

SECTION 40 95 00 – PAC-BASED CONTROL SYSTEMS HARDWARE

PART 1 - GENERAL

1.1 THE REQUIREMENT

- A. The CONTRACTOR, through the use of the Instrumentation Supplier and qualified electrical installers, shall provide and install the PAC-based control system (PACS) hardware complete and operable, in accordance with the Contract Documents.
- B. Instrumentation Supplier: It is the intent of these Specifications to have the Instrumentation Supplier be singularly responsible for selecting, and verifying correct operation of compatible hardware to provide a functional PACS and to provide future support of all PACS hardware.
- C. Minimum Instrumentation Supplier Scope: The exact contractual relationship and scope definition shall be established exclusively between the CONTRACTOR and the Instrumentation Supplier. It is the intent of these Specifications that the Instrumentation Supplier, under the direction of the CONTRACTOR, shall assume full responsibility for the following, as a minimum:
 - 1. Procurement of all hardware required to conform to these Specifications.
 - 2. Design and submit PACS hardware, and spare parts submittals.
 - 3. Perform all required PACS hardware tests, adjustments, and calibrations.
 - 4. Furnish all required PACS tools, test equipment, spare parts, supplies, operations and maintenance manuals, and reproducible record drawings as specified herein.

1.2 SUBMITTALS

- A. Shop Drawings: PACS hardware submittals shall be in accordance with the applicable requirements of Section 40.90.00 – Process Control and Instrumentation Systems. PACS submittals shall, however, be made separately from other process control and instrumentation system submittals.
- B. Hardware Submittals: The PACS hardware submittal shall be a single submittal which includes at least the following:
 - 1. A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tags.
 - 2. Complete grounding requirements for the entire PACS, including any requirements for PACS communication networks and control room equipment.
 - 3. Data sheets shall be included for each PACS component together with a technical product brochure or bulletin. These data sheets shall show the component name as used within the Contract Documents, the manufacturer's model number or other identifying product designation, the project tag number, the project system of which it is a part, the Site to which it applies, the input and output characteristics, the requirements for electric power, the ambient operating condition requirements, and details on materials of construction.

4. Complete and detailed bills of materials: A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component of the PACS system. Bills of material shall include all items within an enclosure.
- C. Owner's Manuals: General requirements for Owner's Manuals are as described in Section 40 90 00 – Process Control and Instrumentation Systems. The following items shall also be included in the PACS manual:
 1. Operation and maintenance manuals for both the PACS, and all other PACS hardware.
- D. Factory Test Procedure: The Instrumentation Supplier shall prepare and submit a factory test procedure which incorporates test sequences, test forms, samples of database lists, a PACS testing block diagram, and an estimated test duration which comply with the requirements of the factory test specified herein.

1.3 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. The CONTRACTOR/Instrumentation Supplier shall arrange for visits by, and services of, technical field representatives of the PAC manufacturer for installation certification, system testing, and start-up. These services shall be part of the WORK.

1.4 STORAGE AND HANDLING

- A. All equipment and materials delivered to the Site shall be stored in a location that shall not interfere with the operations of the OWNER's personnel or interfere with construction. Storage and handling shall be performed in a manner that shall afford maximum protection to the equipment and materials. It is the CONTRACTOR's responsibility to assure proper handling and on-site storage.

1.5 SPECIAL WARRANTY REQUIREMENTS

- A. Equipment and materials selected by the CONTRACTOR that do not achieve design requirements after installation shall be replaced or modified by the Instrumentation Supplier to attain compliance. The cost for doing so shall be the CONTRACTOR's responsibility. Following replacement or modification, the CONTRACTOR shall retest the system and perform any additional procedures needed to place the complete PACS in satisfactory operation and attain design compliance approval from the ENGINEER.
- B. The CONTRACTOR warrants/guarantees the satisfactory performance of the equipment and materials under operating conditions for a period of 1 year after the date of final acceptance of the entire PACS. In the event that tests and inspections disclose latent defects or failure to meet the specified requirements, the Instrumentation Supplier, upon notification by the OWNER, shall proceed at once to correct or repair any such defects or non-conformance or to furnish, at the delivery point named in the Contract Documents, such new equipment or parts as may be necessary for conformity to the requirements, and shall receive no additional

compensation therefore. In case of any required repairs or other corrective or remedial work covered under warranty, the warranties on all such corrections, repairs, new equipment, or parts shall be extended for an additional 24 months from the date of final acceptance, or 12 months from the date of completion of any such corrections, repairs, new equipment, or parts, whichever date is later. If the OWNER performs repair, the CONTRACTOR shall reimburse the OWNER for all costs incurred in the removal of the defective material and installation of the replacement.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The requirements of Section 40 90 00 – Process Control and Instrumentation Systems apply to this Section.
- B. All materials and all PACS equipment furnished under this Contract shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.
- C. Hardware Commonality: Where there is more than one item of similar equipment being furnished all such similar equipment shall be the product of a singular manufacturer.

