114N		Service	Nitrogen (reversing heat exchanger switch valves)	
PIPE	Size Upstream	In.	20"			
	Schedule		10			
	Size Downstream	In.	20"			
	Schedule		10			
VALVE BODY		High Performance Butterfly Valve (Switching)			POSITIONER	
Manufacturer		Jamesbury Neles or equal			Manufacturer	N/A
Model No.		20 815WO-11-3600XZ-MM			Model No.	N/A
Type		High Performance and Cycle Butterfly			Type	N/A
Nominal Size		20 Inches			Action	N/A
Rated Temp./Press.		200 F/ 235 PSIG			Signal Range	N/A
Body Material		316 SST			Filter/ Reg.	N/A
Bonnet Material		N/A			Gauge Set	N/A
Disc and Shaft		Double Eccentric 316 SST Disc and Shaft				
End Connections		Wafer Style				
ACTUATOR				POSITION MONITOR		
Manufacturer		Metso or equal			Manufacturer	Westlock or equal
Model No.		B1CU13-55L			Model No.	2007NBY2B2M0200
Type		Pneumatic Cylinder, Double Acting			Type	Position Limit Switch
Action		Modulate			Signal Range	120 VAC
Air Pressure		60 PSIG				
Failure Mode		N/A				
Solenoid Valve		Included				
Solenoid Mfg.		ASCO				
Solenoid Model No.		8344G074				
Tubing		1/2" SS				

NOTES:

The body thickness of these butterfly valves is considerably less than the existing DeZurik plug style valves. Carbon steel flanged spool pieces must be field fabricated and provided to close the remaining gap in the piping. Replace valve, actuators, position monitor and solenoid. Include filter regulator set at 60 PSIG on supply line.

PURCHASE SPECIFICATIONS
CONTROL VALVES



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EQUIPMENT AND SERVICES FOR THE INDUSTRIAL GASES INDUSTRY

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100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		FV-213A		Service	Air (turbine bypass)				
PIPE	Size Upstream	In.	2"						
	Schedule		40						
	Size Downstream	In.	2"						
	Schedule		40						
VALVE BODY						Cryogenic Proportional Trim Globe Valve		POSITIONER	
Manufacturer		Valtek/Flowserve, Fisher, or equal				Manufacturer		Valtek/Flowserve, Fisher, or equal	
Model No.		TBD				Model No.		TBD	
Type		Globe, Proportional Trim				Type		Electronic	
Nominal Size		2"				Action		Reverse Acting	
Rated Temp./Press.		-320 F/100 PSIG				Signal Range		4 to 12 ma (split)	
Body Material		316 SS				Filter/ Reg.		Included	
Bonnet Material		316SS				Gauge Set		Supply/Output	
Stem Style		30" Extended Stem, Extractable							
End Connections		150#, RF ANSI Flanges							
ACTUATOR						TRIM			
Manufacturer		Valtek/Flowserve, Fisher, or equal				Type		Globe	
Model No.		TBD				Port Size		2"	
Type		Pneumatic Diaphragm				Characteristics		Equal Percent	
Action		Modulate				Rated Cv		Full Flow	
Air Pressure		60 PSIG				Plug/Disc Material		316SS	
Failure Mode		Closed				Seat Material		316SS	
Solenoid Valve		Included				Cage/Guide Matl.		Bronze C93200	
Solenoid Mfg.		ASCO				Stem Material		316SS	
Solenoid Model No.		V0432				Bushing Material		N/A	
Tubing		1/4" SS				Packing Matl./Type		PTFE	
						Shut Off Class		150	
NOTES:									
Replacing Valve, Solenoid, Actuator and Positioner, adding new position monitor. Vermiculite from the turbine box will need to be removed to replace valve. New valve boot will be needed to install valve. Include filter regulator set at 60 PSIG on supply line.									

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74 Sail Away Lane
Moneta, VA 24121
Tel. (513)939-9380

Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
90% Design		1/12/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.			FV-214A	Service	Air (turbine trip)
PIPE	Size Upstream	In.	6"		
	Schedule		40		
	Size Downstream	In.	6"		
	Schedule		40		

VALVE BODY	Cryogenic Butterfly Valve	POSITIONER	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	N/A
Model No.	6 K815WO-30-36-HB-AS	Model No.	N/A
Type	Wafer	Type	N/A
Nominal Size	6 Inches	Action	N/A
Rated Temp./Press.	-320 F/100 PSIG	Signal Range	N/A
Body Material	316 SST	Filter/ Reg.	N/A
Bonnet Material	N/A	Gauge Set	N/A
Stem Style	30" Extended Stem		
End Connections	150#, RF ANSI Flanges		

ACTUATOR		POSITION MONITOR	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	Jamesbury, Fisher, or equal
Model No.	VPVL550SR4B-D	Model No.	QG4WP025DM
Type	Rack and pinion, pneumatic cylinder	Type	Quartz QG
Action	Open/Close	Signal Range	On/OFF
Air Pressure	60 PSIG		
Failure Mode	Closed		
Solenoid Valve	Required		
Solenoid Mfg.	ASCO		
Solenoid Model No.	8316G14		
Tubing	1/4" SS		

NOTES:

Replacing Valve, Solenoid, Actuator and Positioner, adding new position monitor. Vermiculite from the turbine box will need ro be removed to replace valve. New valve boot will be needed to install valve (Hypalon or equal). Incude filter regulator set at 60 PSIG on supply line.

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Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
90% Design		1/12/23	D. Derr
100% Design		11/29/23	D.Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.			FV-215A	Service	Air (heat exchanger bypass)
PIPE	Size Upstream	In.	4"		
	Schedule				
	Size Downstream	In.	4"		
	Schedule				

VALVE BODY	Cryogenic Butterfly Valve	POSITIONER	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	Jamesbury, Fisher, or equal
Model No.	4 K815WO-30-36-HB-AS	Model No.	ND 9102HNUG
Type	Wafer	Type	ND 9000
Nominal Size	4 Inches	Action	Direct Acting
Rated Temp./Press.	-320 F/100 PSIG	Signal Range	12 to 20 ma (split)
Body Material	316 SST	Filter/ Reg.	Included
Bonnet Material	N/A	Gauge Set	Supply/Output
Stem Style	30" Extended Stem		
End Connections	150#, RF ANSI Flanges		

ACTUATOR		POSITION MONITOR	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	N/A
Model No.	QPX4C/MASC	Model No.	N/A
Type	Pneumatic Diaphragm	Type	N/A
Action	Modulate	Signal Range	N/A
Air Pressure	60 PSIG		
Failure Mode	Closed		
Solenoid Valve	Required		
Solenoid Mfg.	ASCO		
Solenoid Model No.	8316G14		
Tubing	1/4" SS		

NOTES:

Replacing Valve, Solenoid, Actuator and Positioner, adding new position monitor. Vermiculite from the turbine box will need ro be removed to replace valve. New valve boot will be needed to install valve (Hypalon or equal). Include filter regulator set at 60 PSIG on supply line.

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90% Design		1/12/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		FV-220A		Service	Air (turbine inlet guide vanes)	
PIPE	Size Upstream	In.	N/A			
	Schedule					
	Size Downstream	In.	N/A			
	Schedule					
VALVE BODY		Turbine Inlet Guide Vane		POSITIONER		
Manufacturer	N/A		Manufacturer	Fisher or equal		
Model No.	N/A		Model No.	TBD		
Type	N/A		Type	TBD		
Nominal Size	N/A		Action	Direct Acting		
Rated Temp./Press.	N/A		Signal Range	4-20 mA		
Body Material	N/A		Filter/ Reg.	Included		
Bonnet Material	N/A		Gauge Set	Supply/Output		
Stem Style	N/A					
End Connections	N/A					
ACTUATOR			POSITION MONITOR			
Manufacturer	Fisher or equal		Manufacturer	Topworks		
Model No.	657-38-3481970		Model No.	DXP-M21GNEB		
Type	Pneumatic Diaphragm		Type	D-Series		
Action	Modulate		Signal Range	4 to 20 mA		
Air Pressure	60 PSIG					
Failure Mode	Closed					
Solenoid Valve	Required					
Solenoid Mfg.	ASCO					
Solenoid Model No.	8316G14					
Tubing	1/4" SS					
NOTES:						
Replacing Actuator, Solenoid, and Positioner Include filter regulator set at 60 PSIG on supply line. Drop in replacement for existing actuator						

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90% Design		1/12/23	D. Derr
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		LV-330A		Service	Crude Liquid Oxygen (lower column level control)
PIPE	Size Upstream	In.	2"		
	Schedule		40		
	Size Downstream	In.	2"		
	Schedule		40		

VALVE BODY		Cryogenic Proportional Trim Globe Valve		POSITIONER	
Manufacturer	Valtek/Flowserve, Fisher, or equal		Manufacturer	Valtek/Flowserve, Fisher, or equal	
Model No.	TBD		Model No.	TBD	
Type	Globe, Proportional Trim		Type	Electronic	
Nominal Size	2"		Action	Direct Acting	
Rated Temp./Press.	-320 F/100 PSIG		Signal Range	4 to 20 ma	
Body Material	316 SS		Filter/ Reg.	Included	
Bonnet Material	316SS		Gauge Set	Supply/Output	
Stem Style	30" Extended Stem, Extractable (minimum 24")				
End Connections	150#, RF ANSI Flanges				

ACTUATOR		POSITION MONITOR	
Manufacturer	Valtek/Flowserve, Fisher, or equal	Manufacturer	Valtek/Flowserve, Fisher, or equal
Model No.	TBD	Model No.	TBD
Type	Pneumatic Diaphragm	Type	Position Feedback
Action	Modulate	Signal Range	4-20ma
Air Pressure	60 PSIG		
Failure Mode	Closed		
Solenoid Valve	Included		
Solenoid Mfg.	ASCO		
Solenoid Model No.	V0432		
Tubing	1/4" SS		

NOTES:

Replacing Valve, Actuator, Solenoid and Positioner, adding new position monitor. Perlite from the cold box will need to be removed to replace valve. New valve boot will be needed to install valve (Hypalon or equal). Include filter regulator set at 60 PSIG on supply line.

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90% Design		1/12/23	D. Derr
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		FV-340N		Service	Liquid Nitrogen (shelf)	
PIPE	Size Upstream	In.	2"			
	Schedule		40			
	Size Downstream	In.	2"			
	Schedule		40			
VALVE BODY						POSITIONER
Manufacturer		Cryogenic Proportional Trim Globe Valve		Valtek/Flowserve, Fisher, or equal		
Model No.		TBD		TBD		
Type		Globe, Proportional Trim		Electronic		
Nominal Size		2"		Direct Acting		
Rated Temp./Press.		-320 F/100 PSIG		Signal Range		
Body Material		316 SS		Filter/ Reg.		
Bonnet Material		316SS		Gauge Set		
Stem Style		30" Extended Stem, Extractable (24" minimum)		Supply/Output		
End Connections		150#, RF ANSI Flanges				
ACTUATOR						POSITION MONITOR
Manufacturer		Valtek/Flowserve, Fisher, or equal		Valtek/Flowserve, Fisher, or equal		
Model No.		TBD		TBD		
Type		Pneumatic Diaphragm		Position Feedback		
Action		Modulate		Signal Range		
Air Pressure		60 PSIG		4-20ma		
Failure Mode		Closed				
Solenoid Valve		Included				
Solenoid Mfg.		ASCO				
Solenoid Model No.		V0432				
Tubing		1/4" SS				

NOTES:

Replacing Valve, Actuator, Solenoid and Positioner, adding new position monitor. Perlite from the cold box will need to be removed to replace valve. New valve boot will be needed to install valve (Hypalon or equal). Include filter regulator set at 60 PSIG on supply line.

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30% Design		12/2/21	D. Boggs
90% Design		1/12/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		LV-350 & LV-351		Service	Liquid Oxygen (make & add)
PIPE	Size Upstream	In.	1"		
	Schedule		Type K (copper)		
	Size Downstream	In.	1"		
	Schedule		Type K (copper)		

VALVE BODY		POSITIONER	
Manufacturer	Cryogenic Proportional Trim Globe Valve	Manufacturer	Valtek/Flowserve, Hammel Dahl, or equal
Model No.	Mark One	Model No.	L1W1L11B100-PP02BW00
Type	Globe, Proportional Trim	Type	Electronic
Nominal Size	2"	Action	Direct Acting & Reverse Acting
Rated Temp./Press.	-320 F/100 PSIG	Signal Range	4 to 20 ma (split)
Body Material	316SS	Filter/ Reg.	Included
Bonnet Material	316SS	Gauge Set	Supply/Output
Stem Style	12" Extended Stem		
End Connections	150#, RF ANSI Flanges		

ACTUATOR		TRIM	
Manufacturer	Valtek/Flowserve, Hammel Dahl, or equal	Type	Globe
Model No.	TBD	Port Size	1"
Type	Pneumatic Diaphragm	Characteristics	Equal Percent
Action	Modulate	Rated Cv	Full Flow
Air Pressure	60 PSIG	Plug/Disc Material	Monel 400
Failure Mode	Closed	Seat Material	Monel 400
Solenoid Valve	Required	Cage/Guide Matl.	Bronze C93200
Solenoid Mfg.	ASCO	Stem Material	Monel 400
Solenoid Model No.	8316G14	Bushing Material	N/A
Tubing	1/4" SS	Packing Matl./Type	PTFE
		Shut Off Class	150

NOTES:

Replacing Valve, Actuator, Solenoid and Positioner. Include filter regulator set at 60 PSIG on supply line.

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30% Design		12/2/21	D. Boggs
90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		FV-600X		Service	Oxygen (product)	
PIPE	Size Upstream	In.	6"			
	Schedule		40			
	Size Downstream	In.	6"			
	Schedule		40			
VALVE BODY		High Performance Butterfly Valve		POSITIONER		
Manufacturer		Jamesbury, Fisher, or equal		Manufacturer		
Model No.		6 815WO-11-3600XZ-MM		Model No.		
Type		Wafer		Type		
Nominal Size		6 Inches		Action		
Rated Temp./Press.		200 F/ 235 PSIG		Signal Range		
Body Material		316 SST		Filter/ Reg.		
Bonnet Material		N/A		Gauge Set		
Stem Style		N/A				
End Connections		Wafer Style				
ACTUATOR				POSITION MONITOR		
Manufacturer		Jamesbury, Fisher, or equal		Manufacturer		
Model No.		QPX4C/MASC		Model No.		
Type		Pneumatic Diaphragm		Type		
Action		Modulate		Signal Range		
Air Pressure		60 PSIG		Filter/ Reg.		
Failure Mode		Closed		Gauge Set		
Solenoid Valve		Required				
Solenoid Mfg.		ASCO				
Solenoid Model No.		8316G14				
Tubing		1/4" SS				
NOTES:						
Replacing Valve, Actuator, Solenoid, and Positioner. Include filter regulator set at 60 PSIG on supply line.						

PURCHASE SPECIFICATIONS
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Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		FV-601X		Service	Oxygen (vent)	
PIPE	Size Upstream	In.	4"			
	Schedule		40			
	Size Downstream	In.	4"			
	Schedule		40			
VALVE BODY		High Performance Butterfly Valve		POSITIONER		
Manufacturer	Jamesbury, Fisher, or equal		Manufacturer	Jamesbury, Fisher, or equal		
Model No.	4 815WO-11-3600XZ-MM		Model No.	ND 9102HNUG		
Type	Wafer		Type	ND 9000		
Nominal Size	4 Inches		Action	Direct Acting		
Rated Temp./Press.	200 F/ 235 PSIG		Signal Range	4 to 20 ma		
Body Material	316 SST		Filter/ Reg.	Included		
Bonnet Material	N/A		Gauge Set	Supply/Output		
Stem Style	N/A					
End Connections	Wafer Style					
ACTUATOR			POSITION MONITOR			
Manufacturer	Jamesbury, Fisher, or equal		Manufacturer	N/A		
Model No.	QPX3C/MASC		Model No.	N/A		
Type	Pneumatic Diaphragm		Type	N/A		
Action	Modulate		Signal Range	N/A		
Air Pressure	60 PSIG		Filter/ Reg.	N/A		
Failure Mode	Closed		Gauge Set	N/A		
Solenoid Valve	Required					
Solenoid Mfg.	ASCO					
Solenoid Model No.	8316G14					
Tubing	1/4" SS					
NOTES:						
Replacing Valve, Actuator, Solenoid, and Positioner. Oxygen Cleaning Required Include filter regulator set at 60 PSIG on supply line.						

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30% Design		12/2/21	D. Boggs
90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		X-600X-1 & X600X-2		Service	Oxygen (midpoint temperature control)
PIPE	Size Upstream	In.	6"		
	Schedule		40		
	Size Downstream	In.	6"		
	Schedule		40		

VALVE BODY	High Performance Butterfly Valve	POSITIONER	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	Jamesbury, Fisher, or equal
Model No.	6 815WO-11-3600XZ-MM	Model No.	ND 9102HNUG
Type	Wafer	Type	ND 9000
Nominal Size	6 Inches	Action	Direct Acting
Rated Temp./Press.	200 F/ 235 PSIG	Signal Range	4 to 20 ma
Body Material	316 SST	Filter/ Reg.	Included
Bonnet Material	N/A	Gauge Set	Supply/Output
Stem Style	N/A		
End Connections	Wafer Style		

ACTUATOR		POSITION MONITOR	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	N/A
Model No.	QPX3C/MASC	Model No.	N/A
Type	Pneumatic Diaphragm	Type	N/A
Action	Modulate	Signal Range	N/A
Air Pressure	60 PSIG	Filter/ Reg.	N/A
Failure Mode	Closed	Gauge Set	N/A
Solenoid Valve	Not Required		
Solenoid Mfg.	N/A		
Solenoid Model No.	N/A		
Tubing	1/4" SS		

NOTES:

Converting manual valves to automatic with positioner, actuator, and solenoid. Include filter regulator set at 60 PSIG on supply line. .

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30% Design		12/2/21	D. Boggs
90% Design		1/12/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		PV-615 & PV-625 (2 sets)		Service	Oxygen (economizer)
PIPE	Size Upstream	In.	1.5"		
	Schedule		Type K (copper)		
	Size Downstream	In.	1.5"		
	Schedule		Type K (copper)		

VALVE BODY		POSITIONER	
Manufacturer	Cryogenic Proportional Trim Globe Valve	Manufacturer	Valtek/Flowserve, Fisher, or equal
Model No.	Mark One	Model No.	TBD
Type	Globe, Proportional Trim	Type	Electronic
Nominal Size	1.5"	Action	Reverse Acting
Rated Temp./Press.	-320 F/100 PSIG	Signal Range	4 to 12 ma (split)
Body Material	Monel	Filter/ Reg.	Included
Bonnet Material	316SS	Gauge Set	Supply/Output
Stem Style	12" Extended Stem		
End Connections	150#, RF ANSI Flanges		

ACTUATOR		TRIM	
Manufacturer	Valtek/Flowserve, Fisher, or equal	Type	Globe
Model No.	TBD	Port Size	1.5"
Type	Pneumatic Diaphragm	Characteristics	Equal Percent
Action	Modulate	Rated Cv	32
Air Pressure	60 PSIG	Plug/Disc Material	Monel 400
Failure Mode	Closed	Seat Material	Monel 400
Solenoid Valve	Not required	Cage/Guide Matl.	Bronze C93200
Solenoid Mfg.	N/A	Stem Material	Monel 400
Solenoid Model No.	N/A	Bushing Material	N/A
Tubing	1/4" SS	Packing Matl./Type	PTFE
		Shut Off Class	150

NOTES:

Replacing Valve, Actuator and Positioner, adding new position monitor. Include filter regulator set at 60 PSIG on supply line.

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30% Design		12/2/21	D. Boggs
90% Design		1/12/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		PV-616 & PV-626 (2 sets)		Service		Liquid Oxygen (pressure build)	
PIPE	Size Upstream	In.	1.5"				
	Schedule		Type K (copper)				
	Size Downstream	In.	1.5"				
	Schedule		Type K (copper)				
VALVE BODY		Cryogenic Proportional Trim Globe Valve			POSITIONER		
Manufacturer		Valtek/Flowserve, Hammel Dahl, or equal			Manufacturer		Valtek/Flowserve, Hammel Dahl, or equal
Model No.		Mark One			Model No.		L1W1L11B100-PP02BW00
Type		Globe, Proportional Trim			Type		Electronic
Nominal Size		1.5"			Action		Direct Acting
Rated Temp./Press.		-320 F/100 PSIG			Signal Range		12 to 20 ma (split)
Body Material		Monel			Filter/ Reg.		Included
Bonnet Material		316SS			Gauge Set		Supply/Output
Stem Style		12" Extended Stem					
End Connections		150#, RF ANSI Flanges					
ACTUATOR				TRIM			
Manufacturer		Valtek/Flowserve, Hammel Dahl, or equal			Type		Globe
Model No.		TBD			Port Size		1.5"
Type		Pneumatic Diaphragm			Characteristics		Equal Percent
Action		Modulate			Rated Cv		32
Air Pressure		60 PSIG			Plug/Disc Material		Monel 400
Failure Mode		Closed			Seat Material		Monel 400
Solenoid Valve		Not required			Cage/Guide Matl.		Bronze C93200
Solenoid Mfg.		N/A			Stem Material		Monel 400
Solenoid Model No.		N/A			Bushing Material		N/A
Tubing		1/4" SS			Packing Matl./Type		PTFE
					Shut Off Class		150
NOTES:							
Replacing Valve, Solenoid, Actuator and Positioner, adding new position monitor. Oxygen cleaning required. Include filter regulator set at 60 PSIG on supply line.							

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90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		PV-635X		Service	Oxygen (product back-up)
PIPE	Size Upstream	In.	6"		
	Schedule		40		
	Size Downstream	In.	6"		
	Schedule		40		

VALVE BODY		High Performance Butterfly Valve		POSITIONER	
Manufacturer	Jamesbury, Fisher, or equal		Manufacturer	Jamesbury, Fisher, or equal	
Model No.	6 815WO-11-3600XZ-MM		Model No.	ND 9102HNUG	
Type	Wafer		Type	ND 9000	
Nominal Size	6 Inches		Action	Direct Acting	
Rated Temp./Press.	200 F/ 235 PSIG		Signal Range	4 to 20 ma	
Body Material	316 SST		Filter/ Reg.	Included	
Bonnet Material	N/A		Gauge Set	Supply/Output	
Stem Style	N/A				
End Connections	Wafer Style				

ACTUATOR		POSITION MONITOR	
Manufacturer	Jamesbury, Fisher, or equal	Manufacturer	N/A
Model No.	QPX3C/MASC	Model No.	N/A
Type	Pneumatic Diaphragm	Type	N/A
Action	Modulate	Signal Range	N/A
Air Pressure	60 PSIG	Filter/ Reg.	N/A
Failure Mode	Closed	Gauge Set	N/A
Solenoid Valve	Required		
Solenoid Mfg.	ASCO		
Solenoid Model No.	8316G14		
Tubing	1/4" SS		

NOTES:	Replacing Valve, Solenoid, Actuator and Positioner. Include filter regulator set at 60 PSIG on supply line.

PURCHASE SPECIFICATIONS
CONTROL VALVES



74 Sail Away Lane
Moneta, VA 24121
Tel. (513)939-9380

Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.		FV-500A-1-1 & FV-500A-1-2 & FV-500A-2-1 & FV-500A-2-2		Service		Main Air Compressor Inlet Guide Vane			
PIPE	Size Upstream	In.	6"						
	Schedule		40						
	Size Downstream	In.	6"						
	Schedule		40						
VALVE BODY								POSITIONER	
Manufacturer		N/A		Manufacturer		Fisher or equal			
Model No.		N/A		Model No.		DVC-3793-4346221			
Type		N/A		Type		Electro Pneumatic			
Nominal Size		N/A		Action		Direct Acting			
Rated Temp./Press.		N/A		Signal Range		4-20 Ma			
Body Material		N/A		Filter/ Reg.		50 PSIG			
Bonnet Material		N/A		Gauge Set		N/A			
Stem Style		N/A		Field Mounting P#		MTG-225-1669010			
End Connections		N/A							
ACTUATOR								POSITION MONITOR	
Manufacturer		Fisher or equal		Manufacturer					
Model No.		656		Model No.					
Size		60		Type					
Action		Direct Acting		Signal Range					
Air Pressure		50 PSIG		Filter/ Reg.					
Failure Mode		Closed		Gauge Set					
Solenoid Valve		Required							
Solenoid Mfg.		ASCO or equal							
Solenoid Model No.		8316G14							
Tubing		1/4" SS							

NOTES:

Replacing Actuator, Solenoid, and Positioner
Include filter regulator set at 60 PSIG on supply line.

PURCHASE SPECIFICATIONS
CONTROL VALVES



SOLUTIONWERKS™
EQUIPMENT AND SERVICES FOR THE INDUSTRIAL GASES INDUSTRY

74 Sail Away Lane
Moneta, VA 24121
Tel. (513)939-9380

Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

	Tag No.	PV-506A-1-1 & PV-506A-1-2 & PV-506A-2-1 & PV-506A-2-2		Service	Main Air Compressor Vent Valve	
PIPE	Size Upstream	In.	4"			
	Schedule		40			
	Size Downstream	In.	4"			
	Schedule		40			
VALVE BODY		Rotary control valve			POSITIONER	
Manufacturer		Masoneilan or equal			Manufacturer	Masoneilan or equal
Model No.		4" 35-3512 Camflex 2			Model No.	4700E
Type		Rotary Control			Type	ElectroPneumatic Positioner
Nominal Size		4 Inches			Action	Reverse Acting
Rated Temp./Press.		200 F/ 235 PSIG			Signal Range	4 to 20 ma
Body Material		316 SST			Filter/ Reg.	Included
Bonnet Material		N/A			Gauge Set	Supply/Output
Stem Style		N/A				
End Connections		Wafer Style				
ACTUATOR				POSITION MONITOR		
Manufacturer		Masoneilan or equal			Manufacturer	N/A
Model No.		35			Model No.	N/A
Type		Spring opposed rolling diaphragm			Type	N/A
Action		Modulate			Signal Range	N/A
Air Pressure		60 PSIG			Filter/ Reg.	N/A
Failure Mode		Open			Gauge Set	N/A
Solenoid Valve		Required				
Solenoid Mfg.		ASCO or equal				
Solenoid Model No.		8316G14				
Tubing		1/4" SS				

NOTES:

Replacing Valve, Solenoid, Actuator and Positioner.
Include filter regulator set at 60 PSIG on supply line.

PURCHASE SPECIFICATIONS
CONTROL VALVES



SOLUTIONWERKS™
EQUIPMENT AND SERVICES FOR THE INDUSTRIAL GASES INDUSTRY

74 Sail Away Lane
Moneta, VA 24121
Tel. (513)939-9380

Revision	No.	Date	By
30% Design		12/2/21	D. Boggs
90% Design		1/26/23	D. Boggs
100% Design		11/29/23	D. Boggs
100% Design	1	3/26/24	D. Boggs
100% Design	2	4/12/2024	D. Boggs

Tag No.	Sample taps and instrument valves		Service	Instrument Sample Lines
PIPE	Size Upstream	In.	1/2'	
	Schedule		40	
	Size Downstream	In.	1/2"	
	Schedule		40	

VALVE BODY	Ball Valves	POSITIONER	
Manufacturer	Jamesbury or equal	Manufacturer	N/A
Model No.	1/2"33-3600TL	Model No.	N/A
Type	Ball Valves	Type	N/A
Nominal Size	1/2 Inch	Action	N/A
Rated Temp.	Negative 60 to 250 F	Signal Range	N/A
Body Material	316 SST	Filter/ Reg.	N/A
Seat material	PTFE Seat with Graphite Seal	Gauge Set	N/A
Stem Style	N/A		
End Connections	Female NPT		

ACTUATOR		POSITION MONITOR	
Manufacturer	N/A	Manufacturer	N/A
Model No.	N/A	Model No.	N/A
Type	N/A	Type	N/A
Action	N/A	Signal Range	N/A
Air Pressure	N/A	Filter/ Reg.	N/A
Failure Mode	N/A	Gauge Set	N/A
Solenoid Valve	N/A		
Solenoid Mfg.	N/A		
Solenoid Model No.	N/A		
Tubing	N/A		

NOTES:

Replacing Valve Only.

END OF SECTION

SECTION 40 05 23b

COOLING WATER RELIEF VALVE PURCHASE SPECIFICATIONS

PURCHASE SPECIFICATION																								
Relief Valve																								
Page 1 of 4																								
 74 Sail Away Lane Moneta, Va 24121 Tel. (617)-660-7882 Fax (617)-660-7882 <table><tr><td>Revision</td><td>No.</td><td>Date</td><td>By</td></tr><tr><td>30% Design</td><td></td><td>1/7/22</td><td>DB</td></tr><tr><td>100% Design</td><td></td><td>12/1/2023</td><td>DB</td></tr><tr><td>100% Design</td><td></td><td>4/23/2024</td><td>DB</td></tr><tr><td colspan="2">Checked</td><td colspan="2">Approved</td></tr></table>					Revision	No.	Date	By	30% Design		1/7/22	DB	100% Design		12/1/2023	DB	100% Design		4/23/2024	DB	Checked		Approved	
Revision	No.	Date	By																					
30% Design		1/7/22	DB																					
100% Design		12/1/2023	DB																					
100% Design		4/23/2024	DB																					
Checked		Approved																						
Tag No.		W-44-CWS-PSV-824-1-1 & W-44-CWS-PSV-834-1-1		Service																				
				Cooling Water																				
PIPE	Size Upstream	In.	3/4"																					
	Schedule																							
	Size Downstream	In.	3/4"																					
	Schedule																							
VALVE BODY				TRIM																				
	Manufacturer	Apollo or equal		Type																				
	Model No.	16-504-01		Port Size																				
	Type	16-504		Characteristics																				
	Nominal Size	3/4"		Rated Cv																				
	Rated Temp./Press.	200 F/ 235 PSIG		Plug/Disc Material																				
	Set Pressure	50 PSIG		Seat Material																				
	Body Material	Cast Bronze		Spring Material																				
	Bonnet Material	N/A		Stem Material																				
	End Connections	NPT		Bushing Material																				
	Flow Direction	N/A		Packing Matl./Type																				
	Flow Direction	N/A		Shut Off Class																				
ACTUATOR				POSITIONER																				
	Manufacturer	N/A		Manufacturer																				
	Model No.	N/A		Model No.																				
	Type	N/A		Type																				
	Size	N/A		Signal Range																				
	Action	N/A		Filter/ Reg.																				
	Air Pressure	N/A		Gauge Set																				
	Failure Mode	N/A																						
	Solenoid Valve	N/A																						
	Solenoid Mfg.	N/A																						
	Solenoid Model No.	N/A																						
	Tubing	N/A																						
	NOTES:																							

PURCHASE SPECIFICATION
Relief Valve

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74 Sail Away Lane
Moneta, Va 24121
Tel. (617)-660-7882
Fax (617)-660-7882

Revision	No.	Date	By
30% Design		1/7/22	DB
100% Design		12/1/2023	DB
100% Design		4/23/2024	DB
Checked		Approved	

	Tag No.	W-44-CWS-PSV-824-1-2 & W-44-CWS-PSV-834-1-2		Service	Cooling Water
PIPE	Size Upstream	In.	3/4"		
	Schedule				
	Size Downstream	In.	3/4"		
	Schedule				

VALVE BODY			TRIM	
	Manufacturer	Apollo or equal	Type	Spring
	Model No.	16-504-01	Port Size	3/4"
	Type	16-504	Characteristics	Full Relief
	Nominal Size	3/4"	Rated Cv	108
	Rated Temp./Press.	200 F/ 235 PSIG	Plug/Disc Material	EPDM cap seal
	Set Pressure	50 PSIG	Seat Material	Silicone soft seat
	Body Material	Cast Bronze	Spring Material	SST
	Bonnet Material	N/A	Stem Material	N/A
	End Connections	NPT	Bushing Material	N/A
	Flow Direction	N/A	Packing Matl./Type	N/A
	Flow Direction	N/A	Shut Off Class	N/A

ACTUATOR			POSITIONER	
	Manufacturer	N/A	Manufacturer	N/A
	Model No.	N/A	Model No.	N/A
	Type	N/A	Type	N/A
	Size	N/A	Signal Range	N/A
	Action	N/A	Filter/ Reg.	N/A
	Air Pressure	N/A	Gauge Set	N/A
	Failure Mode	N/A		
	Solenoid Valve	N/A		
	Solenoid Mfg.	N/A		
	Solenoid Model No.	N/A		
	Tubing	N/A		

NOTES:

PURCHASE SPECIFICATION
Relief Valve

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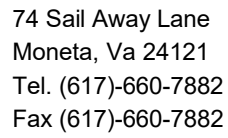
74 Sail Away Lane
Moneta, Va 24121
Tel. (617)-660-7882
Fax (617)-660-7882

Revision	No.	Date	By
30% Design		1/7/22	DB
100% Design		12/1/2023	DB
100% Design		4/23/2024	DB
Checked		Approved	

	Tag No.	W-44-CWS-PSV-824-2-1 & W-44-CWS-PSV-834-2-1		Service	Cooling Water
PIPE	Size Upstream	In.	3/4"		
	Schedule				
	Size Downstream	In.	3/4"		
	Schedule				
VALVE BODY			TRIM		
	Manufacturer	Apollo or equal		Type	Spring
	Model No.	16-504-01		Port Size	3/4"
	Type	16-504		Characteristics	Full Relief
	Nominal Size	3/4"		Rated Cv	108
	Rated Temp./Press.	200 F/ 235 PSIG		Plug/Disc Material	EPDM cap seal
	Set Pressure	50 PSIG		Seat Material	Silicone soft seat
	Body Material	Cast Bronze		Spring Material	SST
	Bonnet Material	N/A		Stem Material	N/A
	End Connections	NPT		Bushing Material	N/A
	Flow Direction	N/A		Packing Matl./Type	N/A
	Flow Direction	N/A		Shut Off Class	N/A
ACTUATOR			POSITIONER		
	Manufacturer	N/A		Manufacturer	N/A
	Model No.	N/A		Model No.	N/A
	Type	N/A		Type	N/A
	Size	N/A		Signal Range	N/A
	Action	N/A		Filter/ Reg.	N/A
	Air Pressure	N/A		Gauge Set	N/A
	Failure Mode	N/A			
	Solenoid Valve	N/A			
	Solenoid Mfg.	N/A			
	Solenoid Model No.	N/A			
	Tubing	N/A			

NOTES:

Relief Valve

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Revision	No.	Date	By
30% Design		1/7/22	DB
100% Design		12/1/2023	DB
100% Design		4/23/2024	DB
Checked		Approved	

	Tag No.	W-44-CWS-PSV-824-2-2 & W-44-CWS-PSV-834-2-2		Service	Cooling Water
PIPE	Size Upstream	In.	3/4"		
	Schedule				
	Size Downstream	In.	3/4"		
	Schedule				

VALVE BODY			TRIM	
Manufacturer	Apollo or equal		Type	Spring
Model No.	16-504-01		Port Size	3/4"
Type	16-504		Characteristics	Full Relief
Nominal Size	3/4"		Rated Cv	108
Rated Temp./Press.	200 F/ 235 PSIG		Plug/Disc Material	EPDM cap seal
Set Pressure	50 PSIG		Seat Material	Silicone soft seat
Body Material	Cast Bronze		Spring Material	SST
Bonnet Material	N/A		Stem Material	N/A
End Connections	NPT		Bushing Material	N/A
Flow Direction	N/A		Packing Matl./Type	N/A
Flow Direction	N/A		Shut Off Class	N/A

ACTUATOR		POSITIONER	
Manufacturer	N/A	Manufacturer	N/A
Model No.	N/A	Model No.	N/A
Type	N/A	Type	N/A
Size	N/A	Signal Range	N/A
Action	N/A	Filter/ Reg.	N/A
Air Pressure	N/A	Gauge Set	N/A
Failure Mode	N/A		
Solenoid Valve	N/A		
Solenoid Mfg.	N/A		
Solenoid Model No.	N/A		
Tubing	N/A		

NOTES:

06/24
SD-428

Purchase Specs Relief Valves

SECTION 40 61 01

INSTRUMENTATION AND CONTROLS GENERAL REQUIREMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide instrumentation and controls in accordance with this Section and applicable reference standards listed in Article 1.03.
2. District has contracted with Emerson Process Management Power & Water Solutions, Inc. (Emerson) for supply of new Distributed Process Control Systems (DCS) hardware and programming. Contractor shall coordinate their work with Emerson as specified herein.
3. Work by District's DCS Vendor (Emerson):
 - a. DCS Programming
 - b. HMI Programming
 - c. Procurement of specified DCS equipment (refer to Scope of Supply)
 - d. Integration of new DCS controls system

B. Related Requirements

1. Division 26 Electrical – Specifications for electrical wiring standards and practices
2. Section 40 05 23 – Process Valves
3. Section 40 70 00 – Instrumentation for Process Systems
4. Section 40 80 00 – Commissioning of Process Systems
5. Section 40 81 00 – System Integrator Qualifications and Summary of Work
6. Section 40 95 13 – Process Control Panels and Hardware

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

1.3 REFERENCES

A. Reference Standards

1. American National Standards Institute (ANSI)
2. ASTM International (ASTM)

3. FM Global (FM)
 4. International Society of Automation (ISA)
 - a. ISA-RP60.3 Recommended Practice
 5. National Electrical Code (NEC)
 6. National Electrical Manufacturers Association (NEMA)
 7. National Fire Protection Association (NFPA)
 - a. NFPA 70
 - b. NFPA 79 Electrical Standard for Industrial Machinery
 8. Occupational Safety and Health Administration (OSHA)
 9. Underwriters Laboratories (UL)
 - a. Standard 508A - Standard for Industrial Control Panels
- B. Definitions
1. PLC – Programmable Logic Controller
 2. DCS – Distributed Control System
 3. RIO – Remote Input/Output Rack
 4. OIT – Operator Interface Terminal
 5. HMI – Human Machine Interface
 6. RTU – Remote Terminal Unit
 7. I/O – Input/Output
 8. SCADA – Supervisory Control and Data Acquisition
 9. Modules – devices that plug into a chassis or connect to an adjacent module and are keyed to allow installation in only one direction

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination, Sequencing, and Scheduling: per Division 01 General Requirements.
1. Coordinate equipment, instrument, and material delivery with Project schedule. Notify Engineer if delivery schedule of equipment, instruments, or material affects Project schedule. Include documentation from equipment Supplier indicating revised delivery schedule and reason for change.

2. Coordinate delivery of equipment, instruments, or materials for installation in system or control panel provided under Sections 40 05 23; 40 70 00; and 40 95 13.

1.5 SUBMITTALS

- A. Submit in accordance with Division 01 General Requirements.
- B. Product Data
 1. Instrumentation: in accordance with Section 40 70 00.
 2. Control Valves: in accordance with Section 40 05 23.
- C. Shop Drawings
 1. DCS control panels: in accordance with Section 40 95 13.
- D. Closeout and Maintenance Material Submittals: per Division 01 General Requirements.
 1. Provide operation procedures, equipment descriptions, intended modes of operation, system unit testing procedures and safety measures during operation.
 2. Provide record drawings and instructions for maintenance of system equipment. Incorporate maintenance procedures and schedules, coordinate and cross-reference to detailed operational procedures provided by manufacturers.
 3. Include a list of local, authorized distributor's service departments stocking manufacturer's parts and equipment and providing local service.
 4. Instrument list or ISA data sheets, including tag numbers.
 5. Configuration and programming manuals for each type of DCS system and each type of OIT.
 6. Copies of all Shop Drawings, reports, maintenance data, and schedules, description of operation, and spare parts information.
 7. Control panel section of O&M manuals shall include:
 - a. Record drawings of control panels updated to reflect the panels after checkout and startup.
 - b. Installation and operation manuals for all major control panel components, network switches, DCS systems, I/O modules, and communication equipment.

1.6 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 01 General Requirements.
- B. Acceptance at Site
 - 1. Check equipment, instruments and materials for damage or defects within 7 days of delivery.

1.8 SITE CONDITIONS

- A. Existing Conditions: per Division 01 General Requirements.

1.9 MAINTENANCE

- A. Extra Materials and Spare Parts: as specified below. Make interchangeable with and of same material and workmanship as corresponding original parts.
- B. Control Panel Spares: one of each type of the following.
 - 1. Surge arrestor
 - 2. Fuses (minimum 20 percent spares of each type)
 - 3. 24 VDC communication power supply
 - 4. Intrinsic safety barrier

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Provide instruments, control panels, and materials in accordance with Division 01 General Requirements.
 - 1. Verify availability of equipment, instruments and materials and submit an “or-equal” or substitute if production is discontinued.

2.2 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

PART 3 – EXECUTION

3.1 GENERAL

- A. District has contracted with Emerson Process Management Power & Water Solutions, Inc. (Emerson) for supply of new Distributed Process Control Systems

(DCS) hardware and programming. A draft scope of supply for Emerson is included in 01 64 03, District-Furnished DCS Equipment. An approved scope of supply for Emerson will be provided to the Contractor. Contractor shall be responsible for supplying all other instruments, wiring, conduit, and appurtenances indicated in the Contract Documents but not supplied by Emerson.

B. Emerson shall be responsible for the following items of work:

1. Furnish DCS equipment indicated in the scope of supply attached.
2. Programming of DCS logic.

C. Contractor shall be responsible for the following items of work:

1. Furnish any instruments, control valves or control equipment indicated in the Contract Documents but not included in the Emerson Scope of Supply.
2. Furnish and install all electrical equipment, including but not limited to: conduit, wiring, cable trays, supports, and other appurtenances shown on the electrical drawings.
3. Furnish, install, and configure PID Process Controllers and coordinate controls work and integration with Emerson DCS programming. Furnish panels and assemble enclosures for DCS equipment – DCS equipment may come unassembled. Perform work as shown on the Drawings and as necessary, including demolition, civil, and electrical work, to install new DCS controllers and remote I/O panels.
4. Receive delivery of, offload, and storage of all equipment furnished by Emerson. Contractor shall coordinate delivery of equipment with Emerson based on the construction schedule. All equipment shall be stored in accordance with the requirements of Division 1 – General Requirements.
5. Contractor shall install all equipment furnished by Emerson in accordance with the Contract Documents. All equipment pads, mounting, wiring terminations, and other work required for a complete installation of the Emerson-supplied equipment shall be the responsibility of the Contractor.
6. Contractor shall complete and coordinate start-up in accordance with these Plans and Specifications, 01 64 03 District-Furnished DCS Equipment, 01 75 17 Field Testing and Startup, 27 08 00 Commissioning of Communications Systems, and 40 80 00 Commissioning of Process Systems.

3.2 FIELD QUALITY CONTROL

A. Provide in accordance with Division 01 General Requirements.

3.3 STARTUP & COMMISSIONING

A. Provide in accordance with Division 01 General Requirements.

1. Test instruments and DCS control panels for proper termination and operation, in presence of Engineer.
2. Calibrate instruments in accordance with manufacturer's recommended procedure.

3.4 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Division 01 General Requirements.

3.5 ATTACHMENTS:

- A. The Contractor shall use the following attachments to develop its field testing plan for functional and performance testing, and start-up and commissioning.
 1. Control Narrative (40 61 00a)
 - a. Assisted Start and Stop Logic
 - b. Assisted Start and Stop DRAFT HMI Template
 2. Control Loop Specifications (40 61 00b)
 3. Except for I/O points not shown on Plans, Plans shall take precedence for I/O points: I/O List (40 61 00c)
 - a. Analog
 - b. Digital
 - c. Bypasses

END OF SECTION

CONTROL NARRATIVE ASSISTED START LOGIC SPECIFICATION 40 60 01a 5 January 2024

ASSISTED START

The following logic should be replicated for both cryo plant control programs with tag numbers adjusted as appropriate. Tag numbers shown in this logic are common to both plants.

A button labeled ASSISTED PLANT START should appear on the HMI overview screen.

When the operator presses ASSISTED PLANT START, the following pop-up screen should appear:

This ASSSITED START program applies to cryo plant no. {insert either no. 1 or no. 2}. Confirm that you are about to start the correct plant.

This ASSISTED START procedure is only to be used when the cryo plant is in a cold state and has been shut down for less than eight hours. If the plant has been shut down for a longer period of time, revert to a MANUAL START (per Operating Manual).

Before proceeding, please verify that the following pre-start up conditions have been satisfied:

- **Check the warm end main heat exchanger “A” and “B” pass temperatures, TE-184 and TE-185. If colder than -10 deg. C, warm those temperatures to at least 10 deg. C by opening the switch valve bypass valves, B111A and B112A, before activating switch valves.**
- **Check the cold end main heat exchanger A and B pass temperatures, TE-188 and TE-201. If either temperature is warmer than minus 130 deg. C, cool those temperatures to minus 140 deg. C or colder by admitting cold oxygen gas thru the drain header per Operating Manual procedures for a warm start-up before proceeding.**
- **Choose the main air compressor to be used and verify that:**
 - **The appropriate air block valves between the selected compressor and the cryo plant to be started have been opened. All other compressor block valves should be closed.**
 - **The auxiliary oil pump is running and providing oil pressure (PIT-53) of at least 20 psig.**

- Cooling water inlet and outlet valves for the intercoolers, aftercooler, and oil cooler are open and that there is water pressure (PI-800) of at least 25 psig.
- The back-up instrument air compressor is running and providing instrument air pressure (PIT-590) of at least 50 psig.
- Verify that the following valves are closed:
 - X214A Turbine Inlet
 - X216A Turbine Outlet
 - B201A CEGT Bypass
- Verify that the following valves are open:
 - X201A CEGT Inlet
 - X203A CEGT Outlet
 - D210A “B” Pass Drain
 - D211A “A” Pass Drain
- Verify that the thaw heater is off (UA-TH-1).
- Acknowledge that the above are complete.*
- Any intervention in the start procedure outside the instructions provided will cause ASSISTED PLANT START to abort. It will then be necessary to continue the start-up manually.

*Provide an **ACKNOWLEDGE** button on the screen to enable the operator to acknowledge that the above checks have been completed.

The DCS should then automatically perform or prompt the operator to perform the following steps for startup of the plant. All steps should appear in a list format on the HMI screen per the template attached with the active step highlighted as it is being executed. Except where otherwise noted, allow 10 seconds between automated execution of each step in the following procedure.

- 1) **DCS** Place LIC-352 in AUTO with a set point (SP) of 55” w.c.
- 2) **OPERATOR** Choose MAC to be used for start-up, i.e. 1-1, 1-2, 2-1, or 2-2 (*from an on-screen menu*).
- 3) **DCS** Verify that all MAC permissives have been satisfied. If not, flash message to operator stating “**MAC permissive(s) not satisfied. Clear before proceeding.**” If permissives have been satisfied, flash message to operator stating “**MAC permissives satisfied. Cleared to start.**”
- 4) **DCS** Turn condenser level bypass switch (HIS-352) ON.
- 5) **DCS** Turn switch valve bypass switch (HS-111) ON.

- 6) **DCS** Place controllers FIC-500, FIC-506, IC-500, TIC-X600X-1, TIC- X600X-2, SIC-219, FIC-340, PIC-600, and PIC-601 in MANUAL with an output of 0%.
- 7) **DCS** Place controller FIC-115 in MANUAL with an output of 50%.
- 8) **DCS** Place controller LIC-330 in AUTO with a set point (SP) of 30%.
- 9) **OPERATOR** Verify that the selected MAC is clear of personnel prior to start.

ACKNOWLEDGE

- 10) **DCS** Turn the vibration bypass (HS-500) ON.
- 11) **DCS** Hold until condenser level (LIT-352) reaches 55" w.c. Then proceed to next step.
- 12) **DCS** Start the selected MAC (PB-500).
- 13) **DCS** Slowly (30 seconds) open the MAC inlet guide vanes, FV-500, in MANUAL to OP = 50%.
- 14) **DCS** Slowly (60 seconds) close the MAC vent valve, PV-506, until the discharge pressure, PIT-506, reaches 65 psig.
- 15) **DCS** Place IT-500 in AUTO with SP = 145 amps.
- 16) **DCS** Turn the vibration bypass (HS-500) OFF.
- 17) **DCS** Switch MAC auxiliary lube oil pump, HS-215-2, to OFF, then AUTO.
- 18) **DCS** Place PIC-506 in AUTO with SP = 65 psig.
- 19) **OPERATOR** Verify seal gas to turbine is flowing (FI-580), turbine lube oil pump is running with supply pressure (PIT-20) of 130 psig minimum and lube oil temperature (TE-24) is at least 80 deg. F.