2.2 PACS ENCLOSURES

- A. Each PAC and its corresponding I/O modules, power supply module(s), communication interface device(s), peripheral equipment, and radio communications shall be mounted inside suitable enclosures. All I/O wiring from the field to the I/O modules shall be terminated on terminal blocks in the enclosure.

2.3 UNINTERRUPTIBLE DC POWER SUPPLY

- A. Provide and install battery supported DC power supplies of the size, number, and location as shown on the Drawings.
- B. The DC power supply shall be per Section 26 33 05 – DC Power Supply/Battery Charger.

2.4 PROGRAMMABLE AUTOMATION CONTROLLER (PAC)

- A. General: Each PAC shall be of solid-state design. All central processor (CPU) operating logic shall be contained on plug-in modules for quick replacement. Chassis-wired logic is not acceptable. The controller shall be capable of operating in a hostile industrial environment and designed to provide high reliability specifically in this process application. The internal wiring of the controller is to be fixed, with the logic functions it must perform in a given application to be programmed into its memory. The controller shall be supplied with the CPU, input/output scanner, inputs,

outputs, memory, power supply, and all power and interface cables necessary to function as a complete and operable PAC system.

- B. Design: Each PAC shall have all of the facilities required to implement the control schemes and database indicated. PACS shall have the following functions and features:
1. Modular, field-expandable design allowing the system to be tailored to this process control application. The capability shall exist to allow for expansion of the system by the addition of hardware and/or user software.
 2. The processor plus input and output circuitry shall be of a modular design with interchangeability provided for all similar modules. Modules are defined herein as devices that plug together to form an interlocking modular chassis. The design must prohibit upside-down insertion of the modules.
 3. The PAC shall have downward compatibility whereby all new module designs can be interchanged with all similar modules in an effort to reduce obsolescence.
 4. All hardware shall operate at an ambient temperature of 0 to 60 degrees C (32 to 140 degrees F), with an ambient temperature rating for storage of - 40 to + 85 degrees C (- 40 to + 185 degrees F), and shall function continuously in the relative humidity range of 5 percent to 95 percent with no condensation. The PAC system shall be designed and tested to operate in the high electrical noise environment of an industrial plant.
 5. The PAC shall provide a means for mounting the chassis in a standard cabinet.
- C. Central Processors: The CPU shall contain all the relays, timers, counters, number storage registers, shift registers, sequencer, arithmetic capability, and comparators necessary to perform the indicated control functions. It shall be capable of interfacing sufficient discrete inputs, analog inputs, discrete outputs, and analog outputs as shown on the drawings. The Processor shall be an **Allen Bradley CompactLogix 1769-L33ER**, as shown on the Drawing, no exceptions, to match AWWU equipment at other AWWU facilities. The CPU shall be supplied with a 1GB **SecureDigital card Allen-Bradley 1784-SD1**, or equal. The PACS shall have the following features and capabilities:
1. All PACS shall be provided to support and implement closed loop floating and PID control which is directly integrated into the PAC's control program.
 2. The CPU shall be a self-contained unit, and shall provide control program execution and support remote or local programming. This device shall also supply I/O scanning and inter-processor and peripheral communication functions.
 3. The operating system shall be contained in removable programmable devices which allow for easy field replacement.
 4. The CPU within the system shall perform internal diagnostic checking and give visual indication to the user by illuminating a "green" indicator when no fault is detected and a "red" indicator when a fault is detected.
 5. Non-volatile memory shall store the operating system information to protect against loss in the case of power loss or system shut-down. Only at the time of a hardware change shall this configuration status be altered or re-entered.
 6. The PAC shall have the ability to fit into Rockwell's Factory Talk Directory's Security Application and participate in the Rockwell Asset Center Disaster Recovery Program.