ACKNOWLEDGE

- 20) **OPERATOR** Open switch valve bypass valves (B111A and B112A) one half turn.

ACKNOWLEDGE

- 21) **DCS** Hold until lower column pressure reaches 10 psig.
- 22) **DCS** Close upper column vent valve (PV-349).
- 23) **DCS** Open air switch valve FCV111 and waste switch valve FCV114 and hold until lower column pressure reaches 30 psig, MAC pressure falls below 30 PSIG, or 15 seconds has elapsed.
- 24) **DCS** Close air switch valve FCV111 and waste switch valve FCV114. Hold until MAC discharge pressure reaches 45 psig or greater.
- 25) **DCS** Open air switch valve FCV112 and waste switch valve FCV113 and hold until lower column pressure reaches 35 psig, MAC pressure falls below 30 PSIG, or 15 seconds has elapsed.

- 26) **DCS** Close air switch valve FCV112 and waste switch valve FCV113. Hold until MAC discharge pressure reaches 45 psig or greater.
- 27) **DCS** Open air switch valve FCV111 and waste switch valve FCV114 and hold until lower column pressure reaches 40 psig or 15 seconds have elapsed.
- 28) **DCS** Close air switch valve FCV111 and waste switch valve FCV114. Hold until MAC discharge pressure reaches 50 psig or greater.
- 29) **DCS** Open air switch valve FCV112 and waste switch valve FCV113 and hold until lower column pressure reaches 40 psig or 15 seconds have elapsed.
- 30) **DCS** Close air switch valve FCV112 and waste switch valve FCV113. Hold until MAC discharge pressure reaches 50 psig or greater.
- 31) **DCS** Open air switch valve FCV111 and waste switch valve FCV114 and hold until lower column pressure reaches 45 psig or 30 seconds have elapsed.
- 32) **DCS** Close air switch valve FCV111 and waste switch valve FCV114. Hold until MAC discharge pressure reaches 50 psig or greater.
- 33) **DCS** Open air switch valve FCV112 and waste switch valve FCV113 and hold until lower column pressure reaches 50 psig or 30 seconds have elapsed.
- 34) **DCS** Close air switch valve FCV112 and waste switch valve FCV113. Hold until MAC discharge pressure reaches 50 psig or greater.
- 35) **DCS** Open air switch valve FCV111A and waste switch valve FCV114N and hold until lower column pressure reaches 45 psig or 1 minute has elapsed.
- 36) **DCS** Close air switch valve FCV111A and waste switch valve FCV114N. Hold until MAC discharge pressure reaches 50 psig.
- 37) **DCS** Open air switch valve FCV112A and waste switch valve FCV113N and hold until lower column pressure reaches 45 psig or 1 minute has elapsed.
- 38) **DCS** Close air switch valve FCV112A and waste switch valve FCV113N. Hold until MAC discharge pressure reaches 50 psig or greater.
- 39) **DCS** Place switch valve control in AUTO with a set point of two minutes.
- 40) **DCS** Open FIC-340 with an output of 30%.
- 41) **DCS** Open FIC-115 with an output of 40%.
- 42) **DCS** Open TIC-X600X-1 with an output of 50% and TIC-X600X-2 with an output of 50%..
- 43) **DCS** Place controller FIC-115 in MANUAL with an output of 50%.
- 44) **DCS** Slowly (15 seconds) open the MAC inlet guide vanes, FV-500A, in MANUAL to OP = 75%.
- 45) **OPERATOR** Close RHX drain valves, D210A and D211A.

ACKNOWLEDGE

- 46) **DCS** Hold until condenser level (LIT-352) continuously stays above 55" w.c. for at least five minutes.
- 47) **DCS** Turn turbine bypass switch (HS-111) ON.
- 48) **OPERATOR** Open turbine inlet valve (X214A) and outlet valve (X216A).

ACKNOWLEDGE

- 49) **DCS** Open turbine inlet trip valve (FV-214).
- 50) **DCS** Hold until turbine inlet temperature (TE-215) is less than -40 deg. C.
- 51) **DCS** Slowly (1%/sec.) open turbine inlet nozzles (FV-220) until speed (ST-219) reaches 25,000 RPM.
- 52) **DCS** Switch turbine speed controller to AUTO with a set point (SP) of 25,000 RPM.
- 53) **DCS** Switch FIC-340 to AUTO.
- 54) **DCS** Switch FIC-115 to AUTO.
- 55) **DCS** Open PIC-600 with an output of 30%.
- 56) **DCS** Switch FIC-500 to AUTO.
- 57) **DCS** When the waste nitrogen purity (AIT-312) drops below 25%, execute next step.
- 58) **OPERATOR** Close switch valve bypass valves, B211A and B212A.

ACKNOWLEDGE

- 59) **DCS** Switch FIC-601 to AUTO with SP = 55 KSCFH.
- 60) **DCS** Hold until condenser level (LIT-352) continuously stays above 55" w.c. for at least five minutes.
- 61) **DCS** Switch PIC-601 to AUTO with SP = 1.0 psig.
- 62) **DCS** Place AIC-355 in AUTO with SP = 95%.
- 63) **DCS** Turn switch valve bypass switch (HS-111) OFF.
- 64) **OPERATOR** Close switch valve bypass valves, B211A and B212A.

ACKNOWLEDGE

- 65) **OPERATOR** Turn back-up instrument air compressor OFF.

ACKNOWLEDGE

- 66) **DCS** Place controllers TIC-X600X-1 and TIC-X600X-2 in AUTO.
- 67) **DCS** Turn condenser level bypass switch (HIS-352) OFF.
- 68) **DCS** Advance switch valve timer to 4 minutes. Every two hours thereafter, advance timer an addition 2 minutes until timer is set at 10 minutes. Hold at 10 minutes.
- 69) **DCS** Flash message on HMI **ASSISTED START is complete.**

CONTROL NARRATIVE ASSISTED STOP LOGIC SPECIFICATION 40 60 01a 5 January 2024

ASSISTED STOP

The following logic should be replicated for both cryo plant control programs with tag numbers adjusted as appropriate. Tag numbers shown in this logic are common to both plants.

A button labeled ASSISTED PLANT STOP should appear on the HMI overview screen.

When the operator presses ASSISTED PLANT STOP, the following pop-up screen should appear:

**This ASSITED STOP program applies to cryo plant no. {insert either no. 1 or no. 2}.
Confirm that you are about to stop the correct plant.**

This ASSISTED STOP procedure is used for a controlled shutdown and cold bottle up of the cryo plant.

Before proceeding, please verify that the following pre-shutdown conditions have been satisfied:

- **The back-up liquid oxygen supply system is operational and ready to supply oxygen to the aeration decks. There should be sufficient LOX inventory in the tanks to cover the anticipated duration of the cryo plant shutdown along with restart of the cryo plant.**
- **All back-up LOX supply system manual valves should be in their proper position to allow withdrawal of LOX from the preferred tank and discharge of vaporized LOX into the pipeline.**
- **Acknowledge that the above are complete.***
- **Any intervention in the stop procedure outside the instructions provided will cause ASSISTED PLANT STOP to abort. It will then be necessary to continue the shutdown manually.**

*Provide an **ACKNOWLEDGE** button on the screen to enable the operator to acknowledge that the above checks have been completed.

The DCS should then automatically perform or prompt the operator to perform the following steps for shutdown of the plant. All steps should appear in a list format on the HMI screen per the template attached with the active step highlighted as it is being executed. Except where otherwise noted, allow 10 seconds between automated execution of each step in the following procedure.

- 1) **OPERATOR** Open RHX drain valves, D210A and D211A.
ACKNOWLEDGE
- 2) **DCS** Change switch valve timer () to 2 minutes. Hold for 60 minutes before moving to the next step. Allow a button to skip this waiting period if the operator has already been running the plant in 2 minutes switches for 60 minutes.
- 3) **DCS** Turn switch valve bypass switch (HS-111) ON.
- 4) **DCS** Turn condenser level bypass switch (HIS-352) ON.
- 5) **DCS** Slowly (1%/sec.) close turbine inlet nozzles (FV220A) to 0% open.
- 6) **DCS** Allow SISL-219 Turbine Low Speed to trip turbine when speed drops below 10K RPM.
- 7) **DCS** Close turbine inlet trip valve (FV214A).
- 8) **OPERATOR** Close turbine inlet valve (X214A) and outlet valve (X216A).
ACKNOWLEDGE
- 9) **DCS** Place PIC-506 in MANUAL with OP = last position (0%).
- 10) **DCS** Slowly (60 seconds) open the running MAC vent valve, PV-506, until fully open (OP = 100%).
- 11) **DCS** Slowly (30 seconds) close the MAC inlet guide vanes, FV-500A, OP = 15%.
- 12) **DCS** Stop the MAC (PB-502).
- 13) **DCS** Open upper column vent valve (PV-349).
- 14) **DCS** Place controllers IC-500, TIC-X600X-1, TIC- X600X-2, SIC-219, FIC-340, LIC-330, PIC-600, and PIC-601 in MANUAL with an output of 0%.
- 15) **DCS** Place FIC-115 in manual with an output of 50%
- 16) **DCS** Place switch valve control in MANUAL.
- 17) **DCS** Close all switch valves, FCV111A, FCV-112, FCV-113 and FCV-114.
- 18) **OPERATOR** Close RHX drain valves, D210A and D211A.
ACKNOWLEDGE
- 19) **DCS** Flash message on HMI **ASSISTED STOP is complete.**

**EAST BAY MUNICIPAL UTILITY DISTRICT
CRYOGENIC OXYGEN GENERATION PLANTS
ASSISTED START PROCEDURE
5-Jan-24**



STEP	RESPONSIBILITY	ACTION				
1	DCS	Place LIC-352 in AUTO with a set point (SP) of 55" w.c.				
2	OPERATOR	Choose MAC to be used for start-up. <table><tr><td>1-1</td><td>1-2</td></tr><tr><td>2-1</td><td>2-2</td></tr></table>	1-1	1-2	2-1	2-2
1-1	1-2					
2-1	2-2					
3	DCS	MAC permissive(s) not satisfied. Clear before proceeding. or MAC permissives satisfied. Cleared to start.				
4	DCS	Turn condenser level bypass switch (HIS-352) ON.				
5	DCS	Turn switch valve bypass switch (HS-111) ON.				
6	DCS	Place controllers FIC-500, FIC-506, IC-500, TIC-X600X-1, TIC-X600X-2, SIC-219, FIC-340, PIC-600, and PIC-601 in MANUAL with an output of 0%.				
7	DCS	Place controller FIC-115 in MANUAL with an output of 50%.				
8	DCS	Place controller LIC-330 in AUTO with a set point (SP) of 30%.				
9	OPERATOR	Verify that the selected MAC is clear of personnel prior to start. ACKNOWLEDGE				
10	DCS	Turn the vibration bypass (HS-500) ON.				
11	DCS	Hold until condenser level (LIT-352) reaches 55" w.c. Then proceed to next step.				
12	DCS	Start the selected MAC (PB-500).				
13	DCS	Slowly (30 seconds) open the MAC inlet guide vanes, FV-500, in MANUAL to OP = 50%.				
14	DCS	Slowly (60 seconds) close the MAC vent valve, PV-506, until the discharge pressure, PIT-506, reaches 65 psig.				
15	DCS	Place <u>IT-500</u> in AUTO with SP = 145 amps.				
16	DCS	Turn the vibration bypass (HS-500) OFF.				
17	DCS	Switch MAC auxiliary lube oil pump, <u>HS-215-2</u> , to OFF, then AUTO.				
18	DCS	Place PIC-506 in AUTO with SP=65 psig.				
19	OPERATOR	Verify seal gas to turbine is flowing (FI-580), turbine lube oil pump is running with supply pressure (PIT-20) of 130 psig minimum and lube oil temperature (TE-24) is at least 80 deg. F. ACKNOWLEDGE				
20	OPERATOR	Open switch valve bypass valves (B111A and B112A) one half turn. ACKNOWLEDGE				
21	DCS	Hold until lower column pressure reaches 10 psig.				
22	DCS	Close upper column vent valve (PV-349).				
23	DCS	Open air switch valve FCV111A and waste switch valve FCV114N and hold until lower column pressure reaches 30 psig, MAC discharge pressure falls below 30, or 15 seconds has elapsed.				
24	DCS	Close air switch valve FCV111A and waste switch valve FCV114N. Hold until MAC discharge pressure reaches 45 PSIG or greater.				
25	DCS	Open air switch valve FCV112A and waste switch valve FCV113N and hold until lower column pressure reaches 30 psig, MAC discharge pressure falls below 30, or 15 seconds has elapsed.				
26	DCS	Close air switch valve FCV112A and waste switch valve FCV113N. Hold until MAC discharge pressure reaches 45 PSIG or greater.				
27	DCS	Open air switch valve FCV111A and waste switch valve FCV114N and hold until lower column pressure reaches 35 psig, MAC discharge pressure falls below 30, or 15 seconds has elapsed.				
28	DCS	Close air switch valve FCV111A and waste switch valve FCV114N. Hold until MAC discharge pressure reaches 50 psig or greater.				
29	DCS	Open air switch valve FCV112A and waste switch valve FCV113N and hold until lower column pressure reaches 35 psig, MAC discharge pressure falls below 30, or 15 seconds has elapsed.				
30	DCS	Close air switch valve FCV112A and waste switch valve FCV113N. Hold until MAC discharge pressure reaches 50 psig or greater.				
31	DCS	Open air switch valve FCV111A and waste switch valve FCV114N and hold until lower column pressure reaches 40 psig or 30 seconds has elapsed				
32	DCS	Close air switch valve FCV111A and waste switch valve FCV114N. Hold until MAC discharge pressure reaches 50 psig or greater.				
33	DCS	Open air switch valve FCV112A and waste switch valve FCV113N and hold until lower column pressure reaches 40 psig or 30 seconds has elapsed				
34	DCS	Close air switch valve FCV112A and waste switch valve FCV113N. Hold until MAC discharge pressure reaches 50 psig or greater.				
35	DCS	Open air switch valve FCV111A and waste switch valve FCV114N and hold until lower column pressure reaches 45 psig, or 30 seconds has elapsed				
36	DCS	Close air switch valve FCV111A and waste switch valve FCV114N. Hold until MAC discharge pressure reaches 50 psig or greater.				
37	DCS	Open air switch valve FCV112A and waste switch valve FCV113N and hold until lower column pressure reaches 45 psig or 30 seconds has elapsed				
38	DCS	Close air switch valve FCV112A and waste switch valve FCV113N. Hold until MAC discharge pressure reaches 50 psig or greater.				
39	DCS	Place switch valve control in AUTO with a set point of two minutes.				
40	DCS	Open FIC-340 with an output of 30%.				
41	DCS	Open FIC-115 with an output of 40%.				
42	DCS	Open TIC-X600X-1 with an output of 50% and TIC- 600X-2 with an output of 50%..				
43	DCS	Place controller FIC-115 in MANUAL with an output of 50%.				
44	DCS	Open the MAC inlet guide vanes, FV-500A, in MANUAL to OP = 75%.				
45	OPERATOR	Close RHX drain valves, D210A and D211A. ACKNOWLEDGE				
46	DCS	Hold until condenser level (LIT-352) continuously stays above 55" w.c. for at least five minutes.				
47	DCS	Turn turbine bypass switch (HS-111) ON.				
48	OPERATOR	Open turbine inlet valve (X214A) and outlet valve (X216A). ACKNOWLEDGE				
49	DCS	Open turbine inlet trip valve (FV214A).				
50	DCS	Hold until turbine inlet temperature (TE-215) is less than -40 deg. C.				
51	DCS	Open turbine inlet nozzles (FV220A) until speed (ST-219) reaches 25,000 RPM.				
52	DCS	Switch turbine speed controller to AUTO with a set point (SP) of 25,000 RPM.				
53	DCS	Switch FIC-340 to AUTO.				
54	DCS	Switch FIC-115 to AUTO.				
55	DCS	Open PIC-600 with an output of 30%.				
56	DCS	Switch FIC-500 to AUTO.				
57	DCS	When waste nitrogen purity (AIT-312) drops below 25%, proceed to next step.				
58	OPERATOR	Close switch valve bypass valves, B211A and B212A. ACKNOWLEDGE				
59	DCS	Switch FIC-601 to AUTO with SP = 55 KSCFH.				
60	DCS	Hold until condenser level (LIT-352) continuously stays above 55" w.c. for at least five minutes.				
61	DCS	Switch PIC-601 to AUTO with SP = 1.0 psig.				
62	DCS	Place AIC-355 in AUTO with SP = 95%.				
63	DCS	Turn switch valve bypass switch (HS-111) OFF.				
64	OPERATOR	Turn back-up instrument air compressor OFF. ACKNOWLEDGE				
65	DCS	Place controllers TIC-X600X-1 and TIC- 600X-2 in AUTO..				
66	DCS	Advance switch valve timer () to 4 minutes. Every two hours thereafter, advance timer an additional 2 minutes until timer is set at 10 minutes. Hold at 10 minutes.				
67	DCS	Turn condenser level bypass switch (HIS-352) OFF.				
68	DCS	ASSISTED START is complete.				

**EAST BAY MUNICIPAL UTILITY DISTRICT
CRYOGENIC OXYGEN GENERATION PLANTS
ASSISTED STOP PROCEDURE
5-Jan-24**



<u>STEP</u>	<u>RESPONSIBILITY</u>	<u>ACTION</u>
1	OPERATOR	Open RHX drain valves, D210A and D211A. ACKNOWLEDGE
2	DCS	Change switch valve timer () to 2 minutes. Hold for 60 minutes.
3	DCS	Turn switch valve bypass switch (HS-111) ON.
4	DCS	Turn condenser level bypass switch (HIS-352) ON.
5	DCS	Slowly (1%/sec.) close turbine inlet nozzles (FV220A) to 0% open.
6	DCS	Close turbine inlet trip valve (FV214A).
7	OPERATOR	Close turbine inlet valve (X214A) and outlet valve (X216A). ACKNOWLEDGE
8	DCS	Place PIC-506 in MANUAL with OP = last position (0%).
9	DCS	Slowly (60 seconds) open the MAC vent valve, PV-506, until fully open (OP = 100%).
10	DCS	Slowly (30 seconds) close the MAC inlet guide vanes, FV-500, OP = 10%.
11	DCS	Stop the MAC (PB-502).
12	DCS	Open upper column vent valve (PV-349).
13	DCS	Place controllers IC-500, LIC-330, TIC-X600X-1, TIC-X600X-2, SIC-219, FIC-340, PIC-600, and PIC-601 in MANUAL with an output of 0%. Place FIC-115 in manual with a set point of 50%
14	DCS	Place switch valve control in MANUAL.
15	DCS	Close all switch valves, FCV-111, FCV-112, FCV-113 and FCV-114.
16	OPERATOR	Close RHX drain valves, D210A and D211A. ACKNOWLEDGE
17	DCS	ASSISTED STOP is complete.

END OF SECTION

CONTROL NARRATIVE
SPECIFICATION 40 60 01a
REV. 6, FEBRUARY 2024

Main Air Compressor Start:

The main air compressor has various permissives that must be satisfied to start. If one of these permissives is in a bad status, then the compressor will not start. Some items like the compressor vibrations will be bypassed for a few seconds during the initial start of the compressor but must be in their ok run status prior to bypassing. A page with a list of permissives will be part of the control system and will designate which permissives are not met. The permissives are as follow:

1. Ensure that the auxiliary lube oil is running. This is achieved by taking a signal off the motor contacts to the control system. The main air compressor will not start if the auxiliary pump is not running. Once the compressor is running, and the main lube oil pump is producing enough oil pressure to support the machine, the auxiliary pump will be shut down. If compressor oil pressure drops below 12 PSIG the auxiliary oil pump will start again until a set point of 24 PSIG is reached and the pump will shut down again. The auxiliary oil pump must also be running for at least 10 minutes before the machine can be started. A timer will need to be incorporated into the programming.
2. The MAC oil pressure supply measured by PIT-53 must be a minimum of 14 PSIG for the MAC to start. If the oil pressure is below that, the main air compressor will not start. There is no bypass for low oil pressure.
3. TIT-53 triggers a low temperature or high temperature alarm. The oil temperature must be between 90 F and 140 F for the compressor to start. If the temperature is lower or higher the compressor will not start. The transmitter does not control the temperature of the oil. The temperature of the oil is controlled by a thermostat built into the lube oil sump heater, and is set between 100 F and 110 F. When the compressor is running the oil cooler cools the oil and prevents over temperature shutdowns. An automatic temperature control valve controls how much oil flows through the cooler. This also has no connection to the control system.

4. The discharge pressure of the compressor must be less than 5 PSIG when read at PIT-506. If the pressure is not less than 5 PSIG then the issue needs to be addressed before the compressor will start.
5. The 1st, 2nd, and 3rd stage vibration monitors, VE-501, VE-502, and VE-503, will all be bypassed when the machine is started, but will need to be under 1.0 mills when bypassed. The bypass should be automatically stopped 30 seconds after the machine has started. After that time, the vibration monitors will be taken out of bypass.
6. The inlet guide vanes, FV-500, must be less than 5% open for the compressor to start. After compressor startup, the user will have control of the inlet guide vanes until placed into automatic control. Note, the 5% setting is by command only, no feedback is included.
7. The vent valve, FV-506, must be 95% or greater open for the compressor to start. After the compressor has started, the user will gain control of the vent valve.
8. The cooling water pressure, as monitored by switch PSL-800, must be greater than 20 PSIG. If water pressure falls below that, the compressor will not start and will shut down after running if water pressure falls below that level for any longer than 15 seconds.
9. The emergency trip system, if engaged, will prevent the compressor from starting. There are emergency push buttons at the local compressor control panels and at the main control panel. All switches must be set in the run mode in order for the compressor to start.
10. TSH-510 and TSH-511 which are the motor drive bearing temperatures must not be high for the compressor to start. These temperature are drawn from TE-510 and TE-511 as analog inputs into the DCS
11. M-1-2 is a switch gear trip monitor I/O that must be in the run state. Switch gear may trip from fault or maintenance. If the switchgear is tripped the compressor will not run and the I/O will report user of an issue with the switchgear.

12. PSL-590, the plant instrument air switch, must be showing good status. Without adequate instrument air pressure the compressor will not start.

After all the aforementioned permissives have been fulfilled, the user will initiate start-up of the main air compressor. The main air compressor takes about 30 seconds to reach its operating speed. After the compressor has reached its operating speed, the operator will load the compressor by modulating the inlet guide vane open and the vent valve closed. The HMI screens should provide indications that the auxiliary oil pump has shut down and the vibration monitors taken out of bypass. The main air compressor is now ready for normal operation.

Main Air Compressor Auxiliary Oil Pump:

The Auxiliary oil pump for the main air compressor is a very important safety device that allows the main air compressor to start and shut down by providing constant oil flow and pressure. The device has three modes of operation: **off**, **on**, and **auto**. **On** means running, **off** means not running. These indicators are used at all times except during maintenance. The first two will be an always **on** and always **off** state based on DCS output. In **Auto** the DCS will monitor the pressure at PIT-53 in order to stop and start the auxiliary oil pump. When the aux oil pump is put into auto it will start the pump and keep the pump on until the lube oil pressure is over 30 PSIG for 5 seconds. It will then turn off the auxiliary lube oil pump. If and when the lube oil pressure drops to or below 12 PSIG then the DCS will restart the lube oil pump. In the event of DCS failure the auxiliary oil pump should start as a fail safe in expectation that the compressor will shut down.

MAC 1-1 Control loop through FIC-500A-1-1:

The required air flow rate into the process is a function of the oxygen production rate, FT-600, and the oxygen product purity. The set point for FIC-500A-1-1 varies, then, with the desired oxygen production rate and the actual oxygen product purity. FIC-600, which sets the oxygen production rate, determines the set point for FIC-500-1-1 (air inlet valve) based on a mathematical function. The cold end air flow, FIT-120, which is the compressor flow rate minus any vented air, will be approximately 6 times the desired oxygen production rate. The air rate is adjusted further based on the oxygen purity measured at AIT-355-1.

FIC-500A-1 should have a selectable set point option of either “Local” or “Remote”. In the Local mode, the set point will be an operator selectable air flow between 0-700 KSCFH which will be set based on the operator’s understanding of the plant’s need for air flow.

In the Remote mode, the air flow set point for FIC-500A-1 will be calculated by DCS logic and derived as follows:

$$SP_{FIC-500A-1} = (PV_{FIC-600} * X) / (OP_{AIC-355-1})$$

where SP is the set point, PV is the process value, OP is the output, "X" is an Operator-adjustable factor accessible from the MAC HMI screen. The approximate value of "X" is 6.0 and the range limits for “X” should be set in the DCS at 5.0 to 7.0. The air rate, then, is increased inversely as purity falls and vice versa. The Operator will adjust “X” as needed to achieve a target oxygen purity of 95%. **X should not be commonly adjusted and can have major impacts to process performance. Adjustments should be confirmed with the Operations shift supervisor.**

FV-500A-1, the inlet guide vanes (IGV), is a fail closed device, air to open.

Current limiter IC-501 will limit how far the guide vanes can open based on the amp draw of the compressor motor. This controller prevents the MAC from running above its service factor.

The vent valve, FV-506A-1, is controlled automatically in normal operation by either PIC-506, discharge air pressure control, or SUIC-506-1, surge controller. If either the discharge pressure exceeds the set point of PIC-506-1 or the surge controller senses the onset of surge, the vent valve will open. The vent valve fails open, air to close. On a plant shutdown, FV-500A closes and FV-506A opens.

The surge controller, SUIC-506, uses the discharge pressure, PIT-506, and interstage flow, FIT-502, to calculate the distance to surge at the current operating conditions. A surge curve will be derived from field testing (of each compressor) where the compressor is operated over a range of flows and pressures to the onset of surge at each operating point. From that data, a surge curve is derived using a basic formula: Surge Pressure = Flow * (Slope + Intercept). The distance to surge (pressure) is then calculated by subtracting the absolute operating pressure from the absolute surge pressure and dividing that result by the surge pressure. Include an operator adjustable distance to surge on the HMI to enable the operator to set the minimum permissible distance to surge prior to initiating an opening of the vent valve. On a separate

supervisor accessible screen, constants for the Slope and Intercept derived from testing of the surge curve should be input.

Upon a shutdown event for either the cryogenic plant or the main air compressor, the controller for the inlet guide vane will cause this device to close, and the controller for the vent valve will cause that valve to open. The solenoids associated with both these valves should also be de-energized causing the actuators to immediately vent and the valves to return to their fail-safe positions.

MAC 1-2, 2-1 and 2-2 Control Loops through FIC-500A-1-2, 2-1 and 2-2:

The loop logic for all four main air compressors will be identical except for the tag numbering which should correspond to the compressor tags.

Main Air Compressor Shutdown:

A main air compressor shutdown can be initiated in various ways. These are as follow:

- Intentionally by an operator following recommended operating instructions
- Due to a loss of power, e.g. a circuit breaker trip due to a lightning strike
- Due to a trip event caused by a plant or compressor operating variable either exceeding or not meeting a minimum value

Trip values for those process parameters that can initiate a MAC shutdown are listed in the Input-Output list.

Maintenance Mode:

A Maintenance Mode will enable technicians to energize and de-energize solenoids throughout the plant while the plant is shut down for maintenance and/or instrument calibration. This is all solenoids associated with the plant system including the compressors. The intent is to allow maintenance to test, calibrate, or install valving. Most of the plant solenoids are associated with a bottle-up system that causes valves to fail to their default closed or open positions when the plant shuts down to safely isolate all of the process equipment. These solenoids are normally only energized, then, when the main air compressor is operating. The maintenance mode enables technicians to change the state of those solenoids without the main air compressor in operation. On-off control buttons will be provided on the HMI maintenance mode screen for each solenoid. This feature should have some sort of protection or prompt before entering into

maintenance mode to prevent accidental activation. All mechanical safeties such as oil pressure permissives and surge controls should still be active.

FIC-115 Unbalanced Air Flow Loop:

In normal operation, the turbine receives a mixture of air from the “unbalanced air pass” of the reversing heat exchanger and cold air coming directly from the cold end gel trap. The unbalanced air is warmer than the cold end gel trap air since it is partially warmed in the reversing heat exchanger. FV-215 in the air stream coming from the cold end gel trap controls the air mixture and thereby controls both the midpoint temperature of the reversing heat exchanger and the turbine inlet temperature. The midpoint temperature indirectly regulates the cold end delta T, i.e. the difference in temperature between the cold end air stream and the cold end waste nitrogen stream.

Cold end Delta T is critical to proper self-cleaning of the Reversing Heat Exchanger (prevention of CO₂ breakthrough at warmer temperatures and complete removal of air contaminants). This is controlled by increasing or decreasing the amount of air flow through the unbalanced air pass. Control is provided by modulating FV-215. The total unbalance air flow rate is equal to approximately 11 to 12% of cold end air flow. The calculation of unbalance air flow will be done within the control system to maintain an ideal cold end delta T of 2.3 degrees Centigrade. FV-213 is the turbine bypass valve which opens when the turbine is shut down. When the turbine is shut down, FV-213A functions like FV-215 to regulate the cold end Delta T. FV-213 is a split range, fail closed valve, reverse acting. FV-215 is a split range, fail closed valve, direct acting.

SIC-220 Turbine Flow Control Loop:

Refrigeration is generated in the plant by the expansion turbine and regulated by increasing or decreasing the amount of air expanded across the turbine by opening or closing the turbine nozzles via the turbine speed controller, SIC-220. Primary control is provided by SIC-220 which regulates turbine flow and, in turn, regulates the turbine speed.

The speed controller can be overridden by the temperature controller, TIC-216, which prevents the turbine outlet from becoming too cold thereby producing liquid at the turbine outlet that could lead to mechanical damage.

Turbine Start:

The turbine, like the main air compressor, has various permissives that must be satisfied in order to start. If one of these permissives is in a bad status, then the turbine will not start. Some items like the turbine vibrations will be bypassed for a few seconds during the initial start of the turbine but must be in their ok run status prior to bypassing. A page with a list of permissives will be part of the control system and will designate which permissives are not met. The permissives (fixed) are as follow:

1. PIT-20 must be at least 90 PSIG
2. The turbine IGV FV-220 must be below 5% open.
3. Lube oil temperature must be greater than 90 F.
4. None of the connected lox tanks can be over 102" water column.
5. Seal gas pressure PSL-580 must be above 15 PSIG. If seal gas pressure is low the oil pump will immediately shut down.
6. The low speed trip bypass must be activated, and then the turbine will start. Once the turbine has reached a speed above 10000 RPM the bypass should turn to normal. At this speed the turbine oil loading solenoid FY-220 should energize.

Turbine Shutdown:

The turbine can be shut down while the cryogenic oxygen plant remains in operation. A turbine shutdown can be initiated two ways:

- Intentionally by an operator following recommended operating instructions
- Due to a trip event caused by a turbine operating variable either exceeding or not meeting a minimum value

The turbine should shut down for the following reasons:

1. Seal gas pressure, PSL-580, drops below 15 PSIG
2. Lube oil return temperature rises above 175 F when read at TSH-24

3. Speed exceeds 27,500 RPM or drops below 10,000 RPM
4. One of the LOX tanks connected to the plant exceeds a high level of 102" w.c.
5. Lube oil pressure at PIT-20 falls below 80 PSIG
6. The cryo plant shuts down.

Any of the above will shut down the turbine. Upon shutdown the slam valve, FV-214, should shut, and FV-220, the IGV for the turbine, should shut as well.

Turbine Oil Pump

The turbine oil pump will always be on when selected on in the control system. This will continuously supply the turbine with lube oil allowing proper function. The only time the lube oil pump will shut off is if PSL-580 trips on low seal gas pressure (below 15 PSIG). This will immediately shut down the turbine and shut off the lube oil pump until the seal gas pressure resets the switch. The turbine lube oil pump is controlled from the DCS by and on/off button.

Switch Valve Function:

In normal operation, the switch valves are actuated open/close in pairs, i.e. one air valve and one waste valve on opposite (A & B) passes of the RHX. The normal cycle is 10 minutes duration between switches but the timer must be adjustable (range: 0.1 to 10 mins) to accommodate shorter cycles during start-up and shutdown transitions. Also, to accommodate start-up and valve verification needs, the switch valve controls must be capable of operation in the following modes:

Auto: Switch valves change position in pairs, e.g. FCV-111/FCV-114N open & FCV-112A/FCV-113 closed, at TMR-100 set point time.

Hand: Switch valves change position in pairs, e.g. FCV-111/FCV-114N open & FCV-112A/FCV-113 closed, on command from "Air in B" jog button (pop up on HMI screen when Hand is selected). Timer is not active. Last opened switch valves remain open until switch valve control is turned "Off".

Manual: Switch valve positions can be controlled individually using Open/Close buttons (pop up on HMI screen when valve icons are selected). Timer is inactive.

Off: Switch valves are all closed. Timer is not active.

* Switch valve actuators are double acting, i.e. instrument air is required to move the valves in either direction. Upon loss of power to the solenoids, the switch valves will fail in the closed position. Upon any plant shutdown, the switch valve control should revert to "Off" closing all four switch valves.

In Maintenance mode the switch valves should be controlled from the DCS system and can be opened or closed.

Mid-Point Temperature Control

The TIC-154 and TIC-155 controllers control the individual midpoint temperatures of each main heat exchanger. Opening the FV-X600X valves allows more cold end oxygen to pass thru that respective RHX, thereby cooling the midpoint temperature of that exchanger; conversely, closing the valve restricts the flow of cold oxygen thru the reversing heat exchanger, thereby warming the midpoint temperature.

The set point for these controllers is the rolling average temperature of TE-154 and TE-155. Mid-point temperature is not directly controlled and, therefore, varies during normal operation but is a function of the Unbalance Air Flow Control, FIC-115, which controls cold end delta T. These TIC controllers will, therefore, keep the two mid-point temperatures as close together as possible. In some cases, one midpoint valve may become almost fully closed with the other midpoint valve fully open.

FV-214 Turbine Inlet Valve

FV-214 is a solenoid operated valve that admits air to the inlet of the turbine. The valve is opened when the turbine is started and closes quickly to shut off the turbine in the event of a either a plant shutdown or turbine over or under speed. The valve opens by energizing the solenoid FY-214.

LIC-330 Lower Column Level Control Loop:

The LIC-330 controller controls the level of crude liquid oxygen (~40% purity) in the lower column. LV-330 regulates the liquid level in the lower column by-transferring (aka kettle liquid) to the upper column for further distillation. LV-330 is a fail closed, air to open valve.

FIC-340 Shelf Transfer Control Loop:

Reflux (aka shelf) nitrogen purity is controlled by the amount of flow through FV-340. Increasing shelf nitrogen flow to the upper column has the effect of decreasing oxygen content in the waste nitrogen stream, reducing shelf nitrogen flow to the lower column and increasing oxygen content in the shelf nitrogen purity. Final product purity is directly related to the waste nitrogen purity. FV-340 flow is managed as a percent of the FT-120, cold end air flow with a bias based on waste nitrogen purity.

LIC-352 Main Condenser Level Control Loop:

Main Condenser Level is controlled by LIC 352. Set points are pre-programmed to maintain liquid level in the main condenser between 50" and 56" during normal operation.

If the condenser level rises above 56", the "make" valve, LV-350, will open and transfer LOX to the storage tank until the level falls to 50" at which time, LV-350 will close. If the level falls below 48", the "add" valve, LV-351, will open and remain open until the condenser level rises above 54". These controller actions will remain in effect regardless of whether the turbine is in operation or shut down.

LV 350 and LV-351 are fail closed valves, air to open.

FIC-600 Oxygen Product Flow Control Loop:

FIC-600 is the product oxygen flow controller. This controller will be configured with two modes: a "Load Following" mode which will regulate oxygen flow based on demand at the oxygen reactors and a "Flow Control" mode which will maintain a constant flow of oxygen in the pipeline.

In the load following mode, the controller becomes PIC-600 and maintains a constant oxygen pressure in the pipeline. As demand rises and falls in the reactors, pipeline pressure tends to fall and rise, and the plant will self-adjust to match the demand.

When the signal is lower than expected the control system will send a signal to the FV-600X to increase oxygen flow to the deck. This will cascade to either FIC-500A-1 or FIC-500A-2 to open the inlet guide vanes and increase cold end air flow. The opposite is also true if too much oxygen flow to the deck is detected.

In the flow control mode, FV-600 will be regulated via FIC-600 as needed to maintain constant oxygen flow to the reactors.

FIC-601 controls the oxygen vent valve and minimum cryogenic plant oxygen production rate. If the production rate falls below the minimum turndown rate for the plant (approximately 50 T/D), FIC-601 will open the product oxygen vent valve, FV-601X, as needed to maintain the minimum production rate.

PIC-615/625 DRIOX Storage Tank Controller

Pressure in the DRIOX LOX storage tanks is controlled by a pair of valves per tank, the pressure build valve PV-615 (or PV-625 for tank nos. 2 & 4), and the economizer valve, PV-616 (PV-626 for tank nos. 2 & 4). If the tank pressure falls below set point, the pressure build valve opens to draw LOX from the tank, vaporize it in the pressure build vaporizer, and inject the vapor back into the vapor space of the tank. If the tank pressure rises above set point, the economizer valve opens to relieve the excess pressure into the pipeline feeding the aeration decks.

These valves are modulated by the output of either PIC-615 or PIC-615A. PIC-615 is the DCS based controller and PIC-615A is the back-up single loop controller. Relays integrated into the control circuit will enable control of the tank pressures via the DCS in normal operation but will fail over to the back-up single loop controller in the event of a DCS failure.

The two storage tanks are alternated between the Make and Add modes; in the Make mode, the tank is maintained close to 0 PSIG to enable transfer of LOX from the low pressure (upper) column to storage and in the Add mode, the tank is maintained at approximately 20 PSIG to vaporize liquid under pressure for feed into the pipeline. A selector switch on the DCS screen will enable selection of the functional mode, i.e. Make or Add, for each tank. The back-up controllers will always be set for the Add pressure (approximately 20 PSIG) to enable all the tanks to either feed the pipeline to the aeration decks or to add LOX back to the cryogenic plant during restart.

The pressure build (PV-615/PV-625,) positioners are reverse acting and the economizer (PV-616/PV-626) positioners are direct acting. In addition, these are split range positioners such that only one controller can control both valves. A controller output of 4 mA will fully open the pressure build valve and an output of 20 mA will fully open the economizer valve. At 12 mA output, both valves are closed.

The economizer line is protected against low temperature via TIC-640 which overrides PIC-615 and modulates PV-616/PV-626 closed as needed to maintain the minimum temperature set point.

LOX Product Back-up system

Back up liquid oxygen is supplied to the pipeline via the vaporizers on plant shutdown. Oxygen flow from the vaporizers is controlled via a pressure controller, PIC-635, and valve FV-635. PV 635 is a fail closed, air to open valve. The solenoid energizes to open. PIC-635 monitors the product oxygen pipeline pressure at PIT-635 (new with this project) and opens FV-635 if the pressure falls below set point. PIC-635 will open and close FV-635 to maintain pipeline pressure at an operator chosen set point (typically ~1 PSIG). TE-635 (formerly TC 635) will provide temperature data to the controller which will then close the valve if the temperature approaches -20 F. When FV-635X is closed liquid oxygen may be trapped between the storage tank and FV-635X in which case the resultant build-up of pressure will be vented to the pipeline via PIC-630 and FV-635X. PIC-630 monitors the pressure at PIT-630 (new to this project). When the fixed set point of 60 psig is approached PIC-630 will send a signal through a low signal select to slightly open FV-635X. The intention is to relieve pressure, but not allow more liquid oxygen to push into the vaporizer. The DRIOX Supply Valve, FV-635, will fail closed via its solenoid valve in the event a PET switch is opened. TE-635 (formerly TC-635 & redundant TC-637) monitors the temperature of the product oxygen gas in the pipeline and will begin to close FV-635X as the temperature approaches -20 F. As the temperature decreases the controller should limit the amount FV-635X can open and should eventually close the valve completely before the set point of -20F is reached. TSL-634 is also involved in the circuit and should immediately close FV-635X if the set point at TSL-634 falls below -20F.

PIC-630 and PIC-635 interact with each other through a high signal select NYH-630 (removed and replaced with logic). Whichever signal is highest being given by the controllers goes to a low signal select NYL-635 (removed and replaced with logic). The low signal select interacts with TE-635/TE-637(removed) (TC-635) through NYL-436 (remove and replace with logic) which limits the open signal being sent based on the temperature. If the temperature is at or below -20 F the signal sent to the valve will be 4 ma (closed). As the temperature increases the valve will be allowed to open incrementally. At ambient temperature the signal will be 20 ma or 100% open. The low signal select will take the lowest signal from either NYH-630 (PIC-635/PIC-630) or NYL-436. This signal will then control FV-635X.

The solenoid valve FY-635 serves as the fail safe for the valve if the PET is tripped, or if TSL-634 triggers. If either of these events occur FY-635 will energize and cut off instrument air supply to the valve. The valve will remain closed until the shutdown condition is reset.

TIC-550

The thaw heater outlet temperature is controlled by TIC-552-2 but must be limited depending on whether the plant or the turbine is being thawed. TE-550-1 and TE-552-1 will trip the heater if the element temperature climbs above 500 F. The HMI will, therefore, display two thaw heater modes, Plant Thaw and Turbine Thaw, with operator adjustable set points and range limits for each. Range limits should be adjustable with supervisory authorization only. Thaw heater operation can also be overridden by its element temperature (TIC-550-1) to ensure that the elements do not overheat. If the heater trips on over temperature from TIC-550-1, the heater must be manually reset by the operator.

Two MAC Control:

When two main air compressors are in operation feeding into a single cryo plant, the air flow demand is to be evenly split between the two compressors. The flow set points for each FIC-500 are to be derived mathematically by the same formula used for single compressor operation except divided by two (2), i.e. $SPFIC-500 = ((PVFIT-600-2 * RSP) / (OPAIC-355-2) / 2)$ where "RSP" is a common factor accessible from the MAC HMI screen. The approximate value of "X" is 5. The amp limit portion of the control output, IC-500, to the inlet guide vanes, FV-500, will be kept separate for each main air compressor and will not affect the opposite compressor. Any trip originating from the operating cryo plant will shut down both operating main air compressors. Alarms and permissives will be separate for each main air compressor and will not affect the opposite running compressor.

The vent valve control for each running compressor is to remain separate for each compressor with the exception that both PIC-506 controllers will share a common set point, i.e. any set point change made by the operator (or Assisted Start) will be made simultaneously in the opposite PIC-506 controller. Surge controls will be independent for each compressor.

END OF SECTION

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EBMUD Cryo Plant Control Loop Specifications
CONTROL LOOP SPECIFICATIONS
40 61 01b

LOOP NO. Overview
LOOP NAME: Summary Overview
PLANT AREA: All
SEQUENTIAL NUMBER: 1 of 18

O2 PLANT 1

PROJECT NAME: EBMUD Controls Improvement Project
PROJECT NUMBER: SD-428
SPECIFICATION NO.: 40 61 01b

REV NO.	DATE	BY	CHECK	APP
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		
4	1/5/24	DB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER						CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	MANUAL		REMOTE	SELECTS	TAG NO.	DESCRIPTION	INPUT	OUTPUT	
The two cryo plants (including their respective turbines), four main air compressors, and liquid oxygen back-up system are to be operated from a common DCS network fed from remote input-output racks at each major equipment station. Provide on-screen ability for the operator to select the main air compressor(s) and cryo plant to be in operation at any point in time. Possible combinations include the operation of one or two cryo plants simultaneously with either one or two main air compressors feeding into each cryo plant. In any of the selected modes of operation, the permissives, alarms, and trips must be configured such that the origin of any fault is clearly identifiable by operating module, e.g. MAC 2-1, Cryo Plant 2, et al, as well as by initiating device tag number. This will be set up as a "first out" protocol such that the first device initiating a fault that leads to a trip of either cryo plant is identified and held on the screen until cleared by the operator. All operating modules are to be accessible from any of the HMI screens on the DCS network. Valves are to be color coded, depending on position, with red indicating closed and green indicating any position other than fully closed. Rotating equipment is to be color coded, depending on status, with red indicating stopped and green indicating running.																