- D. Program Creation and Storage (Memory)
1. The program storage medium shall be of a static RAM type.
 2. The PAC system shall be capable of addressing up to 2MB, where each word is comprised of 8 data bits.
 3. Memory capacity shall be configurable to allow for the most economical match to the intended application. It shall be possible to upgrade to a processor with a larger memory size simply by saving a program, replacing the processor, and downloading the program to the new system without having to make any program changes.
 4. Memory shall be capable of retaining all stored program data through a continuous power outage for 4 months under worst case conditions. A low battery condition must be detectable in ladder logic, but shall not automatically generate a major fault.
 5. All user memory in the processor not used for program storage shall be allocatable from main memory for the purpose of data storage. The PAC system shall be capable of storing the following data types:
 - a. External Output Status
 - b. External Input Status
 - c. Timer Values
 - d. Counter Values
 - e. Signed Integer Numbers (16-bit)
 - f. Floating Point Numbers
 - g. Decimal Numbers
 - h. Binary Numbers
 - i. BCD Numbers
 - j. Direct and Indexed Addressing
 - k. Internal Processor Status Information
 - l. ASCII Character Data
 - m. ASCII String Data
 - n. Block Transfer Control Structures
 - o. Floating Point PID Control Structures
 - p. File Instruction Control Structures
 - q. Message Control Structures
 6. Control logic programs shall have immediate access to the sub-elements of control structures by address and sub-element mnemonic, such as timer accumulator value, timer done bit, or PID Process Variable value.
 7. Each unit shall be supplied with memory to implement the indicated control functions. The memory shall be programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.
- E. Programming Techniques: The ENGINEER and OWNER shall program the PACS.
- F. Ethernet Interface and Network
1. The PAC system shall offer industry standard Ethernet TCP/IP communication capabilities. The controller shall be able to connect to industry standard 100baseT media types by implementing a standard RJ-45 transceiver port that can connect to different transceivers. There shall be a CIP protocol layer that

uses TCP/IP as the transport mechanism to deliver packets of data to other PACS that use the same protocol. This protocol handles the addressing and transfer of all the specific data file types in the PAC to allow for peer-to-peer messaging.

- a. Token passing system.
 - b. Peer-to-peer communication.
 - c. Message error checking.
 - d. Retries of unacknowledged messages.
 - e. Diagnostic checks on other stations.
 - f. Interface to more than one network.
 - g. A user-oriented command language for manipulation of data structures of variable size and organization, such as setting or resetting bits, word and file transfers in a peer processor.
 - h. The ability to perform PAC memory uploads and downloads.
 - i. The ability to communicate with all other models of PAC manufactured by said manufacturer.
 - j. The ability to monitor the status of any processor remotely via the network.
 - k. The ability to automatically broadcast data to (and receive data from) all compatible stations on the link. Once configured, this operation shall be continuous without operator intervention.
 - l. A gateway interface to the Ethernet TCP/IP network for connectivity to host computers as well as other PACS that have direct Ethernet connectivity
2. The PAC system shall allow industry standard repeaters, bridges, routers, and gateways on the network in order to access other PACS and host computers. The controller shall be able to name a specific gateway/router IP address in order to direct data to other networks.
 3. On-line programming and upload/downloads of control programs shall be able to occur over the Ethernet network.

G. PAC Power Supply

1. The PAC shall operate in compliance with an electrical service of 24 VDC. The power supply shall be mounted in the PAC housing and be sized to power all modules mounted in that housing and an "average module load" for any empty housing slots plus 25 percent above that total. Power supply shall be by the same manufacturer as the PAC and shall be of the same product line. A single main power supply shall have the capability of supplying power to the CPU and local input/output modules. Auxiliary power supplies shall provide power to remotely located racks.
2. The power supply shall be **Allen-Bradley 1769-PB4**, no exceptions to the model shown on the Drawings.