3



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. Maintenance Mode

LOOP NAME: N/A

PLANT AREA: Cryo Plant 1

SEQUENTIAL NUMBER: 2 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	6/9/23	DLB		
1	1/5/24	DB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					REV.	
							LOCAL	MANUAL									
TAG NO.	DESCRIPTION	INPUT	OUTPUT				REMOTE	SELECTS			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL		
Solenoid triggers																	
W-44-IA-FY-111-1	#1 Cryo FCV-111A Switch Valve Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-111-1	Air in Switch Valve	Open/Closed	Open/Closed		0	
W-44-IA-FY-112-1	#1 Cryo FCV-112A Switch Valves Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-112-1	Air in Switch Valve	Open/Closed	Open/Closed		0	
W-44-IA-FY-113-1	#1 Cryo FCV-113N Switch Valves Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-113-1	Waste out Switch valve	Open/Closed	Open/Closed		0	
W-44-IA-FY-114-1	#1 Cryo FCV-114N Switch Valves Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-114-1	Waste out Switch valve	Open/Closed	Open/Closed		0	
W-44-AHP-FY-213-1	Turbine Bypass Valve Solenoid	On	Off	FIT-115	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-AHP-FV-213A-1	Turbine Bypass Valve	4-12 ma	% Open		0	
W-44-AHP-FY-214-1	Turbine Inlet Valve Solenoid	On	Off	N/A		N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-AHP-FY-214-1	Turbine Slam Valve	Open/Closed	Open/Closed		0	
W-44-AHP-FY-215-1	Unbalanced Air Valve Solenoid	On	Off	FIT-115	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-AHP-FV-215A-1	Unblanced Air flow control valve	12-20 ma	% Open		0	
W-44-N2-FY-340-1	Shelf Flow Valve Solenoid	On	Off		Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-N2-FV-340N-1	Shelf Nitrogen Flow Valve	4-20 ma	% Open		0	
W-44-N2-FY-349-1	MAC 1-1 Inlet Valve Solenoid	On	Off	FIC-500	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-IA-FV-500A-1-1	MAC Inlet Guide Vanes	4-20 ma	% Open		0	
W-44-IA-FY-500-1-1	MAC 1-2 Inlet Valve Solenoid	On	Off	FIC-500	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-IA-FV-500A-1-2	MAC Inlet Guide Vanes	4-20 ma	% Open		0	
W-44-IA-FY-500-1-2	MAC 1-1 Vent Valve Solenoid	On	Off	PIC-506	Pressure control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-EXH-FV-506A-1-1	MAC Vent Valve	4-20 ma	% Open		0	
W-44-EXH-FY-506-1-1	MAC 1-2 Vent Valve Solenoid	On	Off	PIC-506	Pressure control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-EXH-FV-506A-1-2	MAC Vent Valve	4-20 ma	% Open		0	
W-44-EXH-FY-506-1-2	Oxygen Vent Valve Solenoid	On	Off	FIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	PV-600X-1	Product oxygen Vent Valve	4-20 ma	% Open		0	
W-44-O2-LY-350X-1	Liquid Make Valve LV-350X Solenoid	On	Off	LIC-350	Level Control	N/A	N/A	Auto/Manual	N/A	Open/Closed	W-44-O2-LY-350X-1	Liquid oxygen make valve	Open/Closed	Open/Closed		0	
W-44-O2-LY-351X-1	Liquid Add Valve LV-351X Solenoid	On	Off	LIC-350	Level Control	N/A	N/A	Auto/Manual	N/A	Open/Closed	W-44-O2-LY-351X-1	Liquid oxygen add valve	Open/Closed	Open/Closed		0	
W-44-N2-FY-349-1	Upper Column Vent Valve Solenoid	On	Off	PIC-349	Pressure control	N/A	N/A	Auto/Manual	N/A	Open/Closed	W-44-N2-FY-349-1	Upper column vent valve	Open/Closed	Open/Closed		0	
W-44-O2-FY-600-1	Oxygen Product Valve Solenoid	On	Off	FIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-600X-1	Product oxygen flow control valve	4-20 ma	% Open		0	
W-44-O2-FY-601-1	Oxygen Product Vent Valve Solenoid	On	Off	FIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-601X-1	Product oxygen Vent control valve	4-20 ma	% Open		0	
W-44-O2-LY-330-1	Kettle Transfer Solenoid	On	Off	LIC-330	Level Control	N/A	N/A	Auto/Manual	N/A	% Open	LV-330X-1	Kettle transfer vavle	4-20 ma	% Open		0	
W-44-O2-FY-600-1-1	Oxygen Product Mid-point Temperature Control Valve #1 Solenoid	On	Off	TIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-X600X-1-1	Oxygen Product Mid point Temperature Control Valve #1	4-20 ma	% Open			
W-44-O2-FY-600-1-2	Oxygen Product Mid-point Temperature Control Valve #2 Solenoid	On	Off	TIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-X600X-1-2	Oxygen Product Mid point Temperature Control Valve #2	4-20 ma	% Open			
Safety Items																	
All MAC start permissives must still be met while in maintenance mode in order to start the main air compressor. Mechanical shutdowns should still function. Can still run in auto.																0	
Thaw Heater controls should still be active to turn on and off the heater based on temperature. Switch valve should still be able run in auto																0	
Bypasses																	
W-44-O2-AIT-355-1	High hydrocarbon shutdown switch	High Level	Shutdown alarm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		0
W-44-O2-LIT-352-1	Low or high main condenser level shutdown	High/Low Level	Shutdown alarm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		0
W-44-AHP-PIT-200-1	RHX switch valve cycle failure	Failure shutdown	Shutdown alarm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		0



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. N/A

LOOP NAME: Main Air Compressor Start

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 3 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DB		

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
											TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
TAG NO.	DESCRIPTION	INPUT	OUTPUT	Start Permissives												
W-44-IA-FV-500A-1-1	MAC 1-1 Inlet Valve	0-100%	4-20ma	FSC-500A-1-1	Software Monitor of position	0-100%	0% Open	Auto	No	Closed	W-44-IA-FV-500A-1-1	MAC No. 1-1 Inlet Guide vane Closed	4 ma	0% Open	0% Open	3
W-44-EXH-FV-506A-1-1	MAC 1-1 F.O. (Anti-Surge) Vent Valve	100%-0	4-20ma	FSO-506A-1-1	Software Monitor of position	0-100%	100% Open	Auto	No	Open	W-44-EXH-FV-506A-1-1	MAC No. 1-1 Vent Valve Open	20 ma	100% Open	100% Open	3
RL-505-1-1-1	MAC 1-1 Auxiliary Oil Pump Run Status	On/Off	On/Off	RL-505-1-1-1	Status	Aux pump run	Remote	N/A	No	On	RL-505-1-1-1	MAC 1-1 Auxiliary Oil Pump Run Status	On	On	On	3
PB-500-2-1-1	MAC #1-1 (DCS); Vibration Bypass	Normal/Bypass	Normal/Bypass		Software Switch											
				PB-500-2-1-1		Bypass/Normal	N/A	N/A	Yes	Bypass/Normal	N/A	Vibration bypass	Bypass	Bypass	Normal	3
W-44-LOS-LSL-50-1-1	Mac #1-1 Lube Oil Level	Normal/Alarm	Normal/Alarm	W-44-LOS-LSL-50-1-1	Level Switch	Normal/Alarm	N/A	N/A	No	Level Okay	W-44-LOS-LSL-50-1-1	Mac #1-1 Lube Oil Level	Normal	Normal	Alarm	3
W-44-AHP-LSH-501-1	Plt. #1 Surge Tank High Water Level Permissive	Normal/Alarm	Normal/Alarm	LSH-501-1-1	Level Switch	N/A	N/A	N/A	No	Level Okay	W-44-AHP-LSH-501-1	Plt. #1 Surge Tank High Water Level Permissive	Normal	Normal	Alarm	3
M-1-1	MAC #1-1 Space Heater	Status	Status	M-1-1	Status signal	N/A	N/A	N/A	No	Good Status	M-1-1	MAC #1-1 Space Heater	Good Status	Good Status	Bad Status	3
M-1-1	MAC #1-1 Switchgear Trip	Status	Status	M-1-1	Status Signal	N/A	N/A	N/A	No	Good Status	M-1-1	MAC #1-1 Space Heater	Good Status	Good Status	Bad Status	3
M-1-1	MAC #1-1 Auxiliary Oil Pump Trip	Status	Status	M-1-1	Status Signal	N/A	N/A	N/A	No	Good Status	M-1-1	MAC #1-1 Space Heater	Good Status	Good Status	Bad Status	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
MU/WTR-1-1	MAC #1-1 Motor Winding Temperature High Alarm	Normal/Alarm	Normal/Alarm	MU/WTR-1-1	Status Signal	N/A	N/A	N/A	No	Good Status	MU/WTR-1-1	MAC #1-1 Motor Winding Temperature High Alarm	Normal	Normal/Alarm	Alarm	3
W-44-AHP-PB-502-1-1	MAC #1-1 E Stop (Local Panel)	On/Off	On/Off	PB-501-1-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	W-44-AHP-PB-502-1-1	MAC #1-1 E Stop (Local Panel)	Good Status	On/Off	Depressed	3
PB-502-1-1	MAC #1-1 E Stop (Main Panel)	On/Off	On/Off	PB-502-1-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	PB-502-1-1	MAC #1-1 E Stop (Main Panel)	Good Status	On/Off	Depressed	3
PET-1-1	Plt. #1 Plant Emergency Trip	On/Off	On/Off	PET-1-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	PET-1-1	Plt. #1 Plant Emergency Trip	Good Status	On/Off	Depressed	3
W-44-AHP-PSH-503-1-1	MAC #1-1 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-PSH-503-1-1	Pressure switch	N/A	N/A	N/A	No	Pressure High	W-44-AHP-PSH-503-1-1	MAC #1-1 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
N/A	MAC #1-1 Vibration Bypass	Normal/Bypass	Normal/Bypass	N/A	Software switch	N/A	N/A	N/A	Yes	Bypassed	N/A	MAC #1-1 Vibration Bypass	Bypass for start	Bypass for start	Normal	3
W-44-LOS-TIT-53-1-1	MAC #1-1 Start Circuit; High Oil Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-TIT-53-1-1	Temperature Switch	0-200 F	Less than 150 F	N/A	No	Temp Okay	W-44-LOS-TIT-53-1-1	MAC #1-1 Start Circuit; High Oil Temperature Permissive	Below 140 F Above 90 F	Normal/Alarm	90F > TIT-53 >140 F	3
W-44-AHP-TE-510-1-1A	MAC #1-1 Motor Outboard Bearing High Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-510-1-1A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-510-1-1A	MAC #1-1 Motor Outboard Bearing High Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TE-511-1-1A	MAC #1-1 Motor Drive Bearing Hi Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-511-1-1A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-511-1-1A	MAC #1-1 Motor Drive Bearing Hi Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TSHH-506-1-1	MAC #1-1 Start Circuit; High Discharge Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TSHH-506-1-1	Temperature Switch	0-300 F	Less than 150 F	N/A	No	N/A	W-44-AHP-TSHH-506-1-1	MAC #1-1 Start Circuit; High Discharge Temperature Permissive	Normal	Normal/Alarm	Alarm	3
W-44-LOS-VE-501-1-1	MAC #1-1 Stage #1 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-501-1-1	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-501-1-1	MAC #1-1 Stage #1 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-VE-502-1-1	MAC #1-1 Stage #2 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-502-1-1	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-502-1-1	MAC #1-1 Stage #2 Vibration Proximitior	0 mils	0 mils	1.5 mils	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
W-44-LOS-VE-503-1-1	MAC #1-1 Stage #3 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-503-1-1	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-503-1-1	MAC #1-1 Stage #3 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-PSL-54-1-1	MAC #1-1 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-PSL-54-1-1	Pressure switch	0-50 PSIG	Greater than 12	N/A	No	N/A	W-44-LOS-PSL-54-1-1	MAC #1-1 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-IA-PIT-590-1	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	PSL-590-1	Pressure switch	0-100 PSIG	Greater than 60	N/A	No	N/A	W-44-IA-PIT-590-1	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-AHP-FIT-502-1-1	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	FIT-502-1-1	Transmitter	0-100" H2O	less than 250 SCFM	N/A	No	0	W-44-AHP-FIT-502-1-1	Flow Transmitter, MAC Interstage	0	0	>10 SCFM	3
W-44-IA-FY-500-1-1	Inlet Guide Vane Solenoid	On/Off	On/Off	FY-500-1-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-IA-FY-500-1-1	Turns on when compressor is started	Off	Off	Off	1
W-44-EXH-FY-506-1-1	Compressor Vent Valve solenoid	On/Off	On/Off	FY-500-1-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-EXH-FY-506-1-1	Turns on when compressor is started	Off	Off	Off	1



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. N/A

LOOP NAME: Main Air Compressor Start

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 3 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DB		

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
											TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
TAG NO.		DESCRIPTION	INPUT	OUTPUT												
Start Permissives																
W-44-IA-FV-500A-1-2	MAC 1-2 Inlet Valve	0-100%	4-20ma	FSC-500A-1-2	Software Monitor of position	0-100%	0% Open	Auto	No	Closed	W-44-IA-FV-500A-1-2	MAC No. 1-2 Inlet Guide vane Closed	4 ma	0% Open	0% Open	3
W-44-EXH-FV-506A-1-2	MAC 1-2 F.O. (Anti-Surge) Vent Valve	100%-0	4-20ma	FSO-506A-1-2	Software Monitor of position	0-100%	100% Open	Auto	No	Open	W-44-EXH-FV-506A-1-2	MAC No. 1-2 Vent Valve Open	20 ma	100% Open	100% Open	3
RL-505-1-1-2	MAC 1-2 Auxiliary Oil Pump Run Status	On/Off	On/Off	RL-505-1-1-2	Status	Aux pump run	Remote	N/A	No	On	RL-505-1-1-2	MAC 1-2 Auxiliary Oil Pump Run Status	On	On	On	3
PB-500-2-1-2	MAC #1-2 (DCS); Vibration Bypass	Normal/Bypass	Normal/Bypass		Software Switch											
				PB-500-2-1-2		Bypass/Normal	N/A	N/A	Yes	Bypass/Normal	N/A	Vibration bypass	Bypass	Bypass	Normal	3
W-44-LOS-LSL-50-1-2	Mac #1-2 Lube Oil Level	Normal/Alarm	Normal/Alarm	W-44-LOS-LSL-50-1-2	Level Switch	Normal/Alarm	N/A	N/A	No	Level Okay	W-44-LOS-LSL-50-1-2	Mac #1-2 Lube Oil Level	Normal	Normal	Alarm	3
W-44-AHP-LSH-501-1	Pit. #1 Surge Tank High Water Level Permissive	Normal/Alarm	Normal/Alarm	LSH-501-1-1	Level Switch	N/A	N/A	N/A	No	Level Okay	W-44-AHP-LSH-501-1	Pit. #1 Surge Tank High Water Level Permissive	Normal	Normal	Alarm	3
M-1-2	MAC #1-2 Space Heater	Status	Status	M-1-2	Status signal	N/A	N/A	N/A	No	Good Status	M-1-2	MAC #1-2 Space Heater	Good Status	Good Status	Bad Status	3
M-1-2	MAC #1-2 Switchgear Trip	Status	Status	M-1-2	Status Signal	N/A	N/A	N/A	No	Good Status	M-1-2	MAC #1-2 Space Heater	Good Status	Good Status	Bad Status	3
M-1-2	MAC #1-2 Auxiliary Oil Pump Trip	Status	Status	M-1-2	Status Signal	N/A	N/A	N/A	No	Good Status	M-1-2	MAC #1-2 Space Heater	Good Status	Good Status	Bad Status	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
MU/WTR-1-2	MAC #1-2 Motor Winding Temperature High Alarm	Normal/Alarm	Normal/Alarm	MU/WTR-1-2	Status Signal	N/A	N/A	N/A	No	Good Status	MU/WTR-1-2	MAC #1-2 Motor Winding Temperature High Alarm	Normal	Normal/Alarm	Alarm	3
W-44-AHP-PB-502-1-2	MAC #1-2 E Stop (Local Panel)	On/Off	On/Off	PB-501-2-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	W-44-AHP-PB-502-1-2	MAC #1-2 E Stop (Local Panel)	Good Status	On/Off	Depressed	3
PB-502-1-2	MAC #1-2 E Stop (Main Panel)	On/Off	On/Off	PB-502-1-2	Emergency Trip	N/A	N/A	N/A	No	Not Active	PB-502-1-2	MAC #1-2 E Stop (Main Panel)	Good Status	On/Off	Depressed	3
PET-1-2	Plt. #1 Plant Emergency Trip	On/Off	On/Off	PET-1-2	Emergency Trip	N/A	N/A	N/A	No	Not Active	PET-1-2	Plt. #1 Plant Emergency Trip	Good Status	On/Off	Depressed	3
W-44-AHP-PSH-503-1-2	MAC #1-2 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-PSH-503-1-2	Pressure switch	N/A	N/A	N/A	No	Pressure High	W-44-AHP-PSH-503-1-2	MAC #1-2 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
N/A	MAC #1-2 Vibration Bypass	Normal/Bypass	Normal/Bypass	N/A	Software switch	N/A	N/A	N/A	Yes	Bypassed	N/A	MAC #1-2 Vibration Bypass	Bypass for start	Bypass for start	Normal	3
W-44-LOS-TIT-53-1-2	MAC #1-2 Start Circuit; High Oil Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-TIT-53-1-2	Temperature Switch	0-200 F	Less than 150 F	N/A	No	Temp Okay	W-44-LOS-TIT-53-1-2	MAC #1-2 Start Circuit; High Oil Temperature Permissive	Below 140 F Above 90 F	Normal/Alarm	90F > TIT-53 >140 F	3
W-44-AHP-TE-510-1-2A	MAC #1-2 Motor Outboard Bearing High Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-510-1-2A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-510-1-2A	MAC #1-2 Motor Outboard Bearing High Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TE-511-2-2A	MAC #1-2 Motor Drive Bearing Hi Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-511-2-1A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-511-2-2A	MAC #1-2 Motor Drive Bearing Hi Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TSHH-506-1-2	MAC #1-2 Start Circuit; High Discharge Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TSHH-506-1-2	Temperature Switch	0-300 F	Less than 150 F	N/A	No	N/A	W-44-AHP-TSHH-506-1-2	MAC #1-2 Start Circuit; High Discharge Temperature Permissive	Normal	Normal/Alarm	Alarm	3
W-44-LOS-VE-501-1-2	MAC #1-2 Stage #1 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-501-1-2	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-501-1-2	MAC #1-2 Stage #1 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-VE-502-1-2	MAC #1-2 Stage #2 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-502-1-2	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-502-1-2	MAC #1-2 Stage #2 Vibration Proximitior	0 mils	0 mils	1.5 mils	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
W-44-LOS-VE-503-1-2	MAC #1-2 Stage #3 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-503-1-2	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-503-1-2	MAC #1-2 Stage #3 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-PSL-54-1-2	MAC #1-2 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-PSL-54-1-2	Pressure switch	0-50 PSIG	Greater than 12	N/A	No	N/A	W-44-LOS-PSL-54-1-2	MAC #1-2 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-IA-PIT-590-2	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	PSL-590-1	Pressure switch	0-100 PSIG	Greater than 60	N/A	No	N/A	W-44-IA-PIT-590-1	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-AHP-FIT-502-1-2	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	FIT-502-1-2	Transmitter	0-100" H2O	less than 250 SCFM	N/A	No	0	W-44-AHP-FIT-502-1-2	Flow Transmitter, MAC Interstage	0	0	>10 SCFM	3
W-44-IA-FY-500-1-2	Inlet Guide Vane Solenoid	On/Off	On/Off	FY-500-1-2	Solenoid	On/Off	Off	N/A	No	Off	W-44-IA-FY-500-1-2	Turns on when compressor is started	Off	Off	Off	1
W-44-EXH-FY-506-1-2	Compressor Vent Valve solenoid	On/Off	On/Off	FY-500-1-2	Solenoid	On/Off	Off	N/A	No	Off	W-44-EXH-FY-506-1-2	Turns on when compressor is started	Off	Off	Off	1



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-500A-1-1

LOOP NAME: Main Air Compressor 1-1 Flow

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 5 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE							
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS							REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	Notes		
INLET GUIDE VANE CONTROL																		
W-44-O2-AIT-355-1	Analyzer, Product Oxygen Purity	0 to 100 % Oxygen	4-20 mA	W-44-O2-AIT-355-1	Proportional Output	W-44-O2-AIT-355-1	Imbedded in program: 95%	Always AUTO	N/A	% Bias to FIC-500A-1	FIC-355-1	PID Controller	See Below				1	
W-44-AHP-FIT-120-1	Flow Transmitter, Cold End Air Flow	0 to 700 KSCFH	4-20 mA, w/square root function applied	FIC-500A-1-1	PID Reverse Acting	W-44-AHP-FIT-120-1	Remote: Derived from Process Value of FIC-600-1 and AIC-355-1. See Math section.	Auto/ Manual	Derive Set Point based on PV from AIC-355-1 as follows: $SP_{FIC-500A-1} = (PV_{FIT-600-1} * RSP)/(OP_{AIC-355-1})$ where "RSP" is a factor accessible from the MAC HMI screen. The approximate value of "X" is 5.	Inlet Guide Vane Position, % Open	LSS-500A-1-1	Low Signal Select	DCS Logic Signals	DCS Logic Signal	N/A		1	
W-44-O2-FIT-600-1	Flow Transmitter, Product Oxygen Flow	0 to 150 KSCFH	PLC Logic Signal, Flow															
W-44-AHP-IT-500-1-1	Current Transmitter, MAC Motor Amps	0 to 200 A	4-20 mA															
LSS-500A-1-1	Low Signal Select	PLC Logic Signals, FIC-600 & IY-500-1-1	PLC Logic Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FV-500A-1-1	Inlet Guide Vanes	4- 20 ma	0 to 100% Open	Closed			
SD-500-1-1	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-1-1	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		1	
W-44-IA-FY-500-1-1	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-1-1	Inlet Guide Vanes	4-20 ma	Open/ Closed	Air to Open, Fail Closed	Open when compressor is started	1	

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE							
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS						
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				OUTPUT TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL		Notes
VENT VALVE CONTROL																		
W-44-AHP-PIT-506-1-1	Pressure Transmitter, MAC Discharge Pressure	0 to 100 PSIG	4-20 mA	PIC-506-1-1	PID Direct Acting	W-44-AHP-PIT-506-1-1	Local: Operator Input	Auto/Manual	N/A	Vent Valve Position, % Open	HSS-506-1-1	High Signal Select	HSS-506-1-1 Output Signal, 0 to 100%	4-20 mA	N/A			
W-44-AHP-FIT-502-1-1	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	SUIC 506-1-1	PID Reverse Acting	Distance (%) from surge	Calculated Value	N/A	PV and SP calculated based on surge curve. Include an operator adjustable distance to surge on the HMI to enable the operator to set the minimum permissible distance to surge prior to initiating an opening of the vent valve.	Valve Position, % Open								
HSS-506-1-1	High Signal Select	HSS-506-1-1 Output Signal, 0 to 100%	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FV-506A-1-1	Vent Valve	4- 20 ma	0 to 100% Open	Air to Close, Fail Open		3	
SD-500-1-1	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-1-1	Solenoid, I/A Supply to Vent Valve FV-506-1-1	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		1	
W-44-EXH-FY-506-1-1	Solenoid, Vent Valve I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-1-1	Vent Valve	4-20 ma	Open/ Closed	Air to Close, Fail Open	Open when compressor is started	1	
W-44-LOS-VE-501-1-1	MAC Stage 1 Vibration	0 - 5 mils	4-20 mA	HS-500-1-1	Bypass On/Auto	W-44-LOS-VE-501-1-1	N/A	Always Auto*	N/A	Turn HS-500 graphic "red" when bypass is on; "green" when bypass is off	SD-500-1-1	MAC No. 1-1 Shutdown	Discrete Signal	Relay Output, 120 VAC	Relay Output 0 VAC		1	
W-44-LOS-VE-502-1-1	MAC Stage 2 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-502-1-1	N/A	Always Auto*	N/A									
W-44-LOS-VE-503-1-1	MAC Stage 3 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-503-1-1	N/A	Always Auto*	N/A									
W-44-LOS-PIT-53-1-1	MAC Lube Oil Pressure	0-05 PSIG	4-20 mA	PB-50-1-1	On/Auto/Off	N/A	See Logic Description	N/A	N/A	"Red" when auxiliary oil pump is running; "Green" when off.								
Various	See Permissives, Alarms and Trips List	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A								



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-500A-1-2

LOOP NAME: Main Air Compressor 1-2 Flow

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 5 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
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3	6/8/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE							
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS							REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	Notes		
INLET GUIDE VANE CONTROL																		
W-44-O2-AIT-355-1	Analyzer, Product Oxygen Purity	0 to 100 % Oxygen	4-20 mA	W-44-O2-AIT-355-1	Proportional Output	W-44-O2-AIT-355-1	Imbedded in program: 95%	Always AUTO	N/A	% Bias to FIC-500A-1	FIC-355-1	PID Controller	See Below				1	
W-44-AHP-FIT-120-1	Flow Transmitter, Cold End Air Flow	0 to 700 KSCFH	4-20 mA, w/square root function applied	FIC-500A-1-2	PID Reverse Acting	W-44-AHP-FIT-120-1	Remote: Derived from Process Value of FIC-600-1 and AIC-355-1. See Math section.	Auto/ Manual	Derive Set Point based on PV from AIC-355-1 as follows: $SP_{FIC-500A-1} = (PV_{FIT-600-1} * RSP)/(OP_{AIC-355-1})$ where "RSP" is a factor accessible from the MAC HMI screen. The approximate value of "X" is 5.	Inlet Guide Vane Position, % Open	LSS-500A-1-2	Low Signal Select	DCS Logic Signals	DCS Logic Signal	N/A		1	
W-44-O2-FIT-600-1	Flow Transmitter, Product Oxygen Flow	0 to 150 KSCFH	PLC Logic Signal, Flow															
W-44-AHP-IT-500-1-2	Current Transmitter, MAC Motor Amps	0 to 200 A	4-20 mA													IC-500-1-2		PID Reverse Acting
LSS-500A-1-2	Low Signal Select	PLC Logic Signals, FIC-600 & IY-500-1-2	PLC Logic Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FV-500A-1-2	Inlet Guide Vanes	4-20 ma	0 to 100% Open	Closed			
SD-500-1-2	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-1-2	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		1	
W-44-IA-FY-500-1-2	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-1-2	Inlet Guide Vanes	4-20 ma	Open/ Closed	Air to Open, Fail Closed	Open when compressor is started	1	

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						REV.
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS						
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE			AUTO MANUAL SELECTS	OUTPUT	TAG NO.	DESCRIPTION	INPUT	OUTPUT	
VENT VALVE CONTROL																	
W-44-AHP-PIT-506-1-2	Pressure Transmitter, MAC Discharge Pressure	0 to 100 PSIG	4-20 mA	PIC-506-1-2	PID Direct Acting	W-44-AHP-PIT-506-1-2	Local: Operator Input	Auto/Manual	N/A	Vent Valve Position, % Open	HSS-506-1-2	High Signal Select	HSS-506-1-2 Output Signal, 0 to 100%	4-20 mA	N/A		
W-44-AHP-FIT-502-1-2	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	SUIC 506-1-2	PID Reverse Acting	Distance (%) from surge	Calculated Value	N/A	PV and SP calculated based on surge curve. Include an operator adjustable distance to surge on the HMI to enable the operator to set the minimum permissible distance to surge prior to initiating an opening of the vent valve.	Valve Position, % Open							
HSS-506-1-2	High Signal Select	HSS-506-1-2 Output Signal, 0 to 100%	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FV-506A-1-2	Vent Valve	4- 20 ma	0 to 100% Open	Air to Close, Fail Open		1
SD-500-1-2	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-1-2	Solenoid, I/A Supply to Vent Valve FV-506-1-2	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		
W-44-EXH-FY-506-1-2	Solenoid, Vent Valve I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-1-2	Vent Valve	4- 20 ma	Open/ Closed	Air to Close, Fail Open	Open when compressor is started	1
W-44-LOS-VE-501-2-1	MAC Stage 1 Vibration	0 - 5 mils	4-20 mA	HS-500-1-2	Bypass On/Auto	W-44-LOS-VE-501-2-1	N/A	Always Auto*	N/A	Turn HS-500 graphic "red" when bypass is on; "green" when bypass is off	SD-500-1-2	MAC No. 1-2 Shutdown	Discrete Signal	Relay Output, 120 VAC	Relay Output 0 VAC		1
W-44-LOS-VE-502-1-2	MAC Stage 2 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-502-1-2	N/A	Always Auto*	N/A								
W-44-LOS-VE-503-1-2	MAC Stage 3 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-503-1-2	N/A	Always Auto*	N/A								
W-44-LOS-PIT-53-1-2	MAC Lube Oil Pressure	0-05 PSIG	4-20 mA	PB-50-1-2	On/Auto/Off	N/A	See Logic Description	N/A	N/A	"Red" when auxiliary oil pump is running; "Green" when off.							
Various	See Permissives, Alarms and Trips List	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A							



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. Two MAC Control

LOOP NAME: Two Main Air Compressor Operation

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 7 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE				CONTROLLER						CONTROLLED DEVICE					REV.	
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP) LOCAL REMOTE	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	INPUT	OUTPUT		FAIL
LOGIC DESCRIPTION: When two main air compressors are in operation feeding into a single cryo plant, the air flow demand is to be evenly split between the two compressors. The flow set points for each FIC-500A are to be driven mathematically by the same formula used for single compressor operation except divided by two (2), i.e. $SP_{FIC-500A} = ((PV_{FIT-600-2} * RSP) / (OPAIC-355-2) / 2)$ where "RSP" is a common factor accessible from the MAC HMI screen. The approximate value of "X" is 5. The amp limit portion of the control output, W-44-AHP-IT-500-X-X, to the inlet guide vanes, W-44-AHP-FV-500A-X-X, will be kept separate for each main air compressor and will not affect the opposite compressor. Any trip originating from the operating cryo plant will shut down both operating main air compressors. Alarms and permissives will be separate for each main air compressor and will not affect the opposite running compressor. The vent valve control for each running compressor is to remain separate for each compressor with the exception that both PIC-506 controllers will share a common set point, i.e. any set point change made by the operator (or Assisted Start) will be made simultaneously in the opposite PIC-506 controller. Surge controls will be independent for each compressor.															3	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FCV-111A-1

LOOP NAME: Switch Valve Control

LOOP DRAWING NO.:

PLANT AREA: Cold Box

SEQUENTIAL NUMBER: 8 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECKED	APPROVED
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		
4	1/5/2024	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					Rev. No.
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
N/A	N/A	N/A	N/A	TMR-100-1	DCS Timer	Minutes Remaining in Cycle	Local: 0 to 10 minutes	See Logic Description Below	N/A	Valve Colors Change with Position Changes (red -- closed; green -- open)	W-44-IA-FY-111-1	4-way Solenoid, I/A Supply to FCV-111A-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
											W-44-IA-FY-112-1	4-way Solenoid, I/A Supply to FCV-112A-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
											W-44-IA-FY-113-1	4-way Solenoid, I/A Supply to FCV-113N-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
											W-44-IA-FY-114-1	4-way Solenoid, I/A Supply to FCV-114N-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
W-44-IA-FY-111-1	4-way Solenoid, I/A Supply to FCV-111A-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-111A-1	Air Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-IA-FY-112-1	4-way Solenoid, I/A Supply to FCV-112A-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-112A-1	Air Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-IA-FY-113-1	4-way Solenoid, I/A Supply to FCV-113N-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-113N-1	Waste Nitrogen Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-IA-FY-114-1	4-way Solenoid, I/A Supply to FCV-114N-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-114N-1	Waste Nitrogen Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-AHP-ZSH-111-1, W-44-AHP-ZSH-112-1, W-44-AHP-ZSH-113-1, W-44-AHP-ZSH-114-1	Open/Closed Position Switches for Switch Valves	Closed/ Open Valve Position	0/24 VDC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Switch valve colors are to be animated based on position feedback. If switches fail to actuate properly, colors will be green if ZS's are closed, red if ZSC's are open, gray if neither condition is satisfied.					1

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					Rev. No.	
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT		FAIL
W-44-AHP-PIT-200-1	Pressure Transmitter, "B" Pass Air to RHX	0 to100 PSIG	4-20 mA	HS-200-1	Hand Switch (on HMI)	When "On" will bypass output to SD-200-1 from PT-200-1 to enable operation during start-up/shutdown transitions.	N/A	N/A	N/A	Bypass On/Off	TMR-100-1	Switch Valve Timer	PLC Logic Signals	Digital Signals	Off	1	
				If pressure does not exceed 40 psig after 30 seconds when FCV-111A-1 is opened, initiate RHX VALS ALARM-200-1; set alarm; If pressure does not exceed 40 psig after 60 seconds when FCV-111A-1 is opened, initiate RHX VALS SD-200-1; shut down running MAC(s); If pressure is greater than 10 psig after 30 seconds when FCV-111A-1 is closed, initiate RHX VALS ALARM-200-1; set alarm; If pressure is greater than 10 psig after 60 seconds when FCV-111A-1 is closed, initiate RHX VALS SD-200-1; shut down running MAC(s)						N/A	N/A	N/A	N/A	N/A	3		



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. TIC-X600X

LOOP NAME: Individual RHX Mid Point Temperature Control

LOOP DRAWING NO.: 2

PLANT AREA: Cold Box

SEQUENTIAL NUMBER: 9 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECKED	APPROVED
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23			
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					Rev. No.	
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT		FAIL
W-44-AHP-TE-154-1	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 1	-328 to 1562 Deg. F	Microvolts	AVGMPT-1	Average Function	Average temperature of TE-154-1 + TE-155-1 over last 10 minutes	N/A	N/A	Calculate rolling average temperature of TE-154-1 + TE-155-1 over last 10 minutes	AVGMPT-1 PV	AVGMPT-1 PV	Average temperature of TE-154-1 + TE-155-1 over last 10 minutes	N/A	N/A	N/A	1	
W-44-AHP-TE-155-1	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 2	-328 to 1562 Deg. F	Microvolts														
W-44-AHP-TE-154-1	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 1	-328 to 1562 Deg. F	Microvolts	TIC-X600X-1-1	PID Direct Acting	W-44-AHP-TE-154-1: Calculate rolling average temperature over last 10 minutes	Remote: AVGMPT-1 PV	Auto/Manual	N/A	W-44-O2-FV-X600X-1-1 GOX Valve Position, % Open	W-44-O2-FV-X600X-1-1	RHX No. 1 GOX Flow Control Valve I/P	4-20 mA	3-15 psig	N/A	1	
W-44-O2-FV-X600X-1-1	RHX No. 1 GOX Flow Control Valve I/P	4-20 mA	3-15 psig	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FV-X600X-1-1	RHX No. 1 GOX Flow Control Valve	3-15 psig	0 to 100% Open	Air to Open, Fail Closed	1	
W-44-AHP-TE-155-1	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 2	-328 to 1562 Deg. F	Microvolts	TIC-X600X-1-2	PID Direct Acting	W-44-AHP-TE-155-1: Calculate rolling average temperature over last 10 minutes	Remote: AVGMPT-1 PV	Auto/Manual	N/A	W-44-O2-FV-X600X-1-2 GOX Valve Position, % Open	W-44-O2-FV-X600X-1-2	RHX No. 2 GOX Flow Control Valve I/P	4-20 mA	3-15 psig	N/A	1	
W-44-O2-FV-X600X-1-2	RHX No. 2 GOX Flow Control Valve I/P	4-20 mA	3-15 psig	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FV-X600X-1-2	RHX No. 2 GOX Flow Control Valve	3-15 psig	0 to 100% Open	Air to Open, Fail Closed	1	
RL-500	RHX No. 1 GOX Flow Control Valve I/P	On/Off	On/Off	W-44-O2-FY-600-1-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-O2-FY-600-1-1	Turns on when compressor is started	Off	Off	Off	1	
RL-500	RHX No. 2 GOX Flow Control Valve I/P	On/Off	On/Off	W-44-O2-FY-600-1-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-O2-FY-600-1-2	Turns on when compressor is started	Off	Off	Off	1	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-115-1

LOOP NAME: Unbalance Air Flow Control

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 10 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					Notes	REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE	MANUAL SELECTS			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL		
W-44-AHP-TE-186-1	RTD, Cold End Air Temperature	-180 to +400 Deg C	Variable resistance, 100± ohms	N/A	N/A		N/A	N/A	N/A	Delta T, Deg. C	W-44-CAD-TDIT-186-1	Differential Temperature Transmitter, Cold End Delta T	W-44-AHP-'TE-187-1 minus W-44-AHP-TE-186-1	4-20 mA	N/A		1
W-44-N-TE-187-1	RTD, Cold End Waste Nitrogen Temperature	-180 to +400 Deg C	Variable resistance, 100± ohms														
W-44-CAD-TDIT-186-1	Flow Transmitter, Unbalance Air Flow	0 to 200 KSCFH	4-20 mA	FIC-115-1	PID, Direct Acting	Rolling average of TDT-186-1 over 10 minutes. Sample and refresh every 10 seconds.	SET POINT (SP) is fixed at 2.5 deg. C	Auto/ Manual	N/A	FV-213A & FV-215A, Valve Positions, % Open	W-44-AHP-FV-213A-1	Turbine Bypass Valve, Reverse acting, split range.	4 to 12 mA	100 to 0% Open	Air to Open, Fail Closed		1
W-44-AHP-FIT-115-1	Flow Transmitter, Unbalance Air Flow	0 to 200 KSCFH	4-20 mA								W-44-AHP-FV-215A-1	Unbalance Air Bypass Valve, Direct acting, split range.	12 to 20 mA	0 to 100% Open	Air to Open, Fail Closed		
N/A	Plant Shutdown	PLC Logic Signal	0 VAC	W-44-AHP-FY-213-1	Solenoid	N/A	N/A	N/A	Energize when compressor starts	N/A	W-44-AHP-FV-213A-1	Turbine Bypass Valve, Reverse acting, split range.	0-120 VAC	Opened/ Closed	Air to Open, Fail Closed	Solenoid activates when compressor is started	3
				W-44-AHP-FY-215-1	Solenoid						W-44-AHP-FV-215A-1	Unbalance Air Bypass Valve, Direct acting, split range.	0-120 VAC	Opened/ Closed	Air to Open, Fail Closed	Solenoid activates when compressor is started	3



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. SIC-219-1

LOOP NAME: Turbine Speed Control

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 11 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APPROVED
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-AHP-TE-216-1	Turbine Outlet Temp	-270 to 400 Deg C	0-100 Ohms	TIC-216-1	PID Direct Acting, Turbine Outlet Temperature	TE-216-1	Fixed: -180 deg. C	Auto/Manual	N/A	W-44-ALP-FV-220A-1, % Open, Nozzle Position	LSS-214-1	Low Signal Select	PID Output Signals (0 to 100%) for TIC-216-1 & SIC-219-1	LSS-216-1 Output Signal, 0 to 100%	N/A	3
W-44-AHP-ST-219-1	Turbine Speed	0 to 60K RPM	4-20 mA	SIC-219-1	PID, Reverse Acting, Turbine Speed	ST-219-1	Local: Operator Input, limit range between 10,000 and 26,000 rpm	Auto/Manual	N/A	W-44-ALP-FV-220A-1, % Open, Nozzle Position						
LSS-214-1	Low Signal Select	LSS-214-1 Output Signal, 0 to 100%	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-ALP-FV-220A-1	Turbine Inlet Nozzle	4-20 mA	0 to 100% Open	Closed	
W-44-O2-LIT-616-1	LOX Tank No. 1-1 Level Transmitter	0-150" W.C.	4-20 mA	LIC-616-1-1	Discrete Switch	W-44-O2-LIT-616-1	Local: Supervisor Input	N/A	Discrete Output Only Active if Tank Is In Make Mode	No. 1-1 Tank Full	HSS-616-1	LOX Tank High Level Turbine Shutdown	PLC Logic Signal	Relay Output On/Off	Off	1
W-44-O2-LIT-616-2	LOX Tank No. 1-2 Level Transmitter	0-150" W.C.	4-20 mA	LIC-626-1-2	Discrete Switch	W-44-O2-LIT-616-2	Local: Supervisor Input	N/A	Discrete Output Only Active if Tank Is In Make Mode	No. 1-2 Tank Full						
HSS-616-1	LOX Tank High Level Turbine Shutdown	PLC Logic Signal	Relay Output On/Off	W-44-AHP-FY-214-1	Solenoid Valve	N/A	Opens when turbine starts	N/A	N/A	N/A	W-44-AHP-FY-214-1	Turbine Inlet Valve	20 PSIG	Opened/ Closed	ATO, Spring to Close	1
N/A	Plant Shutdown or Turbine Under/Over Speed	N/A	N/A													
W-44-AHP-ST-219-1	Turbine Speed	0-60 KRPM	On/Off	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-LOR-FY-220-1	Turbine Oil Loading Solenoid	Energize at 10 KRPM	On/Off	De-Energized	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. LIC-330-1

LOOP NAME: Lower Column Liquid Level Control

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 12 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE				
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS				
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL
W-44-O2-LIT-330-1	Level Transmitter, Lower Column (Kettle) Level	0 to 100 inches w.c.	4-20 mA	LIC-330-1	PID Direct Acting, Level Controller		Local: Operator Input (Normally 30 in. w.c., limit range between 15 in. w.c. and 40 in. w.c.)	Auto/ Manual	N/A	LV-330A-1 Valve Position, % Open	W-44-O2-LV-330A-1	Kettle Level Control Valve	4 to 20 mA	0 to 100% Open	Closed
RL-500	Compressor Running	On/Off	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-LY-330-1	Kettle Level Control Valve Solenoid	Running	Energized	Closed



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-340-1

LOOP NAME: Shelf Transfer (Reflux to upper column) Controller

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 13 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-AHP-FIT-120-1	Flow Transmitter, Cold End Air Flow	0 to 700 KSCFH	4-20 mA	FIC-340-1	PID, Reverse Acting	FIT-340-1	Remote (see Math)	Auto/Manual	Derive Set Point based on PV from FIT-120-1 as follows: $SP_{FIC-340-1} = (PV_{FIT-120-1}) * R$ where "R" is a factor accessible from the Columns HMI screen. The approximately value of R is 0.34; the permissible range of values for "R" should be set at 0.25 to 0.45.	W-44-N2-FV-340N-1 Valve Position, % Open	W-44-N2-FV-340N-1	Shelf Transfer Valve	4-20 mA	0 - 100% Open	Closed	1
W-44-N2-FIT-340-1	Flow Transmitter, Shelf Nitrogen	0 to 250 KSCFH	4-20 mA													
RL-500	Compressor Running	On/Off	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-N2-FY-340-1	Shelf Transfer Valve Solenoid	Running	Energized	Closed	0



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. LIC-352-1

LOOP NAME: Main Condenser Level Controller

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 14 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE	MANUAL SELECTS			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-O2-LIT-352-1	Level Transmitter, Main Condenser	0 to 100 inches water column	4-20 mA	LIC-352-1	Discrete Level Controller	LIT-352-1	Local: Supervisor-only input of high and low level limits	Auto/ Manual Selection of Either Make or Add Mode	Discrete Out -- W-44-O2-LV-350X-1 to open when W-44-O2-LIT-352-1 ≥ 56" and close when ≤ 50"; W-44-O2-LV-351X-1 to open when W-44-O2-LIT-352-1 ≤ 48" and close when ≥ 54"	W-44-O2-LV-351-1 and W-44-O2-LV-352-1, Valve Position, open or closed	W-44-O2-LY-350X-1	Main Condenser "MAKE" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	Energize to Open, Fail Closed	3
											W-44-O2-LY-351X-1	Main Condenser "ADD" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	Energize to Open, Fail Closed	
W-44-O2-LY-350X-1	Main Condenser "MAKE" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	N/A	N/A	N/A	N/A	N/A	Energized when compressor running	Color code position: red = closed; green = open	W-44-O2-LY-350X-1	Main Condenser "MAKE" Valve	On/Off	Open/ Close	Closed	
W-44-O2-LY-351X-1	Main Condenser "ADD" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	N/A	N/A	N/A	N/A	N/A	Energized when compressor running	Color code position: red = closed; green = open	W-44-O2-LY-351X-1	Main Condenser "ADD" Valve	On/Off	Open/ Close	Closed	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. PIC-600-1

LOOP NAME: Product Oxygen Pressure Control

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 15 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/19/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
PRESSURE (LOAD FOLLOWING) CONTROL																
W-44-O2-PIT-600-1	O2 Product Pipeline Pressure	0 to 10 psig	4-20 mA	PIC-600-1	PID, Reverse Acting	W-44-O2-PIT-600-1	Local	Auto/Manual	N/A	W-44-O2-FV-600X-1 Valve Position, % Open	W-44-O2-FV-600X-1	O2 Product Valve Positioner	4-20 mA	0 to 100% Open	Closed	3
				Selector Switch -- Pressure (load following) Control or Flow Control												
W-44-O2-FIT-600-1	O2 Product Flow Ex Cold Box	0-150 KSCFH	4-20 mA	FIC-600-1	PID, Reverse Acting	W-44-O2-FIT-600-1	Local	Auto/Manual	N/A	W-44-O2-FV-600X-1 Valve Position, % Open					0 to 100% Open	Closed
OXYGEN PRODUCT VENT VALVE CONTROL																
W-44-O2-FIT-600-1	O2 Product Flow Ex Cold Box	0-150 KSCFH	4-20 mA	FIC-601-1	PID, Reverse Acting	W-44-O2-FIT-600-1	Local	Auto/Manual	N/A	W-44-O2-FV-601X-1 Valve Position, % Open	W-44-O2-FV-601X-1	O2 Vent Valve Positioner	4-20 mA	0 to 100% Open	Closed	3
RL-500-1	Plant Shutdown	PLC Logic Signal	0 VAC	W-44-O2-FY-600X-1	Solenoid	N/A	N/A	N/A	Energized when compressor running	N/A	W-44-O2-FV-600X-1	O2 Product Valve	0-120 VAC	Opened/ Closed	Air to Open, Fail Closed	3
				W-44-O2-FY-601X-1	Solenoid						W-44-O2-FV-601X-1	O2 Vent Valve	0-120 VAC	Opened/ Closed	Air to Open, Fail Closed	3



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. PIC-615/625

LOOP NAME: DRIOX Storage Tank Pressure Control

PLANT AREA: LOX Back-up System, Tanks #1 & #2

SEQUENTIAL NUMBER: 16 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT		FAIL
TANK MODE SELECTOR SWITCH																	
HS-615-1-1	Tank No. 1 Mode Selector Switch	N/A	N/A	HS-615	HMI Switch	N/A	N/A	Manual Only	N/A	Make	N/A	Make Mode Selection	HMI Logic	Lo Remote Set Point to PIC-615-1-1	N/A	1	
										Add		Add Mode Selection	HMI Logic	Hi Remote Set Point to PIC-615-1-1	N/A	1	
HS-615-1-2	Tank No. 2 Mode Selector Switch	N/A	N/A	HS-625	HMI Switch	N/A	N/A	Manual Only	N/A	Make	N/A	Make Mode Selection	HMI Logic	Lo Remote Set Point to PIC-615-1-2	N/A	1	
										Add		Add Mode Selection	HMI Logic	Hi Remote Set Point to PIC-615-1-2	N/A	1	

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				FAIL	REV.				
TANK NO. 1 PRESSURE CONTROL																1	
W-44-O2-PIT-616-1	LOX Tank No. 1 Pressure	0 to 100 psig	4-20 mA	PIC-615-1-1	PID, Direct Acting	PIT-616-1-1	Local: Operator setpoint in psig, one SP for Make mode, one SP for Add mode		Auto/ Manual	N/A	W-44-O2-PV-615X-1-1 % Open	W-44-O2-PV-615X-1-1	Pressure Build Valve Positioner Reverse Acting, Split Range	4-12 mA	100 to 0% Open	Closed	1
											W-44-O2-PV-616X-1-1 % Open	W-44-O2-PV-616X-1-1	Economizer Valve Positioner Direct Acting, Split Range	12-20 mA	0 to 100% Open	Closed	1
PET-1	Plant Emergency Trip Switch	120 VAC	0 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FY-616-1-1	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	Energize to Open, Fail Closed	1	
W-44-O2-TSL-640	Economizer Outlet Temperature	-328 - 1498 deg. F.	0-100 Ohms	W-44-O2-TSH-640	Discrete Switch	N/A	Field Calibrated	N/A	N/A	On/Off						1	
W-44-O2-PY-616-1	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	N/A	N/A	N/A	N/A	N/A	Close if TSL-640 alarms	N/A	W-44-O2-PV-616X-1-1	Economizer Valve Positioner	0-120 VAC	0 to 100% Open	Closed	1	
TANK NO. 2 PRESSURE CONTROL																1	
W-44-O2-PIT-626-1-2	LOX Tank No. 2 Pressure	0 to 100 psig	4-20 mA	PIC-625-1-2	PID, Direct Acting	W-44-O2-PIT-626-1-2	Local: Operator setpoint in psig, one SP for Make mode, one SP for Add mode		Auto/ Manual	N/A	W-44-O2-PV-625X-1-2 % Open	W-44-O2-PV-625X-1-2	Pressure Build Valve Positioner Reverse Acting, Split Range	4-12 mA	100 to 0% Open	Closed	1
											W-44-O2-PV-626X-1-2 % Open	W-44-O2-PV-626X-1-2	Economizer Valve Positioner Direct Acting, Split Range	12-20 mA	0 to 100% Open	Closed	1
PET-1	Plant Emergency Trip Switch	120 VAC	0 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FY-616-1-2	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	Energize to Open, Fail Closed	1	
W-44-O2-TSL-640	Economizer Outlet Temperature	-328 - 1498 deg. F.	0-100 Ohms	TSH-640	Discrete Switch	N/A	Field Calibrated	N/A	N/A	On/Off						1	
W-44-O2-PY-626-1	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	N/A	N/A	N/A	N/A	N/A	Close if W-44-O2-TSL-640 alarms	N/A	W-44-O2-PV-626X-1-2	Economizer Valve Positioner	0-120 VAC	0 to 100% Open	Closed	1	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. PIC 635

LOOP NAME: DRIOX Pipeline Pressure Control

PLANT AREA: LOX Back-up System

SEQUENTIAL NUMBER: 17 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP) LOCAL REMOTE	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-O2-PIT-630	Pressure Transmitter, Vaporizer Pressure PSIG	0 to 80 PSIG	4-20 mA	PIC-630	PID, Direct Acting	W-44-O2-PIT-630	Fixed, 80 PSIG	Auto/Manual	N/A	W-44-O2-'PV-635X, % Open	HSS-635P	High Signal Select	PLC Logic Signal	PLC Logic Signal	N/A	3
W-44-O2-PIT-635	Pressure Transmitter, DRIOX Pipeline Pressure PSIG	0 to 20 PSIG	4-20 mA	PIC-635	PID, Reverse Acting	W-44-O2-PIT-635	Local: Operator Input	Auto/Manual	N/A	W-44-O2-'PV-635X, % Open						
HSS-635P	High Signal Select	PLC Logic Signal	PLC Logic Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	LSS-635	Low Signal Select	PLC Logic Signal	PLC Logic Signal	N/A	3
W-44-O2-TE-635	RTD, Oxygen Temperature from DRIOX	-328 to +900 deg. F	Variable Ohms	TIC-635	PID, Direct Acting	W-44-O2-TE-635	Fixed: -20 deg. F	Always Auto	N/A	W-44-O2-PV-635X, % Open						
LSS-635	Low Signal Select	PLC Logic Signal	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-PV-635X	DRIOX Supply Valve	4-20 mA	0 to 100% Open	Closed	3
PET-1/2	Plant Emergency Trip Switch	120 VAC	0 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FY-635	Solenoid Valve	Relay Output, 120 VAC	Open/Closed	Energize to Open, Fail Closed	3
W-44-O2-FY-635	Solenoid Valve	Relay Output, 120 VAC	Open/Closed	N/A	N/A	N/A	N/A	N/A	Close if W-44-O2-TE-635 is below -20 F	N/A	W-44-O2-'PV-635X	DRIOX Supply Valve	0-120 VAC	0 to 100% Open	Closed	1



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. TIC-550-1

LOOP NAME: Thaw Heater Control

PLANT AREA: Cold Box 1

SEQUENTIAL NUMBER: 18 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		
4	1/5/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE				
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS				
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL
HS-550-1	Thaw Heater Mode Selector Switch	N/A	N/A	HS-550-1	HMI Switch	N/A	N/A		N/A	Off	N/A	Contactors Open	480 VAC	0 VAC	Open
										Plant	N/A	30 kW Contactor Closed	480 VAC	480 VAC	Open
										Turbine	N/A	30 kW + 90 kW Contactors Closed	480 VAC	480 VAC	Open
W-44-AHP-TE-550-1	Thermocouple (Type K), Thaw Heater Element Temperature	-328 to +2282 deg. F	Variable Ohms	TIC-550-1	Discrete Heater Shutdown	W-44-AHP-TE-550-1	Fixed: 1050 deg. F	Always Auto	N/A	On (Red); Off (Green)	LSS-550-1	Low Signal Select	PLC Logic Signal	Heater On/Off Command	Off
W-44-AHP-TE-552-1	Thermocouple (Type K), Thaw Heater Element Temperature	-328 to +2282 deg. F	Variable Ohms	TIC-550-1	Discrete Heater Shutdown	W-44-AHP-TE-550-1	Fixed: 1050 deg. F	Always Auto	N/A						
W-44-AHP-TE-552-2	Thermocouple (Type T), Thaw Heater Outlet Temperature	-328 to +900 deg. F	Variable Ohms	TIC-552-1	Discrete Heater Controller	W-44-AHP-TE-552-1	Local: Operator Inputs for Plant Mode and Turbine Mode	On-Off/ Switch Between Plant and Turbine Thaw Modes	N/A						
LSS-550-1	Low Signal Select	DCS Logic	120 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	HS-THTR (R-1601)-1	Relay	120 VAC	120 VAC	Open



EBMUD Cryo Plant Control Loop Specifications
CONTROL LOOP SPECIFICATIONS
40 61 01b

LOOP NO. Overview

LOOP NAME: Summary Overview

PLANT AREA: All

SEQUENTIAL NUMBER: 1 of 18

O2 PLANT 2

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 00b

REV NO.	DATE	BY	CHECK	APP
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		
4	1/4/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER						CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT	→ OUTPUT SIGNALS				REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	MANUAL		DISPLAY	TAG NO.	DESCRIPTION	INPUT	OUTPUT	
The two cryo plants (including their respective turbines), four main air compressors, and liquid oxygen back-up system are to be operated from a common DCS network fed from remote input-output racks at each major equipment station. Provide on-screen ability for the operator to select the main air compressor(s) and cryo plant to be in operation at any point in time. Possible combinations include the operation of one or two cryo plants simultaneously with either one or two main air compressors feeding into each cryo plant. In any of the selected modes of operation, the permissives, alarms, and trips must be configured such that the origin of any fault is clearly identifiable by operating module, e.g. MAC 2-1, Cryo Plant 2, et al, as well as by initiating device tag number. This will be set up as a "first out" protocol such that the first device initiating a fault that leads to a trip of either cryo plant is identified and held on the screen until cleared by the operator. All operating modules are to be accessible from any of the HMI screens on the DCS network. Valves are to be color coded, depending on position, with red indicating closed and green indicating any position other than fully closed. Rotating equipment is to be color coded, depending on status, with red indicating stopped and green indicating running.															



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. Maintenance Mode
LOOP NAME: N/A
PLANT AREA: Cryo Plant 2
SEQUENTIAL NUMBER: 2 of 18

PROJECT NAME: EBMUD Controls Improvement Project
PROJECT NUMBER: SD-428
SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	6/9/23	DLB		
1	1/4/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
							LOCAL	MANUAL								
							REMOTE	SELECTS								
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	REV.
Solenoid triggers																
W-44-IA-FY-111-2	#1 Cryo FCV-111A Switch Valve Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-111-2	Air in Switch Valve	Open/Closed	Open/Closed		0
W-44-IA-FY-112-2	#1 Cryo FCV-112A Switch Valves Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-112-2	Air in Switch Valve	Open/Closed	Open/Closed		0
W-44-IA-FY-113-2	#1 Cryo FCV-113N Switch Valves Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-113-2	Waste out Switch valve	Open/Closed	Open/Closed		0
W-44-IA-FY-114-2	#1 Cryo FCV-114N Switch Valves Solenoid	On	Off	N/A	Hand switch	N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-IA-FY-114-2	Waste out Switch valve	Open/Closed	Open/Closed		0
W-44-AHP-FY-213-2	Turbine Bypass Valve Solenoid	On	Off	W-44-AHP-FIT-115-2	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-AHP-FV-213A-2	Turbine Bypass Valve	4-12 ma	% Open		0
W-44-AHP-FY-214-2	Turbine Inlet Valve Solenoid	On	Off	N/A		N/A	N/A	Auto Open Closed	N/A	Open/Closed	W-44-AHP-FY-214-2	Turbine Slam Valve	Open/Closed	Open/Closed		0
W-44-AHP-FY-215-2	Unbalanced Air Valve Solenoid	On	Off	W-44-AHP-FIT-115-2	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-AHP-FV-215A-2	Unblanced Air flow control valve	12-20 ma	% Open		0
W-44-N2-FY-340-2	Shelf Flow Valve Solenoid	On	Off		Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-N2-FV-340N-2	Shelf Nitrogen Flow Valve	4-20 ma	% Open		0
W-44-N2-FY-349-2	MAC 2-1 Inlet Valve Solenoid	On	Off	FIC-500	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-IA-FV-500A-2-1	MAC Inlet Guide Vanes	4-20 ma	% Open		0
W-44-IA-FY-500-2-1	MAC 2-2 Inlet Valve Solenoid	On	Off	FIC-500	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-IA-FV-500A-2-2	MAC Inlet Guide Vanes	4-20 ma	% Open		0
W-44-IA-FY-500-2-2	MAC 2-1 Vent Valve Solenoid	On	Off	PIC-506	Pressure control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-EXH-FV-506A-2-1	MAC Vent Valve	4-20 ma	% Open		0
W-44-EXH-FY-506-2-1	MAC 2-2 Vent Valve Solenoid	On	Off	PIC-506	Pressure control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-EXH-FV-506A-2-2	MAC Vent Valve	4-20 ma	% Open		0
W-44-EXH-FY-506-2-2	Oxygen Vent Valve Solenoid	On	Off	FIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	PV-600X-2	Product oxygen Vent Valve	4-20 ma	% Open		0
W-44-O2-LY-350X-2	Liquid Make Valve LV-350X Solenoid	On	Off	LIC-350	Level Control	N/A	N/A	Auto/Manual	N/A	Open/Closed	W-44-O2-LY-350X-2	Liquid oxygen make valve	Open/Closed	Open/Closed		0
W-44-O2-LY-351X-2	Liquid Add Valve LV-351X Solenoid	On	Off	LIC-350	Level Control	N/A	N/A	Auto/Manual	N/A	Open/Closed	W-44-O2-LY-351X-2	Liquid oxygen add valve	Open/Closed	Open/Closed		0
W-44-N2-FY-349-2	Upper Column Vent Valve Solenoid	On	Off	PIC-349	Pressure control	N/A	N/A	Auto/Manual	N/A	Open/Closed	W-44-N2-FY-349-2	Upper column vent valve	Open/Closed	Open/Closed		0
W-44-O2-FY-600-2	Oxygen Product Valve Solenoid	On	Off	FIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-600X-2	Product oxygen flow control valve	4-20 ma	% Open		0
W-44-O2-FY-601-2	Oxygen Product Vent Valve Solenoid	On	Off	FIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-601X-2	Product oxygen Vent control valve	4-20 ma	% Open		0
W-44-O2-LY-330-2	Kettle Transfer Solenoid	On	Off	LIC-330	Level Control	N/A	N/A	Auto/Manual	N/A	% Open	LV-330X-2	Kettle transfer vavle	4-20 ma	% Open		0
W-44-O2-FY-600-2-1	Oxygen Product Mid-point Temperature Control Valve #1 Solenoid	On	Off	TIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-X600X-2-1	Oxygen Product Mid point Temperature Control Valve #1	4-20 ma	% Open		
W-44-O2-FY-600-2-2	Oxygen Product Mid-point Temperature Control Valve #2 Solenoid	On	Off	TIC-600	Flow Control	N/A	N/A	Auto/Manual	N/A	% Open	W-44-O2-FV-X600X-2-2	Oxygen Product Mid point Temperature Control Valve #2	4-20 ma	% Open		
Safety Items																
All MAC start permissives must still be met while in maintenance mode in order to start the main air compressor. Mechanical shutdowns should still function. Can still run in auto.																0
Thaw Heater controls should still be active to turn on and off the heater based on temperature. Switch valve should still be able run in auto																0
Bypasses																
W-44-O2-AIT-355-2	High hydrocarbon shutdown switch	High Level	Shutdown alarm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
W-44-O2-LIT-352-2	Low or high main condenser level shutdown	High/Low Level	Shutdown alarm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
W-44-AHP-PIT-200-2	RHX switch valve cycle failure	Failure shutdown	Shutdown alarm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. N/A

LOOP NAME: Main Air Compressor Start 2-1

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 3 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
											TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
TAG NO.		DESCRIPTION	INPUT	OUTPUT												
Start Permissives																
W-44-IA-FV-500A-2-1	MAC 2-1 Inlet Valve	0-100%	4-20ma	FSC-500A-2-1	Software Monitor of position	0-100%	0% Open	Auto	No	Closed	W-44-IA-FV-500A-2-1	MAC No. 2-1 Inlet Guide vane Closed	4 ma	0% Open	0% Open	3
W-44-EXH-FV-506A-2-1	MAC 2-1 F.O. (Anti-Surge) Vent Valve	100%-0	4-20ma	FSO-506A-2-1	Software Monitor of position	0-100%	100% Open	Auto	No	Open	W-44-EXH-FV-506A-2-1	MAC No. 2-1 Vent Valve Open	20 ma	100% Open	100% Open	3
RL-505-2-1-1	MAC 2-1 Auxiliary Oil Pump Run Status	On/Off	On/Off	RL-505-2-1-1	Status	Aux pump run	Remote	N/A	No	On	RL-505-2-1-1	MAC 2-1 Auxiliary Oil Pump Run Status	On	On	On	3
PB-500-2-2-1	MAC #2-1 (DCS); Vibration Bypass	Normal/Bypass	Normal/Bypass		Software Switch											
				PB-500-2-2-1		Bypass/Normal	N/A	N/A	Yes	Bypass/Normal	N/A	Vibration bypass	Bypass	Bypass	Normal	3
W-44-LOS-LSL-50-2-1	Mac #2-1 Lube Oil Level	Normal/Alarm	Normal/Alarm	W-44-LOS-LSL-50-2-1	Level Switch	Normal/Alarm	N/A	N/A	No	Level Okay	W-44-LOS-LSL-50-2-1	Mac #2-1 Lube Oil Level	Normal	Normal	Alarm	3
W-44-AHP-LSH-502-1	Pit. #2 Surge Tank High Water Level Permissive	Normal/Alarm	Normal/Alarm	LSH-502-1-1	Level Switch	N/A	N/A	N/A	No	Level Okay	W-44-AHP-LSH-502-2	Pit. #1 Surge Tank High Water Level Permissive	Normal	Normal	Alarm	3
M-2-1	MAC #2-1 Space Heater	Status	Status	M-2-1	Status signal	N/A	N/A	N/A	No	Good Status	M-2-1	MAC #2-1 Space Heater	Good Status	Good Status	Bad Status	3
M-2-1	MAC #2-1 Switchgear Trip	Status	Status	M-2-1	Status Signal	N/A	N/A	N/A	No	Good Status	M-2-1	MAC #2-1 Space Heater	Good Status	Good Status	Bad Status	3
M-2-1	MAC #2-1 Auxiliary Oil Pump Trip	Status	Status	M-2-1	Status Signal	N/A	N/A	N/A	No	Good Status	M-2-1	MAC #2-1 Space Heater	Good Status	Good Status	Bad Status	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
MU/WTR-2-1	MAC #2-1 Motor Winding Temperature High Alarm	Normal/Alarm	Normal/Alarm	MU/WTR-2-1	Status Signal	N/A	N/A	N/A	No	Good Status	MU/WTR-2-1	MAC #2-1 Motor Winding Temperature High Alarm	Normal	Normal/Alarm	Alarm	3
W-44-AHP-PB-502-2-1	MAC #2-1 E Stop (Local Panel)	On/Off	On/Off	PB-502-1-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	W-44-AHP-PB-502-2-1	MAC #2-1 E Stop (Local Panel)	Good Status	On/Off	Depressed	3
PB-502-2-1	MAC #2-1 E Stop (Main Panel)	On/Off	On/Off	PB-502-2-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	PB-502-2-1	MAC #2-1 E Stop (Main Panel)	Good Status	On/Off	Depressed	3
PET-2-1	Plt. #1 Plant Emergency Trip	On/Off	On/Off	PET-2-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	PET-2-1	Plt. #1 Plant Emergency Trip	Good Status	On/Off	Depressed	3
W-44-AHP-PSH-503-2-1	MAC #2-1 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-PSH-503-2-1	Pressure switch	N/A	N/A	N/A	No	Pressure High	W-44-AHP-PSH-503-2-1	MAC #2-1 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
N/A	MAC #2-1 Vibration Bypass	Normal/Bypass	Normal/Bypass	N/A	Software switch	N/A	N/A	N/A	Yes	Bypassed	N/A	MAC #2-1 Vibration Bypass	Bypass for start	Bypass for start	Normal	3
W-44-LOS-TIT-53-2-1	MAC #2-1 Start Circuit; High Oil Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-TIT-53-2-1	Temperature Switch	0-200 F	Less than 150 F	N/A	No	Temp Okay	W-44-LOS-TIT-53-2-1	MAC #2-1 Start Circuit; High Oil Temperature Permissive	Below 140 F Above 90 F	Normal/Alarm	90F > TIT-53 >140 F	3
W-44-AHP-TE-510-2-1A	MAC #2-1 Motor Outboard Bearing High Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-510-2-1A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-510-2-1A	MAC #2-1 Motor Outboard Bearing High Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TE-512-1-1A	MAC #2-1 Motor Drive Bearing Hi Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-512-1-1A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-512-1-1A	MAC #2-1 Motor Drive Bearing Hi Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TSHH-506-2-1	MAC #2-1 Start Circuit; High Discharge Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TSHH-506-2-1	Temperature Switch	0-300 F	Less than 150 F	N/A	No	N/A	W-44-AHP-TSHH-506-2-1	MAC #2-1 Start Circuit; High Discharge Temperature Permissive	Normal	Normal/Alarm	Alarm	3
W-44-LOS-VE-502-1-1	MAC #2-1 Stage #1 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-502-1-1	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-502-1-1	MAC #2-1 Stage #1 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-VE-502-2-1	MAC #2-1 Stage #2 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-502-2-1	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-502-2-1	MAC #2-1 Stage #2 Vibration Proximitior	0 mils	0 mils	1.5 mils	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
W-44-LOS-VE-503-2-1	MAC #2-1 Stage #3 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-503-2-1	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-503-2-1	MAC #2-1 Stage #3 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-PSL-54-2-1	MAC #2-1 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-PSL-54-2-1	Pressure switch	0-50 PSIG	Greater than 12	N/A	No	N/A	W-44-LOS-PSL-54-2-1	MAC #2-1 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-IA-PIT-590-2	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	PSL-590-1	Pressure switch	0-100 PSIG	Greater than 60	N/A	No	N/A	W-44-IA-PIT-590-2	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-AHP-FIT-502-2-1	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	FIT-502-2-1	Transmitter	0-100" H2O	less than 250 SCFM	N/A	No	0	W-44-AHP-FIT-502-2-1	Flow Transmitter, MAC Interstage	0	0	>10 SCFM	3
W-44-IA-FY-500-2-1	Inlet Guide Vane Solenoid	On/Off	On/Off	FY-500-2-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-IA-FY-500-2-1	Turns on when compressor is started	Off	Off	Off	1
W-44-EXH-FY-506-2-1	Compressor Vent Valve solenoid	On/Off	On/Off	FY-500-2-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-EXH-FY-506-2-1	Turns on when compressor is started	Off	Off	Off	1



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. N/A

LOOP NAME: Main Air Compressor Start 2-2

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 3 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
											TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
TAG NO.		DESCRIPTION	INPUT	OUTPUT												
Start Permissives																
W-44-1A-FV-500A-2-2	MAC 2-2 Inlet Valve	0-100%	4-20ma	FSC-500A-2-2	Software Monitor of position	0-100%	0% Open	Auto	No	Closed	W-44-1A-FV-500A-2-2	MAC No. 2-2 Inlet Guide vane Closed	4 ma	0% Open	0% Open	3
W-44-EXH-FV-506A-2-2	MAC 2-2 F.O. (Anti-Surge) Vent Valve	100%-0	4-20ma	FSO-506A-2-2	Software Monitor of position	0-100%	100% Open	Auto	No	Open	W-44-EXH-FV-506A-2-2	MAC No. 2-2 Vent Valve Open	20 ma	100% Open	100% Open	3
RL-505-1-2-2	MAC 2-2 Auxiliary Oil Pump Run Status	On/Off	On/Off	RL-505-1-2-2	Status	Aux pump run	Remote	N/A	No	On	RL-505-1-2-2	MAC 2-2 Auxiliary Oil Pump Run Status	On	On	On	3
PB-500-2-2-2	MAC #2-2 (DCS); Vibration Bypass	Normal/Bypass	Normal/Bypass		Software Switch											
				PB-500-2-2-2		Bypass/Normal	N/A	N/A	Yes	Bypass/Normal	N/A	Vibration bypass	Bypass	Bypass	Normal	3
W-44-LOS-LSL-50-2-2	Mac #2-2 Lube Oil Level	Normal/Alarm	Normal/Alarm	W-44-LOS-LSL-50-2-2	Level Switch	Normal/Alarm	N/A	N/A	No	Level Okay	W-44-LOS-LSL-50-2-2	Mac #2-2 Lube Oil Level	Normal	Normal	Alarm	3
W-44-AHP-LSH-501-2	Pit. #2 Surge Tank High Water Level Permissive	Normal/Alarm	Normal/Alarm	LSH-501-1-1	Level Switch	N/A	N/A	N/A	No	Level Okay	W-44-AHP-LSH-501-2	Pit. #2 Surge Tank High Water Level Permissive	Normal	Normal	Alarm	3
M-2-2	MAC #2-2 Space Heater	Status	Status	M-2-2	Status signal	N/A	N/A	N/A	No	Good Status	M-2-2	MAC #2-2 Space Heater	Good Status	Good Status	Bad Status	3
M-2-2	MAC #2-2 Switchgear Trip	Status	Status	M-2-2	Status Signal	N/A	N/A	N/A	No	Good Status	M-2-2	MAC #2-2 Space Heater	Good Status	Good Status	Bad Status	3
M-2-2	MAC #2-2 Auxiliary Oil Pump Trip	Status	Status	M-2-2	Status Signal	N/A	N/A	N/A	No	Good Status	M-2-2	MAC #2-2 Space Heater	Good Status	Good Status	Bad Status	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
MU/WTR-2-2	MAC #2-2 Motor Winding Temperature High Alarm	Normal/Alarm	Normal/Alarm	MU/WTR-2-2	Status Signal	N/A	N/A	N/A	No	Good Status	MU/WTR-2-2	MAC #2-2 Motor Winding Temperature High Alarm	Normal	Normal/Alarm	Alarm	3
W-44-AHP-PB-502-2-2	MAC #2-2 E Stop (Local Panel)	On/Off	On/Off	PB-502-2-1	Emergency Trip	N/A	N/A	N/A	No	Not Active	W-44-AHP-PB-502-2-2	MAC #2-2 E Stop (Local Panel)	Good Status	On/Off	Depressed	3
PB-502-2-2	MAC #2-2 E Stop (Main Panel)	On/Off	On/Off	PB-502-2-2	Emergency Trip	N/A	N/A	N/A	No	Not Active	PB-502-2-2	MAC #2-2 E Stop (Main Panel)	Good Status	On/Off	Depressed	3
PET-2-2	Plt. #1 Plant Emergency Trip	On/Off	On/Off	PET-2-2	Emergency Trip	N/A	N/A	N/A	No	Not Active	PET-2-2	Plt. #1 Plant Emergency Trip	Good Status	On/Off	Depressed	3
W-44-AHP-PSH-503-2-2	MAC #2-2 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-PSH-503-2-2	Pressure switch	N/A	N/A	N/A	No	Pressure High	W-44-AHP-PSH-503-2-2	MAC #2-2 Start Circuit; High Discharge Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
N/A	MAC #2-2 Vibration Bypass	Normal/Bypass	Normal/Bypass	N/A	Software switch	N/A	N/A	N/A	Yes	Bypassed	N/A	MAC #2-2 Vibration Bypass	Bypass for start	Bypass for start	Normal	3
W-44-LOS-TIT-53-2-2	MAC #2-2 Start Circuit; High Oil Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-TIT-53-2-2	Temperature Switch	0-200 F	Less than 150 F	N/A	No	Temp Okay	W-44-LOS-TIT-53-2-2	MAC #2-2 Start Circuit; High Oil Temperature Permissive	Below 140 F Above 90 F	Normal/Alarm	90F > TIT-53 >140 F	3
W-44-AHP-TE-510-2-2A	MAC #2-2 Motor Outboard Bearing High Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-510-2-2A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-510-2-2A	MAC #2-2 Motor Outboard Bearing High Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TE-512-2-2A	MAC #2-2 Motor Drive Bearing Hi Temp Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TE-512-2-1A	Temperature Switch	0-300 F	Less than 200 F	N/A	No	N/A	W-44-AHP-TE-512-2-2A	MAC #2-2 Motor Drive Bearing Hi Temp Permissive	Normal	Normal/Alarm	Alarm	3
W-44-AHP-TSHH-506-2-2	MAC #2-2 Start Circuit; High Discharge Temperature Permissive	Normal/Alarm	Normal/Alarm	W-44-AHP-TSHH-506-2-2	Temperature Switch	0-300 F	Less than 150 F	N/A	No	N/A	W-44-AHP-TSHH-506-2-2	MAC #2-2 Start Circuit; High Discharge Temperature Permissive	Normal	Normal/Alarm	Alarm	3
W-44-LOS-VE-501-2-2	MAC #2-2 Stage #1 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-501-2-2	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-501-2-2	MAC #2-2 Stage #1 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-VE-502-2-2	MAC #2-2 Stage #2 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-502-2-2	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-502-2-2	MAC #2-2 Stage #2 Vibration Proximitior	0 mils	0 mils	1.5 mils	3

PROCESS VARIABLE MEASUREMENT DEVICE				Permissive related to Measurement device							Expected values					
INPUT SIGNALS from Hardware and Software →				TAG NO.	TYPE	Range	Start-up Value	Auto/Manual	Bypass on startup	HMI Display	→ HMI Settings					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	Expected	HMI Display	FAIL	Rev
W-44-LOS-VE-503-2-2	MAC #2-2 Stage #3 Vibration Proximitior	4-20 ma	0-2 mils	W-44-LOS-VE-503-2-2	Vibration Switch	0-5 mils	0 Mils	N/A	Yes	Mils	W-44-LOS-VE-503-2-2	MAC #2-2 Stage #3 Vibration Proximitior	0 mils	0 mils	1.5 mils	3
W-44-LOS-PSL-54-2-2	MAC #2-2 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	W-44-LOS-PSL-54-2-2	Pressure switch	0-50 PSIG	Greater than 12	N/A	No	N/A	W-44-LOS-PSL-54-2-2	MAC #2-2 Low Oil Pressure Permissive	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-IA-PIT-590-2	Plant #1 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	PSL-590-1	Pressure switch	0-100 PSIG	Greater than 60	N/A	No	N/A	W-44-IA-PIT-590-2	Plant #2 Instrument Gas Low Pressure Alarm	Normal/Alarm	Normal/Alarm	Alarm	3
W-44-AHP-FIT-502-2-2	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	FIT-502-2-2	Transmitter	0-100" H2O	less than 250 SCFM	N/A	No	0	W-44-AHP-FIT-502-2-2	Flow Transmitter, MAC Interstage	0	0	>10 SCFM	3
W-44-IA-FY-500-2-2	Inlet Guide Vane Solenoid	On/Off	On/Off	FY-500-2-2	Solenoid	On/Off	Off	N/A	No	Off	W-44-IA-FY-500-2-2	Turns on when compressor is started	Off	Off	Off	1
W-44-EXH-FY-506-2-2	Compressor Vent Valve solenoid	On/Off	On/Off	FY-500-2-2	Solenoid	On/Off	Off	N/A	No	Off	W-44-EXH-FY-506-2-2	Turns on when compressor is started	Off	Off	Off	1



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-500A-2-1

LOOP NAME: Main Air Compressor 2-1 Flow

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 5 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		
4	1/4/24	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE								
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS							REV.	
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE			AUTO MANUAL SELECTS	TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	Notes		
INLET GUIDE VANE CONTROL																			
W-44-O2-AIT-355-2	Analyzer, Product Oxygen Purity	0 to 100 % Oxygen	4-20 mA	W-44-O2-AIT-355-2	Proportional Output	W-44-O2-AIT-355-2	Imbedded in program: 95%	Always AUTO	N/A	% Bias to FIC-500A-2	FIC-355-2	PID Controller	See Below				1		
W-44-AHP-FIT-120-2	Flow Transmitter, Cold End Air Flow	0 to 700 KSCFH	4-20 mA, w/square root function applied	FIC-500A-2-2	PID Reverse Acting	W-44-AHP-FIT-120-2	Remote: Derived from Process Value of FIC-600-2 and AIC-355-2. See Math section.	Auto/ Manual	Derive Set Point based on PV from AIC-355-2 as follows: $SP_{FIC-500A-2} = (PV_{FIT-600-2} * RSP)/(OP_{AIC-355-2})$ where "RSP" is a factor accessible from the MAC HMI screen. The approximate value of "X" is 5.	Inlet Guide Vane Position, % Open	LSS-500A-2-1			DCS Logic Signals	DCS Logic Signal	N/A		1	
W-44-O2-FIT-600-2	Flow Transmitter, Product Oxygen Flow	0 to 150 KSCFH	PLC Logic Signal, Flow																
W-44-AHP-IT-500-2-1	Current Transmitter, MAC Motor Amps	0 to 200 A	4-20 mA																IC-500-2-1
LSS-500A-2-1	Low Signal Select	PLC Logic Signals, FIC-600 & IY-500-2-1	PLC Logic Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FV-500A-2-1	Inlet Guide Vanes	4- 20 ma	0 to 100% Open	Closed				
SD-500-2-1	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-2-1	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		1		
W-44-IA-FY-500-2-1	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-2-1	Inlet Guide Vanes	4-20 ma	Open/ Closed	Air to Open, Fail Closed	Open when compressor is started	1		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE							REV.
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS							
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				OUTPUT SIGNALS	TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	Notes	
VENT VALVE CONTROL																		
W-44-AHP-PIT-506-2-1	Pressure Transmitter, MAC Discharge Pressure	0 to 100 PSIG	4-20 mA	PIC-506-2-1	PID Direct Acting	W-44-AHP-PIT-506-2-1	Local: Operator Input	Auto/Manual	N/A	Vent Valve Position, % Open	HSS-506-2-1	High Signal Select	HSS-506-2-1 Output Signal, 0 to 100%	4-20 mA	N/A		3	
W-44-AHP-FIT-502-2-1	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	SUIC 506-2-1	PID Reverse Acting	Distance (%) from surge	Calculated Value	N/A	PV and SP calculated based on surge curve. Include an operator adjustable distance to surge on the HMI to enable the operator to set the minimum permissible distance to surge prior to initiating an opening of the vent valve.	Valve Position, % Open								
HSS-506-2-1	High Signal Select	HSS-506-2-1 Output Signal, 0 to 100%	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FV-506A-2-1	Vent Valve	4- 20 ma	0 to 100% Open	Air to Close, Fail Open		1	
SD-500-2-1	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-2-1	Solenoid, I/A Supply to Vent Valve FV-506-2-1	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed			
W-44-EXH-FY-506-2-1	Solenoid, Vent Valve I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-2-1	Vent Valve	4-20 ma	Open/ Closed	Air to Close, Fail Open	Open when compressor is started	1	
W-44-LOS-VE-502-2-1	MAC Stage 1 Vibration	0 - 5 mils	4-20 mA	HS-500-2-1	Bypass On/Auto	W-44-LOS-VE-502-1-1	N/A	Always Auto*	N/A	Turn HS-500 graphic "red" when bypass is on; "green" when bypass is off	SD-500-2-1	MAC No. 2-1 Shutdown	Discrete Signal	Relay Output, 120 VAC	Relay Output 0 VAC		1	
W-44-LOS-VE-502-2-1	MAC Stage 2 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-502-2-1	N/A	Always Auto*	N/A									
W-44-LOS-VE-503-2-1	MAC Stage 3 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-503-2-1	N/A	Always Auto*	N/A									
W-44-LOS-PIT-53-2-1	MAC Lube Oil Pressure	0-05 PSIG	4-20 mA	PB-50-2-1	On/Auto/Off	N/A	See Logic Description	N/A	N/A	"Red" when auxiliary oil pump is running; "Green" when off.								
Various	See Permissives, Alarms and Trips List	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A								



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-500A-2-2

LOOP NAME: Main Air Compressor 2-2 Flow

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 5 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE							
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS							REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	Notes		
INLET GUIDE VANE CONTROL																		
W-44-O2-AIT-355-2	Analyzer, Product Oxygen Purity	0 to 100 % Oxygen	4-20 mA	W-44-O2-AIT-355-2	Proportional Output	W-44-O2-AIT-355-2	Imbedded in program: 95%	Always AUTO	N/A	% Bias to FIC-500A-2	FIC-355-2	PID Controller	See Below				1	
W-44-AHP-FIT-120-2	Flow Transmitter, Cold End Air Flow	0 to 700 KSCFH	4-20 mA, w/square root function applied	FIC-500A-2-2	PID Reverse Acting	W-44-AHP-FIT-120-2	Remote: Derived from Process Value of FIC-600-1 and AIC-355-1. See Math section.	Auto/ Manual	Derive Set Point based on PV from AIC-355-2 as follows: $SP_{FIC-500A-2} = (PV_{FIT-600-2} * RSP)/(OP_{AIC-355-2})$ where "RSP" is a factor accessible from the MAC HMI screen. The approximate value of "X" is 5.	Inlet Guide Vane Position, % Open	LSS-500A-2-2	Low Signal Select	DCS Logic Signals	DCS Logic Signal	N/A		1	
W-44-O2-FIT-600-2	Flow Transmitter, Product Oxygen Flow	0 to 150 KSCFH	PLC Logic Signal, Flow															
W-44-AHP-IT-500-2-2	Current Transmitter, MAC Motor Amps	0 to 200 A	4-20 mA													IC-500-2-2		PID Reverse Acting
LSS-500A-2-2	Low Signal Select	PLC Logic Signals, FIC-600 & IY-500-2-2	PLC Logic Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FV-500A-2-2	Inlet Guide Vanes	4-20 ma	0 to 100% Open	Closed			
SD-500-2-2	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-2-2	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		1	
W-44-IA-FY-500-2-2	Solenoid, Inlet Guide Vanes I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-IA-FY-500-2-2	Inlet Guide Vanes	4-20 ma	Open/ Closed	Air to Open, Fail Closed	Open when compressor is started	1	

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						REV.
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS						
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE			AUTO MANUAL SELECTS	TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
VENT VALVE CONTROL																	
W-44-AHP-PIT-506-2-2	Pressure Transmitter, MAC Discharge Pressure	0 to 100 PSIG	4-20 mA	PIC-506-2-2	PID Direct Acting	W-44-AHP-PIT-506-2-2	Local: Operator Input	Auto/Manual	N/A	Vent Valve Position, % Open	HSS-506-2-2	High Signal Select	HSS-506-2-2 Output Signal, 0 to 100%	4-20 mA	N/A		3
W-44-AHP-FIT-502-2-2	Flow Transmitter, MAC Interstage	0 to100 inches wc	4-20 mA	SUIC 506-2-2	PID Reverse Acting	Distance (%) from surge	Calculated Value	N/A	PV and SP calculated based on surge curve. Include an operator adjustable distance to surge on the HMI to enable the operator to set the minimum permissible distance to surge prior to initiating an opening of the vent valve.	Valve Position, % Open							
HSS-506-2-2	High Signal Select	HSS-506-2-2 Output Signal, 0 to 100%	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FV-506A-2-2	Vent Valve	4- 20 ma	0 to 100% Open	Air to Close, Fail Open		1
SD-500-2-2	MAC Shutdown Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-2-2	Solenoid, I/A Supply to Vent Valve FV-506-2-2	Relay Output 120 VAC	Closed/ Open	ETO, Fail Closed		
W-44-EXH-FY-506-2-2	Solenoid, Vent Valve I/A Supply	Relay Output 120 VAC	Closed/ Open	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-EXH-FY-506-2-2	Vent Valve	4- 20 ma	Open/ Closed	Air to Close, Fail Open	Open when compressor is started	1
W-44-LOS-VE-502-2-1	MAC Stage 1 Vibration	0 - 5 mils	4-20 mA	HS-500-2-2	Bypass On/Auto	W-44-LOS-VE-502-2-1	N/A	Always Auto*	N/A	Turn HS-500 graphic "red" when bypass is on; "green" when bypass is off	SD-500-2-2	MAC No. 2-2 Shutdown	Discrete Signal	Relay Output, 120 VAC	Relay Output 0 VAC		1
W-44-LOS-VE-502-2-2	MAC Stage 2 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-502-2-2	N/A	Always Auto*	N/A								
W-44-LOS-VE-503-2-2	MAC Stage 3 Vibration	0 - 5 mils	4-20 mA			W-44-LOS-VE-503-2-2	N/A	Always Auto*	N/A								
W-44-LOS-PIT-53-2-2	MAC Lube Oil Pressure	0-05 PSIG	4-20 mA	PB-50-2-2	On/Auto/Off	N/A	See Logic Description	N/A	N/A	"Red" when auxiliary oil pump is running; "Green" when off.							
Various	See Permissives, Alarms and Trips List	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A							



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. Two MAC Control

LOOP NAME: Two Main Air Compressor Operation

PLANT AREA: Main Air Compressor Room

SEQUENTIAL NUMBER: 7 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		

PROCESS VARIABLE				CONTROLLER					CONTROLLED DEVICE					REV.		
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP) LOCAL REMOTE	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT								TAG NO.	DESCRIPTION	INPUT		OUTPUT	FAIL
LOGIC DESCRIPTION:																
When two main air compressors are in operation feeding into a single cryo plant, the air flow demand is to be evenly split between the two compressors. The flow set points for each FIC-500A are to be driven mathematically by the same formula used for single compressor operation except divided by two (2), i.e. $SP_{FIC-500A} = ((PV_{FIT-600-2} * RSP) / (OPAIC-355-2) / 2)$ where "RSP" is a common factor accessible from the MAC HMI screen. The approximate value of "X" is 5. The amp limit portion of the control output, W-44-AHP-IT-500-X-X, to the inlet guide vanes, W-44-AHP-FV-500A-X-X, will be kept separate for each main air compressor and will not affect the opposite compressor.																
Any trip originating from the operating cryo plant will shut down both operating main air compressors. Alarms and permissives will be separate for each main air compressor and will not affect the opposite running compressor.																
The vent valve control for each running compressor is to remain separate for each compressor with the exception that both PIC-506 controllers will share a common set point, i.e. any set point change made by the operator (or Assisted Start) will be made simultaneously in the opposite PIC-506 controller. Surge controls will be independent for each compressor.																

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EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FCV-111A-1

LOOP NAME: Switch Valve Control

LOOP DRAWING NO.:

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 8 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECKED	APPROVED
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		
4	1/4/2024	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					Rev. No.
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
N/A	N/A	N/A	N/A	TMR-100-1	DCS Timer	Minutes Remaining in Cycle	Local: 0 to 10 minutes	See Logic Description Below	N/A	Valve Colors Change with Position Changes (red -- closed; green -- open)	W-44-IA-FY-111-2	4-way Solenoid, I/A Supply to FCV-111A-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
											W-44-IA-FY-112-2	4-way Solenoid, I/A Supply to FCV-112A-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
											W-44-IA-FY-113-2	4-way Solenoid, I/A Supply to FCV-113N-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
											W-44-IA-FY-114-2	4-way Solenoid, I/A Supply to FCV-114N-1	Relay Output 120 VAC	Energize to Open	*See Logic Description	1
W-44-IA-FY-111-2	4-way Solenoid, I/A Supply to FCV-111A-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-111A-2	Air Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-IA-FY-112-2	4-way Solenoid, I/A Supply to FCV-112A-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-112A-2	Air Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-IA-FY-113-2	4-way Solenoid, I/A Supply to FCV-113N-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-113N-2	Waste Nitrogen Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-IA-FY-114-2	4-way Solenoid, I/A Supply to FCV-114N-1	Relay Output 120 VAC	De-energ. A Open Energ. B Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	FCV-114N-2	Waste Nitrogen Switch Valve	Supply Inst. Air (50 PSIG) A/B	A Open B Closed	*See Logic Description	1
W-44-AHP-ZSH-111-2, W-44-AHP-ZSH-112-2, W-44-AHP-ZSH-113-2, W-44-AHP-ZSH-114-2	Open/Closed Position Switches for Switch Valves	Closed/ Open Valve Position	0/24 VDC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Switch valve colors are to be animated based on position feedback. If switches fail to actuate properly, colors will be green if ZS's are closed, red if ZSC's are open, gray if neither condition is satisfied.					1

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					Rev. No.
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE	MANUAL SELECTS			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-AHP-PIT-200-2	Pressure Transmitter, "B" Pass Air to RHX	0 to100 PSIG	4-20 mA	HS-200-1	Hand Switch (on HMI)	When "On" will bypass output to SD-200-2 from PT-200-2 to enable operation during start-up/shutdown transitions.	N/A	N/A	N/A	Bypass On/Off	TMR-100-2	Switch Valve Timer	PLC Logic Signals	Digital Signals	Off	1
				If pressure does not exceed 40 psig after 30 seconds when FCV-111A-2 is opened, initiate RHX VALS ALARM-200-2; set alarm; If pressure does not exceed 40 psig after 60 seconds when FCV-111A-2 is opened, initiate RHX VALS SD-200-2; shut down running MAC(s); If pressure is greater than 10 psig after 30 seconds when FCV-111A-2 is closed, initiate RHX VALS ALARM-200-2; set alarm; If pressure is greater than 10 psig after 60 seconds when FCV-111A-2 is closed, initiate RHX VALS SD-200-2; shut down running MAC(s)						N/A	N/A	N/A	N/A	N/A	3	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. TIC-X600X

LOOP NAME: Individual RHX Mid Point Temperature Control

LOOP DRAWING NO.: 2

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 9 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECKED	APPROVED
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23			

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					Rev. No.	
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT		FAIL
W-44-AHP-TE-154-2	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 1	-328 to 1562 Deg. F	Microvolts	AVGMPT-2	Average Function	Average temperature of TE-154-2 + TE-155-2 over last 10 minutes	N/A	N/A	Calculate rolling average temperature of TE-154-2 + TE-155-2 over last 10 minutes	AVGMPT-2 PV	AVGMPT-2 PV	Average temperature of TE-154-2 + TE-155-2 over last 10 minutes	N/A	N/A	N/A	1	
W-44-AHP-TE-155-2	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 2	-328 to 1562 Deg. F	Microvolts														
W-44-AHP-TE-154-2	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 1	-328 to 1562 Deg. F	Microvolts	TIC-X600X-2-1	PID Direct Acting	W-44-AHP-TE-154-2: Calculate rolling average temperature over last 10 minutes	Remote: AVGMPT-2 PV	Auto/Manual	N/A	W-44-O2-FV-X600X-2-1 GOX Valve Position, % Open	W-44-O2-FV-X600X-2-1	RHX No. 1 GOX Flow Control Valve I/P	4-20 mA	4-20 ma	N/A	1	
W-44-O2-FV-X600X-2-1	RHX No. 1 GOX Flow Control Valve I/P	4-20 mA	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FV-X600X-2-1	RHX No. 1 GOX Flow Control Valve	4-20 mA	0 to 100% Open	Air to Open, Fail Closed	1	
W-44-AHP-TE-155-2	Temperature Element, Mid-pt Unbal. Air Pass, RHX No. 2	-328 to 1562 Deg. F	Microvolts	TIC-X600X-2-1	PID Direct Acting	W-44-AHP-TE-155-2: Calculate rolling average temperature over last 10 minutes	Remote: AVGMPT-2 PV	Auto/Manual	N/A	W-44-O2-FV-X600X-2-2 GOX Valve Position, % Open	W-44-O2-FV-X600X-2-2	RHX No. 2 GOX Flow Control Valve I/P	4-20 mA	4-20 ma	N/A	1	
W-44-O2-FV-X600X-2-2	RHX No. 2 GOX Flow Control Valve I/P	4-20 mA	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FV-X600X-2-2	RHX No. 2 GOX Flow Control Valve	4-20 mA	0 to 100% Open	Air to Open, Fail Closed	1	
RL-500	RHX No. 1 GOX Flow Control Valve I/P	On/Off	On/Off	W-44-O2-FY-600-2-1	Solenoid	On/Off	Off	N/A	No	Off	W-44-O2-FY-600-2-1	Turns on when compressor is started	Off	Off	Off	1	
RL-500	RHX No. 2 GOX Flow Control Valve I/P	On/Off	On/Off	W-44-O2-FY-600-2-2	Solenoid	On/Off	Off	N/A	No	Off	W-44-O2-FY-600-2-2	Turns on when compressor is started	Off	Off	Off	1	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-115-2

LOOP NAME: Unbalance Air Flow Control

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 10 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					Notes	REV.
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	MANUAL			REMOTE	SELECTS	TAG NO.	DESCRIPTION	INPUT		
W-44-AHP-TE-186-2	RTD, Cold End Air Temperature	-180 to +400 Deg C	Variable resistance, 100± ohms	N/A	N/A		N/A	N/A	N/A	Delta T, Deg. C	W-44-CAD-TDIT-186-2	Differential Temperature Transmitter, Cold End Delta T	W-44-AHP-'TE-187-2 minus W-44-AHP-TE-186-2	4-20 mA	N/A		1
W-44-N-TE-187-2	RTD, Cold End Waste Nitrogen Temperature	-180 to +400 Deg C	Variable resistance, 100± ohms														
W-44-CAD-TDIT-186-2	Flow Transmitter, Unbalance Air Flow	0 to 200 KSCFH	4-20 mA	FIC-115-2	PID, Direct Acting	Rolling average of TDT-186-1 over 10 minutes. Sample and refresh every 10 seconds.	SET POINT (SP) is fixed at 2.5 deg. C	Auto/ Manual	N/A	FV-213A & FV-215A, Valve Positions, % Open	W-44-AHP-FV-213A-2	Turbine Bypass Valve, Reverse acting, split range.	4 to 12 mA	100 to 0% Open	Air to Open, Fail Closed		1
W-44-AHP-FIT-115-2	Flow Transmitter, Unbalance Air Flow	0 to 200 KSCFH	4-20 mA								W-44-AHP-FV-215A-2	Unbalance Air Bypass Valve, Direct acting, split range.	12 to 20 mA	0 to 100% Open	Air to Open, Fail Closed		
N/A	Plant Shutdown	PLC Logic Signal	0 VAC	W-44-AHP-FY-213-2	Solenoid	N/A	N/A	N/A	Energize when compressor starts	N/A	W-44-AHP-FV-213A-2	Turbine Bypass Valve, Reverse acting, split range.	0-120 VAC	Opened/ Closed	Air to Open, Fail Closed	Solenoid activates when compressor is started	3
				W-44-AHP-FY-215-2	Solenoid						W-44-AHP-FV-215A-2	Unbalance Air Bypass Valve, Direct acting, split range.	0-120 VAC	Opened/ Closed	Air to Open, Fail Closed	Solenoid activates when compressor is started	3



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. SIC-219-2

LOOP NAME: Turbine Speed Control

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 11 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APPROVED
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-AHP-TE-216-2	Turbine Outlet Temp	-270 to 400 Deg C	0-100 Ohms	TIC-216-2	PID Direct Acting, Turbine Outlet Temperature	W-44-AHP-TE-216-2	Fixed: -180 deg. C	Auto/Manual	N/A	W-44-ALP-FV-220A-2, % Open, Nozzle Position	LSS-214-2	Low Signal Select	PID Output Signals (0 to 100%) for TIC-216-2 & SIC-219-2	LSS-216-2 Output Signal, 0 to 100%	N/A	3
W-44-AHP-ST-219-2	Turbine Speed	0 to 60K RPM	4-20 mA	SIC-219-2	PID, Reverse Acting, Turbine Speed	W-44-AHP-'ST-219-2	Local: Operator Input, limit range between 10,000 and 26,000 rpm	Auto/Manual	N/A	W-44-ALP-FV-220A-2, % Open, Nozzle Position						
LSS-214-2	Low Signal Select	LSS-214-2 Output Signal, 0 to 100%	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-ALP-FV-220A-2	Turbine Inlet Nozzle	4-20 mA	0 to 100% Open	Closed	
W-44-O2-LIT-616-2-1	LOX Tank No. 2-1 Level Transmitter	0-150" W.C.	4-20 mA	LIC-616-2-1	Discrete Switch	W-44-O2-LIT-616-1	Local: Supervisor Input	N/A	Discrete Output Only Active if Tank Is In Make Mode	No. 2-1 Tank Full	HSS-616-2	LOX Tank High Level Turbne Shutdown	PLC Logic Signal	Relay Output On/Off	Off	1
W-44-O2-LIT-616-2-1	LOX Tank No. 2-2 Level Transmitter	0-150" W.C.	4-20 mA	LIC-626-2-2	Discrete Switch	W-44-O2-LIT-616-2	Local: Supervisor Input	N/A	Discrete Output Only Active if Tank Is In Make Mode	No. 2-2 Tank Full						
HSS-616-1	LOX Tank High Level Turbine Shutdown	PLC Logic Signal	Relay Output On/Off	W-44-AHP-FY-214-2	Solenoid Valve	N/A	Opens when turbine starts	N/A	N/A	N/A	W-44-AHP-FY-214-2	Turbine Inlet Valve	4-20 mA	Opened/ Closed	ATO, Spring to Close	1
N/A	Plant Shutdown or Turbine Under/Over Speed	N/A	N/A													
W-44-AHP-ST-219-2	Turbine Speed	0-60 KRPM	On/Off	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-LOR-FY-220-2	Turbine Oil Loading Solenoid	Energize at 10 KRPM	On/Off	De-Energized	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. LIC-330-2