H. PAC Input/Output (I/O) Modules

1. I/O Modules General: All I/O housings and modules shall be suitable for hostile industrial environments. All I/O modules shall be isolated and conform to IEEE Surge Withstand Standards and NEMA Noise Immunity Standards. The I/Os shall be 4-20 mA DC for all analog inputs and outputs and shall be 24 VDC for discrete inputs and dry relay contacts for safe discrete outputs. Each PAC I/O

- location shall contain the I/O module quantity and type as shown on the Drawings.
2. Discrete Input Modules with Diagnostics: Defined as contact closure inputs from devices external to the programmable controller module. Individual inputs shall be optically isolated from low energy common mode transients to 1500 volts peak from users wiring or other I/O modules. Input modules shall be **Allen-Bradley 1769-IQ16** or **1756-IB16**, unless noted on the Drawings.
 - a. DC input for devices that operate at 5 to 30 VDC.
 3. Discrete Output Modules with Electronic Fuse: Defined as contact closure outputs for ON/OFF operation of devices external to the programmable controller module. The output modules shall be optically isolated from inductively-generated, normal mode and low energy, common mode transients to 1500 volts peak. Discrete output contacts shall be provided with interposing relays in the control panel. Output modules shall be **Allen-Bradley 1769-OB16** or **1756-OB16**, unless noted on the Drawings.
 - a. DC output for devices that operate at 10 to 30 VDC.
 4. Analog Input Modules: Defined as 4 to 20 mA DC signals, where an analog to digital conversion is performed with 14-bit precision and the digital result is entered into the processor. The analog to digital conversion shall be updated with each scan of the processor. Input modules shall be source or sink to handle 2-wire or 4-wire transmitters, respectively. Input modules shall be **Allen-Bradley 1769-IF4** or **1756-IF16**, unless noted on the Drawings.
 5. Analog Output Modules: Defined as 4 to 20 mA DC output signals where each output circuit performs a digital to analog conversion minimum of 12-bit precision with each scan of the processor. Each analog output module shall have two isolated output points which shall be rated for loads of up to 1200 ohms. The CONTRACTOR shall provide current loop isolators as required to break ground loops. Output modules shall be **Allen-Bradley 1769-OF2** or **1756-OF8**, unless noted on the Drawings.
 6. DeviceNet Scanner Module: Any PAC location which requires communication to remote devices via DeviceNET shall be supplied with a DeviceNET scanner module in PAC Rack 00, located in the slot position next to the PAC. The DeviceNET module shall be **Allen-Bradley model 1769-SDN**.
 7. DeviceNet Adapter Module: Any remote I/O location which requires communication to a PAC via DeviceNet shall be supplied with a DeviceNet adapter module, **Allen-Bradley model 1769-ADN**.
- I. PAC Rack Configuration: The PAC, power supply, and I/O modules shall be mounted in the Rack configurations show on the drawings. Space is to be provided for future expansion of the racks in keeping with Allen-Bradley guidelines.
 - J. Operator Interface: A color LCD, touch sensitive, Operator Interface is to be provided at each facility to allow local display. The unit is to be supplied at 24 VDC and is to communicate to the PAC via an Ethernet interface. The Operator Interface shall be **Allen-Bradley model Panel View Plus 6 700 2711P** no exception.

2.5 NETWORK HARDWARE

- A. All unshielded twisted pair cabling shall be rated EIA/TIA 568 category 5 for plenum space.
- B. Ethernet Radio: Radio shall be **MDS Entranet 900 Ethernet remote**, configured from the factory for multiple endpoints and network management, no exception. Radios must communicate with existing AWWU MDS poling master radios and no substitutions will be accepted. Mounting shall be done with a **MDS 35 mm DIN Rail Mounting Bracket (Part No. 03-4022A02)**.
- C. Antenna: Antenna shall be 10 dB gain Yagi antenna, **MDS Clearwave**, or equal.
- D. High Gain Panel Antennas: The antennas shall have a gain of USLS 18 db at 910 MHz, with a polarization of ± 45 degrees, a front-to-back ratio of 34 db or higher, a VSWR 1.4:1 or better, and a wind rating of 125 mph. The unit shall be equipped with a weather shield, DIN connector, lightning protection, and mounting hardware for the antenna pole shown on the drawings. The antenna shall be a **Decibel model LBX-3316DS-TOM**, or equal.
- E. The CONTRACTOR shall provide all antennas, coax cables and fittings as shown on the Drawings. The Coax cable shall be as specified in Section 26 05 19 and shall not be spliced. The cable and all fittings shall be weatherproof.
- F. DIN Rail-mounted Ethernet Switch: The switch shall be compact size and designed to mount to DIN rail, be 10Base-T/100Base-TX compliant, be Auto sensing full and half duplex, have 6 to 10 ports as shown, and have a UL 508 listing. The power supply shall be 8 VDC to 24 VDC. The switch shall be **STRATIX 5700**, or equal. The ENGINEER has tested this switch and is satisfied that it will function in the SCADA system as intended.
- G. DeviceNet Hardware
 1. Trunk Line Drop Connection: **Allen-Bradley T-Port tap**, or **DeviceNet Plug with lock 1787 Plug 10R**.
 2. Power Tap: **Allen-Bradley PowerTap**.
 3. Terminating Resistors: **Allen-Bradley 1485A Series**.
- H. Westermo TD33/V.9 Modem and Router: The CONTRACTOR shall provide the TCP/IP modems and PPP routers as shown on the drawings and instrumentation details. The modems shall be designed to use in industrial applications, shall transmit at 33.6 kbits/s, operate on 24 vdc power, provide AT-commands set, provide EIA RS-232-C/V.24 interface, provide Password/Callback, DTR Hotcall, and operate from 0 to 60 degrees C. The CONTRACTOR shall install the modems and routers in the SCADA panels as shown on the PAC Rack View drawings. The CONTRACTOR shall furnish for installation by the OWNER the modems for the Ship Creek WTP as shown on the details. The OWNER will configure the modems and routers. The router shall be a **Westermo model PPP ED-20** router designed to connect to the Westermo Tele Modem, the modem shall be **Westermo TD33/V.9 US**, and shall match existing Westermo equipment.