LOOP NAME: Lower Column Liquid Level Control

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 12 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/9/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE				
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS				
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL
W-44-O2-LIT-330-2	Level Transmitter, Lower Column (Kettle) Level	0 to 100 inches w.c.	4-20 mA	LIC-330-2	PID Direct Acting, Level Controller	W-44-O2-LIT-330-2	Local: Operator Input (Normally 30 in. w.c., limit range between 15 in. w.c. and 40 in. w.c.)	Auto/ Manual	N/A	LV-330A-2 Valve Position, % Open	W-44-O2-LV-330A-2	Kettle Level Control Valve	4 to 20 mA	0 to 100% Open	Closed
RL-500	Compressor Running	On/Off	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-LY-330-2	Kettle Level Control Valve Solenoid	Running	Energized	Closed



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. FIC-340-2

LOOP NAME: Shelf Transfer (Reflux to upper column) Controller

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 13 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					REV
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE	MANUAL SELECTS			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-AHP-FIT-120-2	Flow Transmitter, Cold End Air Flow	0 to 700 KSCFH	4-20 mA	FIC-340-2	PID, Reverse Acting	FIT-340-1	Remote (see Math)	Auto/Manual	Derive Set Point based on PV from FIT-120-2 as follows: $SP_{FIC-340-2} = (PV_{FIT-120-2}) * R$ where "R" is a factor accessible from the Columns HMI screen. The approximately value of R is 0.34; the permisslble range of values for "R" should be set at 0.25 to 0.45.	W-44-N2-FV-340N-2 Valve Position, % Open	W-44-N2-FV-340N-2	Shelf Transfer Valve	4-20 mA	0 - 100% Open	Closed	1
W-44-N2-FIT-340-2	Flow Transmitter, Shelf Nitrogen	0 to 250 KSCFH	4-20 mA													
RL-500	Compressor Running	On/Off	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-N2-FY-340-2	Shelf Transfer Valve Solenoid	Running	Energized	Closed	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. LIC-352-2

LOOP NAME: Main Condenser Level Controller

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 14 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-O2-LIT-352-2	Level Transmitter, Main Condenser	0 to 100 inches water column	4-20 mA	LIC-352-2	Discrete Level Controller	LIT-352-2	Local: Supervisor-only input of high and low level limits	Auto/ Manual Selection of Either Make or Add Mode	Discrete Out -- W-44-O2-LV-350X-2 to open when W-44-O2-LIT-352-2 > 56" and close when < 50"; W-44-O2-LV-351X-2 to open when W-44-O2-LIT-352-2 < 48" and close when > 54"	W-44-O2-LV-351-2 and W-44-O2-LV-352-2 , Valve Position, open or closed	W-44-O2-LY-350X-2	Main Condenser "MAKE" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	Energize to Open, Fail Closed	3	
											W-44-O2-LY-351X-2	Main Condenser "ADD" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	Energize to Open, Fail Closed		
W-44-O2-LY-350X-2	Main Condenser "MAKE" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	N/A	N/A	N/A	N/A	N/A	Energized when compressor running	Color code position: red = closed; green = open	W-44-O2-LY-350X-2	Main Condenser "MAKE" Valve	On/Off	Open/ Close	Closed		
W-44-O2-LY-351X-2	Main Condenser "ADD" Solenoid Valve	Relay Output, 120 VAC	Open/ Close	N/A	N/A	N/A	N/A	N/A	Energized when compressor running	Color code position: red = closed; green = open	W-44-O2-LY-351X-2	Main Condenser "ADD" Valve	On/Off	Open/ Close	Closed		



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. PIC-600-2

LOOP NAME: Product Oxygen Pressure Control

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 15 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/19/22	DLD		
2	2/3/23	DLB		
3	6/8/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE	MANUAL SELECTS			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
PRESSURE (LOAD FOLLOWING) CONTROL																
W-44-O2-PIT-600-2	O2 Product Pipeline Pressure	0 to 10 psig	4-20 mA	PIC-600-2	PID, Reverse Acting	W-44-O2-PIT-600-2	Local	Auto/Manual	N/A	W-44-O2-FV-600X-2 Valve Position, % Open	W-44-O2-FV-600X-2	O2 Product Valve Positioner	4-20 mA	0 to 100% Open	Closed	3
				Selector Switch -- Pressure (load following) Control or Flow Control												
W-44-O2-FIT-600-2	O ₂ Product Flow Ex Cold Box	0-2 50 KSCFH	4-20 mA	FIC-600-2	PID, Reverse Acting	W-44-O2-FIT-600-2	Local	Auto/Manual	N/A	W-44-O2-FV-600X-2 Valve Position, % Open					0 to 100% Open	Closed
OXYGEN PRODUCT VENT VALVE CONTROL																
W-44-O2-FIT-600-2	O ₂ Product Flow Ex Cold Box	0-2 50 KSCFH	4-20 mA	FIC-601-2	PID, Reverse Acting	W-44-O2-FIT-600-2	Local	Auto/Manual	N/A	W-44-O2-FV-601X-2 Valve Position, % Open	W-44-O2-FV-601X-2	O2 Vent Valve Positioner	4-20 mA	0 to 100% Open	Closed	
RL-500-2	Plant Shutdown	PLC Logic Signal	0 VAC	W-44-O2-FY-600X-2	Solenoid	N/A	N/A	N/A	Energized when compressor running	N/A	W-44-O2-FV-600X-2	O2 Product Valve	0-2 20 VAC	Opened/ Closed	Air to Open, Fail Closed	
				W-44-O2-FY-601X-2	Solenoid						W-44-O2-FV-601X-2	O2 Vent Valve	0-2 20 VAC	Opened/ Closed	Air to Open, Fail Closed	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. PIC-615/625

LOOP NAME: DRIOX Storage Tank Pressure Control

PLANT AREA: LOX Back-up System, Tanks #1 & #2

SEQUENTIAL NUMBER: 16 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	MANUAL			SELECTS	TAG NO.	DESCRIPTION	INPUT	OUTPUT	
TANK MODE SELECTOR SWITCH																
HS-615-2-1	Tank No. 1 Mode Selector Switch	N/A	N/A	HS-615	HMI Switch	N/A	N/A	Manual Only	N/A	Make	N/A	Make Mode Selection	HMI Logic	Lo Remote Set Point to PIC-615-2-1	N/A	1
										Add		Add Mode Selection	HMI Logic	Hi Remote Set Point to PIC-615-2-1	N/A	1
HS-615-2-2	Tank No. 2 Mode Selector Switch	N/A	N/A	HS-625	HMI Switch	N/A	N/A	Manual Only	N/A	Make	N/A	Make Mode Selection	HMI Logic	Lo Remote Set Point to PIC-615-2-2	N/A	1
										Add		Add Mode Selection	HMI Logic	Hi Remote Set Point to PIC-615-2-2	N/A	1

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE						
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS						
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE			MANUAL	SELECTS	TAG NO.	DESCRIPTION	INPUT		OUTPUT
TANK NO. 1 PRESSURE CONTROL																1	
W-44-O2-PIT-616-2	LOX Tank No. 2-1 Pressure	0 to 100 psig	4-20 mA	PIC-615-2-1	PID, Direct Acting	W-44-O2-PIT-616-2	Local: Operator setpoint in psig, one SP for Make mode, one SP for Add mode		Auto/Manual	N/A	W-44-O2-PV-615X-2-1 % Open	W-44-O2-PV-615X-2-1	Pressure Build Valve Positioner Reverse Acting, Split Range	4-12 mA	100 to 0% Open	Closed	1
											W-44-O2-PV-616X-2-1 % Open	W-44-O2-PV-616X-2-1	Economizer Valve Positioner Direct Acting, Split Range	12-20 mA	0 to 100% Open	Closed	1
PET-2	Plant Emergency Trip Switch	120 VAC	0 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FY-616-2-1	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	Energize to Open, Fail Closed	1	
W-44-O2-TSL-640	Economizer Outlet Temperature	-328 - 1498 deg. F.	0-100 Ohms	W-44-O2-TSH-640	Discrete Switch	N/A	Field Calibrated	N/A	N/A	On/Off						1	
W-44-O2-PY-616-2	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	N/A	N/A	N/A	N/A	N/A	Close if TSL-640 alarms	N/A	W-44-O2-PV-616X-2-1	Economizer Valve Positioner	0-120 VAC	0 to 100% Open	Closed	1	
TANK NO. 2 PRESSURE CONTROL																1	
W-44-O2-PIT-626-2	LOX Tank No. 2-2 Pressure	0 to 100 psig	4-20 mA	PIC-625-2-2	PID, Direct Acting	W-44-O2-PIT-626-1-2	Local: Operator setpoint in psig, one SP for Make mode, one SP for Add mode		Auto/Manual	N/A	W-44-O2-PV-625X-2-2 % Open	W-44-O2-PV-625X-2-2	Pressure Build Valve Positioner Reverse Acting, Split Range	4-12 mA	100 to 0% Open	Closed	1
											W-44-O2-PV-626X-2-2 % Open	W-44-O2-PV-626X-2-2	Economizer Valve Positioner Direct Acting, Split Range	12-20 mA	0 to 100% Open	Closed	1
PET-2	Plant Emergency Trip Switch	120 VAC	0 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FY-616-2-2	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	Energize to Open, Fail Closed	1	
W-44-O2-TSL-640	Economizer Outlet Temperature	-328 - 1498 deg. F.	0-100 Ohms	TSH-640	Discrete Switch	N/A	Field Calibrated	N/A	N/A	On/Off						1	
W-44-O2-PY-626-2	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	N/A	N/A	N/A	N/A	N/A	Close if W-44-O2-TSL-640 alarms	N/A	W-44-O2-PV-626X-2-2	Economizer Valve Positioner	0-120 VAC	0 to 100% Open	Closed	1	



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. PIC 635

LOOP NAME: DRIOX Pipeline Pressure Control

PLANT AREA: LOX Back-up System

SEQUENTIAL NUMBER: 17 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER							CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)	AUTO MANUAL SELECTS	MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS					REV
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL REMOTE				TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL	
W-44-O2-PIT-630	Pressure Transmitter, Vaporizer Pressure PSIG	0 to 80 PSIG	4-20 mA	PIC-630	PID, Direct Acting	W-44-O2-PIT-630	Fixed, 80 PSIG	Auto/Manual	N/A	W-44-O2-'PV-635X, % Open	HSS-635P	High Signal Select	PLC Logic Signal	PLC Logic Signal	N/A	3
W-44-O2-PIT-635	Pressure Transmitter, DRIOX Pipeline Pressure PSIG	0 to 20 PSIG	4-20 mA	PIC-635	PID, Reverse Acting	W-44-O2-PIT-635	Local: Operator Input	Auto/Manual	N/A	W-44-O2-'PV-635X, % Open						
HSS-635P	High Signal Select	PLC Logic Signal	PLC Logic Signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	LSS-635	Low Signal Select	PLC Logic Signal	PLC Logic Signal	N/A	3
W-44-O2-TE-635	RTD, Oxygen Temperature from DRIOX	-328 to +900 deg. F	Variable Ohms	TIC-635	PID, Direct Acting	W-44-O2-TE-635	Fixed: -20 deg. F	Always Auto	N/A	W-44-O2-PV-635X, % Open						
LSS-635	Low Signal Select	PLC Logic Signal	4-20 mA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-PV-635X	DRIOX Supply Valve	4-20 mA	0 to 100% Open	Closed	3
PET-1/2	Plant Emergency Trip Switch	120 VAC	0 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	W-44-O2-FY-635	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	Energize to Open, Fail Closed	3
W-44-O2-FY-635	Solenoid Valve	Relay Output, 120 VAC	Open/ Closed	N/A	N/A	N/A	N/A	N/A	Close if W-44-O2-TE-635 is below -20 F	N/A	W-44-O2-'PV-635X	DRIOX Supply Valve	0-120 VAC	0 to 100% Open	Closed	1



EBMUD Cryo Plant Control Loop Specifications

LOOP NO. TIC-550-2

LOOP NAME: Thaw Heater Control

PLANT AREA: Cold Box 2

SEQUENTIAL NUMBER: 18 of 18

PROJECT NAME: EBMUD Controls Improvement Project

PROJECT NUMBER: SD-428

SPECIFICATION NO.: 40 61 01b

REV NO.	DATE	BY	CHECK	APP
0	1/5/22	DLB		
1	1/27/22	DLD		
2	2/3/23	DLB		
3	5/21/23	DLB		

PROCESS VARIABLE MEASUREMENT DEVICE				CONTROLLER						CONTROLLED DEVICE					
INPUT SIGNALS →				TAG NO.	TYPE	PROCESS VALUE (PV)	SETPOINT (SP)		MATH	OUTPUT DISPLAY (OP)	→ OUTPUT SIGNALS				
TAG NO.	DESCRIPTION	INPUT	OUTPUT				LOCAL	REMOTE			TAG NO.	DESCRIPTION	INPUT	OUTPUT	FAIL
HS-550-2	Thaw Heater Mode Selector Switch	N/A	N/A	HS-550-2	HMI Switch	N/A	N/A		N/A	Off	N/A	Contactors Open	480 VAC	0 VAC	Open
										Plant	N/A	30 kW Contactor Closed	480 VAC	480 VAC	Open
										Turbine	N/A	30 kW + 90 kW Contactors Closed	480 VAC	480 VAC	Open
W-44-AHP-TE-550-2	Thermocouple (Type K), Thaw Heater Element Temperature	-328 to +2282 deg. F	Variable Ohms	TIC-550-2	Discrete Heater Shutdown	W-44-AHP-TE-550-2	Fixed: 1050 deg. F	Always Auto	N/A	On (Red); Off (Green)	LSS-550-2	Low Signal Select	PLC Logic Signal	Heater On/Off Command	Off
W-44-AHP-TE-552-2	Thermocouple (Type K), Thaw Heater Element Temperature	-328 to +2282 deg. F	Variable Ohms	TIC-550-2	Discrete Heater Shutdown	W-44-AHP-TE-550-2	Fixed: 1050 deg. F	Always Auto	N/A						
W-44-AHP-TE-552-2	Thermocouple (Type T), Thaw Heater Outlet Temperature	-328 to +900 deg. F	Variable Ohms	TIC-552-2	Discrete Heater Controller	W-44-AHP-TE-552-2	Local: Operator Inputs for Plant Mode and Turbine Mode	On-Off/ Switch Between Plant and Turbine Thaw Modes	N/A						
LSS-550-2	Low Signal Select	DCS Logic	120 VAC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	HS-THTR (R-2 601)-2	Relay	120 VAC	120 VAC	Open

END OF SECTION

CRYO I/O LIST, 5 January 2024
SD428 ASU I-O List

I/O LIST
SPECIFICATION 40 61 00c

Plant #2
CC SCHED. COORD. 10-11-2022, LAM
PID COORD. 10-11-2022, LAM

I/O RACK ANALOG SIGNALS

ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	ANALOG TYPE	DEVICE TAG #	P&ID TAG #	RANGE		ENGINEERING UNITS	DESCRIPTION	COMMENTS	ALARMS/TRIPS					PERMISSIVES	
								LOW VALUE	HIGH VALUE				LL	L	H	HH	TRIP ACTION	VALUE	ACTION
CPU RACK #1																			
1		1	1	1	AI	W-44-AHP-IT-500-1-1		0	200	AMPS	MAC 1-1 Motor Current				145	167	MAC shutdown		
2		1	1	2	AI	W-44-AHP-IT-500-2-1		0	200	AMPS	MAC 2-1 Motor Current				145	167	MAC shutdown		
3		1	1	3	AI	W-44-O2-AIT-312-1		0	20	% O2	Nitrogen Purity Analyzer (Waste Or Shelf)								
4		1	1	4	AI	W-44-O2-AIT-312-1		0	250	PPM HC	Hydrocarbon Analyzer	TMR 1 Minute For Shutdown			100	150	MAC shutdown		
5		1	1	5	AI	W-44-O2-AIT-352-1		0	100	% O2	Product Oxygen Purity Analyzer								
6		1	1	6	AI						Wired Spare								
CPU RACK #2																			
6	W44-I-110-A	2	1	1	AI	W-44-AHP-IT-500-1-2		0	200	AMPS	MAC 1-2 Motor Current				145	167	MAC shutdown		
7	Not Shown	2	1	2	AI	W-44-AHP-IT-500-2-2		0	200	AMPS	MAC 2-2 Motor Current				145	167	MAC shutdown		
8	W44-I-112-B	2	1	3	AI	W-44-O2-AIT-312-2		0	20	% O2	Nitrogen Purity Analyzer (Waste Or Shelf)								
9	Not Shown	2	1	4	AI	W-44-O2-AIT-312-2		0	250	PPM HC	Hydrocarbon Analyzer	TMR 1 Minute For Shutdown			100	150	MAC shutdown		
10	W44-I-112-A	2	1	5	AI	W-44-O2-AIT-352-2		0	100	% O2	Product Oxygen Purity Analyzer								
11		2	1	6	AI						Wired Spare								
MAIN AIR COMPRESSOR 1-1																			
11		3	1	1	AI	W-44-LOS-PIT-53-1-1		0	50	PSIG	MAC 1-1, Lube Oil Supply Press	Retain existing gauge; add a transmitter	8 PSIG	12 PSIG	70 PSIG		MAC shutdown; auxiliary oil pump starts when pressure <12 PSIG	> 8 PSIG	MAC Will Start
12		3	1	2	AI	W-44-LOS-TIT-53-1-1		0	200	DEGS F	MAC 1-1, Lube Oil Supply Temp	Currently a gauge; upgrade to transmitter		100 F	140 F	150 F	MAC shutdown	> 90F & < 150F	MAC Will Start
13		3	1	3	AI	W-44-AHP-FIT-502-1-1		0	100	" H2O	MAC 1-1, 3rd Stage DP For Anti-Surge Control	New transmitter							
14		3	1	4	AI	W-44-AHP-PIT-506-1-1		0	100	PSIG	MAC 1-1, Discharge Press For Anti-Surge Control					80 PSIG	MAC shutdown		
15		3	1	5	AI	W-44-ALP-TIT-501-1-1		0	150	DEGS F	MAC 1-1, Aftercooler Outlet Temp	Currently a switch; upgrade to transmitter			100 F	130 F			
16		3	1	6	AI	W-44-LOS-VE-501-1-1		0	5	MILS	MAC 1-1, 1st Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
17		3	1	7	AI	W-44-LOS-VE-502-1-1		0	5	MILS	MAC 1-1, 2nd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
18		3	1	8	AI	W-44-LOS-VE-503-1-1		0	5	MILS	MAC 1-1, 3rd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
19		3	1	9	AI						Wired Spare								
19		3	2	1	AO	W-44-IA-FV-500A-1-1		0	100	% Open	MAC 1-1 Inlet Valve	Replace positioner						< 5% Open	MAC Will Start
20		3	2	2	AO	W-44-EXH-FV-506A-1-		0	100	% Open	MAC 1-1 F.O. (Anti-Surge) Vent Valve	Replace positioner						> 95% Open	MAC Will Start
21		3	1	3	AO						Wired Spare								

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PID COORD. 10-11-2022, LAM

I/O RACK ANALOG SIGNALS

ITEM #	P&I D SHEET #	BRANCH #	MOD #	CHANNEL #	ANALOG TYPE	DEVICE TAG #	P&ID TAG #	RANGE		ENGINEERING UNITS	DESCRIPTION	COMMENTS	ALARMS/TRIPS					PERMISSIVES	
								LOW VALUE	HIGH VALUE				LL	L	H	HH	TRIP ACTION	VALUE	ACTION
MAIN AIR COMPRESSOR 2-1																			
21		4	1	1	AI	W-44-LOS-PIT-53-2-1		0	50	PSIG	MAC 2-1, Lube Oil Supply Press	Retain existing gauge; add a transmitter	8 PSIG	12 PSIG	70 PSIG		MAC shutdown; auxiliary oil pump starts when pressure <12 PSIG	> 8 PSIG	MAC Will Start
22		4	1	2	AI	W-44-LOS-TIT-53-2-1		0	200	DEGS F	MAC 2-1, Lube Oil Supply Temp	Currently a gauge; upgrade to transmitter		100 F	140 F	150 F	MAC shutdown	> 90F & < 150F	MAC Will Start
23		4	1	3	AI	W-44-AHP-FIT-502-2-1		0	100	" H2O	MAC 2-1, 3rd Stage DP For Anti-Surge Control	New transmitter							
24		4	1	4	AI	W-44-AHP-PIT-506-2-1		0	100	PSIG	MAC 2-1, Discharge Press For Anti-Surge Control					80 PSIG	MAC shutdown		
25		4	1	5	AI	W-44-ALP-TIT-501-2-1		0	150	DEGS F	MAC 2-1, Aftercooler Outlet Temp	Currently a switch; upgrade to transmitter			100 F	130 F			
26		4	1	6	AI	W-44-LOS-VE-501-2-1		0	5	MILS	MAC 2-1, 1st Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
27		4	1	7	AI	W-44-LOS-VE-502-2-1		0	5	MILS	MAC 2-1, 2nd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
28		4	1	8	AI	W-44-LOS-VE-503-2-1		0	5	MILS	MAC 2-1, 3rd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
29		4	1	9	AI						Wired Spare								
29		4	2	1	AO	W-44-1A-FV-500A-2-1		0	100	% Open	MAC 2-1 Inlet Valve	Replace positioner						< 5% Open	MAC Will Start
30		4	2	2	AO	W-44-EXH-FV-506A-2-		0	100	% Open	MAC 2-1 F.O. (Anti-Surge) Vent Valve	Replace positioner						> 95% Open	MAC Will Start
31		4	2	3	AO						Wired Spare								
MAIN AIR COMPRESSOR 1-2																			
31	W44-I-110-A	5	1	1	AI	W-44-LOS-PIT-53-1-2		0	50	PSIG	MAC 1-2, Lube Oil Supply Press	Retain existing gauge; add a transmitter	8 PSIG	12 PSIG	70 PSIG		MAC shutdown; auxiliary oil pump starts when pressure <12 PSIG	> 8 PSIG	MAC Will Start
32	W44-I-110-A	5	1	2	AI	W-44-LOS-TIT-53-1-2		0	200	DEGS F	MAC 1-2, Lube Oil Supply Temp	Currently a gauge; upgrade to transmitter		100 F	140 F	150 F	MAC shutdown	> 90F & < 150F	MAC Will Start
33	W44-I-110-A	5	1	3	AI	W-44-AHP-FIT-502-1-2		0	100	" H2O	MAC 1-2, 3rd Stage DP For Anti-Surge Control	New transmitter							
34	W44-I-110-B	5	1	4	AI	W-44-AHP-PIT-506-1-2		0	100	PSIG	MAC 1-2, Discharge Press For Anti-Surge Control					80 PSIG	MAC shutdown		
35	W44-I-110-B	5	1	5	AI	W-44-ALP-TIT-501-1-2		0	150	DEGS F	MAC 1-2, Aftercooler Outlet Temp	Currently a switch; upgrade to transmitter			100 F	130 F			
36	W44-I-110-A	5	1	6	AI	W-44-LOS-VE-501-1-2		0	5	MILS	MAC 1-2, 1st Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
37	W44-I-110-A	5	1	7	AI	W-44-LOS-VE-502-1-2		0	5	MILS	MAC 1-2, 2nd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
38	W44-I-110-A	5	1	8	AI	W-44-LOS-VE-503-1-2		0	5	MILS	MAC 1-2, 3rd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
39		5	1	9	AI						Wired Spare								
39	W44-I-110-A	5	2	1	AO	W-44-1A-FV-500A-1-2		0	100	% Open	MAC 1-2 Inlet Valve	Replace positioner						< 5% Open	MAC Will Start
40	Not Shown	5	2	2	AO	W-44-EXH-FV-506A-1-		0	100	% Open	MAC 1-2 F.O. (Anti-Surge) Vent Valve	Replace positioner						> 95% Open	MAC Will Start
41		5	2	3	AO						Wired Spare								
MAIN AIR COMPRESSOR 2-2																			
41		6	1	1	AI	W-44-LOS-PIT-53-2-2		0	50	PSIG	MAC 2-2, Lube Oil Supply Press	Retain existing gauge; add a transmitter	8 PSIG	12 PSIG	70 PSIG		MAC shutdown; auxiliary oil pump starts when pressure <12 PSIG	> 8 PSIG	MAC Will Start
42		6	1	2	AI	W-44-LOS-TIT-53-2-2		0	200	DEGS F	MAC 2-2, Lube Oil Supply Temp	Currently a gauge; upgrade to transmitter		100 F	140 F	150 F	MAC shutdown	> 90F & < 150F	MAC Will Start
43		6	1	3	AI	W-44-AHP-FIT-502-2-2		0	100	" H2O	MAC 2-2, 3rd Stage DP For Anti-Surge Control	New transmitter							
44		6	1	4	AI	W-44-AHP-PIT-506-2-2		0	100	PSIG	MAC 2-2, Discharge Press For Anti-Surge Control					80 PSIG	MAC shutdown		
45		6	1	5	AI	W-44-ALP-TIT-501-2-2		0	150	DEGS F	MAC 2-2, Aftercooler Outlet Temp	Currently a switch; upgrade to transmitter			100 F	130 F			
46		6	1	6	AI	W-44-LOS-VE-501-2-2		0	5	MILS	MAC 2-2, 1st Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
47		6	1	7	AI	W-44-LOS-VE-502-2-2		0	5	MILS	MAC 2-2, 2nd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
48		6	1	8	AI	W-44-LOS-VE-503-2-2		0	5	MILS	MAC 2-2, 3rd Stage Vibration				1.0	1.5	MAC shutdown	Bypass	MAC Will Start
49		6	1	9	AI						Wired Spare								
49		6	2	1	AO	W-44-1A-FV-500A-2-2		0	100	% Open	MAC 2-2 Inlet Valve	Replace positioner						< 5% Open	MAC Will Start
50		6	2	2	AO	W-44-EXH-FV-506A-2-		0	100	% Open	MAC 2-2 F.O. (Anti-Surge) Vent Valve	Replace positioner						> 95% Open	MAC Will Start
51		6	2	3	AO						Wired Spare				1.0	1.5	MAC shutdown	Bypass	MAC Will Start

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I/O RACK ANALOG SIGNALS

ITEM #	P&I D SHEET #	BRANCH #	MOD #	CHANNEL #	ANALOG TYPE	DEVICE TAG #	P&ID TAG #	RANGE		ENGINEERING UNITS	DESCRIPTION	COMMENTS	ALARMS/TRIPS					PERMISSIVES	
								LOW VALUE	HIGH VALUE				LL	L	H	HH	TRIP ACTION	VALUE	ACTION
CRYO PLANT 1																			
51		7	1	1	AI	W-44-AHP-FIT-115-1		0	100	KSCFH	Unbalanced Air Flow Transmitter								
52		7	1	2	AI	W-44-AHP-FIT-120-1		0	700	KSCFH	Cold End Air Flow Transmitter								
53		7	1	3	AI	W-44-N2-FIT-340-1		0	250	KSCFH	Shelf Flow Transmitter								
54		7	1	4	AI	W-44-AHP-PIT-200-1		0	100	PSIG	RHX Pass "A" Air / Waste Press	Currently a switch; upgrade to							
55		7	1	5	AI	W-44-AHP-PIT-300-1		0	100	PSIG	Lower Column Press								
56		7	1	6	AI	W-44-O2-LIT-330-1		0	100	IN W.C.	Kettle Level Transmitter (IN W.C.)		< 15" W.C.			> 45" W.C.	MAC shutdown		
57		7	1	7	AI	W-44-N2-PIT-349-1		0	15	PSIG	Upper Column Pressure								
58		7	1	8	AI	W-44-O2-LIT-352-1		0	88	IN W.C.	Upper Column Level Transmitter		< 36.4"			> 59.8"	MAC shutdown		
59		7	1	9	AI	W-44-O2-PIT-352-1		0	15	PSIG	Main Condenser Pressure								
60		7	1	10	AI	W-44-AHP-PIT-590-1		0	100	PSIG	Instrument Air Press	Currently a switch; upgrade to transmitter	< 40 psig	< 45 psig			MAC shutdown	> 40 psig	MAC will start
61		7	1	11	AI	W-44-O2-FIT-600-1		0	100	KSCFH	Oxygen Flow Transmitter								
62		7	1	12	AI	W-44-O2-PIT-600-1		-2.5	10	PSIG	Product O2 From Cold Box Press								
63		7	1	14	AI						Wired Spare								
63		7	1	13	AI	W-44-AHP-TDT-186-1		-250	200	DEGS C	Cold End Delta Temp								
64		7	2	1	AO	W-44-O2-LV-330A-1		0	100	% Open	Kettle Level Control Valve	Replace positioner							
65		7	2	2	AO	W-44-N2-FV-340N-1		0	100	% Open	Shelf Flow Control Valve	Replace positioner							
66		7	2	3	AO						Wired Spare								
66		7	2	4	AO	W-44-O2-X-600X-1-1		0	100	% Open	Oxygen Product Mid-point Temperature Control Valve #1	Add actuator and positioner							
67		7	2	5	AO	W-44-O2-X-600X-2-1		0	100	% Open	Oxygen Product Mid-point Temperature Control Valve #2	Add actuator and positioner							
68		7	2	6	AO	W-44-O2-PV-600X-1		0	100	% Open	Oxygen Product Valve	Replace positioner							
69		7	2	7	AO	W-44-O2-FV-601X-1		0	100	% Open	Oxygen Vent Valve	Replace positioner							
70		7	2	8	AO						Wired Spare								
70		7	3	1	TC	W-44-O2-TE-149-1		-250	200	DEGS C	Cold End Product O2 Thermocouple								
71		7	3	2	TC	W-44-O2-TE-150-1		-270	400	DEGS C	Product O2 Warm End Temperature		< -10 C				MAC shutdown		
72		7	3	3	TC	W-44-AHP-TE-154-1		-250	200	DEGS C	Unbalanced Air Mid-Point Thermocouple								
73		7	3	4	TC	W-44-AHP-TE-155-1		-250	200	DEGS C	Unbalanced Air Mid-Point Thermocouple								
74		7	3	5	TC	W-44-AHP-TE-184-1		-250	200	DEGS C	Warm Air, Stream "B" Thermocouple								
75		7	3	6	TC	W-44-AHP-TE-185-1		-250	200	DEGS C	Warm Air, Stream "A" Thermocouple								
76		7	3	7	TC	W-44-N2-TE-188-1		-250	200	DEGS C	Waste N2, Cold End Thermocouple								
77		7	3	8	TC	W-44-N2-TE-190-1		-250	200	DEGS C	Shelf Transfer Thermocouple								
78		7	3	9	TC	W-44-O2-TE-191-1		-250	200	DEGS C	Cool Down System Thermocouple								
79		7	3	10	TC	W-44-AHP-TE-201-1		-270	400	DEGS C	Gel Trap Inlet Temperature								
80		7	3	11	TC	W-44-AHP-TE-550-1-1		-454	2,498	DEGS F	Thaw Heater Element 1 Temperature, Type K								
81		7	3	12	TC	W-44-AHP-TE-550-2-1		-454	2,498	DEGS F	Thaw Heater Element 2 Temperature, Type K								
82		7	3	13	TC	W-44-AHP-TE-552-1		-454	752	DEGS F	Thaw Heater Outlet Temp								
83		7	3	14	TC						Wired Spare								

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ITEM #	P&I D SHEET #	BRANCH #	MOD #	CHANNEL #	ANALOG TYPE	DEVICE TAG #	P&ID TAG #	RANGE		ENGINEERING UNITS	DESCRIPTION	COMMENTS	ALARMS/TRIPS					PERMISSIVES	
								LOW VALUE	HIGH VALUE				LL	L	H	HH	TRIP ACTION	VALUE	ACTION
CRYO PLANT 2																			
83	W44-I-111-A	8	1	1	AI	W-44-AHP-FIT-215-2	FT-115	0	100000	KSCFH	Unbalanced Air Flow Transmitter								
84	W44-I-111-A	8	1	2	AI	W-44-AHP-FIT-220-2	FT-120	0	700000	KSCFH	Cold End Air Flow Transmitter								
85	W44-I-112-A	8	1	3	AI	W-44-N2-FIT-340-2	FT-340	0	250	KSCFH	Shelf Flow Transmitter								
86	W44-I-111-A	8	1	4	AI	W-44-AHP-PIT-200-2		0	100	PSIG	RHX Pass "A" Air / Waste Press	Currently a switch; upgrade to transmitter							
87	W44-I-112-B	8	1	5	AI	W-44-AHP-PIT-300-2		0	100	PSIG	Lower Column Press								
88	W44-I-112-B	8	1	6	AI	W-44-O2-LIT-330-2	LT-330	0	100	IN W.C.	Kettle Level Transmitter (IN W.C.)		< 15" W.C.			> 45" W.C.	MAC shutdown		
89	W44-I-112-A	8	1	7	AI	W-44-N2-PIT-349-2		0	15	PSIG	Upper Column Pressure								
90	W44-I-112-A	8	1	8	AI	W-44-O2-LIT-352-2	LT-352	0	88	IN W.C.	Upper Column Level Transmitter		< 36.4"			> 59.8"	MAC shutdown		
91	W44-I-112-A	8	1	9	AI	W-44-O2-PIT-352-2		0	15	PSIG	Main Condenser Pressure								
92	W44-I-111-A	8	1	10	AI	W-44-AHP-PIT-590-2		0	100	PSIG	Instrument Air Press	Currently a gauge; upgrade to transmitter	< 40 PSIG	< 45 PSIG			MAC shutdown		
93	W44-I-111-A	8	1	11	AI	W-44-O2-FIT-600-2	FT-600	0	100	KSCFH	Oxygen Flow Transmitter								
94	W44-I-111-A	8	1	12	AI	W-44-O2-PIT-600-2		-2.5	10	PSIG	Product O2 From Cold Box Press								
95		8	1	14	AI						Wired Spare								
95	W44-I-111-A	8	1	13	AI	W-44-AHP-TDT-186-2		-250	200	DEGS C	Cold End Delta Temp								
96	W44-I-112-A	8	2	1	AO	W-44-O2-LV-330A-2		0	100	% Open	Kettle Level Control Valve	Replace positioner							
97	W44-I-112-A	8	2	2	AO	W-44-N2-FV-340N-2		0	100	% Open	Shelf Flow Control Valve	Replace positioner							
98		8	2	3	AO						Wired Spare								
98	W44-I-111-A	8	2	4	AO	W-44-O2-X-600X-1-2		0	100	% Open	Oxygen Product Mid-point Temperature Control Valve #1	Add actuator and positioner							
99	W44-I-111-A	8	2	5	AO	W-44-O2-X-600X-2-2		0	100	% Open	Oxygen Product Mid-point Temperature Control Valve #2	Add actuator and positioner							
100	W44-I-111-A	8	2	6	AO	W-44-O2-PV-600X-2	PCV-600	0	100	% Open	Oxygen Product Valve	Replace positioner							
101	W44-I-111-A	8	2	7	AO	W-44-O2-FV-601X-2	PCV-601	0	100	% Open	Oxygen Vent Valve	Replace positioner							
102		8	2	8	AO						Wired Spare								
102	Not Shown	8	3	1	TC	W-44-O2-TE-149-2		-250	200	DEGS C	Cold End Product O2 Thermocouple								
103	Not Shown	8	3	2	TC	W-44-O2-TE-150-2		-270	400	DEGS C	Product O2 Warm End Temperature		< -10 C				MAC shutdown		
104	Not Shown	8	3	3	TC	W-44-AHP-TE-154-2		-250	200	DEGS C	Unbalanced Air Mid-Point Thermocouple								
105	Not Shown	8	3	4	TC	W-44-AHP-TE-155-2		-250	200	DEGS C	Unbalanced Air Mid-Point Thermocouple								
106	Not Shown	8	3	5	TC	W-44-AHP-TE-184-2		-250	200	DEGS C	Warm Air, Stream "B" Thermocouple								
107	Not Shown	8	3	6	TC	W-44-AHP-TE-185-2		-250	200	DEGS C	Warm Air, Stream "A" Thermocouple								
108	Not Shown	8	3	7	TC	W-44-N2-TE-188-2		-250	200	DEGS C	Waste N2, Cold End Thermocouple								
109	Not Shown	8	3	8	TC	W-44-N2-TE-190-2		-250	200	DEGS C	Shelf Transfer Thermocouple								
110	Not Shown	8	3	9	TC	W-44-O2-TE-191-2		-250	200	DEGS C	Cooldown System Thermocouple								
111	Not Shown	8	3	10	TC	W-44-AHP-TE-201-2		-270	400	DEGS C	Gel Trap Inlet Temperature								
112	W44-I-110-B	8	3	11	TC	W-44-AHP-TE-550-2-2		-454	2,498	DEGS F	Thaw Heater Element 1 Temperature, Type K								
113	W44-I-110-B	8	3	12	TC	W-44-AHP-TE-550-2-2	TE-550	-454	2,498	DEGS F	Thaw Heater Element 2 Temperature, Type K								
114	W44-I-110-B	8	3	13	TC	W-44-AHP-TE-552-2		-454	752	DEGS F	Thaw Heater Outlet Temp								
115		8	3	14	TC						Wired Spare								

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ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	ANALOG TYPE	DEVICE TAG #	P&ID TAG #	RANGE		ENGINEERING UNITS	DESCRIPTION	COMMENTS	ALARMS/TRIPS					PERMISSIVES	
								LOW VALUE	HIGH VALUE				LL	L	H	HH	TRIP ACTION	VALUE	ACTION
TURBINE PLANT #1																			
115		9	1	1	AI	W-44-LOR-PIT-20-1		0	200	PSIG	Expansion Turbine Lube Oil To Filters Press	Currently a gauge; upgrade to transmitter Revised Inst. No. per Dillon		110 PSIG				> 90 PSIG	Turbine will start
116		9	1	2	AI	W-44-AHP-PIT-214-1		0	30	PSIG	Turbine Inlet Press	Currently a gauge; upgrade to transmitter							
117		9	1	3	AI	W-44-ALP-PIT-216-1		0	15	PSIG	Turbine Outlet Pressure	Currently a gauge; upgrade to transmitter							
118		9	1	4	AI	W-44-AHP-ST-219-1		0	60000	RPM	Turbine Speed								
119		9	1	5	AI						Wired Spare								
119		9	2	1	AO	W-44-AHP-FV-213A-1/ W-44-AHP-FV-215A-1		0	100	% Open	Turbine Bypass/Unbalanced Air Flow Valves (split range)	Replace positioner							
120		9	2	2	AO			0	100	% Open	Unbalanced Air Flow Control Valve	Replace positioner							
121		9	2	3	AO	W-44-AHP-FV-220A-1		0	100	% Open	Turbine IGV	Replace positioner							
122		9	2	4	AI						Wired Spare								
122		9	3	1	TC	W-44-AHP-TE-215-1		-250	200	DEGS C	Expansion Turbine Inlet Thermocouple								
123		9	3	2	TC	W-44-AHP-TE-216-1		-250	200	DEGS C	Expansion Turbine Outlet Thermocouple		-182 C						
124		9	3	3	TC						Wired Spare								
TURBINE PLANT #2																			
124	W44-I-111-B	10	1	1	AI	W-44-LOR-PIT-20-1		0	10	PSIG	Expansion Turbine Lube Oil To Filters Press	Currently a gauge; upgrade to transmitter Revised Inst. No. per Dillon		110 PSIG					
125	W44-I-111-B	10	1	2	AI	W-44-AHP-PIT-214-1		0	30	PSIG	Turbine Inlet Pressure	Currently a gauge; upgrade to transmitter							
126	W44-I-111-B	10	1	3	AI	W-44-ALP-PIT-216-1		0	15	PSIG	Turbine Outlet Press	Currently a gauge; upgrade to transmitter							
127	W44-I-111-B	10	1	4	AI	W-44-AHP-ST-219-1		0	60000	RPM	Turbine Speed			11,000	26,300				
128		10	1	5	AI						Wired Spare								
128	W44-I-111-B	10	2	1	AO	W-44-AHP-FV-213A-1/ W-44-AHP-FV-215A-1	FV-213	0	100	% Open	Turbine Bypass/Unbalanced Air Flow Valves (split range)	Replace positioner							
129	W44-I-111-B	10	2	3	AO	W-44-AHP-FV-220A-1		0	100	% Open	Turbine IGV	Replace positioner							
130		10	2	4	AO						Wired Spare								
130	W44-I-111-B	10	3	1	TC	W-44-AHP-TE-215-1		-250	200	DEGS C	Expansion Turbine Inlet Thermocouple								
131	W44-I-111-B	10	3	2	TC	W-44-AHP-TE-216-1		-250	200	DEGS C	Expansion Turbine Outlet Thermocouple		-182 C						
132		10	3	3	TC						Wired Spare								
LOX BACK-UP SYSTEM																			
132		11	1	1	AI	W-44-O2-LIT-616-1		0	146	IN WC	LOX Storage Tank 1-1 Level			20" W.C.	95" W.C.	102" W.C.	Turbine shutdown		
133		11	1	2	AI	W-44-O2-LIT-626-1		0	146	IN WC	LOX Storage Tank 1-2 Level			20" W.C.	95" W.C.	102" W.C.	Turbine shutdown		
134	W44-I-113-A	11	1	3	AI	W-44-O2-LIT-616-2		0	146	IN WC	LOX Storage Tank 2-1 Level			20" W.C.	95" W.C.	102" W.C.	Turbine shutdown		
135	W44-I-113-B	11	1	4	AI	W-44-O2-LIT-626-2		0	146	IN WC	LOX Storage Tank 2-2 Level			20" W.C.	95" W.C.	102" W.C.	Turbine shutdown		
136		11	1	5	AI	W-44-O2-PIT-616-1		0	80	PSIG	LOX Storage Tank 1-1 Pressure	Signal to be split between DCS and SLC							
137		11	1	6	AI	W-44-O2-PIT-626-1		0	100	PSIG	LOX Storage Tank 1-2 Pressure	Signal to be split between DCS and SLC							
138	W44-I-113-A	11	1	7	AI	W-44-O2-PIT-616-2		0	80	PSIG	LOX Storage Tank 2-1 Pressure	Signal to be split between DCS and SLC							
139	W44-I-113-B	11	1	8	AI	W-44-O2-PIT-626-2		0	100	PSIG	LOX Storage Tank 2-2 Pressure	Signal to be split between DCS and SLC							
140		11	1	9	AI						Wired Spare								
140	Not Shown	11	1	10	AI	W-44-O2-PIT-630		0	80	PSIG	O2 From Product Vaporizers Press								
141	W44-I-115	11	1	11	AI	W-44-O2-PIT-635	PI-635	0	15	PSIG	Back Up Product Pressure Transmitter								
142		11	1	12	AI						Wired Spare								
143		11	2	1	AO	W-44-O2-PV-615-1/ W-44-O2-PV-616-1		0	100	% OPEN	LOX Storage Tank 1-1 Press Build/Economizer Valves (split range)	Relay switches between DCS and SLC							
144	W44.00-I-113A	11	2	3	AO	W-44-O2-PV-615-2/ W-44-O2-PV-616-2	PV-616X or PCV-616	0	100	% OPEN	LOX Storage Tank 2-1 Press Build/Economizer Valves I/P (split range)	Relay switches between DCS and SLC							
145		11	2	2	AO	W-44-O2-PV-625-1/ W-44-O2-PV-626-1		0	100	% OPEN	LOX Storage Tank 1-2 Press Build/Economizer Valves I/P (split range)	Relay switches between DCS and SLC							
145	W44.00-I-113B	11	2	4	AO	W-44-O2-PV-625-2/ W-44-O2-PV-626-2	PV-626X or PCV-626	0	100	% OPEN	LOX Storage Tank 2-2 Press Build/Economizer Valves I/P (split range)	Relay switches between DCS and SLC							
146		11	2	5	AO						Wired Spare								
146	W44.00-I-	11	2	6	AO	W-44-O2-PY-635	FY-635	0	20	PSIG	Product O2 Back-up Valve	Relay switches between DCS and SLC							
147	W44.00-I-	11	3	1	TC	W-44-O2-TE-635		-20	150	F	Temperature From Product Vaporizer, Thermocouple Type	Signal to be split between DCS and SLC							

NOTES:

- 1) ALL RTDs SHALL BE WIRED FOR 3-WIRE 100 OHM PLATINUM ELEMENTS
- 2) ALL T/C SHALL BE TYPE 'T' EXCEPT THE 2 THAW HTR ELEMENTS WHICH ARE TYPE 'K' AS NOTED
- 3) ALL ANALOG OUTPUTS SHALL BE WIRED FOR 4-20MA UON.

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Plant #2
CC SCHED. COORD. 10-11-2022, LAM
PID COORD. 10-11-2022, LAM

I/O RACK DIGITAL SIGNALS

ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	DIGITAL TYPE	PLC TAG NUMBER	P&ID TAG No.	ACTION		DESCRIPTION	COMMENTS	ALARM STATE		TRIP STATE		PERMISSIVE STATE		
								SWITCH CLOSED	SWITCH OPEN			SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)
CPU RACK #1																		
1		1	2	1	DI	W-44-O2-ASL-355-1	HMI Alarm			Plt. 1 O2 Purity Low			X					
2		1	2	2	DI	W-44-AHP-PB-502-1-1				MAC 1-1 Main Control Panel E-Stop	Replace hard-wired button				X	MAC shutdown	X	MAC will start
3		1	2	3	DI	W-44-AHP-PB-502-2-1				MAC 2-1 Main Control Panel E-Stop	Replace hard-wired button				X	MAC shutdown	X	MAC will start
4		1	2	4	DI	UA-UPS-1				Plt 1 UPS Failure	New UPS; to all plt. 1 racks Revised Inst. No. per Dillon	X						
5		1	2	5	DI					Wired Spare								
6		1	2	6	DI	RL-550-2-1				Plt. 1 Thaw Heater Element 1 On Status		X						
7		1	2	7	DI	RL-550-3-1				Plt 1 Thaw Heater Element 2 On Status		X						
8		1	2	8	DI	RL-505-1-1-1				MAC 1-1 Aux Oil Pump Run Status	TMR MINIMUM 10 MIN PRE LUBE	X				Auxiliary Oil Pump Running	X	MAC will start
9		1	2	9	DI	RL-505-1-2-1				MAC 2-1 Aux Oil Pump Run Status	TMR MINIMUM 10 MIN PRE LUBE	X				Auxiliary Oil Pump Running	X	MAC will start
10		1	2	10	DI	RL-500-8-1-1				MAC 1-1 Run Status			X			Tripped from Switchgear		
11		1	2	11	DI	RL-500-8-2-1				MAC 2-1 Run Status			X			Tripped from Switchgear		
12		1	2	12	DI	M-1-1-1				MAC 1-1 Switchgear Trip		X						
13		1	2	13	DI	M-1-2-1				MAC 2-1 Switchgear Trip		X						
14		1	2	14	DI	RL-550-1				Plt 1 Thaw Heater Failure		X						
15		1	2	15	DI					Wired Spare								
16		1	3	1	DI	W-44-CWS-PSL-800				Plt 1 Low Cooling Water Pressure	TMR 15 SEC Below 20 PSIG				X	MAC shutdown	X	MAC will start
17		1	3	2	DI	W-44-IA-MSH-580-1				Back-up Instrument Air High Moisture			X					
18		1	4	1	RO	W-44-AHP-PB-502-1-1			STOP	MAC 1-1 Stop								
19		1	4	2	RO	W-44-AHP-PB-502-2-1			STOP	MAC 2-1 Stop								
20		1	4	3	RO	PB-550-1	HMI PUSH Button		STOP	Plt. # 1 Thaw Heater Stop								
21		1	4	4	RO	PB-551-1	HMI PUSH Button	START		Plt. #1 Thaw Heater Start								
22		1	4	5	DI					Wired Spare								
CPU RACK #2																		
23	Not Shown	2	2	1	DI	W-44-O2-ASL-355-2				Plt 2 O2 Purity Low			X					
24	Not Shown	2	2	2	DI	W-44-AHP-PB-502-1-2				MAC 1-2 Main Control Panel E-Stop	Replace hard-wired button				X	MAC shutdown	X	MAC will start
25	Not Shown	2	2	3	DI	W-44-AHP-PB-502-2-2				MAC 2-2 Main Control Panel E-Stop	Replace hard-wired button				X	MAC shutdown	X	MAC will start
26	Not Shown	2	2	4	DI	UA-UPS-2				Plt 2 UPS Failure	New UPS; to all plt. 1 racks	X						
27	Not Shown	2	2	5	DI					Wired Spare								
28	Not Shown	2	2	6	DI	RL-550-2-2				Plt. 2 Thaw Heater Element 1 On Status		X						
29	Not Shown	2	2	7	DI	RL-550-3-2				Plt. 2 Thaw Heater Element 2 On Status		X						
30	Not Shown	2	2	8	DI	RL-505-1-1-1				MAC 1-2 Aux Oil Pump Run Status	TMR MINIMUM 10 MIN PRE LUBE	X				Auxiliary Oil Pump Running	X	MAC will start
31	Not Shown	2	2	9	DI	RL-505-1-2-1				MAC 2-2 Aux Oil Pump Run Status	TMR MINIMUM 10 MIN PRE LUBE	X				Auxiliary Oil Pump Running	X	MAC will start
32	Not Shown	2	2	10	DI	RL-500-8-1-2				MAC 1-2 Run Status			X			Tripped from Switchgear		
33	Not Shown	2	2	11	DI	RL-500-8-2-2				MAC 2-2 Run Status			X			Tripped from Switchgear		
34	Not Shown	2	2	12	DI	M-1-1-2				MAC 1-2 Switchgear Trip	Also use for run status	X						
35	Not Shown	2	2	13	DI	M-1-2-2				MAC 2-2 Switchgear Trip	Also use for run status	X						
36	Not Shown	2	2	14	DI	RL-550-2				Plt 2 Thaw Heater Failure		X						
37	Not Shown	2	2	15	DI					Wired Spare								
38	Not Shown	2	3	1	DI	W-44-CWS-PSL-800				Plt. 2 Low Cooling Water Pressure	TMR 15 SEC 20 PSIG				X	MAC shutdown	X	MAC will start
39	Not Shown	2	3	2	DI	MSH-580				Back-up Instrument Air High Moisture	Revised Instr. No. per Dillon		X					
40	Not Shown	2	4	1	RO	W-44-AHP-PB-502-1-2			ON	MAC 1-2 Stop								
41	Not Shown	2	4	2	RO	W-44-AHP-PB-502-2-2				MAC 2-2 Stop								
42	Not Shown	2	4	3	RO	PB-550-2	HMI PUSH Button		ON	Plt. # 2 Thaw Heater Stop								
43	Not Shown	2	4	4	RO	PB-551-2	HMI PUSH Button	ON		Plt. #2 Thaw Heater Start								
44	Not Shown	2	4	5	RO					Wired Spare								

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Plant #2
CC SCHED. COORD. 10-11-2022, LAM
PID COORD. 10-11-2022, LAM

I/O RACK DIGITAL SIGNALS

ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	DIGITAL TYPE	PLC TAG NUMBER	P&ID TAG No.	ACTION		DESCRIPTION	COMMENTS	ALARM STATE		TRIP STATE		PERMISSIVE STATE			
								SWITCH CLOSED	SWITCH OPEN			SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION
MAIN AIR COMPRESSOR 1-1																			
45		3	3	1	DI	W-44-LOS-LSL-50-1-1				Lube Oil Tank Level Low				X	MAC shutdown				
46		3	3	2	DI	W-44-LOS-PSL-54-1-1		START		MAC 1-1 Low Oil Pressure Shutdown First Out		X		X	MAC shutdown	X			
47		3	3	3	DI	W-44-AHP-PSH-503-1-1				Discharge Pressure High	75 PSI			X	MAC shutdown				
48		3	3	4	DI	MU/WTR-1-1				Motor Winding Temp High			X						
49		3	3	5	DI	RL-511-1-1-1				MAC 1-1 Shutdown or Alarm			X						
50		3	3	6	DI	TISH-510-1-1				Motor Outboard Bearing Temp High	Replaced with W-44-AHP-TE-510-1-1A & W-44-AHP-TE-510-1-1B								
51		3	3	7	DI	TISH-511-1-1				Motor Inboard Bearing Temp High	Replaced with W-44-AHP-TE-511-1-1A & W-44-AHP-TE-511-1-1B								
52		3	3	8	DI	W-44-AHP-TSH-506-1-1				MAC 1-1 Discharge Temp High High				X	MAC shutdown				
53		3	3	9	DI	W-44-AHP-TSH-506-1-1				Wired Spare	Replace hard-wired button								
54		3	3	10	DI	W-44-AHP-TSH-506-1-1			STOP	MAC 1-1 Stop Button (Local Panel)	Replace hard-wired button								
55		3	4	1	RO	PB-500-1-1		START		MAC 1-1 Start; Vibration Bypass	Replace with HMI button								
56		3	4	2	RO	W-44-AHP-PB-501-1-1			STOP	MAC 1-1 Stop Button (Local Panel)									
57		3	4	3	RO	W-44-IA-FY-500-1-1		OPEN	CLOSE	MAC 1-1 Inlet Guide Vane Solenoid									
58		3	4	4	RO	W-44-EXH-FY-506-1-1		OPEN	CLOSE	MAC 1-1 Vent Valve Solenoid									
59		3	4	5	RO	W-44-LOS-SW-50-1-1		START		MAC 1-1 Oil Heater Off/Auto									
60		3	4	6	RO	W-44-LOS-SW-53-1-1		START		MAC 1-1 Aux Oil Pump Auto/Off									
61		3	4	7	RO					Wired Spare	Replace hard-wired button								
MAIN AIR COMPRESSOR 2-1																			
62		4	3	1	DI	W-44-LOS-LSL-50-2-1				Lube Oil Tank Level Low				X	MAC shutdown				
63		4	3	2	DI	W-44-LOS-PSL-54-2-1		START		MAC 2-1 Low Oil Pressure Shutdown First Out		X		X	MAC shutdown	X			
64		4	3	3	DI	W-44-AHP-PSH-503-2-1				Discharge Pressure High	75 PSI			X	MAC shutdown				
65		4	3	4	DI	MU/WTR-2-1				Motor Winding Temp High			X						
66		4	3	5	DI	RL-511-1-2-1				MAC 2-1 Shutdown or Alarm			X						
67		4	3	6	DI	TISH-510-2-1				Motor Outboard Bearing Temp High									
68		4	3	7	DI	TISH-511-2-1				Motor Inboard Bearing Temp High									
69		4	3	8	DI	W-44-AHP-TSH-506-2-1				MAC 2-1 Discharge Temp High High				X	MAC shutdown				
70		3	3	9	DI	W-44-AHP-TSH-506-2-1				Wired Spare									
71		4	3	10	DI	W-44-AHP-TSH-506-2-1			STOP	MAC 2-1 Stop Button (Local Panel)	Replace hard-wired button								
72		4	4	1	RO	PB-500-2-1		START		MAC 2-1 Start; Vibration Bypass									
73		4	4	2	RO	W-44-AHP-PB-501-2-1			STOP	MAC 2-1 Stop Button (Local Panel)									
74		4	4	3	RO	W-44-IA-FY-500-2-1		OPEN	CLOSE	MAC 2-1 Inlet Guide Vane Solenoid									
75		4	4	4	RO	W-44-EXH-FY-506-2-1		OPEN	CLOSE	MAC 2-1 Vent Valve Solenoid									
76		4	4	5	RO	W-44-LOS-SW-50-2-1		START		MAC 2-1 Oil Heater Off/Auto									
77		4	4	6	RO	W-44-LOS-SW-53-2-1		START		MAC 2-1 Aux Oil Pump Auto/Off									
78		4	4	7	RO					Wired Spare									
MAIN AIR COMPRESSOR 1-2																			
79	W44.00-I-110A	5	3	1	DI	W-44-LOS-LSL-50-1-2		START		Lube Oil Tank Level Low				X	MAC shutdown				
80	W44.00-I-110A	5	3	2	DI	W-44-LOS-PSL-54-1-2			START	MAC 1-2 Low Oil Pressure Shutdown First Out		X		X	MAC shutdown	X			
81	W44.00-I-110B	5	3	3	DI	W-44-AHP-PSH-503-1-2				Discharge Pressure High	75 PSI			X	MAC shutdown				
82	Not Shown	5	3	4	DI	MU/WTR-1-2				Motor Winding Temp High			X						
83	Not Shown	5	3	5	DI	RL-511-1-1-2				MAC 1-2 Shutdown or Alarm			X						
84	W44.00-I-110A	5	3	6	DI	TISH-510-1-2				Motor Outboard Bearing Temp High									
85	W44.00-I-110A	5	3	7	DI	TISH-511-1-2				Motor Inboard Bearing Temp High									
86	W44.00-I-110B	5	3	8	DI	W-44-AHP-TSH-506-1-2	TSH-506			MAC 1-2 Discharge Temp High High				X	MAC shutdown				
87	Not Shown	3	3	9	DI	W-44-AHP-TSH-506-1-2				Wired Spare									
88	Not Shown	5	3	10	DI	W-44-AHP-TSH-506-1-2			STOP	MAC 1-2 Stop Button (Local Panel)	Replace hard-wired button								
89	Not Shown	5	4	1	RO	PB-500-1-2		START		MAC 1-2 Start; Vibration Bypass									
90	Not Shown	5	4	2	RO	W-44-AHP-PB-501-1-2			STOP	MAC #1-2 Stop Button (Local Panel)									
91	W44.00-I-110A	5	4	3	RO	W-44-IA-FY-500-1-2	PY-500	OPEN	CLOSE	MAC 1-2 Inlet Guide Vane Solenoid									
92	W44.00-I-110B	5	4	4	RO	W-44-EXH-FY-506-1-2		OPEN	CLOSE	MAC 1-2 Vent Valve Solenoid									
93	Not Shown	5	4	5	RO	W-44-LOS-SW-50-1-2		START		MAC 1-2 Oil Heater Off/Auto									
94	Not Shown	5	4	6	RO	W-44-LOS-SW-53-1-2		START		MAC 1-2 Aux Oil Pump Auto/Off									
95	Not Shown	5	4	7	RO					Wired Spare									

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I/O RACK DIGITAL SIGNALS

ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	DIGITAL TYPE	PLC TAG NUMBER	P&ID TAG No.	ACTION		DESCRIPTION	COMMENTS	ALARM STATE		TRIP STATE		PERMISSIVE STATE			
								SWITCH CLOSED	SWITCH OPEN			SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION
MAIN AIR COMPRESSOR 2-2																			
96		6	3	1	DI	W-44-LOS-LSL-50-2-2				Lube Oil Tank Level Low				X	MAC shutdown				
97		6	3	2	DI	W-44-L-LOS-PSL-54-2-2		START		MAC 2-2 Low Oil Pressure Shutdown First		X			X	MAC shutdown	X		
98		6	3	3	DI	W-44-AHP-PSH-503-2-2				Discharge Pressure High	75 PSI				X	MAC shutdown			
99		6	3	4	DI	MU/WTR-2-2				Motor Winding Temp High			X						
100		6	3	5	DI	RL-511-1-2-2				MAC 2-2 Shutdown or Alarm			X						
101		6	3	6	DI	TISH-510-2-2				Motor Outboard Bearing Temp High									
102		6	3	7	DI	TISH-511-2-2				Motor Inboard Bearing Temp High									
103		6	3	8	DI	W-44-AHP-PSH-503-2-2				MAC 2-2 Discharge Temp High High				X		MAC shutdown			
104		3	3	9	DI	W-44-AHP-PSH-503-2-2				Wired Spare									
105		6	3	10	DI	W-44-AHP-PSH-503-2-2			STOP	MAC 2-2 Stop Button (Local Panel)	Replace hard-wired button								
106		6	4	1	RO	PB-500-2-2		START		MAC 2-2 Start; Vibration Bypass									
107		6	4	2	RO	W-44-AHP-PB-501-2-2			STOP	MAC 2-2 Stop Button (Local Panel)									
108		6	4	3	RO	W-44-IA-FY-500-2-2			OPEN	MAC 2-2 Inlet Guide Vane Solenoid									
109		6	4	4	RO	W-44-EXH-FY-506-2-2			OPEN	MAC 2-2 Vent Valve Solenoid									
110		6	4	5	RO	W-44-LOS-SW-50-2-2			START	MAC 2-2 Oil Heater Off/Auto									
111		6	4	6	RO	W-44-LOS-SW-53-2-2			START	MAC 2-2 Aux Oil Pump Auto/Off									
112		6	4	7	RO					Wired Spare									
CRYO PLANT 1																			
113		7	4	1	DI	W-44-AHP-LSH-501-1		OK	SHUTD OWN	Surge Tank High Water Level			X		X	Set alarm with shutdown warning for 5 mins.; MAC shutdown			
114		7	4	2	DI	W-44-AHP-ZSC-111-1		CLOSE	OPEN	Switch Valve FCV-111 Closed Position	"B" Pass Air In			A RHX switch valve failure is initiated by pressure in the "A" pass (W-44-AHP-PIT-200-1 & -2) coupled with position feedback from the switch valves. When air is in the "A" pass (W-44-AHP-ZSH-112 indicating open), the air pressure (W-44-AHP-PIT-200-1 & -2) must be >40 PSIG. If the pressure is below that value for more than 10 seconds, the air compressor will shut down. When air is in the "B" pass (W-44-AHP-ZSH-111 indicating open), the air pressure (W-44-AHP-PIT-200-1 & -2) must be < 5 PSIG. If the pressure is above that value for more than 10 seconds, the air compressor					
115		7	4	3	DI	W-44-AHP-ZSC-112-1		CLOSE	OPEN	Switch Valve FCV-112 Closed Position	"A" Pass Air In								
116		7	4	4	DI	W-44-N2-ZSC-113-1		CLOSE	OPEN	Switch Valve FCV-113 Closed Position	"B" Pass Waste N2 Out								
117		7	4	5	DI	W-44-N2-ZSC-114-1		CLOSE	OPEN	Switch Valve FCV-114 Closed Position	"A" Pass Waste N2 Out								
118		7	4	6	DI	W-44-AHP-ZSO-111-1		OPEN	CLOSED	Switch Valve FCV-111 Open Position	"B" Pass Air In								
119		7	4	7	DI	W-44-AHP-ZSO-112-1		OPEN	CLOSED	Switch Valve FCV-112 Open Position	"A" Pass Air In								
120		7	4	8	DI	W-44-N2-ZSO-113-1		OPEN	CLOSED	Switch Valve FCV-113 Open Position	"B" Pass Waste N2 Out								
121		7	4	9	DI	W-44-N2-ZSO-114-1		OPEN	CLOSED	Switch Valve FCV-114 Open Position	"A" Pass Waste N2 Out								
122		7	4	10	DI	UA-PET-1		OK	SHUTD OWN	Plant Emergency Trip Activated					X	MAC shutdown			
123		7	4	11	DI					Wired Spare									
124		7	5	1	RO	SW-111-1		OPEN	CLOSE	FV111 Switch Valve Control	Replace with HMI Switch								
125		7	5	2	RO	SW-112-1		OPEN	CLOSE	FV112 Switch Valve Control	Replace with HMI Switch								
126		7	5	3	RO	SW-113-1		OPEN	CLOSE	FV113 Switch Valve Control	Replace with HMI Switch								
127		7	5	4	RO	SW-114-1		OPEN	CLOSE	FV114 Switch Valve Control	Replace with HMI Switch								
128		7	5	5	RO					Wired Spare									
129		7	5	6	RO	W-44-O2-LY-330-1		OPEN	CLOSE	Kettle Transfer Solenoid									
130		7	5	7	RO	W-44-N2-FY-340N-1		OPEN	CLOSE	Shelf Flow Valve Solenoid									
131		7	5	8	RO	W-44-O2-LY-350X-1		OPEN	CLOSE	Liquid Make Valve LV-350X's Solenoid									
132		7	5	9	RO	W-44-O2-LY-351X-1		OPEN	CLOSE	Liquid Add Valve LV-351X's Solenoid									
133		7	5	10	RO					Wired Spare									
134		7	5	11	RO	W-44-O2-PY-600-1		OPEN	CLOSE	Oxygen Product Valve Solenoid									
135		7	5	12	RO	W-44-O2-FY-601-1		OPEN	CLOSE	Oxygen Vent Valve Solenoid									
136		7	5	13	RO					Wired Spare									
137		7	5	14	RO	W-44-AHP-LY-510-1		OPEN	CLOSE	Surge Tank Condensate Drain Solenoid	Include operator adjustable timers for interval and								
138		7	5	15	RO	W-44-N2-PY-349-1		OPEN	CLOSE	Upper Column Vent Valve									
139		7	5	16	RO					Wired Spare									

CRYO I/O LIST, 5 January 2024
SD428 ASU I-O List

I/O LIST
SPECIFICATION 40 61 00c

Plant #2
CC SCHED. COORD. 10-11-2022, LAM
PID COORD. 10-11-2022, LAM

I/O RACK DIGITAL SIGNALS

ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	DIGITAL TYPE	PLC TAG NUMBER	P&ID TAG No.	ACTION		DESCRIPTION	COMMENTS	ALARM STATE		TRIP STATE		PERMISSIVE STATE			
								SWITCH CLOSED	SWITCH OPEN			SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION
CRYO PLANT 2																			
140	W44.00-I-110B	8	4	1	DI	W-44-AHP-LSH-501-2		OK	SHUTD OWN	Surge Tank High Water Level			X		X	Set alarm with shutdown warning for 5 mins.; MAC shutdown			
141	W44.00-I-111A	8	4	2	DI	W-44-AHP-ZSC-111-2		CLOSE	OPEN	Switch Valve FCV-111 Closed Position	"B" Pass Air In			A RHX switch valve failure is initiated by pressure in the "A" pass (W-44-AHP-PIT-200-1 & -2) coupled with position feedback from the switch valves. When air is in the "A" pass (W-44-AHP-ZSH-112 indicating open), the air pressure (W-44-AHP-PIT-200-1 & -2) must be >40 PSIG. If the pressure is below that value for more than 10 seconds, the air compressor will shut down. When air is in the "B" pass (W-44-AHP-ZSH-111 indicating open), the air pressure (W-44-AHP-PIT-200-1 & -2) must be < 5 PSIG. If the pressure is above that value for more than 10 seconds, the air compressor					
142	W44.00-I-111A	8	4	3	DI	W-44-AHP-ZSC-112-2		CLOSE	OPEN	Switch Valve FCV-112 Closed Position	"A" Pass Air In								
143	W44.00-I-111A	8	4	4	DI	W-44-N2-ZSC-113-2		CLOSE	OPEN	Switch Valve FCV-113 Closed Position	"B" Pass Waste N2 Out								
144	W44.00-I-111A	8	4	5	DI	W-44-N2-ZSC-114-2		CLOSE	OPEN	Switch Valve FCV-114 Closed Position	"A" Pass Waste N2 Out								
145	Not Shown	8	4	6	DI	W-44-AHP-ZSO-111-2		OPEN	CLOSED	Switch Valve FCV-111 Open Position	"B" Pass Air In								
146	Not Shown	8	4	7	DI	W-44-AHP-ZSO-112-2		OPEN	CLOSED	Switch Valve FCV-112 Open Position	"A" Pass Air In								
147	Not Shown	8	4	8	DI	W-44-N2-ZSO-113-2		OPEN	CLOSED	Switch Valve FCV-113 Open Position	"B" Pass Waste N2 Out								
148	Not Shown	8	4	9	DI	W-44-N2-ZSO-114-2		OPEN	CLOSED	Switch Valve FCV-114 Open Position	"A" Pass Waste N2 Out								
149	Not Shown	8	4	10	DI	UA-PET-2		OK	SHUTD OWN	Plant Emergency Trip Activated					X	MAC shutdown			
150	Not Shown	8	4	11	DI					Wired Spare									
151	W44.00-I-111A	8	5	1	RO	SW-111-2	FCV-111A	OPEN	CLOSE	FV111 Switch Valve Control									
152	W44.00-I-111A	8	5	2	RO	SW-112-2	FCV-112A	OPEN	CLOSE	FV112 Switch Valve Control									
153	W44.00-I-111A	8	5	3	RO	SW-113-2	FCV-113N	OPEN	CLOSE	FV113 Switch Valve Control									
154	W44.00-I-111A	8	5	4	RO	SW-114-2	FCV-114N	OPEN	CLOSE	FV114 Switch Valve Control									
155	Not Shown	7	5	5	RO					Wired Spare									
156	W44.00-I-112A	8	5	6	RO	W-44-O2-LY-330A-2	FY-330	OPEN	CLOSE	Kettle Transfer Solenoid									
157	W44.00-I-112A	8	5	7	RO	W-44-N2-FY340N-2	FY-340	OPEN	CLOSE	Shelf Flow Valve Solenoid									
158	W44.00-I-112B	8	5	8	RO	W-44-O2-LY-350X-2		OPEN	CLOSE	Liquid Make Valve LV-350X Solenoid									
159	W44.00-I-112B	8	5	9	RO	W-44-O2-LY-351X-2		OPEN	CLOSE	Liquid Add Valve LV-351X Solenoid									
160	Not Shown	8	5	10	RO					Wired Spare									
161	W44.00-I-111A	8	5	11	RO	W-44-O2-PY-600 -2		OPEN	CLOSE	Oxygen Product Valve Solenoid									
162	W44.00-I-111A	8	5	12	RO	W-44-O2-FY-601-2		OPEN	CLOSE	Oxygen Vent Valve Solenoid									
163	Not Shown	8	5	13	RO					Wired Spare									
164	W44.00-I-110B	8	5	14	RO	W-44-N2-LY-510-2		OPEN	CLOSE	Surge Tank Condensate Drain Solenoid	Include operator adjustable timers for interval and								
165	W44.00-I-112A	8	5	15	RO	W-44-N2-PY-349-2	FY-349	OPEN	CLOSE	Upper Column Vent Valve									
166	Not Shown	8	5	16	RO					Wired Spare									
TURBINE PLANT #1																			
167		9	4	1	DI	W-44-IA-PSL-580-1				Seal Gas Pressure Low	15 PSIG				X	Turbine shutdown	X		Turbine will start
168		9	4	2	DI	W-44-LOS-TSH-24-1-1				Lube Oil Return Temp High First Out	175 F		X						
169		9	4	3	DI	SISH-219-1				Turbine Speed High	27,500 RPM (Monitored by W-44-AHP-ST-219-1, not a physical switch)				X	Turbine shutdown			
170		9	4	4	DI	SISL-219-1				Turbine Speed Low	10,000 RPM (Monitored by W-44-AHP-ST-219-1, not a physical switch)				X	Turbine shutdown			
171		9	5	1	RO	W-44-AHP-FY-213-1		OPEN	CLOSE	Turbine Bypass Solenoid									
172		9	5	2	RO	W-44-IA-FY-220-1		OPEN	CLOSE	Starting Unload Solenoid	Energize above 10,000 RPM								
173		9	5	3	RO	PB-213-1				Turbine Lube Oil Pump Off/On	Now an HMI switch								
174		9	5	4	RO	PB-211-1		OPEN	CLOSE	Plt. #1 Turbine Start Button	Now an HMI switch								
175		9	5	5	RO	W-44-AHP-FY-215-1		OPEN	CLOSE	Unbalanced Air Valve Solenoid									
176	Not Shown	9	5	6	RO					Wired Spare									
TURBINE PLANT #2																			
177	W44.00-I-111B	10	4	1	DI	W-44-IA-PSL-580-2				Seal Gas Pressure Low	15 PSIG				X	Turbine shutdown	X		Turbine will start
178	W44.00-I-111B	10	4	2	DI	W-44-LOS-TSH-24-1-2				Lube Oil Return Temp High First Out	175 F		X				X		Turbine will start
179	W44.00-I-111B	10	4	3	DI	SISH-219-2				Turbine Speed High	27,500 RPM (Monitored by W-44-AHP-ST-219-2, not a physical switch)				X	Turbine shutdown			
180	W44.00-I-111B	10	4	4	DI	SISL-219-2				Turbine Speed Low	10,000 RPM (Monitored by W-44-AHP-ST-219-2, not a physical switch)				X	Turbine shutdown			
181	W44.00-I-111B	10	5	1	RO	W-44-AHP-FY-213-2		OPEN	CLOSE	Turbine Bypass Valve Solenoid									
182	W44.00-I-111B	10	5	2	RO	W-44-LOS-FY-220-2		OPEN	CLOSE	Starting Unload Solenoid	Energize above 10,000 RPM								
183	Not Shown	10	5	3	RO	PB-213-2				Turbine Lube Oil Pump Off/On									
184	Not Shown	10	5	4	RO	PB-211-2		OPEN	CLOSE	Plt. #2 Turbine Start Button									
185	W44.00-I-111B	10	5	5	RO	W-44-AHP-FY-215-2		OPEN	CLOSE	Unbalanced Air Valve Solenoid									
186	Not Shown	10	5	6	RO					Wired Spare									

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Plant #2
CC SCHED. COORD. 10-11-2022, LAM
PID COORD. 10-11-2022, LAM

I/O RACK DIGITAL SIGNALS

ITEM #	P&ID SHEET #	BRANCH #	MOD #	CHANNEL #	DIGITAL TYPE	PLC TAG NUMBER	P&ID TAG No.	ACTION		DESCRIPTION	COMMENTS	ALARM STATE		TRIP STATE		PERMISSIVE STATE		
								SWITCH CLOSED	SWITCH OPEN			SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)	ACTION	SWITCH CLOSED (ON)	SWITCH OPEN (OFF)
LOX BACK-UP SYSTEM																		
187		11	4	1	DI	PSL-616-1				DRIOX Storage Tank #1-1 Low Pressure Alarm	Replaced with Logic		X					
188		11	4	2	DI	PSL-626-1				DRIOX Storage Tank #2-1 Low Pressure Alarm	Replaced with Logic		X					
189	Not Shown	11	4	3	DI	PSL-616-2				DRIOX Storage Tank #1-2 Low Pressure Alarm	Replaced with Logic		X					
190	Not Shown	11	4	4	DI	PSL-626-2				DRIOX Storage Tank #2-2 Low Pressure Alarm	Replaced with Logic		X					
191	Not Shown	11	4	5	DI					Wired Spare								
192	W44.00-I-115	11	4	6	DI	W-44-O2-TSH-631				Water Bath Temp High (200F)								
193	W44.00-I-115	11	4	7	DI	W-44-O2-TSL-631				Water Bath Temp Low (100F)								
194	Not Shown	11	4	8	DI	W-44-O2-TSL-634				LOX Vaporizer Discharge Temp Low		X						
195	W44.00-I-115	11	4	9	DI	W-44-O2-TSL-640		CLOSE	OPEN	Economizer Outlet Temp Low	Closes FV-616 & FV-626							
196	W44.00-I-115	11	4	10	DI	W-44-O2-TSL-690		CLOSE	OPEN	Drain Vaporizer Outlet Temp Low	Closes FV-690							
197	Not Shown	11	4	11	DI					Wired Spare								
198	W44.00-I-113A	11	5	1	RO	W-44-O2-FY-616		OPEN	CLOSE	Economizer Valve Solenoid								
199	W44.00-I-115	11	5	2	RO	W-44-O2-FY-635		OPEN	CLOSE	Product Valve Solenoid								
200	W44.00-I-115	11	5	3	RO	W-44-O2-FY-690		OPEN	CLOSE	Drain Valve Solenoid								
201	Not Shown	11	5	4	RO					Wired Spare								
202		11	5	5	RO	W-44-O2-PY-616-1		OPEN	CLOSE	LOX Tank 1-1 Economizer Valve Solenoid								
203		11	5	6	RO	W-44-O2-PY-616-2		OPEN	CLOSE	LOX Tank 1-2 Economizer Valve Solenoid								
204	W44.00-I-113A	11	5	7	RO	W-44-O2-PY-626-1		OPEN	CLOSE	LOX Tank 2-1 Economizer Valve Solenoid								
205	W44.00-I-113B	11	5	8	RO	W-44-O2-PY-626-2		OPEN	CLOSE	LOX Tank 2-2 Economizer Valve Solenoid								
206	Not Shown	11	4	9	RO					Wired Spare								

NOTES:
1) ALL DIGITAL INPUTS & OUTPUTS ARE 120V AC UON.

CRYO I/O LIST, 5 January 2024
SD428 ASU I-O List

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SPECIFICATION 40 61 00c
CONTROL BYPASSES

<u>BYPASS TAG NO.</u>	<u>DESCRIPTION</u>
HS-1-1	MAC 1-1 Vibration Bypass
HS-1-2	MAC 1-2 Vibration Bypass
HS-2-1	MAC 2-1 Vibration Bypass
HS-2-2	MAC 2-2 Vibration Bypass
HS-111-1	Cryo Plant 1 Switch Valve Failure Bypass
HS-111-2	Cryo Plant 2 Switch Valve Failure Bypass
HS-219-1	Turbine 1 Low Speed Bypass
HS-219-2	Turbine 2 Low Speed Bypass
HS-352-1	Cryo Plant 1 Condenser Level Bypass
HS-352-2	Cryo Plant 2 Condenser Level Bypass
HS-355-1	Cryo Plant 1 Hydrocarbon Analyzer Bypass
HS-355-2	Cryo Plant 2 Hydrocarbon Analyzer Bypass

END OF SECTION

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I/O LIST

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I/O LIST

SECTION 40 70 00

INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Provide labor, materials, and equipment necessary to install and start-up instruments as specified in accordance with this Section and applicable reference standards listed in Section 40 61 01.
2. All process instruments provided shall meet the entire manufacturer's published performance specifications for functional and operational parameters whether or not specifically specified for the item in these Specifications.
3. The instruments specified in this Section are the primary element components for the control loops shown on the "I" series Drawings and specified under Division 40. These instruments are integrated with other control system components specified under Division 40 specification series to produce the functional control defined in the Contract Documents.

B. Work by Others: as specified in Section 40 61 01.

C. Related Sections:

1. Section 01 33 00 – Submittal Procedures.
2. Section 01 75 17 – Field Testing and Startup.
3. Section 01 91 13.10 – Asset Identification Tags.
4. Section 40 05 00 – Common Work Results for Process Interconnections
5. Section 40 61 01 – Instrumentation and Controls General Requirements.

1.2 DESIGN CRITERIA

- A. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by the Contractor.
- B. Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

- C. The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the drawings or as indicated in the Instrument Index. The instruments shall be installed at the locations indicated on the drawings or in the Instrument Index.
- D. Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the drawings or in the Instrument Index. Transmitters or similar measurement instruments shall be calibrated using National Institute Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the drawings and/or Instrument Index.

1.3 REFERENCES

- A. Reference Standards: in accordance with Section 40 61 01.
- B. Definitions: in accordance with Section 40 61 01.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 and 40 61 01.
- B. Product Data and Shop Drawings
 - 1. Instrument data sheet for each instrument
 - 2. Product name and tag number as shown on the Drawings
 - 3. Manufacturers complete model number
 - 4. Location of device
 - 5. Input - output characteristics
 - 6. Range, size, and graduations
 - 7. Physical size with dimensions, NEMA enclosure classification and mounting details
 - 8. Materials of construction of components
 - 9. Calibration certificates provided by manufacturer
 - 10. Supply Voltage and frequency
 - 11. Electrical Load
 - 12. Operating environment
 - 13. Accuracy

- 14. Description of operation, and Operating Instructions
- 15. Mounting requirements with dimensions and elevations
- 16. Connection and input/output diagrams
- 17. Manufacturer's installation instructions
- 18. Certified factory and field calibration data sheets with stated accuracy
- 19. Warranty Data
- C. Closeout and maintenance material submittals: in accordance with Division 01 General Requirements and Section 40 61 01.

1.5 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 01 General Requirements.
- B. Equipment provided under this section shall be shipped, protected, and stored in accordance with the manufacturer recommendations.

1.7 SITE CONDITIONS

- A. Existing Conditions: per Division 01 General Requirements.

1.8 MAINTENANCE

- A. Provide in accordance with Section 40 61 01.

PART 2 – PRODUCTS

2.1 INSTRUMENTATION – GENERAL

- A. Provide brackets and hangers for all equipment.
- B. Instrumentation supplied must be the manufacturer's latest design and produce or be activated by signals that are established standards for the water and wastewater industries.
- C. Instrumentation requiring power supplied from a source other than the control panel to which it is connected must operate on 120 VAC, single phase, 60 HZ current, unless specifically indicated otherwise. This power will be supplied from the closest local electrical lighting panel with a breaker for each circuit.
- D. Electronic instrumentation must be solid-state. Analog control signals shall be linear and be industry standard currents of 4 to 20 mA DC, however, signals

between instruments within the same panel or cabinet may be 1-5 VDC, or the like. No zero-based signals are allowed.

- E. Unless otherwise specified or shown, equipment shall be rated for service NEMA 4X, SS-316, outdoors, fully exposed, explosion proof, corrosive environment.
- F. Outputs of equipment that are not of the standard signals as outlined, will have the output immediately raised or converted to compatible standards signals for remote transmission. No zero-based signals are allowed.
- G. Instruments shall be provided with stainless steel mounting hardware or galvanized steel floor stands, wall brackets, or instrument racks as appropriate for each location.
- H. Equipment installed in a hazardous area shall meet class, group, and division as shown on the electrical Drawings, to comply with the National Electrical Code.
- I. Indicators and recorder readouts must be linear in the process units.
- J. Transmitters shall be provided with either integral indicators or remote-mount indicators with process units accurate to plus or minus 2 percent.
- K. Electronic equipment must be the manufacturer's latest design. Circuit boards and associated components must have suitable conformal coating to prevent contamination by dust, moisture, and fungus. Solid-state components must be conservatively rated for their purpose to assure optimum long-term performance and dependability over normally anticipated atmospheric conditions of temperature, pressure, and humidity. The field-mounted equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions.
- L. Instruments furnished shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and will consist of equipment models that are currently in production. All equipment provided shall be of modular construction and be capable of field expansion.
- M. Lightning/Surge Suppression - Provide individual surge protection means for each field instrument mounted outside the building from the control panel to which they are connected. Instruments mounted inside the same building as the control panel to which they are connected shall not require surge protection.
- N. Instruments shall be provided as indicated on the instrument index and in the Instrument Data Sheets, included as an attachment at the end of this Section. These documents include the instrument tag names, physical requirements, control requirement, and basis of design manufacturer and model number information.
- O. All instrumentation making contact with process fluids shall be oxygen cleaned and be completely functional in oxygen service.

2.2 INSTRUMENTS

- A. Provide as specified in the Instrument Index and Data Sheets.

2.3 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

PART 3 – EXECUTION

3.1 INSTALLATION AND MOUNTING

- A. Provide labor, tools, material, and equipment required to install instruments in the locations shown on the Drawings, in accordance with manufacturer-recommended installation and mounting practices. The location of equipment, transmitters, alarms, and similar devices shown on the Drawings are approximate only. Exact locations shall be approved by the Engineer during construction. Obtain in the field information relevant to the placing of process control Work and in case of any interference with other Work, proceed as requested by the Engineer.
- B. Make necessary mechanical changes to install new instrumentation and associated equipment provided under this Contract. This Work includes fittings, fabrications, supports, guides, restraints, bolting, gaskets, and accessories.
- C. The instrumentation Drawings indicate the intent of the interconnections between the individual instruments. Any exceptions should be noted and communicated to the Engineer in writing.
- D. Instrument cabinets located outdoors or in unheated locations shall be provided with heating or cooling devices as necessary to maintain all instruments and/or electronics installed in those cabinets within their design temperature limits.
- E. Install brackets and hangers to avoid interference with other equipment.
- F. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded as directed by the manufacturer of the instrumentation equipment, but in no case shall more than 1 ground point be employed for each shield.
- G. Coordinate the installation, placing and location of system components, their connections to the process equipment panels, cabinets, and devices. Ensure field wiring for power and signal circuits is done in accordance with best Industry Practice and provide for necessary system grounding to ensure a satisfactory and functioning installation.
- H. For replacement of existing gas flow meters, provide all mechanical fittings for connection to existing stainless steel gas piping. Perform all electrical and controls wiring connections and perform calibrations and adjustments required to interface with existing systems.

- I. Gas flow meters shall be installed with a minimum 20 pipe diameters upstream straight run and 10 pipe diameters downstream straight run.

3.2 INSPECTION AND TESTING

- A. Submit detailed test, procedure, and startup instructions for each instrument.
- B. Provide the services of a qualified service representative for checking the installation, making the necessary adjustments and calibrations, placing the equipment in operation, and performing the acceptance tests. The representative will be available for not less than 2 days to instruct operating personnel in the use, operation, and maintenance of the equipment during the initial operating period.
- C. Test and calibrate in place the instrumentation to demonstrate that it meets the accuracy requirements for the conditions specified. Provide labor, equipment, and incidentals required for the tests, including electric power, water, instrument air, etc. required for tests. The Engineer will witness field tests and conduct field inspections. Provide the Engineer a minimum of 10 working days' notice of the dates and times scheduled for tests. Rectify any deficiencies found and retest Work affected by such deficiencies at the Contractor's expense. Record data from each field test will be recorded and documented in a formal field test report.

3.3 FIELD TESTING AND STARTUP

- A. Provide in accordance with Section 01 75 17 – Field Testing and Startup.

3.4 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Division 01 General Requirements.

3.5 ATTACHMENTS

- A. Data Sheets

END OF SECTION



Industrial Gases & Services
74 Sail Away Lane,
Moneta, Va 24121
1 513-939-9380
info@solutionwerks.com

TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	1 OF 14
CURRENT TRANSDUCERS							
#	BY	DATE	REVISION	PROJECT #	SD428		
0	RH	01/17/22	INITIAL	SPEC. #			
1	DB	02/01/23	90% Design	P.O. #			
2	DB	January 2024	100% Design	PREPARED BY	RH		
3	DB	April 2024	100% Design	CHECKED BY			
4							

TAG NUMBER	W-44-AHP-IT-500
SERVICE	Main Air Comp Motor Current
MANUFACTURER	PHOENIX CONTACT. NO SUBSTITUTIONS ALLOWED.
QTY	4

SERVICE CONDITIONS		
FLUID	N/A	
OPER. TEMP.	-20 TO 60 DEGC	
OPER. PRESS.	N/A	
STATE	N/A	
AMBIENT TEMP.	120 DEGF	

DESIGN DETAILS		
TYPE (ELEC/PNEUM)	ELECTRICAL/ELECTRONIC	
OUTPUT SIGNAL	4-20 mA	
POWER SUPPLY	LOOP 24 VDC	
ADJUSTABLE RANGE	N/A	
CALIBRATED RANGE	0-200A / 4-20 mADC	
ACCURACY	+/- 1% OF END VALUE	
SENSOR	CT	
PROCESS CONN. SIZE	N/A	
ELECTRICAL CLASS	CLASS 1 DIV 2	
DISPLAY	N/A	
MOUNTING BRACKET	DIN RAIL	

MATERIALS		
ELECTR. HOUSING	POLYAMIDE PA	
WETTED PARTS	N/A	
HARDWARE	STD	
FILL FLUID	N/A	
MODEL NO.	MCR-SL-S-200-I-LP	

ACCESSORIES		
	TAGS: IT-500-1-1 IT-500-1-2 IT-500-2-1 IT-500-2-2	
MANUFACTURER		
MODEL NO.		
MANUFACTURER		
MODEL NO.		

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.

Industrial Gases & Services
74 Sail Away Lane,
Moneta, Va 24121
1 513-939-9380
info@solutionwerks.com

ANALYZER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	2 of 14
PROCESS ANALYZERS							
#	BY	DATE	REVISION	PROJECT #	SD-428		
0	RH	11/11/21	INITIAL	SPEC. #			
1	RH	01/17/22	REVISED AIT-312, ADDED TAGS	P.O. #			
2	DB	1/31/23	90% Design	PREPARED BY	RLH		
3	DB	January 2024	100% Design	CHECKED BY			
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-O2-AIT-312	W-44-O2-AIT-352	W-44-O2-AIT-355
SERVICE	Nitrogen Purity Analyzer (Waste or Shelf)	Hydrocarbon Analyzer	Product Oxygen Purity Analyzer
MANUFACTURER	Servomex, Siemens, or equal	Servomex, Siemens or equal	Servomex, Siemens or equal
MODEL	MultiExact 4100 or 7MB2011-1AA00AA1	Servopro FID or 7MB2421-1BA100A2	MultiExact 4100 or 7MB2011-1AA00AA1
QTY	2	2	2

SERVICE CONDITIONS				
FLUID	GAN	GOX from MC	GOX product	
STATE	VAPOR	VAPOR	VAPOR	
OPER. TEMP/PRESS.	5 psig	5 psig	5 psig	
SP.GR. @ OP. T&P				
AMBIENT TEMP.	60-105 DEGF	60-105 DEGF	60-105 DEGF	
SENSOR				
TYPE	PARAMAGNETIC	FID	PARAMAGNETIC	
REQ. FLOW RATE	1-2 SCFH	1 SLPM	1-2 SCFH	
RESPONSE	90% FS IN <10 SEC	90% FS IN <15 SEC	90% FS IN <10 SEC	
ACCURACY	+/-1% FS	+/- 2% FS	+/-1% FS	
ZERO DRIFT	1% O2/1 MONTH	2% FS / 1 WEEK	1% O2/1 MONTH	
REPEATABILITY	0.1%/FS	1% FS	0.1%/FS	
ZERO GAS	ZERO GRADE AIR	UHP O2 <.1 PPM HC	ZERO GRADE AIR	
SPAN GAS	UHP O2	90% FS PPM / BAL O2	UHP O2	
TRANSMITTER				
OUTPUT SIGNAL	4-20 mAdc	4-20 mAdc	4-20 mAdc	
ELECT CLASS	GP	GP	GP	
POWER SUPPLY	120 VAC	120 VAC	120 VAC	
MOUNTING	FLUSH- 19"	FLUSH- 19"	FLUSH-19"	
CALIBRATED RANGE	0-100%	0-100 PPM	0-100 %	
INTEGRAL DISPLAY	5 DIGIT RED LED	LED	5 DIGIT RED LED	
AMB TEMP RANGE	32 TO 113 DEGF	40 TO 110 DEGF	32 TO 113 DEGF	
XMTR HOUSING	GP	GP	GP	
OPTIONS				
4-20 MADC OUT				
SENSOR	Paramagnetic	FID	Paramagnetic	
OUTPUT ADAPTER				
OEM				
	TAGS: AIT-312-1 AIT-312-2	COMB AIR HC FREE AIR FUEL GAS 40/60 H2/N2 TAGS: AIT-352-1, AIT-352-2	TAGS: AIT-355-1 AIT-355-2	

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13 10 Asset Identification Tags.

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TRANSMITTER PURCHASE SPECIFICATION			PROJECT:	EBMUD	SHEET #:	3 of 14
FLOW TRANSMITTERS						
#	BY	DATE	REVISION		PROJECT #	SD428
0	RH	11/11/21	INITIAL		SPEC. #	
1	DB	02/01/23	90% Design		P.O. #	
2	DB	January 2024	100% Design		PREPARED BY	RLH
3	DB	April 2024	100% Design		CHECKED BY	
4						

TAG NUMBER	W-44-AHP-FIT-115	W-44-AHP-FIT-120	W-44-N2-FIT-340	W-44-O2-FIT-600
SERVICE	Unbalanced Air Flow Transmitter	Cold End Air Flow Transmitter	Shelf Flow Transmitter	Oxygen Flow Transmitter
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2
QTY	2	2	2	2

SERVICE CONDITIONS.				
FLUID	VAPOR	VAPOR	VAPOR	VAPOR
OPER. TEMP.	AMBIENT	AMBIENT	AMBIENT	AMBIENT
OPER. PRESS.	65 PSIG	65 PSIG	65 PSIG	10 PSIG
SP.GR. @ OP. T&P				
AMBIENT TEMP.	45 TO 105 DEGF	45 TO 105 DEGF	45 TO 105 DEGF	45 TO 105 DEGF
DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC	ELECTRONIC	ELECTRONIC	ELECTRONIC
OUTPUT SIGNAL	4-20 mADC	4-20 mADC	4-20 mADC	4-20 mADC
POWER SUPPLY	LOOP 24 VDC	LOOP 24 VDC	LOOP 24 VDC	LOOP 24 VDC
ADJUSTABLE RANGE				
CALIBRATED RANGE				
ACCURACY	+/- 0.1% SPAN	+/- 0.1% SPAN	+/- 0.1% SPAN	+/- 0.1% SPAN
MAX. ALLOW. PRESS.	2000 PSIG	2000 PSIG	2000 PSIG	2000 PSIG
PROCESS CONN. SIZE	½" NPT	½" NPT	½" NPT	½" NPT
ELECTRICAL CLASS	4X	4X	4X	4X
DISPLAY	LCD	LCD	LCD	LCD
MOUNTING BRACKET	COPLANAR 2" PIPE	COPLANAR 2" PIPE	COPLANAR 2" PIPE	COPLANAR 2" PIPE

MATERIALS				
ELECTR. HOUSING	ALUMINUM	ALUMINUM	ALUMINUM	ALUMINUM
WETTED PARTS	SST	SST	SST	SST
HARDWARE	SST	SST	SST	SST
FILL FLUID	INERT	INERT	INERT	INERT
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	3051CDXA22A2AS5B4M5Q4P2	3051CDXA22A2AS5B4M5Q4P2	3051CDXA22A2AS5B4M5Q4P2	3051CDXA22A2AS5B4M5Q4P2
ACCESSORIES				
MANIFOLD	3-VALVE	3-VALVE	3-VALVE	3-VALVE
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	4 of 14
FLOW TRANSMITTERS							
#	BY	DATE	REVISION		PROJECT #		SD428
0	RH	11/11/21	INITIAL		SPEC. #		
1	RH	01/14/22	ADDITIONS		P.O. #		
2	DB	02/01/23	90% Design		PREPARED BY		RLH
3	DB	January 2024	100% Design		CHECKED BY		
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-AHP-FIT-502
SERVICE	Main Air Comp, 3rd Stage DP For Anti-Surge Control
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
QTY	4

SERVICE CONDITIONS		
FLUID	AIR	
OPER. TEMP.	AMBIENT	
OPER. PRESS.	65 PSIG	
SP.GR. @ OP. T&P		
AMBIENT TEMP.	45 TO 105 DEGF	

DESIGN DETAILS		
TYPE (ELEC/PNEUM)	ELECTRONIC	
OUTPUT SIGNAL	4-20 mA DC	
POWER SUPPLY	LOOP 24 VDC	
ADJUSTABLE RANGE	-250 TO 250 INWC	
CALIBRATED RANGE	0-100 INWC	
ACCURACY	+/- 0.1% SPAN	
MAX. ALLOW. PRESS.	2000 PSIG	
PROCESS CONN. SIZE	1/2" NPT	
ELECTRICAL CLASS	4X	
DISPLAY	LCD	
MOUNTING BRACKET	COPLANAR 2" PIPE	

MATERIALS		
ELECTR. HOUSING	ALUMINUM	
WETTED PARTS	SST	
HARDWARE	SST	
FILL FLUID	INERT	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	3051CD2A22A2AS5B4M5Q4P2	

ACCESSORIES		
MANIFOLD	3-VALVE	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	0305-R-C-3-2B-11-B4-P2	
MANUFACTURER		

GENERAL NOTES: Vendor to supply a permanently attached stainless steel nameplate, engraved with the instrument tag.



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TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	5 of 14
LEVEL TRANSMITTERS							
#	BY	DATE	REVISION		PROJECT #		SD428
0	RH	11/11/21	INITIAL		SPEC. #		
1	DB	02/01/23	90% Design		P.O. #		
2	DB	January 2024	100% Design		PREPARED BY		RLH
3	DB	April 2024	100% Design		CHECKED BY		
4							

TAG NUMBER	W-44-O2-LIT-330	W-44-O2-LIT-352
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
SERVICE	Kettle Level Transmitter	Upper Column Level Transmitter
QTY	2	2

SERVICE CONDITIONS			
FLUID	VAPOR	VAPOR	
OPER. TEMP.	AMBIENT	AMBIENT	
OPER. PRESS.	65 PSIG	65 PSIG	
SP.GR. @ OP. T&P			
AMBIENT TEMP.	45 TO 105 DEGF	45 TO 105 DEGF	

DESIGN DETAILS			
TYPE (ELEC/PNEUM)	ELECTRONIC	ELECTRONIC	
OUTPUT SIGNAL	4-20 mADC	4-20 mADC	
POWER SUPPLY	LOOP 24 VDC	LOOP 24 VDC	
ADJUSTABLE RANGE	-250 TO +250 INWC	-250 TO +250 INWC	
CALIBRATED RANGE	0-100 INWC	0-88 INWC	
ACCURACY	+/- 0.1% SPAN	+/- 0.1% SPAN	
MAX. ALLOW. PRESS.	2000 PSIG	2000 PSIG	
PROCESS CONN. SIZE	½" NPT	½" NPT	
ELECTRICAL CLASS	4X	4X	
DISPLAY	LCD	LCD	
MOUNTING BRACKET	COPLANAR 2" PIPE	COPLANAR 2" PIPE	

MATERIALS			
ELECTR. HOUSING	ALUMINUM	ALUMINUM	
WETTED PARTS	SST	SST	
HARDWARE	SST	SST	
FILL FLUID	INERT	INERT	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	3051CD2A22A2AS5B4M5Q4P2	3051CD2A22A2AS5B4M5Q4P2	

ACCESSORIES			
MANIFOLD	3-VALVE	3-VALVE	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	0305-R-C-3-2B-11-B4-P2	0305-R-C-3-2B-11-B4-P2	

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.

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TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	6 of 14
PRESSURE TRANSMITTER							
#	BY	DATE	REVISION	PROJECT #	SD428		
0	RH	10/13/21	INITIAL	SPEC. #			
1	RH	01/18/22	UPDATED TAGS; MODEL CODES	P.O. #			
2	DB	02/01/23	90% Design	PREPARED BY	RH		
3	DB	January 2024	100% Design	CHECKED BY			
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-AHP-PIT-214	W-44-ALP-PIT-216	W-44-N2-PIT-300	W-44-O2-PIT-352
SERVICE	TURBINE INLET PRESSURE	TURBINE OUTLET PRESSURE	LOWER COLUMN PRESSURE	MAIN CONDENSER PRESS.
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
QTY	2	2	2	2

SERVICE CONDITIONS				
FLUID	AIR	AIR	AIR	AIR
OPER. TEMP.	70 °F	70 °F	70 °F	70 °F
OPER. PRESS.	60 PSIG	15 PSIG	60 PSIG	15 PSIG
STATE	VAPOR	VAPOR	VAPOR	VAPOR
AMBIENT TEMP.	20-110 DEGF	20-110 DEGF	20-110 DEGF	20-110 DEGF
DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)
OUTPUT SIGNAL	4-20 mA	4-20 mA	4-20 mA	4-20 mA
POWER SUPPLY	24 VDC	24 VDC	24 VDC	24 VDC
ADJUSTABLE RANGE	-14.2 TO +300 PSIG	-14.2 TO +36 PSIG	-14.2 TO +300 PSIG	-14.2 TO +36 PSIG
CALIBRATED RANGE	0 to 100 PSIG	0 TO 15 PSIG	0 to 100 PSIG	0 TO 15 PSIG
ACCURACY	0.075 % SPAN	0.075 % SPAN	0.075 % SPAN	0.075 % SPAN
MAX. ALLOW. PRESS.	3626 PSIG	3626 PSIG	3626 PSIG	3626 PSIG
PROCESS CONN. SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
ELECTRICAL CLASS	NEMA 4X	NEMA 4X	NEMA 4X	NEMA 4X
DISPLAY	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR
MOUNTING BRACKET	2" PIPE	2" PIPE	2" PIPE	2" PIPE

MATERIALS				
ELECTR. HOUSING	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH
WETTED PARTS	316 SS	316 SS	316 SS	316 SS
HARDWARE	316 SS	316 SS	316 SS	316 SS
FILL FLUID	INERT	INERT	INERT	INERT
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2	3051CG-3-A22-A2A-S5-B4-M5-Q4-P2	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2	3051CG-3-A22-A2A-S5-B4-M5-Q4-P2

ACCESSORIES				
	2-VALVE MANIFOLD	2-VALVE	2-VALVE	2-VALVE
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	0305RC22B11B4P2	0305RC22B11B4P2	0305RC22B11B4P2	0305RC22B11B4P2
MANUFACTURER				
MODEL NO.				

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	7 OF 14
PRESSURE TRANSMITTER							
#	BY	DATE	REVISION		PROJECT #	SD428	
0	RH	11/11/21	INITIAL		SPEC. #		
1	RH	01/14/22	REVISIONS, ADDITIONS		P.O. #		
2	RH	01/18/22	REVISIONS, ADDITIONS		PREPARED BY	RH	
3	DB	02/01/23	90% Design		CHECKED BY		
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-AHP-PIT-506	W-44-LOS-PIT-53	W-44-IA-PIT-590
SERVICE	Discharge Pressure	Main Air Comp, Lube Oil Supply Press	Instrument Air Press
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
P&ID	4	4	2

SERVICE CONDITIONS				
FLUID	AIR	LUBE OIL	AIR	
OPER. TEMP.	70 °F	120 °F	AMBIENT	
OPER. PRESS.	60 PSIG	40 PSIG	60 PSIG	
STATE	VAPOR	LIQUID	VAPOR	
AMBIENT TEMP.	40-105 DEGF	40-105 DEGF	40-105 DEGF	

DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)	
OUTPUT SIGNAL	4-20 mA	4-20 mA	4-20 mA	
POWER SUPPLY	24 VDC	24 VDC	24 VDC	
ADJUSTABLE RANGE	-300 TO +300 PSIG	-300 TO +300 PSIG	-300 TO +300 PSIG	
CALIBRATED RANGE	0 to 100 PSIG	0-50 PSIG	0-100 PSIG	
ACCURACY	0.075 % SPAN	0.075 % SPAN	0.075 % SPAN	
MAX. ALLOW. PRESS.	3626 PSIG	3626 PSIG	3626 PSIG	
PROCESS CONN. SIZE	1/2" NPT	1/2" NPT	1/2" NPT	
ELECTRICAL CLASS	NEMA 4X	NEMA 4X	NEMA 4X	
DISPLAY	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	
MOUNTING BRACKET	2" PIPE	2" PIPE	2" PIPE	

MATERIALS				
ELECTR. HOUSING	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	
WETTED PARTS	316 SS	316 SS	316 SS	
HARDWARE	316 SS	316 SS	316 SS	
FILL FLUID	INERT	INERT	INERT	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2	

ACCESSORIES				
MANIFOLD	2-VALVE	2-VALVE	2-VALVE	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	0305RC22B11B4P2	0305RC22B11B4P2	0305RC22B11B4P2	
MANUFACTURER				
MODEL NO.				

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	8 OF 14
PRESSURE TRANSMITTER							
#	BY	DATE	REVISION		PROJECT #		SD428
0	RH	01/14/22	INITIAL		SPEC. #		
1	RH	01/18/22	REVISED MODEL CODES		P.O. #		
2	DB	02/01/23	90% Design		PREPARED BY		RH
3	DB	January 2024	100% Design		CHECKED BY		
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-AHP-PIT-200	W-44-N2-PIT-349	W-44-O2-PIT-600	W-44-LOR-PIT-20
SERVICE	RHX Pass "A" Air / Waste Press	Upper Column Pressure	Product O2 From Cold Box Press	Expansion Turbine Lube Oil To Filters Press
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2	3051CG-3-A22-A2A-S5-B4-M5-Q4-P2	3051CG-3-A22-A2A-S5-B4-M5-Q4-P2	3051CG-4-A22-A2A-S5-B4-M5-Q4-P2
QTY	2	2	1	2

SERVICE CONDITIONS				
FLUID	AIR	OXYGEN	OXYGEN	LUBE OIL
OPER. TEMP.	150 °F	70 °F	AMBIENT	120 °F
OPER. PRESS.	60 PSIG	5 PSIG	5 PSIG	140 PSIG
STATE	VAPOR	VAPOR	VAPOR	VAPOR
AMBIENT TEMP.	40-105 DEGF	40-105 DEGF	40-105 DEGF	40-105 DEGF
DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)
OUTPUT SIGNAL	4-20 mA	4-20 mA	4-20 mA	4-20 mA
POWER SUPPLY	24 VDC	24 VDC	24 VDC	24 VDC
ADJUSTABLE RANGE	-300 TO +300 PSIG	-36 TO +36 PSIG	-36 TO +36 PSIG	-300 TO +300 PSIG
CALIBRATED RANGE	0 to 100 PSIG	0-15 PSIG	-2.5 TO 10 PSIG	0-200 PSIG
ACCURACY	0.075 % SPAN	0.075 % SPAN	0.075 % SPAN	0.075 % SPAN
MAX. ALLOW. PRESS.	3626 PSIG	3626 PSIG	3626 PSIG	3626 PSIG
PROCESS CONN. SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
ELECTRICAL CLASS	NEMA 4X	NEMA 4X	NEMA 4X	NEMA 4X
DISPLAY	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR
MOUNTING BRACKET	2" PIPE	2" PIPE	2" PIPE	2" PIPE

MATERIALS				
ELECTR. HOUSING	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH
WETTED PARTS	316 SS	316 SS	316 SS	316 SS
HARDWARE	316 SS	316 SS	316 SS	316 SS
FILL FLUID	INERT	INERT	INERT	INERT

ACCESSORIES				
MANIFOLD	2-VALVE	2-VALVE	2-VALVE	2-VALVE
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	0305RC22B11B4P2	0305RC22B11B4P2	0305RC22B11B4P2	0305RC22B11B4P2
MANUFACTURER				
MODEL NO.				

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.

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TRANSMITTER PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	9 OF 14
PRESSURE TRANSMITTER							
#	BY	DATE	REVISION	PROJECT #	SD428		
0	RH	01/14/22	INITIAL	SPEC. #			
1	RH	01/18/22	REVISED MODEL CODES	P.O. #			
2	DB	3/2/22	Additions	PREPARED BY	RH		
3	DB	02/01/23	90% Design	CHECKED BY			
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-O2-PIT-630	W-44-O2-PIT-635		
SERVICE	O2 Product from Vaporizer Pressure	Back-up product pressure		
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.		
QTY	1	1		

SERVICE CONDITIONS				
FLUID	Oxygen	OXYGEN		
OPER. TEMP.	70 °F	70 °F		
OPER. PRESS.	5 PSIG	5 PSIG		
STATE	VAPOR	VAPOR		
AMBIENT TEMP.	40-105 DEGF	40-105 DEGF		

DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC (SMART - HART)	ELECTRONIC (SMART - HART)		
OUTPUT SIGNAL	4-20 mA	4-20 mA		
POWER SUPPLY	24 VDC	24 VDC		
ADJUSTABLE RANGE	-36 TO +36 PSIG	-36 TO +36 PSIG		
CALIBRATED RANGE	0-15 PSIG	0-15 PSIG		
ACCURACY	0.075 % SPAN	0.075 % SPAN		
MAX. ALLOW. PRESS.	3626 PSIG	3626 PSIG		
PROCESS CONN. SIZE	1/2" NPT	1/2" NPT		
ELECTRICAL CLASS	NEMA 4X	NEMA 4X		
DISPLAY	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR		
MOUNTING BRACKET	2" PIPE	2" PIPE		

MATERIALS				
ELECTR. HOUSING	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH		
WETTED PARTS	316 SS	316 SS		
HARDWARE	316 SS	316 SS		
FILL FLUID	INERT	INERT		
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.		
MODEL NO.	3051CG-4-A22-AA-S5-B4-M5-Q4-P2	3051CG-3-A22-A2A-S5-B4-M5-Q4-P2		

ACCESSORIES				
MANIFOLD	2-VALVE	2-VALVE		
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.		
MODEL NO.	0305RC22B11B4P2	0305RC22B11B4P2		

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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SWITCH PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	10 OF 14
TEMPERATURE SWITCHES							
#	BY	DATE	REVISION		PROJECT #		SD428
0	RH	12/17/21	INITIAL		SPEC. #		
1	RH	01/18/22	ADDED TAGS		P.O. #		
2	DB	02/01/23	90% Design		PREPARED BY		RLH
3	DB	January 2024	100% Design		CHECKED BY		
4	DB	April 2024	100% Design				

TAG NUMBER	W-44-AHP-TSHH-506		
SERVICE	MAC#1 DISCHARGE TEMPERATURE		
MANUFACTURER	UNITED ELECTRIC. NO SUBSTITUTIONS ALLOWED.		
MODEL NO.	F400 7BS M201 M446		
QTY	4		

SERVICE CONDITIONS				
FLUID	AIR			
OPER. TEMP.	AMBIENT			
OPER. PRESS.	THERMOWELL			
RANGE	0-400 DEGF			
SETPOINT	160 DEGF INC			

DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRIC			
OUTPUT SIGNAL	CONTACT			
POWER SUPPLY	N/A			
CONTACTS QTY	1			
CONTACT RATING	15A 125 VAC			
CONTACT CONFIG	SPDT			
VISUAL INDICATOR	NONE			
PROCESS CONN. SIZE	BULB 3/8" X 3" + 20' CAPILLARY			
ELECTRICAL CLASS	NEMA 4X			
ELECTRICAL CONN	7/8" ELEC. OPENING			
MOUNTING BRACKET	PROCESS/WALL MOUNT			

MATERIALS				
HOUSING	DIE-CAST ALUMINUM			
DIAPHRAGM/FILL	NON-TOXIC OIL FILLED			
PROCESS CONN.	BULB 3/8" X 3" + 20' CAPILLARY			
PROOF PRESS	N/A			
ADDL. MODEL INFO	SW: 160 DEGF INC			
ADDL. MODEL INFO	20 FOOT CAPILLARY LENGTH			

ACCESSORIES				
	TAGS: TSHH-506-1-1 TSHH-506-1-2 TSHH-506-2-1 TSHH-506-2-2			
MANUFACTURER				
MODEL NO.				

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.

SWITCH PURCHASE SPECIFICATION				PROJECT:	EBMUD	SHEET #:	11 OF 14
THERMOCOUPLES / RTDs							
#	BY	DATE	REVISION		PROJECT #	SD428	
0	RH	12/28/21	INITIAL		SPEC. #		
1	RH	01/17/22	30% Design		P.O. #		
2	DB	02/01/23	90% Design		PREPARED BY	RLH	
3	DB	January 2024	100% Design		CHECKED BY		
4	DB	April 2024	100% Design				

TAG NUMBER	VARIOUS - SEE LIST	VARIOUS - SEE LIST	VARIOUS - SEE LIST
SERVICE	VARIOUS FOR 2"-6" PIPE	VARIOUS FOR 8" - 12" PIPE	VARIOUS FOR 18" - 20" PIPE
MANUFACTURER	OMEGA OR EQUAL	OMEGA OR EQUAL	OMEGA OR EQUAL
MODEL NO.	NB4-CPSS-14U-4-CAL-3	NB4-CPSS-14U-4-CAL-3	NB4-CPSS-14U-4-CAL-3
QTY	2	2	2

SERVICE CONDITIONS				
FLUID	VARIES	VARIES	VARIES	
OPER. TEMP.	CRYOGENIC	CRYOGENIC	CRYOGENIC	
OPER. PRESS.	<70 PSIG	<70 PSIG	<70 PSIG	
SP.GR. @ OP. T&P	N/A	N/A	N/A	
AMBIENT TEMP.	N/A	N/A	N/A	

DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRIC	ELECTRIC	ELECTRIC	
OUTPUT SIGNAL	THERMOCOUPLE VOLTAGE	THERMOCOUPLE VOLTAGE	THERMOCOUPLE VOLTAGE	
SENSOR DIAMETER	3/8" OD	3/8" OD	3/8" OD	
SENSOR LENGTH	3.5"	5.5"	8.5"	
CABLE LENGTH	150 FT.	150 FT.	150 FT.	
SENSOR TYPE	Dual, UNGROUNDED	Dual, UNGROUNDED	Dual, UNGROUNDED	
THERMOCOUPLE TYPE	"T" COPPER/CONSTANTAN	"T" COPPER/CONSTANTAN	"T" COPPER/CONSTANTAN	
PROCESS CONN. SIZE	3/8" SWAGELOK	3/8" SWAGELOK	3/8" SWAGELOK	
PIPE CONN	3/8" SWAGELOK MALE ADAPTER	3/8" SWAGELOK MALE ADAPTER	3/8" SWAGELOK MALE ADAPTER	
THERMOWELL				

MATERIALS				
SENSOR	304 SS	304 SS	304 SS	
CABLE	PFA INSULATED	PFA INSULATED	PFA INSULATED	
HARDWARE	316L SS	316L SS	316L SS	
HEAD				

TAGS				
	TE-154-1, -2	TE-149-1, -2	TE-184-1, -2	
	TE-155-1, -2	TE-186-1, -2	TE-185-1, -2	
	TE-190-1, -2	TE-201-1, -2	TE-187-1, -2	
	TE-191-1, -2	TE-216-1, -2	TE-188-1, -2	
	TE-215-1, -2			
	TE-150-1, -2			
	TE-24-1, -2			

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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SWITCH PURCHASE SPECIFICATION			PROJECT:	EBMUD	SHEET #:	12 OF 14
THERMOCOUPLES / RTDs						
#	BY	DATE	REVISION	PROJECT #	SD428	
0	RH	01/17/22	INITIAL	SPEC. #		
1	DB	02/01/23	90% Design	P.O. #		
2	DB	January 2024	100% Design	PREPARED BY	RLH	
3	DB	April 2024	100% Design	CHECKED BY		
4						

TAG NUMBER	W-44-AHP-TE-552
SERVICE	Thaw Heater Outlet Temp
MANUFACTURER	BURNS OR EQUAL
MODEL NO.	100GKD035/LY240M02C40A240/FC0324
QTY	2

SERVICE CONDITIONS		
FLUID	AIR	
OPER. TEMP.	350 DEGF	
OPER. PRESS.	70 PSIG	
SP.GR. @ OP. T&P	N/A	
AMBIENT TEMP.	N/A	

DESIGN DETAILS		
TYPE (ELEC/PNEUM)	ELECTRIC	
OUTPUT SIGNAL	THERMOCOUPLE VOLTAGE	
SENSOR DIAMETER	3/8" OD	
SENSOR LENGTH	3.5"	
CABLE LENGTH	20 FT.	
SENSOR TYPE	Dual, UNGROUNDED	
THERMOCOUPLE TYPE	TYPE K	
PROCESS CONN. SIZE	3/8" MNPT	
PIPE CONN	3/8" SWAGelok MALE ADAPTER	
THERMOWELL	YES	

MATERIALS		
SENSOR	316L SS	
CABLE	CHROMEL/INCONEL	
HARDWARE	316L SS	
HEAD	N/A	

TAGS		
	TE-552-1	
	TE-552-2	

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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TRANSMITTER PURCHASE SPECIFICATION			PROJECT:	EBMUD	SHEET #:	13 OF 14
TEMPERATURE TRANSMITTERS						
#	BY	DATE	REVISION		PROJECT #	SD428
0	RH	01/17/22	INITIAL		SPEC. #	
1	DB	02/01/23	90% Design		P.O. #	
2	DB	January 2024	100% Design		PREPARED BY	RH
3	DB	April 2024	100% Design		CHECKED BY	
4						

TAG NUMBER	W-44-LOS-TIT-53	W-44-AHP-TIT-505	W-44-O2-TIT-635
SERVICE	Main Air Comp, Lube Oil Supply Temp	Air From Main Air Comp, Aftercooler Temp	Air From Main Air Comp, Aftercooler Temp
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	644-F-A-NA-R2-M5-Q4-XA	644-FA-R2-B5-M5-Q4-XA	644-FA-R2-B5-M5-Q4-XA
QTY	4	4	4

SERVICE CONDITIONS				
FLUID	LUBE OIL	AIR	Oxygen	
OPER. TEMP.	120 °F	100 DEGF	100 DEGF	
OPER. PRESS.	60 PSIG	65 PSIG	10 PSIG	
STATE	LIQUID	VAPOR	VAPOR	
AMBIENT TEMP.	45 TO 105 DEGF	45 TO 105 DEGF	45 TO 105 DEGF	

DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC (SMART - HART)	ELECTRONIC	ELECTRONIC	
OUTPUT SIGNAL	4-20 mA	4-20 mADC	4-20 mADC	
POWER SUPPLY	LOOP 24 VDC	LOOP 24 VDC	LOOP 24 VDC	
ADJUSTABLE RANGE	-328 TO 1562 DEGF	-328 TO 1562 DEGF	-328 TO 1562 DEGF	
CALIBRATED RANGE	0 to 150 DEGF	0-120 DEGF	-20-120 DEGF	
ACCURACY	+/- 0.18 DEGC	+/- 0.18 DEGC	+/- 0.18 DEGC	
SENSOR	100 OHM PLAT RTD	100 OHM PLAT RTD	100 OHM PLAT RTD	
PROCESS CONN. SIZE	½" NPT	½" NPT	½" NPT	
ELECTRICAL CLASS	NEMA 4X	NEMA 4X	NEMA 4X	
DISPLAY	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	LCD LOCAL INDICATOR	
MOUNTING BRACKET	L-BRACKET FOR 2" PIPE	L-BRACKET FOR 2" PIPE	L-BRACKET FOR 2" PIPE	

MATERIALS				
ELECTR. HOUSING	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	ALUMINUM w/ POLY FINISH	
WETTED PARTS	316 SS	316 SS	316 SS	
HARDWARE	316 SS	316 SS	316 SS	
FILL FLUID	INERT	N/A	N/A	

ACCESSORIES				
	SENSOR/THERMOWELL	SENSOR	SENSOR/Thermowell	
MANUFACTURER	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	ROSEMOUNT. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	0068-N21-C30-A-030-T26-XA	0068-N21-C30-A-060-T26-XA	0068-N21-C30-A-060-T26-XA	
	TAGS: TIT-53-1-1 TIT-53-1-2 TIT-53-2-1 TIT-53-2-1	TAGS: TIT-505-1-1 TIT-505-1-2 TIT-505-2-1 TIT-505-2-1	TAGS: TIT-635	

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.



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TRANSMITTER PURCHASE SPECIFICATION			PROJECT:	EBMUD	SHEET #:	14 OF 14
VIBRATION TRANSMITTERS						
#	BY	DATE	REVISION		PROJECT #	SD428
0	RH	01/14/22	INITIAL		SPEC. #	
1	RH	01/18/22	ADDED TAGS		P.O. #	
2	DB	02/01/23	90% Design		PREPARED BY	RLH
3	DB	January 2024	100% Design		CHECKED BY	
4	DB	April 2024	100% Design			

TAG NUMBER	W-44-LOS-VE-501	W-44-LOS-VE-502	W-44-LOS-VE-503
SERVICE	Main Air Comp, 1st Stage Vibration	Main Air Comp, 2nd Stage Vibration	Main Air Comp, 3rd Stage Vibration
MANUFACTURER	BENTLY NEVADA. NO SUBSTITUTIONS ALLOWED.	BENTLY NEVADA. NO SUBSTITUTIONS ALLOWED.	BENTLY NEVADA. NO SUBSTITUTIONS ALLOWED.
MODEL NO.	990-05-50-03-00	990-05-50-03-00	990-05-50-03-00
QTY	4	4	4

SERVICE CONDITIONS				
FLUID	N/A	N/A	N/A	
OPER. TEMP.	150 DEGF	150 DEGF	150 DEGF	
OPER. PRESS.	65 PSIG	65 PSIG	65 PSIG	
SP.GR. @ OP. T&P	N/A	N/A	N/A	
AMBIENT TEMP.	45 TO 105 DEGF	45 TO 105 DEGF	45 TO 105 DEGF	

DESIGN DETAILS				
TYPE (ELEC/PNEUM)	ELECTRONIC	ELECTRONIC	ELECTRONIC	
OUTPUT SIGNAL	4-20 mADC	4-20 mADC	4-20 mADC	
POWER SUPPLY	LOOP 24 VDC	LOOP 24 VDC	LOOP 24 VDC	
ADJUSTABLE RANGE	200mV/MIL	200mV/MIL	200mV/MIL	
CALIBRATED RANGE	0-1.5 MILS	0-1.5 MILS	0-1.5 MILS	
ACCURACY	+/-1.5% SCALE	+/-1.5% SCALE	+/-1.5% SCALE	
TEMP RANGE	-31 TO 350 DEGF	-31 TO 350 DEGF	-31 TO 350 DEGF	
PROCESS CONN. SIZE	N/A	N/A	N/A	
ELECTRICAL CLASS	GENERAL PURPOSE	GENERAL PURPOSE	GENERAL PURPOSE	
DISPLAY	N/A	N/A	N/A	
MOUNTING BRACKET	DIN RAIL MTD.	DIN RAIL MTD.	DIN RAIL MTD.	

MATERIALS				
ELECTR. HOUSING	SST	SST	SST	
WETTED PARTS	N/A	N/A	N/A	
HARDWARE				
FILL FLUID	N/A	N/A	N/A	

ACCESSORIES				
	PROBE	PROBE	PROBE	
MANUFACTURER	BENTLY NEVADA. NO SUBSTITUTIONS ALLOWED.	BENTLY NEVADA. NO SUBSTITUTIONS ALLOWED.	BENTLY NEVADA. NO SUBSTITUTIONS ALLOWED.	
MODEL NO.	330909 AXB BXB CXX DXX EXX	330909 AXB BXB CXX DXX EXX	330909 AXB BXB CXX DXX EXX	
	TAGS: XIT-501-1 XIT-501-2 XIT-501-3 XIT-501-4	TAGS: XIT-502-1 XIT-502-2 XIT-502-3 XIT-502-4	TAGS: XIT-503-1 XIT-503-2 XIT-503-3 XIT-503-4	

GENERAL NOTES: Vendor to supply asset identification tags in accordance with Section 01 91 13.10 Asset Identification Tags.

SECTION 40 80 00

COMMISSIONING OF PROCESS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. It is the intent of these tests to assure that all Process Control Systems (PCS) equipment supplied is functional and within industry and manufactures tolerances and is installed in accordance with manufacturer's design and specifications.
2. The testing and commissioning of the PCS shall be performed by the Contractor's system integrator (PCSS) with support from the District's DCS supplier (or vendor).
3. The system integrator shall maintain a written record of the tests and upon completion of project, assemble and certify a final test report for review by the District.
4. The District will handoff DCS equipment procured from the District's DCS supplier to the Contractor.

B. Related sections:

1. Section 01 75 17 - Field Testing and Startup
2. Section 40 70 00 Instrumentation for Process Systems
3. Section 40 81 00 System Integrator Qualifications and Summary of Work
4. NOT USED.
5. Section 40 95 13 - Process Control Panels and Hardware
6. NOT USED.
7. NOT USED.
8. NOT USED.

1.2 QUALITY ASSURANCE

A. Experience:

1. The system integrator shall be regularly engaged in the testing of process control equipment devices, installations, and system integration.

2. The system integrator shall have been engaged in such practices for a minimum of five years.
3. The system integrator shall utilize only full-time technicians or engineers who are regularly employed by the firm. Electrically unskilled employees are not permitted to perform testing or assistance of any kind. Electricians or linemen may assist, but may not perform testing or inspection services.

1.3 SUBMITTALS

A. The system integrator shall furnish submittals for approval as outlined below:

1. Proposed field functional and acceptance tests
2. Field functional and acceptance test reports
3. Un-witnessed Factory Test (UFT)
4. UFT report, certifying the UFT was completed satisfactorily
5. Factory Demonstration Test (FDT)
6. Functional Test (FT)
7. Control System Functional Test (CSFT)
8. List of proposed testing equipment
9. Draft testing checklists specific to this project

B. NOT USED.

C. NOT USED.

1. NOT USED.
2. NOT USED.
3. NOT USED.
4. NOT USED.

D. DCS Reporting Submittals

1. DCS Kickoff Meeting: Coordinate and schedule a virtual two-hour kickoff meeting with the construction manager, the District's DCS Vendor, and plant personnel to review scope of work. The Contractor's PCSS shall attend the meeting. The meeting shall cover roles and responsibilities, bill of material, coordination needed between the Contractor and District's DCS Vendor,

schedule, O&M manuals, training, DCS Vendor's support during testing and start-up, and any other discussion topics as needed to complete the Work.

2. Submit a proposed schedule and agenda for the DCS Kickoff Meeting at least two weeks in advance to the Engineer.
 3. NOT USED.
 4. NOT USED.
- E. Provide user training to the District operations and maintenance staff. Coordinate training with District's DCS Vendor. Training shall be offered to District's day, swing, and grave shifts and in accordance with 01 79 00, Demonstration and Training.
- F. Operation and Maintenance Data
1. Compile Operation and Maintenance Manuals (O&M) submitted by Contractor and District DCS Vendor prior to final system startup.
 2. Furnish Operation and Maintenance Manuals (O&M) as listed below and in accordance with Section 40 61 01, Instrumentation and Controls General Requirements.
 3. The O&M Manuals shall include installation, set-up, and troubleshooting manuals for the Project equipment and instrumentation.
 4. NOT USED.
 5. NOT USED.
 6. The O&M manual shall include as-built Instrumentation and Control system drawings in native electronic and PDF format.
 7. NOT USED.
 8. The O&M manual shall include a maintenance section showing typical trouble shooting procedures for Instrumentation and Control computers, software, control panels, and communications equipment.
- G. NOT USED.

1.4 SCHEDULING

- A. Work shall be coordinated with other systems in accordance with 01 75 17, Field Testing and Startup.
- B. The Contractor shall notify the Engineer a minimum of six weeks prior to commencement of any testing.

1. The Contractor shall pay, arrange, and schedule for two District representatives to be present for Factory Testing. The Contractor shall reimburse airfare, local transportation, meals, and separate lodging for the District representatives.
 - a. The Contractor shall obtain written approval from the Engineer at minimum ten weeks in advance prior to Factory Testing.
- C. The Contractor shall coordinate with the Engineer and District's DCS Vendor on handoff of DCS equipment to be provided by the District.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor's system integrator shall perform general equipment inspection and checking procedures recommended by the manufacturer and as specified in other sections of these specifications.
- B. Any system, material, or workmanship which is found defective on the basis of acceptance tests shall be reported, corrected and retested all at no additional cost to the District.
- C. All customized DCS programs will be developed and tested by the District's DCS Vendor. Contractor shall develop their own testing procedures to test individual input/output (I/O) points to ensure its functionalities and the I/O wire terminations in the control panel are correctly mapped for their factory quality check.
- D. Prior to I/O checkout, the system integrator shall coordinate with the District's DCS supplier to schedule activities associated with functional testing, performance testing, start-up, commissioning, and other testing milestones as described in these specifications. The Contractor shall be responsible for notifying the District's DCS supplier and coordinating schedule for activities requiring the DCS supplier.

3.2 TESTING

- A. General:
 1. All elements of the PCS hardware shall be tested to demonstrate that the total system satisfies all of the requirements of this specification. The tests are unique to the PCS and the following specification sections:
 - a. NOT USED.
 2. As a minimum, the testing shall include the following:
 - a. Un-witnessed Factory Test (UFT)

- b. Factory Demonstration Tests (FDT)
 - c. Functional Test (FT)
 - d. Control System Functional Test (CSFT)
- 3. The system integrator shall include the tests in the scheduling requirements of specification Section 01 75 17 – Field Testing and Startup.
- 4. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and, upon the system's producing the correct result (effect), the specific test requirement will have been satisfied.
- 5. Except for the Un-witnessed Factory Tests, all tests shall be conducted in accordance with, and documented on, prior District-approved procedures, forms, and checklists. Each specific test to be performed shall be described and a space provided after it for signoff by the appropriate party after its satisfactory completion. Contractor shall submit all forms for a given Test prior to starting the next Test in sequence.
- 6. The District will actively participate in many of the tests. The District reserves the right to test or retest any and all specified functions whether or not explicitly stated in the prior-approved Test Procedures.
- 7. The District's decision shall be final regarding the acceptability and completeness of all testing.
- 8. If any of the following witnessed tests or portion of a test fails to the point where it needs to be rescheduled at a later date, additional tests shall be required at the system integrators expense. Included shall be expenses for the Engineer's travel, accommodations, and sustenance of the same quality used for the original test. Retest expense shall be for a maximum of two persons.

B. Un-witnessed Factory Tests (UFT):

- 1. Prior to the start of the witnessed Factory Demonstration Test, the panels and panel assemblies shall be inspected and tested at the system integrator factory to ensure that it is fully functional and ready for demonstration testing.
- 2. All panels and assemblies shall be inspected and tested to verify that they are in conformance with related submittals and these specifications.

C. Factory Demonstration Tests (FDT):

- 1. At the system integrator factory, the system integrator shall assemble all the components shown on the contract drawings so that the control panels can be inspected, and the communication and I/O networks tested.

2. The system integrator, as a minimum, shall gather and assemble the following components:
 - a. All control panels shown on the contract drawings. The panels and consoles shall be complete and have been subjected to a UFT.
 - b. Operator interface terminal (OIT) and Ethernet switches.
 - c. Temporary Ethernet and ControlNet copper and fiber optic cabling, connectors, and other required networking hardware.
3. Where applicable, the system integrator shall make all the temporary copper and fiber optic Ethernet network connections between the panels, Operator Interface Units, and Ethernet switches as shown on the contract drawings network diagram. The network connections shall be in accordance with the equipment manufacturer's instructions.
4. The factory demonstration tests shall be witnessed by the District, and the tests shall demonstrate the following:
 - a. Correctness of wiring from all panel field terminals to all input/output points and to all front of panel components.
 - b. Proper workmanship and correctness of internal panel and console wiring.
 - c. Proper operation of Operator Interfaces Units and Ethernet switches.
 - d. Proper operation and installation of the Ethernet.
5. The system integrator shall allot minimum five (5) eight-hour days for testing and shall have a system integrator electrician or technician available for testing during the duration of the test.
6. At the factory demonstration test, provide District all programs and configuration files for the OIT, DCS, I/O communication modules, and Ethernet switches.
7. The tests shall demonstrate the specified functions to the satisfaction of the Engineer.
8. All factory test punch list items shall be completed and the Engineer notified in writing before the panels are released for shipment.

D. Functional Tests (FT):

1. General: Prior to startup, the entire installed PCS shall be certified (inspected, tested, and documented) by the system integrator and the District's DCS

Vendor to ensure the PCS is ready for startup. These inspections and tests shall include the functional test outlined in Section 01 75 17 and specific PCS functional tests described in this section.

2. The following PCS functions shall be tested during the FT:
 - a. Power failure and system restart
 - b. Proper grounding
 - c. All indicating lights, fuse, breakers, and components make up of the system
 - d. Fault detection
 - e. Diagnostic functions:
 - 1) On line
 - 2) Off line
 - 3) Error codes
 - f. RS-232, Ethernet, ControlNet, DeviceNet, DNP 3.0, Modbus communications, and etc. as applicable.
3. As a minimum, the following PCS items shall be inspected:
 - a. Wiring
 - b. Damages and scratches
 - c. Copper and fiber optic network terminations
 - d. Where applicable power supply, IO modules, I/O rack, fusing, cabling and termination integrity, UPS power, sub-chassis power supply loading and calculations, and nameplates.
 - e. Spare installed and non-installed I/O
 - f. Component layout, future spare allocation
 - g. Identification, labels:
 - 1) Equipment
 - 2) Cables
 - 3) Sub-chassis

- 4) Power supplies
 - 5) I/O cards
 - 6) Wiring
4. Loop/Component Inspections and Tests: The entire PCS shall be checked for proper installation, calibrated, and adjusted on a loop-by-loop and component-by-component basis from the field device to the DCS I/O terminals to ensure that it is in conformance with related submittals and these specifications.
- a. The Loop/Component Inspections and Tests shall be implemented using District-approved forms and checklists. The testing checklists shall be developed on Microsoft Excel or Word and configured to sort and search for all loops that have not been tested, wired, installed, calibrated, etc.
 - 1) Each loop shall have a Status Report to organize and track its inspection, adjustment, and calibration. These reports shall include the following information and checklist items with spaces for signoff by the system integrator, the District's DCS Vendor and District:
 - a) Project Name
 - b) Loop Number, assigned by the system integrator
 - c) Tag Number for each component
 - d) The following checklist/signoffs for each component:
 - i) Tag/identification
 - ii) Installation
 - iii) Termination-wiring
 - iv) Termination-tubing
 - v) Calibration/adjustment
 - vi) FT complete
 - e) The following checklist/signoffs for the loop:
 - i) Panel interface terminations
 - ii) I/O interface terminations with PCS

- iii) I/O signal operation relative to PCS, inputs/outputs operational: received/sent, processed, adjusted
 - iv) PCS functions
 - v) Total loop operational
 - vi) Space for comments
- 2) Each active element (except simple hand switches, lights, etc.) and each PCS I/O module shall have a Component Calibration Sheet. These calibration sheets shall also be developed in Microsoft Excel or Word and configured to sort by loop number and status of calibration check. These sheets shall have the following information, spaces for data entry, and a space for signoff by the system integrator and the District:
 - a) Project Name
 - b) Loop Number (ISA 5.4)
 - c) Component Tag Number or I/O Module Number
 - d) Component Code Number
 - e) Manufacturer
 - f) Model Number/Serial Number
 - g) Summary of Functional Requirements, for example:
 - i) For Indicators and Recorders: Scale and chart ranges
 - ii) For Transmitters/Converters: Input and output ranges
 - iii) For Computing Elements: Function
 - iv) For Controllers: Action (direct/reverse), control modes (PID), configuration diagram, scales
 - v) For Switching Elements: Unit range, differential (FIXED/ADJUSTABLE), reset (AUTO/MANUAL)

- vi) For I/O Modules: Input or output
- h) Calibrations; for example:
 - i) For Analog Devices: Required and actual inputs and outputs at 0, 25, 50, and 100 percent of span, rising and falling
 - ii) For Discrete Devices: Required and actual trip points and reset points
 - iii) For Controllers: Mode settings (PID)
 - iv) For analog I/O Modules: Required and actual inputs or outputs of 0, 25, 50, and 100 percent of span, rising and falling
- i) Space for comments
- j) Space for signoff by the system integrator
- b. The system integrator shall maintain the Component Calibration Sheets at the jobsite and make them available to the District at any time.
- c. The system integrator shall provide the Status Reports for the District. After a specific test has been completed, the system integrator shall provide a copy of the signed-off test form to the District, and the system integrator shall enter it in the data file.
- d. These inspections and tests shall require witnessing by the District.

E. Startup Tests:

1. General: Startup test shall not proceed until the Control System Functional Test has been successfully completed. Startup testing shall be in accordance with Section 01 75 17, Field Testing and Startup.

END OF SECTION

INSTRUMENT CALIBRATION SHEET

COMPONENT	MANUFACTURER	PROJECT
EQUIPMENT TAG NO.:	MANUFACTURER:	NUMBER:
NAME:	MODEL:	NAME:

FUNCTIONS							
		RANGE	VALUE	UNITS	COMPUTING FUNCTION: Y / N	CONTROL: Y / N	
Indicate:		CHART			Describe:	Action: Direct / Reverse	
Record:		SCALE				Modes: P / I / D	
Trans.:		INPUT				SWITCH: Y / N	
Convert:		OUTPUT				Unit Range:	
						Differential: Fixed / Adjustable	
						Reset: Automatic / Manual	

ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS					NOTE No.
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED		
Input	Scale / Indicated	Output	Scale Increasing	Output Increasing	Scale Decreasing	Output Decreasing	Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
0%		4.00 mA					1					
25%		8.00 mA					2					
50%		12.00 mA					3					
75%		16.00 mA					4					
100%		20.00 mA					5					
							6					
							7					
							8					
CONTROL MODE SETTING:			P:	I:	D:		9					

No.	NOTES:	Component Calibrated and Ready for Start-up.	
		By:	
		Date:	
		Calibration Instrument. M/N:	

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SECTION 40 81 00

SYSTEM INTEGRATOR QUALIFICATIONS AND SUMMARY OF WORK

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes

1. The system integrator shall provide a fully functioning instrumentation and control system as specified in the Contract Documents and shall integrate, test, start-up, and make operational a complete instrumentation and control system in accordance with the Contract Documents including this Section and applicable reference standards listed in Article 1.3.
2. The system integrator shall provide all labor and incidentals as required to configure, install, and calibrate all instrumentation as specified on the plans and Specification Section 40 70 00.
3. The system integrator shall be responsible for the design and manufacturing of the control system enclosures as specified on the plans and in Specification Section 40 95 13. The system integrator shall take delivery of specific DCS equipment provided by the District and integrate those components into the control system enclosures as specified. The system integrator shall coordinate and lead a Factory Acceptance Test of the enclosures prior to delivery to the site.
4. The Contractor shall be responsible for the placement and anchoring of the control system enclosures provided by the system integrator.
5. The system integrator shall coordinate and lead all site acceptance testing of the instrumentation and control system.

B. Related Sections:

1. Section 01 33 12 – Seismic Design Criteria.
2. Section 01 75 17 – Field Testing and Startup.
3. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
4. Section 40 61 01 – Instrumentation – Controls General Requirements.
5. Section 40 70 00 – Instrumentation for Process Systems.
6. Section 40 80 00 - Commissioning of Process Systems.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

1.3 REFERENCES

A. Reference Standards

1. The Instrumentation, Systems and Automation Society (ISA)
2. Underwriters' Laboratories, Inc. (UL)
3. American Water Works Association (AWWA)
4. National Electrical Manufacturer's Association (NEMA)
5. Occupational Safety and Health Administration (OSHA)
6. American National Standards Institute (ANSI)
7. National Fire Protection Association (NFPA)
8. National Fire Protection Association 79, Annex "D" Standards (NFPA)
9. Institute of Electrical and Electronic Engineers (IEEE)
10. National Electrical Code (NEC)
11. Factory Mutual (FM)

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination, Sequencing, and Scheduling: per Division 01 General Requirements.

1.5 SUBMITTALS

- A. Submit in accordance with Division 01 General Requirements.

B. Qualifications Package Submittal

1. The system integrator shall submit a qualifications package for review and approval to demonstrate compliance with the requirements described. The submittal shall include demonstration of all requirements, including but not limited to:
 - a. Include resumes for Project Manager, Field Engineers, and Technicians demonstrating comparable projects and field experience.

- b. List the names and home office location of the Engineers and Technicians located within 75 miles and within 2 hours travel time of the Project Site.
 - c. Project references for water or wastewater projects.
 - C. Instrumentation and Control System Testing Plan
 - 1. The system integrator shall submit an instrumentation and control system testing plan that describes the testing process for all instrumentation and control equipment throughout the various stages of the project. At a minimum the procedure shall cover the following project stages:
 - a. Bench Testing
 - b. Factory Acceptance Testing
 - c. Loop Testing
 - d. Site Acceptance Testing and Functional Testing
 - e. Commissioning
 - f. Performance Testing
 - 2. The system integrator shall coordinate all testing activities with the Contractor, the DCS equipment supplier, the District, and the Construction Manager. The system integrator shall provide advance notice for all testing activities.

1.6 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.
- B. Qualifications: per Division 01 General Requirements for System Integrator and as follows.
 - 1. Employ personnel on this Project who have a minimum of 5 years' experience programming and starting up Instrumentation and Control related hardware, computers, integrating with Emerson Ovation DCS, power monitors, communication with motor protection devices, and other network communications equipment.
 - 2. Employ personnel on this Project who have completed factory training in development of the Instrumentation and Control software programming, alarm notification software, and reporting software.
 - 3. Personnel shall be experienced configuring process instrumentation typically found in a water or wastewater treatment plant. Key personnel shall include, at a minimum, the lead field technician.
 - 4. Successfully completed Work of equal or greater complexity on at least 3 other water or wastewater treatment projects within the last 5 years.

5. The system integrator shall maintain a permanent, fully staffed, and equipped office within 2 hours travel time of the Project Site with full time employees capable of programming, troubleshooting and testing the Instrumentation and Control system specified.
6. For the duration of the Project the system integrator shall provide an on Site response within 4 hours of notification. For the remainder of the Warranty Period, the system integrator shall provide on Site response within 1 business day.
7. The system integrator responsibilities include but are not limited to:
 - a. Integrating all Instrumentation and Control equipment as specified in the Contract Documents.
 - b. Integrating all communications equipment including serial, fiber optic, and Ethernet communication material and equipment.
 - c. Integrating all instrumentation and process equipment, including packaged systems with the control panels required for the complete monitoring and control of the Instrumentation and Control system as described in the Contract Plans, equipment O&M manuals and submittals, Specifications and applicable codes.
 - d. Conduct testing of all software provided by the DCS supplier required for the complete monitoring and control of the Instrumentation and Control system as described in the Contract Plans, Specifications and applicable codes by or under the supervision of qualified personnel.
 - e. Preparation, assembly, and correction of all submittals in accordance with the Contract Documents.
 - f. Supervision of the installation of control system panels, perform instrument tests, wiring checkout to the control system panels, and other components required by or under the supervision of qualified personnel.
 - g. Documentation of I/O testing and startup of the Instrumentation and Control system.
 - h. Training of the District's personnel in operation and maintenance of the Instrumentation and Control system. A minimum of 8 hours formal training is required for all Instrumentation and Control operations staff. Formal training can be a combination of on Site classroom style with handouts, whiteboard or projector and hands on usage of the Instrumentation and Control system. Training shall include one, 4-hour session, 1 week prior to system startup, as well as two, 2-hour follow-up sessions after the system is successfully started up and accepted by the construction manager. The system integrator shall submit training agendas for all sessions to the

construction manager for review and approval prior to scheduling the training sessions.

- i. Coordination with the Contractor on handling of all warranty obligations for the Instrumentation and Control system components or any errors or omissions related to Instrumentation and Control programming for a period of 12 months.
- j. Maintaining one on Site, up to date, copy of the integration plan and applications including fully documented programs for use in restoring the system during startup should part of the Instrumentation and Control system fail. The documented programs can be backups of the native electronic files.
- k. One hard copy and one electronic copy, on USB flash drive, of the Instrumentation and Control Operations and Maintenance Manual.

8. System Integrator Project Personnel

a. Project Manager

- 1) The system integrator shall appoint a Project manager who shall coordinate and schedule all Instrumentation and Control Work and assure that the Project schedule is met.
- 2) The Project manager shall act as the liaison with the design-builder's installation Contractor and the construction manager, for the integration, testing and startup of the Instrumentation and Control system and shall assist in all matters required for proper coordination and interfacing of the equipment and processes.

b. Field Engineer

- 1) The system integrator shall appoint a field Engineer with responsibilities as follows:
 - a) Installed system checkout, adjustment, and start up including tuning of all control loops.
 - b) Instrumentation and Control support services for the duration of any equipment or system availability trials.
 - c) Involvement in the on Site system training of plant personnel.
 - d) Resolving of control problems encountered during initial startup and testing of all Instrumentation and Control equipment.

C. Integration

1. The integration tasks include, but are not limited to, the following
 - a. Calibration, installation, startup, and commissioning of all instrumentation.
 - b. Establish serial interface between MAC motor protection units and DCS.
 - c. Fiber optic routing and installation oversight.
 - d. The system integrator shall be responsible for configuration of all I/O within control panels required to provide a complete and functional Instrumentation and Control system.
 - e. Participate in startup testing of all equipment, instruments and controls to ensure operation of systems.

D. Testing

1. The system integrator shall allocate time for control panel testing, full field-testing of instrumentation, DCS, and reporting programs in accordance with the Contract Documents. The system integrator shall provide documentation as a record of testing I/O points through to OIT and HMI screens. The system integrator shall note any changes made in the field.

E. Coordination and Progress Meetings

1. The system integrator shall be responsible for the scheduling with the installation Contractor and coordinating the system integration with regard to all other Work on the Site and in accordance with the provisions of the General Conditions. The coordination shall be documented on the Project Schedule.
2. The system integrator shall be responsible for scheduling with the construction manager all DCS equipment startup and testing, and reporting submittal review meetings.
3. Routine progress and coordination meetings will be scheduled by the construction manager. The system integrator shall be required to attend weekly meetings, or as scheduled by the construction manager.
4. The purpose of the meetings shall be to review the progress of the Work involving the controls system and provide coordination for integration of the equipment to ensure Project schedule is met.
5. Representatives at the meetings shall have the authority to make all necessary decisions. Decisions and statements made at the meetings shall commit the system integrator to agreed procedures and schedules.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 01 General Requirements.

1.8 SITE CONDITIONS

A. Existing Conditions: per Division 01 General Requirements.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 95 13

PROCESS CONTROL PANELS AND HARDWARE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: Furnish control panel and local display panel as shown on the drawings and specified herein.
- B. Related Sections:
 - 1. Section 01 33 12 – Seismic Design Criteria.
 - 2. Section 01 75 17 – Field Testing and Startup.
 - 3. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
 - 4. Section 40 05 23 – Process Valves
 - 5. Section 40 61 01 – Instrumentation & Controls General Requirements.
 - 6. Section 40 70 00 – Instrumentation for Process Systems.

1.2 SUBMITTALS

- A. The Contractor shall furnish submittals for approval in accordance with Section 01 33 00 Submittal Procedures and as outlined below:
 - 1. Product data.
 - 2. Warranty.
 - 3. Bill of materials.
 - 4. Plan, front, and side view drawing including overall dimensions, weights, and anchoring details.
 - 5. Assembly drawing.
 - 6. All design drawings, panel drawings, wiring diagrams, and interconnection diagrams shall be drafted using the latest version of AutoCAD or Intergraph's MicroStation. Drawings shall be developed in accordance with the District's procedures and standards, copies of which

are available on request.

7. Catalog material for all control panels and enclosures. Provide control panels sized as shown on the drawings. Where control panel dimensions have not been shown, size panels with a minimum of 30 percent spare usable space horizontally and vertically on all internal and external panel surfaces and mounting panels. Drawings shall be to scale and shall show the location of all panel mounted devices (such as terminal blocks, relays, wire ducts, power supplies, color coding of terminal strips, nameplates, etc.) as well as doors, louvers, and subpanels. Drawings shall include a panel legend and a bill of materials. The panel legend shall list and identify all front of panel devices by their assigned tag numbers, all nameplate inscriptions, service legends, and annunciator inscriptions. The bill of materials shall list all devices mounted within the panel that are not listed in the panel legend, and shall include the tag number, description, manufacturer, quantity, and model number for each.
8. Catalog cuts of all application software being provided.
9. Internal schematics (elementary diagrams), wiring diagrams, and point-to-point interconnection diagrams for all components internal and external connections.
10. Detailed panel elementary diagrams of all pre-wired panels. Diagrams shall be similar to those typical diagrams shown on the drawings, but with the addition of all the auxiliary devices such as relays, alarms, fuses, circuit breakers, lights, fans, heaters, etc. Provide panel control diagrams for all discrete control and power circuits. Diagrams shall be ladder type schematic diagrams similar to the typical diagrams shown in the drawings, but shall include all devices requiring electrical connections. Panel control diagrams shall identify all wire numbers and types, terminal numbers, tag numbers, and DCS input/output I/O identification (branch and module) or PLC input/output I/O identification (rack and slot) numbers. Control diagrams shall show all circuits individually; no typical or common diagrams will be allowed. Line numbers and sheet numbers shall reference relay contacts. Where multiple relays are required, their coils shall be wired parallel. All discrete devices shall be labeled to define their switching action (close on rising or close on falling process variable).
11. Shop drawings and catalog material for all control and field panels, instrument racks, and enclosures. Drawings shall be to scale and shall show the location of all panel mounted devices as well as doors, louvers, and sub-panels. Drawings shall include a panel legend and a bill of materials. The panel legend shall list and identify all front of panel devices by their assigned tag numbers, all nameplate inscriptions, service legends, and annunciator inscriptions. The bill of materials shall list all devices mounted within the panel that are not listed in the panel legend, and shall include the tag number, description, manufacturer, quantity, and model

number for each.

12. Drawings showing any modifications or additional details as may be required to supplement the Contract Documents and adequately define the installation of the process control system elements.
13. Interconnecting wiring diagrams that follow the format shown on the drawings, showing all component and panel terminal board identification numbers and external wire numbers in the same format as shown on the drawings. Wiring tables or wire lists will not be considered as a suitable substitute for these drawings unless approved by the District. These diagrams shall include all intermediate terminations between field elements and panels (e.g., terminal junction boxes, motor control centers, etc.). These diagrams shall be coordinated with the electrical subcontractor and shall bear a statement that this has been done. Reference the drawings for a typical interconnecting wiring diagram showing the format to be used. These drawings shall be provided to the electrical subcontractor for wiring system coordination and shall be used to provide wire numbers on the field wiring that is identical to the panel wire number. When wire numbers are not shown on the drawings, the Contractor shall generate wire numbers in accordance to Section 26 05 53.
14. Physical drawings shall show equipment arrangement and terminal block locations.
15. A listing of all the panels, racks, instruments, DCS, PLCs, servers, OIUs, and equipment supplied as a part of the Process Control Panel. All components shall be grouped by component type. The list shall be submitted in electronic format in an Excel.
16. Catalog information, descriptive literature, wiring diagrams (showing internal wiring and external connections for power and signal), and shop drawings for all recorders, indicators, transmitters, primary elements, flowmeters, DCS, PLCs, I/O modules, networking equipment and appurtenances, and all other components of the Process Control Panel. Also, provide catalog information on all electrical devices furnished under this Division (for example: power supplies, relays, surge suppressors, terminal blocks, circuit breakers, heaters, thermostats, fans, louver kits, etc.).
17. Equipment seismic qualifications, seismic calculations, and anchorage details as specified in this Section and Section 01 33 12.
18. Heat load calculations for each enclosure or panel based on the highest ambient temperature listed in Job Conditions Paragraph listed below for the area in which the subject panel will be located. Where a panel is provided with a cooling system, show how the heat load calculations were made for the selection of the BTU size of the proposed cooling system.

19. Complete installation and field assembly instruction manuals.
20. As-built documents and Operation and Maintenance (O&M) manuals.
21. Spare parts list, expendables, and test equipment list.
22. Certified factory test reports.
23. Test procedures including: factory demonstration test, functional test, performance test, and commissioning.
24. Test documentation including: factory demonstration test, functional test, performance test, and commissioning.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Control panels shall be shipped directly to the site from the factory. Before the control panels are shipped, remove all case-mounted instruments from the face of the panels, and repack in their original shipping cartons for shipment to the site with the control panel.
- B. Throughout this contract, the Contractor shall provide protection for materials and equipment against loss or damage and from the effects of weather and dust. Prior to installation, store items in indoors in a dry location and follow all manufacturers' storage instructions. Provide heating in storage areas for items subject to corrosion under damp conditions. Provide covers for panels and other elements that may be exposed to dusty construction environments. Specific storage requirements shall be in accordance with the manufacturer's recommendations of the equipment being provided.

1.4 REFERENCES

- A. Codes and Standards: Unless otherwise specified herein, or shown on the drawings, work under this specification shall be performed in accordance with the following codes, standards and publications to the extent indicated by the references herein. Any conflict among these standards shall be brought to the attention of the District for clarification and final ruling. The date of issue or version shall be the current version at time of bid.
 1. NFPA Standard 70 National Electrical Code.
 2. IEEE Standard 472 Electrical Surge Protection.
 3. EIA Standard RS-232-C Interface between data terminal equipment and data communication equipment employing serial binary data interchange.

4. EIA Standard RS-422-A Electrical characteristics of balanced voltage digital interface circuits.
5. NFPA Standard 820 Recommended Practice for Fire Protection in Wastewater Treatment and Collection Facilities.
6. NEMA ICS6 Enclosures for Industrial Controls and Systems.
7. SAMA PMC-33.1 Electromagnetic Susceptibility of Process Control Instrumentation.
8. IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
9. ISA S5.1 Instrumentation Symbols and Identification.
10. ISA S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.

1.5 JOB CONDITIONS

A. Environmental

1. Ambient temperature range: 0 to +50 degrees Celsius (32 to 122°F).
2. Ambient humidity range: 5 percent - 95 percent RH non-condensing.
3. Ambient environment: Indoor.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Unless otherwise approved by the Engineer, all control panels and display panels shall be outdoor rated and constructed with external dimensions as shown on the drawings. The panel construction and all interior wiring shall be built to the strict standards in accordance to the industry. Instrument arrangement shall be as shown, with minor modifications as may be required for the particular equipment furnished. Modifications shall be subject to the approval of the Engineer.
- B. The construction of the panels shall be by a UL listed Industrial Control Panels Fabricator. The panel shall be completely fabricated, instruments installed, wired, and plumbed at the Fabricator's factory. The same Fabricator shall fabricate all control and display panels. Unless otherwise indicated, provide all new materials and equipment, free from any defects, and suitable for the space provided. Provide materials and equipment listed by UL wherever standards have been established by that agency.

- C. The control panels shall conform to UL listing 508 and bear a UL 508 label stating "suitable for use as an industrial control panel".
- D. Where two or more units of the same class of materials or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- E. Standard products: Unless otherwise indicated, provide material and equipment that is the standard product of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design that conforms to the specifications.

2.2 TYPICAL EQUIPMENT

- A. Enclosure Construction:
 - 1. Fabricate panels per Drawings.
 - 2. For NEMA Type 1 and 12 cabinets located indoors, the cabinet shall be manufactured with 12-gauge steel, with ANSI 61 (light gray) or RAL 7035 (light gray) with Electrostatic Powder paint external finish. Cabinet dimensions are as shown on the design drawings. Include back panels and side panels as shown on the drawings.
 - 3. For cabinets located outdoors, cabinet shall be NEMA Type 4X, manufactured with 14-gauge Type 316L stainless steel, complete with back panel. Cabinet dimensions are as shown on the design drawings. Include back panels and side panels as shown on the drawings. Cabinets located outdoors shall be supported by a SS316 Unistrut metal frame and mounted at the height shown on the design drawings.
 - 4. Seams shall be continuously welded and ground smooth without holes or knockouts.
 - 5. Single door cabinet shall have hinge on the left-hand side and the door latch on the right-hand side when facing the front of the enclosure.
 - a. Door shall have heavy-duty continuous hinges, with die-cast padlocking handle and two-point latch on cabinet up to 36 inch height and three-point latch on cabinet 42 inch and above.
 - b. Door gaskets shall be of oil resistant material and shall be attached with oil-resistant adhesive.
 - 6. Each enclosure shall be provided with a print pocket 12" wide x 12" high x 2" deep provided on door.
 - 7. Acceptable Manufacturers (For wall mounted enclosures):

- a. Hammond Manufacturing.
- b. Hoffman.
- c. Or equal.

8. Acceptable Manufacturers (For pad/floor mounted enclosures):

- a. Hammond Manufacturing.
- b. Hoffman.
- c. Or equal.

B. Enclosure Work Light:

- 1. All enclosures and panels over 24" width and 6" depth size shall have a work light. Work light shall be mounted top center. Light shall be triggered by door-activate switch. Light shall be on when door(s) is opened and turns off when door(s) is closed. Work light shall have pre-wired terminal block for easy connection to the electric supply. Unless specified on Drawing, light type shall be LED and operates on 24VDC.

- 2. Acceptable Manufacturers:

- a. Hoffman.
 - b. Stego.
 - c. Or equal.

C. Enclosure Cooling Fans:

- 1. All indoor type NEMA 12 enclosures and panels over 24" width and 10" depth size shall have cooling fan. Unless otherwise shown on drawings cooling fan shall be mounted in a location to remove warm air out of the enclosure or panel. Cooling fan can also be used to bring in ambient air into enclosure or panel. Cooling capacity shall be rated to remove warm air to meet components operating temperature. Minimum rating shall be 150 CFM. Fan shall be compact type, quiet operation, and operates on 115Vac, 60 Hz.

Acceptable Manufacturers:

- a. Hammond Manufacturing.
 - b. Hoffman.
 - c. Or equal.

D. Enclosure Cooling Air Conditioning (A/C) Units:

- 1. Unless otherwise shown on drawings all enclosures and panels containing programmable logic controllers (PLCs), human machine interfaces (HMIs), or other microprocessor based equipment shall have A/C unit system designed to maintain internal panel temperature of 90 degree F or less.

2. The A/C unit shall be wall mounted type and does not exchange cabinet interior air with ambient air. The cold air stays inside and the ambient air stays outside. The cooling system shall be either a closed glycol loop heat exchange system or a CFC-free refrigeration system as required for the specified equipment and instrument complement and ambient temperature conditions. The A/C unit shall be rated for outdoor, and the compressor coils shall be Heresite, or equal coated and protected from corrosion, 110-240Vac, 60Hz.
3. Acceptable manufacturer:
 - a. Rittal Blue e+ Series
 - b. Delta – T
 - c. Or equal.

E. Wiring and Terminal Devices:

1. Single conductor wiring shall be stranded copper with 600 volt Type MTW insulation unless otherwise specified.

Color Coding:

<u>Function</u>	<u>Gauge</u>	<u>Color</u>	<u>Remarks</u>
DC Power (12V or 24V)	14	Blue	
DC Power (0V, Grounded)	14	Blue with Grey Stripes	
DC Control	14	Blue	
AC Control	14	Red	
AC Common	14	White	Or larger wire
AC Power	14	Black	Or larger wire
AC Ground	14	Green	Or larger wire

2. Wiring to receptacles shall be No. 12 AWG stranded black (line), white (grounded neutral), and green (ground).
3. Instrumentation cables shall be 300 volt twisted shielded pairs, No. 18 AWG stranded copper conductors, 105 degrees C PVC insulation and jacket, color coded black and white, with aluminum/mylar shield overlapped to provide 100 percent coverage, and stranded copper drain wire.

4. No more than 2 wires shall be connected to one terminal.
5. Wires carrying instrument and control D.C. signals shall be physically separated a minimum of 6" from wires carrying A.C. (120 VAC).
6. Din rail channel shall be steel, zinc plated with 2mm slot, 35mmX7.5mm dimension, lead free/RoHS compliant.
 - a. Acceptable Manufacturers:
 - 1) American Electrical, Inc.
 - 2) Weidmuller.
 - 3) Or equal.
7. All wiring shall be neatly routed in wiring ducts and labeled with their assigned wire numbers as shown on the drawings. Wire labels shall be machine printed, permanent type heat shrinkable polyolefin labels, Brady Permasleeve printable wire markers, or equal as approved by the Engineer.
8. Ground bar shall be CDA-110 electrolytic copper and tin plated. UL listed 467 for grounding and bonding equipment. CSA certified 22.2 4. Can be mounted directly to panel or mounted using UGB-IN-SO, or using UGB-B-SO. Maximum equipment grounding conductor or 2/0 AWG copper wire.
 - a. Acceptable Manufacturers:
 - 1) Panduit.
 - 2) Hammond Manufacturing.
 - 3) Or equal.
9. Instruments with grounding terminals shall be grounded to the panel steel. Provide grounding lug for grounding the console to earth ground.
10. Wires terminating to screw type terminal blocks without pressure plates shall be crimped into nylon solderless fork terminals. Wires terminating to ground studs shall be crimped into nylon solderless ring terminals. Insulators are rated at a continuous operating temperature range from -40 degrees C to 105 degrees C.
 - a. Acceptable Manufacturers:
 - 1) AMP, Inc.
 - 2) Thomas & Betts Co. Sta-Kon.
 - 3) Or equal.
11. Open-slot-wiring duct sized for the application shall be provided to hold the wires neatly in place. Wiring ducts shall have narrow or open slot,

lead-free PVC, frame retardant, and UL 94 recognized. Provide one-inch minimum wire bending radius to prevent wires from being kinked or stressed at the wiring duct junctions. Wiring duct sizes shown on the drawings are minimum sizes; wiring duct fill shall not exceed 50 percent.

a. Acceptable Manufacturers:

- 1) Panduit.
- 2) Phoenix Contact.
- 3) Or equal

12. Whenever there is any discrepancy between wiring drawings and the control schematic, the control schematics shall take precedence.
13. Terminal blocks: Shall be screw clamp rated 600 VAC/VDC minimum and as specified on drawings. If fuse terminal blocks are specified, they shall be with built-in puller, blown indicator, and with fuse size as shown on drawings. Provide 30 percent spare terminals for every terminal strip, space permitting. Terminals shall be clearly and permanently labeled with embossed numbers as shown on drawings.
14. Terminal block jumpers: Where indicated on the drawings, terminal block jumpers shall be pre-made specifically designed for the application. Jumpers designed to screw in on top of terminal blocks are preferred.
15. Provide all necessary accessories, partition plates, separating plates, end cover, group markers, etc., as required for proper installation of the terminal blocks.
16. Standard control terminal blocks shall be designed to accept No. 22 to No. 12 AWG wires. Terminal blocks shall be gray or brown colored and rated for 30 amperes, 600 VAC/VDC.
 - 1) Acceptable Manufacturers:
 - a) Phoenix Contact, UT series.
 - b) Weidmuller, WDU series.
 - c) Or equal.
 - b. PE terminal blocks shall have similar rating as standard terminal blocks and shall be green-yellow colored and meet all requirements of the IEC 60947-7-2 standard.
 - c. Terminal blocks for analog 4-20mA circuits shall be knife-style or fuse terminal block isolation (circuit disconnect) type.
17. Fuse terminal block shall have built in cartridge for fuse insertion. Fuse terminal block shall be Din rail mountable. Acceptable glass type fuse size

6.3x32mm. Fuse terminal block shall have blown fuse indicator LED rated for 24Vdc application. Maximum current rating of 12A, 300VAC/VDC. Connection type shall be screw connection.

a. Acceptable Manufacturers:

- 1) Allen Bradley, Cat. No. 1492-H5,
- 2) Weidmuller.
- 3) Or equal.

18. Din rail mounted circuit breakers shall be the high density, 1-pole or 2-pole, energy limiting type rated 250VAC or 120VDC, with current ratings as shown on the drawings. Circuit breakers shall be code compliance with respect to UL1077 or UL489.

a. Acceptable Manufacturers:

- 1) Allen Bradley, 1492-GH (250VAC) and 1492-CB Series B (120VDC).
- 2) Square D.
- 3) Or equal.

F. Control units and devices:

1. Molded case circuit breakers shall be panel mountable, 2-pole, energy limiting type rated 250VAC or 120VDC, with current ratings as shown on the drawings. The molded case circuit breaker shall have an integral padlockable handle which will allow the circuit breaker to be locked in the off position. The manufacture of the locking device shall be the same manufacture of the molded case circuit breaker. Molded case circuit breaker shall be in accordance with requirements and type specified in Section 26 24 16 Panelboards.

2. Miniature Circuit Breakers

a. UL 489 miniature circuit breakers shall provide upstream overcurrent and short-circuit protection for supplementary protectors within the process control panel enclosure and branch circuits leaving the enclosure. These circuit breakers shall have the following characteristics:

- 1) Thermal-magnetic trip.
- 2) Dual-rated for AC and DC applications.
- 3) Energy-limiting type with voltage and current ratings as shown in the drawings.

- 4) Operating Voltage:
 - a) 1-Pole: 277 VAC, 48 VDC
 - b) 2-Pole: 480Y/277 VAC, 96 VDC
 - 5) Operating Temperature: -40 to 167°F.
 - 6) Short-Circuit Rating: 10kAIC minimum.
 - 7) DIN rail mountable.
 - 8) Cable in / cable out terminations.
 - 9) Compliance: UL 489 and UL Listed.
- b. Acceptable Manufacturers:
- 1) Eaton Type FAZ-NA Series.
 - 2) Allen-Bradley 1489-M Series.
 - 3) Or equal.

3. Supplementary Protectors

- a. UL1077 Supplementary protectors shall provide short-circuit and overcurrent protection for power supplies, relays, PLC I/O points, and control circuits that originate and remain within the process control panel enclosure. These circuit breakers shall have the following characteristics:
- 1) Thermal-magnetic.
 - 2) Dual-rated for AC and DC applications.
 - 3) Energy-limiting type with voltage and current ratings as shown in the drawings.
 - 4) Operating Voltage:
 - a) 1-Pole: 277 VAC, 48 VDC
 - b) 2-Pole: 480Y/277 VAC, 96 VDC
 - 5) Operating Temperature: -40° to 167°F
 - 6) Short-Circuit Rating: 10kAIC minimum.
 - 7) DIN rail mountable.
 - 8) Cable in / cable out terminations.

- 9) Compliance: UL 1077 and UL Recognized.
- b. Acceptable Manufacturers
 - 1) Eaton Type FAZ Series.
 - 2) Allen-Bradley 1492-SP Series.
 - 3) Or equal.
- 4. Selector Switches:
 - a. Selector switch shall be constructed with heavy-duty zinc die-cast material. The switch shall be corrosive resistant with zinc alloy mechanism. Typical functions of the device shall be used for Local/Off/Remote or DCS/Emergency, Hand/Off/Auto, etc selector switches:
 - 1) Maintained selector control, minimum 1,000,000 mechanical contact cycles.
 - 2) Black knob and maintained position unless indicated otherwise on the drawings.
 - 3) 30.5 mm diameter.
 - 4) Heavy-duty, watertight/oiltight.
 - 5) Provide at minimum 1 NC and 1 NO contact block and engraving as shown on the drawings. Minimum 10A contact rating.
 - 6) Operating temperature: -40° to 131°F.
 - 7) Humidity: 50 to 95%.
 - 8) Dielectric strength: 2200V for 1 minute.
 - 9) Compliance: UL.
 - b. Acceptable Manufacturers:
 - 1) Eaton Corp, 10250T Series.
 - 2) Allen-Bradley, 800T Series.
 - 3) Or equal.
- 5. Pushbuttons:
 - a. Pushbuttons shall be constructed with heavy-duty zinc die-cast material. The button shall be corrosive resistant with zinc alloy

actuator shaft and stainless steel return spring. Typical functions of the device shall be used for Start / Stop, Open / Close, Reset, etc. Pushbuttons:

- 1) Momentary, minimum 10,000,000 mechanical contact cycles.
- 2) Red cap for Start (Open), green cap for Stop (Close), black cap for Up / Down and Reset. Cap color shall be shown on drawings.
- 3) 30.5 mm diameter.
- 4) Flush button.
- 5) Watertight/oiltight.
- 6) Provide at minimum 1 NC and 1 NO contact block and engraving as shown on the drawings. Minimum 10A contact rating.
- 7) Operating temperature: -40° to 131°F.
- 8) Humidity: 50 to 95%.
- 9) Dielectric strength: 2200V for 1 minute.
- 10) Compliance: UL.

b. Acceptable Manufacturers:

- 1) Eaton, 10250T Series.
- 2) Allen-Bradley, 800T Series.
- 3) Or equal.

6. Illuminating Pushbuttons and Indicating Lights:

a. Indicating pushbuttons and indicating light shall be constructed with heavy-duty zinc die-cast material and corrosive resistant. The device shall have push-to-test light feature:

- 1) Momentary, minimum 250,000 mechanical contact cycles.
- 2) LED, Transformer 120VAC.
- 3) Red cap for Start (Open), green cap Stop (Close), amber cap for alarm. Cap color shall be shown on drawings.

- 4) 30.5 mm diameter.
 - 5) Flush button.
 - 6) Heavy-duty, watertight/oiltight.
 - 7) Press-to-test feature.
 - 8) Provide at minimum 1 NC and 1 NO contact block and engraving as shown on the drawings. Minimum 10A contact rating.
 - 9) Operating temperature: -40° to 131°F.
 - 10) Humidity: 50 to 95%.
 - 11) Dielectric strength: 2200V for 1 minute.
 - 12) Compliance: UL.
- b. Acceptable Manufacturers:
- 1) Eaton, 10250T Series.
 - 2) Allen-Bradley, 800T Series.
 - 3) Or equal.

7. Potentiometer:

- a. Linear type, +/-10%, speed control potentiometer:
- 1) 25,000 mechanical cycles.
 - 2) 10k ohm.
 - 3) Black knob and variable position unless indicated otherwise on the drawings.
 - 4) 30.5 mm diameter.
 - 5) Heavy-duty, watertight/oiltight.
 - 6) 3-wire operator device.
 - 7) Operating temperature: -40° to 131°F.
 - 8) Humidity: 50 to 95%.
 - 9) Dielectric strength: 2200V for 1 minute.

- 10) Compliance: UL.
 - b. Acceptable Manufacturers:
 - 1) Eaton, 10250T Series.
 - 2) Allen-Bradley, 800T Series.
 - 3) Or equal.
8. 24V DC Power Supply:
- a. The DC power supply shall be compact with built in features including sag immunity, power factor correction, universal voltage input, and parallel operation capability for redundancy. The power supply shall be industrial grade design, DIN rail mountable with user LEDs for status and accessible screw terminals. User adjustable output voltage shall be accessible via front face and shall have the following requirements.
 - 1) Input voltage: 115/230Vac.
 - 2) Output voltage: 24Vdc (22.5 – 28.5Vdc Adjustable).
 - 3) Power rating: 240W.
 - 4) Power Factor Correction: .92.
 - 5) Line and load regulation: <0.5%.
 - 6) Operating temperature: -25° to 60°C.
 - 7) Compliance: UL Listed.
 - 8) Warranty: 5 years
 - b. Acceptable Manufacturers:
 - 1) Sola, M/N SDN-10-24-100.
 - 2) Phoenix Contact, QUINT-PS-100-240AC/24DC/10.
 - 3) Or equal.
9. 12V DC Power Supply:
- a. The DC power supply shall be compact with built in features including sag immunity, power factor correction, universal voltage input, and parallel operation capability for redundancy. The power supply shall be industrial grade design, DIN rail mountable with user LEDs for status and accessible screw terminals. User

adjustable output voltage shall be accessible via front face and shall have the following requirements.

- 1) Input voltage: 115/230Vac.
- 2) Output voltage: 12Vdc (5 – 18Vdc Adjustable).
- 3) Power rating: 210W.
- 4) Power Factor Correction: .92 or meeting EN61000-3-2 requirements
- 5) Line and load regulation: <0.5%
- 6) Operating temperature: -25° to 60°C
- 7) Compliance: UL Listed.
- 8) Warranty: 5 years.

b. Acceptable Manufacturers:

- 1) Sola, M/N SDN-9-12-100PC.
- 2) Phoenix Contact, QUINT-PS/1AC/12DC/15.
- 3) Or equal.

10. DC Power Supply Redundancy Module:

- a. The DC power supply redundancy module shall connect two input DC power supplies and compensate for a device failing. The module shall have output capacity rating matching the incoming DC power supplies output rating. The module shall utilize diode components and incorporated voltage surge (over voltage protection) feature.

- 1) Input voltage: 0 – 60Vdc.
- 2) Input current: 2 x 12A.
- 3) Output voltage: Matching input.
- 4) Output current: 1 x 24A.
- 5) Temperature rating: -40° to 70° C.
- 6) Humidity: 5 to 95%.
- 7) Mounting: DIN Rail.

b. Acceptable Manufacturers:

- 1) Weidmuller, PRO DM Series
- 2) Phoenix Contact, QUINT4-DIODE/12-24DC/2X20/1X40 - 2907719

- 3) Or equal.

11. Control Relays

- a. Relay shall be socket plug-in type. Socket shall be DIN rail mounted style. Relay clip shall be included with the relay. Relay contact shall be silver cadmium oxide. Minimum two Form C output contacts. Relay shall have the following features.
 - 1) Manual check buttons.
 - 2) LED indicator.
 - 3) Integral surge suppressor.
 - 4) Contact rating of 10A at 250VAC.
 - 5) Operating coil voltage as shown on drawing.
 - 6) Operating temperature: -30° to 70°C.
 - 7) Compliance: UL rated.
- b. Acceptable products:
 - 1) Idec, RH Series.
 - 2) Allen Bradley, 700-HB Series.
 - 3) Or equal.

12. Time Delay Relays:

- a. Relay shall be socket plug-in type. Socket shall be DIN rail mounted style. Discrete output on timer delay relay with timed out LED indicator light and adjustable range.
- b. Voltage Rating: 120Vac Coil.
- c. Contact Rating: DPDT, 10A @ 250Vac Minimum.
- d. Adjustable Range: 1 second to 10 hours unless otherwise noted on drawing and UL listed.
- e. Compliance: UL Listed.
- f. Acceptable Manufacturers:
 - 1) IDEC RTE analog timer Part no. RTE-B12-AC120V.
 - 2) Cutler Hammer.

- 3) Or equal.

13. Voltage Monitor Relay:

- a. Relay shall be used to monitor over voltage and under voltage conditions. Relay shall be user adjustable for pickup and drop out voltages. Relay shall be socket plug-in type. Socket shall be DIN rail mounted style. Minimum two Form C output contacts. Relay shall have the following features.

- 1) Monitor voltage: 208 - 240Vac, single phase
- 2) Voltage Settings
 - a) Pick-up: Adjustable from 85 – 115% of nominal voltage
 - b) Drop-out: Adjustable from 75 – 95% of pick up setting
- 3) Adjustable delay for pick-up and drop-out: 0.1 – 10 seconds
- 4) Reset: Automatic
- 5) LED indicator: Red when energized and green when off
- 6) Integral surge suppressor.
- 7) Contact rating of 10A at 240VAC/30VDC.
- 8) Operating temperature of -30°C to 70°C.
- 9) Acceptable Manufacturers:
 - a) Macromatic, VAKPU Series.
 - b) Or equal.

14. Intrinsically Safe Barriers (ISB) for Discrete Devices

- a. The ISB shall be designed to isolate and power a 2-wire (dry contact) switch device for transfer of binary switching signals from a classified area to a non-classified area. The circuit must be segregated from other non-intrinsically safe circuits. The input, output, and supply circuits shall be galvanically isolated from each other. The ISB shall have “Power ON” status indicator, wire-break monitoring, and short circuit monitoring features.. The unit shall be module type with screw terminal blocks and DIN rail mountable

with the following requirements:

- 1) Supply Power: 24 Vdc.
- 2) No-Load Voltage: 8.2V
- 3) Short Circuit Current: 8.2mA
- 4) Output Contact: Form C Relay Type, Configurable for N.O. / N.C. function.
- 5) Compliance: UL or FM approved for use with a device located in a Class 1, Division 1 area.

b. Acceptable Manufacturers:

- 1) Phoenix Contact Model MACX MCR-EX-SL-NAM-R
- 2) Turck Model IMX12 Series
- 3) Omega, SIB Series.
- 4) Or equal.

15. Signal Multipliers:

a. Signal multiplier shall be used to multiply and electrically isolate analog signals. The unit shall be configurable for any combination of input and output with current or voltage signal. The unit shall be module type with screw terminal block style and DIN rail mountable with the following requirements:

- 1) Supply voltage: 24Vdc
- 2) Configurable input signal type: Current or Voltage
- 3) Configurable output signal type: Current or Voltage
- 4) Current input range: 0–20mA, 0–10mA, 4-20mA
- 5) Voltage input range: 0-10V, 1-5V, 0-5V
- 6) Current output range: 0-20mA, 4-20mA
- 7) Voltage output range: 0-10V, 1-5V, 0-5V
- 8) Operating temperature: -20°C to 55°C
- 9) UL recognized.

b. Acceptable Manufacturers:

- 1) Phoenix Contact MCR-FL-C-UI-2UI-DCI series.
- 2) Weidmuller.
- 3) Or equal.

16. Potentiometer Input Isolating Signal Conditioner:

- a. Signal conditioner shall be used as a potentiometer input signal supporting 3-wire potentiometer and slidewire devices from 100 ohms to 10k ohms or as required for the application. The unit shall be loop powered type with selectable for DC voltage output or current output and configurable for any range. Unit shall have built in LED indication alarm conditions for over and under ranges of output signals. The unit shall be DIN rail mountable block style with screw terminal block with the following requirements:
 - 1) Supply voltage: Loop powered 9-30Vdc, 1 Watt typical, 2-Watt Max.
 - 2) Input Potentiometer range: 100 ohms to 100k ohms
 - 3) Configurable output signal type: Current or Voltage
 - 4) Configured output current range: 0–20mA and 4-20mA
 - 5) Configured output voltage range: 0–10VDC
 - 6) Output impedance
 - a) Voltage Output: < 100 ohms
 - b) Current Output: > 100k ohms
 - 7) Operating temperature: 0°C to 60°C
- b. Acceptable Manufacturers:
 - 1) Action Instruments, Ultra Slimpak II series, p/n: WV438
 - 2) Or equal.

17. Process and Temperature Display Meters:

- a. The process and temperature display meter shall be configurable to display process ranges and units as shown on the drawing. The meter shall have a minimum 0.56” bright LED display (red color), 2-wire loop powered 4-20mA. The meter shall be outdoor rated and type NEMA 4X and shall meet the following requirements:
 - 1) Display unit: 5 digit (0 – 10,000)

- 2) Supply Power: Loop power, 24Vdc
- 3) Current input range: 0-20mA, 4-20mA, 1-5V, and $\pm 10V$.
- 4) Accuracy and Linearity: $\pm .01\%$ of Full Scale, ± 1 Digit
- 5) Standard Calibration: 4 – 20mA = 0 – 10,000 counts
- 6) Operating temperature: -40°C to 65°C.
- 7) Compliance: UL, CE certified.
- b. Acceptable Manufacturers:
 - 1) Precision Digital, PD765 Series.
 - 2) Red Lion, PAX Series.
 - 3) Or equal.

18. Receptacle:

- a. Ground fault interrupted type, duplex industrial specification rating, 15 Amp, 125 Volt, 2 Pole, 3 Wire, 5-15R NEMA GFCI feed thru type with "test" and "reset" buttons and UL listed.
- b. Acceptable Manufacturers:
 - 1) Cooper Wiring Devices.
 - 2) Hubbell, Inc.
 - 3) Or equal.

19. Fuses

- a. Time delay glass tube construction with nickel plated brass endcaps, 1/4" x 1-1/4" size, for use in Allen-Bradley 1492-H5 fuse blocks.
- b. Provide fuse sizes as shown on the drawings.
- c. Acceptable products:
 - 1) Bussman MDL,
 - 2) Littlefuse.
 - 3) Or equal.

20. Rotating Light:

- a. Rotating light shall produce a 360 degree visual signal. The device shall use a synchronous motor to drive a parabolic reflector around

a LED lamp. Rotating light shall have 5 years warranty.
Additional requirements are as followed:

- 1) Lamp life: 25,000 hours.
- 2) Candela: 1,655.
- 3) Mounting: Surface mount or ½” NPT pipe mount.
- 4) Flash rate: 60 revolutions per minute.
- 5) Operating voltage: 120VAC, 60Hz.
- 6) Operating temperature: -40 deg F – 150 deg F.
- 7) Material of construction: Zinc die-cast alloy base.
- 8) Dome color: Amber, polycarbonate dome.
- 9) Environmental: Indoor and Outdoor rated, type NEMA 4X, and IP66 enclosure.
- 10) Compliance: UL listed.

b. Acceptable Manufacturers:

- 1) Federal Signal Corp. Model 121SLED.
- 2) Edwards Signal, Model Polaris Class LED Beacon 94PLED.
- 3) Or equal.

21. Vibrating Horn:

a. Vibrating horn shall produce sound output level of 100dBa at ten feet distance. The device shall produce sound by the electro-mechanical vibration of a stainless steel diaphragm. The device shall be suitable for hazardous location application and corrosive environments. Additional requirements are as followed:

- 1) Operating voltage: 120VAC, 60Hz
- 2) Mounting: Wall mount.
- 3) Operating voltage: 120VAC, 60Hz.
- 4) Operating temperature: -65 deg F – 150 deg F.

- 5) Material of construction: Die-cast zinc housing with corrosion resistance polyurethane finish.
- 6) Environmental: Indoor and Outdoor rated, type NEMA 4X.
- 7) Classification: Class 1, Div.2 rated.
- 8) Compliance: UL listed.
- 9) Acceptable Manufacturers:
 - a) Federal Signal Corp. Model 350WBX Series
 - b) Edwards Signal
 - c) Or equal.

22. Blocking Diode

- a. Blocking diode to provide battery isolation from power supplies shall be rated for a minimum $I_f = 30A$, minimum $V_{rrm} = 200 V$, maximum $V_f = 1.3 V$.
- b. Acceptable Manufacturers:
 - 1) International Rectifier, input rectifier diode
 - 2) Or equal.

23. EMI/RFI Filter

- a. Main incoming interference filter, DIN-rail mounted, rated 10A at 264VAC maximum voltage, for use on a 120VAC system and UL recognized.
- b. Differential mode (symmetrical) (DM) and common mode (asymmetrical) (CM) input attenuation shall be no less than:
 - 1) 100kHz: 20dB DM, 20dB CM.
 - 2) 500kHz: 70dB DM, 40dB CM.
 - 3) 1MHz: 90dB DM, 40dB CM.
 - 4) 5MHz: 60dB DM, 40dB CM.
 - 5) 10MHz: 40dB DM, 50dB CM.
- c. Acceptable Manufacturers:
 - 1) Phoenix Contact Model 2788977.
 - 2) Or equal.

24. Surge Suppressor:

- a. Surge suppressors shall be type Type 3, UL listed, and consist of a removable plug and a hardwired base element that accepts wire sizes from No. 20 AWG to No. 2 AWG. Units shall be DIN-rail mounted.
- b. Units shall be rated for 120 VAC nominal, 150 VAC maximum and 15kA nominal, 40kA maximum surge current (8/20us).
- c. Compliance: UL listed.
- d. Acceptable Manufacturers:
 - 1) Phoenix Contact, Valvetrab system (Part numbers are listed below).
 - a) Line-Neutral: 120VAC to neutral plug VAL-MS 120 ST Model 2807586; Base element VAL-MS-BE Model 2817741.
 - b) Neutral-Ground Base and Plug: F-MS 12/FM Model 2817974.
 - c) Or equal.

25. Thermostat

- a. Thermostat shall be mechanical base with built in bimetallic sensor and for use in filter fans and heaters temperature control. The thermostat shall be din-rail mountable with a Form C contact or with one N.O. that closes on temperature rise adjustable temperature range of 40 to 140°F. The thermostat shall have the following features:
 - 1) Input Voltage: 115Vac.
 - 2) Contact Rating: 10A Resistive load @ 115Vac.
 - 3) Protection: IP20.
- b. Acceptable Manufacturers:
 - 1) Hoffman.
 - 2) Rital.
 - 3) Or equal.

26. Cabinet Door Switch

- a. Cabinet door switch shall be rated for 15 amperes at 120 VAC and 0.5 amperes at 24 VDC, plunger-type door switch, SPST.
- b. Acceptable Manufacturers:
 - 1) Honeywell, Microswitch Model 1AC2.
 - 2) Or equal.

27. Nameplates:

- a. Nameplates shall be provided as shown on drawing. Nameplate shall be lamicoid with black background and white text. Quantity, size, and inscriptions as shown on drawing.

28. Ethernet Switch:

- a. The Ethernet switches shall be a din-rail mounted switch. The switch store and forward switching mode, auto-crossing, auto-negotiation, auto-polarity, QoS support, unmanged, and industrial grade with redundant input power supply and have the following features and characteristics:
 - 1) Ports: Minimum 5 ports, RJ45 10/100Base-TX ports.
 - 2) Speed: Auto switching 10/100/1000 Mbits.
 - 3) The switch shall have LED indicators for input power status, fault status, and port status.
 - 4) Power: 24VDC.
 - 5) Operating Temperature: -40 to 70 degrees Celsius with a relative humidity of up to 95 percent non-condensing.
 - 6) Supports IEEE 802.1D Ethernet standards.
- b. Acceptable Manufacturers:
 - 1) Hirschmann, SPIDER II Giga 5T EEC Pro.
 - 2) N-Tron, 508TX.
 - 3) Moxa, 2891064
 - 4) Or equal.

29. ALARM AGENT

- a. The Alarm Agent is a wireless, web-based alarm detection and notification system that functions as a WRTU (Wireless Remote Terminal Unit) via cellular communication. The system shall be customizable for the notification and shall be remote accessible via internet connected devices. The system shall operate in real-time mode and on-demand reporting to a remote central server of the detected input signals from the device. The detected input signals are as shown on Drawings. The system shall include built in battery to allow for continue monitoring input even with the loss of power supply. Monthly cellular service subscriber contract for the device shall be by District.
- b. The system shall include build-in 128-bit encryption and requiring proper user names and password authentication to accessing the system.
- c. The system shall be capable of automatically notifying pre-assigned individuals if a preset alarm condition is met through selectable by the CSA in any combination of voice phone call to landline phone, 2nd landline phone, cellular phone, SMS text message, alpha-numeric pagers, or primary and secondary emails.
- d. The Alarm Agent shall have the following features:
 - 1) Continuously monitor the presence of AC power, the status of (8) contact closure inputs, and the status of (2) universal inputs. AC power failure or violation of the alarm criteria at any input shall cause the unit to go into alarm status.
 - 2) Digital Inputs: (8) digital inputs to monitor (dry) unpowered contacts. These inputs shall be opto-isolated, surge protected, and independently programmable without the need to manipulate circuit board switches or jumpers. Each input shall be capable of individually adjust the delay timer setting.
 - 3) Universal Analog/Digital Inputs: (2) analog 4-20mA inputs with 10-bit resolution, single-ended and surge protected. Analog inputs shall be user-configurable to serve as digital inputs in lieu of analog inputs.
 - 4) Relay Outputs: (2) normally open output relays rated 1/2A at 120VAC.
 - 5) Wiring Connections: Wiring connections shall be via unpluggable screw-clamp terminal blocks that accept wire sizes 16AWG to 26AWG.

- 6) Enclosure: NEMA 1 with indoor antenna.
- 7) Power: 24VDC.
- 8) Battery Backup: WRTU shall incorporate a sealed lead-acid backup battery within the enclosure. The battery shall charge automatically, providing 24-hour nominal backup time.
- 9) Operating Temperature: -30 to 70 degrees Celsius
- 10) Relative Humidity: 95%, non-condensing.
- 11) Alarm Trip Delay: All alarm inputs, power failure alarms shall have individually assigned alarm trip delay settings. The range shall be 2 seconds – 1 hour.
- 12) Warranty: 3 years minimum.
- 13) Acceptable Manufacturers:
 - a) RACO Manufacturing, Alarm Agent (No substitutions)

2.3 JUNCTION TERMINAL BOXES

A. Junction terminal boxes shall have the following features:

1. Unless shown on drawings wall mounted panel type with minimum size of 30"W x 30"H x 8"D with provision for padlocking.
2. Type NEMA 4X, SS316 for all outdoor and indoor wet or corrosive areas.
3. Type NEMA 12 for all indoor dry areas.
4. Single door, continuous stainless steel hinge, and literature pocket on the inside side of door.
5. Door secures with stainless steel clamp.
6. Removable 12 gauge inner panel.
7. Acceptable Manufacturers:
 - a. Hoffman Company.
 - b. Hammond Mfg.
 - c. Or equal.

2.4 CONTROL STATION

- A. Control station shall be installed for operating in all areas local to the equipment. The control station shall be sized to accommodate 30mm control devices as required per the drawings with one spare. Control station shall be type NEMA 4X, SS316 for all areas. Nameplate shall be provided to identify the function of the equipment.
- B. Acceptable Manufacturers:
 - 1. GE
 - 2. Cutler Hammer
 - 3. Or equal.

2.5 SPARES, AND EXPENDABLES

- A. General:
 - 1. In addition to the items noted below and in the other specification sections, the PCSS shall provide suitable spare parts and expendable items in sufficient quantities to sustain ICPS for a period of 1 year after acceptance. All spare parts shall be delivered to the site before testing begins.
 - 2. The following tabulation of spare parts and maintenance equipment is presented as a minimum of suitable types and quantities to be provided. The PCSS shall review the actual ICPS provided and submit to the District for approval a specific list. The District's decision as to both types and quantities to be provided shall be final:
 - a. Provide the following spares:
 - 1) Fuses: 30 percent spares of each size and type used, but no less than 10 of each size and type.
 - 2) Relays: 30 percent spares of each type used, but no less than five of each type.
 - 3) Indicating Light Bulb: 30 percent spares of each size and type used, but no less than 10 of each size and type.

2.6 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. The UPS shall be solid state, continuous-duty, and operate on-line double-conversion scheme protecting electronic equipment from power disturbances from upstream power source. The disturbances include voltage fluctuations, brown-outs, blackouts, power surges, and sags. The UPS shall be commercial grade and

high-quality AC power for sensitive electronic equipment loads. The system shall include filter, rectification, inverter components. The UPS shall be completed with a built-in internal battery unit, external battery cabinet, and battery charging system. The UPS system shall also include an external manual maintenance bypass (MBP) switch.

- B. In normal mode the rectification circuit shall derive power from the AC source and supply regulated and filtered DC power to the on-line inverter. The inverter shall convert the DC power at its input to highly regulated and filtered AC power for the sensitive loads.
- C. In battery mode the UPS shall provide power to the critical loads sourced from the internal batteries, external battery cabinet, and inverter. When AC source returns, the unit shall return to Normal operation. Battery cabinet shall be suitable for a minimum runtime of 120 minutes at 100% loading.
- D. In standby mode the UPS shall initially connect to the AC source or a secondary external source. In this mode the UPS shall recharge the batteries, but power shall not be supplied to the sensitive load. The UPS will remain in standby mode until the user activates the normal mode.
- E. The batteries shall be valve regulated lead acid (VRLA), non-spillable, lead acid cells, and maintenance free. The system shall allow for hot swappable internal batteries.
- F. The battery charger shall utilize advanced battery management sensing circuitry and a three-stage charging technique to extend the service life of the UPS batteries while optimizing the battery recharge time.
- G. One set of the battery management software for load monitor, configuration, and alarm management shall be licensed to the District along with a USB cable for connecting to a computer.
- H. The MBP switch shall be provided with the UPS of the same manufacturer to allow for manual switch between two incoming AC sources while the load side connection is maintained without affecting the sensitive load operation. The MBP switch shall house a rotary type and a make-before-break selector switch with UPS-compatible 208VAC input and output connection. The MBP switch shall be externally wall-mounted.
- I. The UPS shall also have the following features.
 - 1. Mounting: 19-inch rack mounted with 3U height

2. Display and Control: Front LCD display with navigational configuration buttons
3. Input Voltage:
 - a. 100/200, 110/220, 120/240 VAC 180 degree three-phase displacement, 60Hz
 - b. 120/208, 127/220 VAC 120 degree single phase displacement, 60Hz
4. Output Voltage (User Selectable):
 - a. 200/100, 220/110, 240/120 VAC, 180-degree three phase displacement, 60Hz
 - b. 208/120, 220/127 VAC, 120-degree single phase displacement, 60Hz. Selectable through front panel or through serial port connection with power management software.
5. Voltage Regulation: +/- 1% Steady-state
6. Power: 12kVA
7. Power Factor: 0.95
8. Output Voltage Distortion (THDV %): < 2% linear load and < 5% non-linear load
9. Input Connection: Hardwired
10. Output Connection: Hardwired
11. Operating Rating Temperature: 0 to 40 degree C (40 to 104 degree F)
12. Relative Humidity: 0 to 95%
13. Audible Noise: < 45 dB at 1 meter
14. Communications: (1) Network Card for network communication
15. Conformance: UL 1778, IEC/EN 62040-3m IEEE ANSI C62.41 Cat B2
16. Warranty: Two years warranty on the UPS, external manual maintenance bypass switch, and all batteries from the date of acceptance
17. Acceptable Manufacturers:

- a. Eaton 9155 (for UPS), NO SUBSTITUTIONS
- b. Eaton BPM125XX (for MBP), NO SUBSTITUTIONS

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Furnish and install control panel and local display panel as shown on drawings.
- B. Install control panels and local display panel with terminal blocks and wire numbers as shown on drawings.
- C. Provide connections to resist seismic forces as detailed on the approved submittals in compliance with Section 01 33 12.
- D. Fuse terminal block shall be installed for each programmable logic controller (PLC) digital input, analog input, and analog output point.

3.2 FACTORY QUALITY CONTROL

- A. All factory testing shall be in accordance with Sections 01 75 17 Field Testing and Startup and 40 80 00.

3.3 FIELD QUALITY CONTROL

- A. All field testing shall be in accordance with Sections 01 75 17 and 40 80 00.

END OF SECTION