- I. Cisco Network Hardware: The CONTRACTOR shall provide the new Cisco router extension board to plug in to the OWNER's existing Cisco router as shown on the instrument details. The OWNER will install and configure the Cisco hardware.
- J. EtherNet / IP Distributed I/O Module: Allows CompactLogix user to re-use existing 1769 I/O. **Allen-Bradley-AENTR I/O Module.**
- K. EtherNet Tap Module: **Allen-Bradley 1783-ETAP.**

2.6 SPARE PARTS

- A. Provide one card, power supply, radio, and switch of each type as required to be installed in the SCADA panel.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The CONTRACTOR shall utilize qualified personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies that it provides. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it provides.
- B. All components of the PACS, including all communication cabling, shall be the installation responsibility of the CONTRACTOR unless specifically noted otherwise. The installation of the communication network shall be the complete installation responsibility of the CONTRACTOR, including all cables, connectors, transceivers, antennas, and any required electrical grounds. Grounding shall be shown on submittal drawings. After installation of the PACS is completed, the installation shall be inspected jointly by the CONTRACTOR and the Equipment Manufacturer's representatives. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the ENGINEER. The certification shall state that all PAC communication and I/O modules, modems, system grounds, communication network, and all other components of the PACS System have been inspected and are installed in accordance with the Manufacturer's guidelines.
- C. All DeviceNet cabling shall be done in accordance with Allen-Bradley DeviceNet Planning and Installation Manual.
 - 1. Maximum length of DeviceNet drop lines shall not exceed 20 feet.
 - 2. Terminating resistors shall be installed at each end of the trunk line.
 - 3. Where a DeviceNet MCC is installed, DeviceNet power connection shall be made with a PowerTap in a separate enclosure. In facilities with no DeviceNet MCC, DeviceNet power connection shall be made from SCADA panel fuse directly to the DeviceNet scanner module.

3.2 FACTORY TEST

- A. General: Prior to shipment of the PACS from the factory, but after the procurement, assembly, and configuration of all components, the CONTRACTOR shall conduct a factory test on the panel fabricator shop floor. This test shall be witnessed by a representative of the OWNER and the ENGINEER of record, at the place of fabrication. No PACS shall be shipped without the ENGINEER's written approval of the factory test. The factory test is intended to be a complete PACS. The factory test shall demonstrate the functionality and performance of specified features of the PAC. The test shall include verification of all radios, PACS, and remote I/O system I/O points. Each point shall be checked from the terminal strip to register in the PAC processor. A complete system checklist shall be available during the test for recording results of selected points. **A minimum of ten (10) working days** notification shall be provided to the ENGINEER prior to testing.
- B. Test Setup: The complete PACS system as shown on the drawings shall be assembled and interconnected on the CONTRACTOR's factory floor. The system shall include communication cable segments for the LANs, an Ethernet switch provided by the CONTRACTOR, and the radios to simulate as closely as possible the eventual Site installation. The PACS and communication devices shall be loaded with their applicable software packages. PAC input and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures. The CONTRACTOR shall have a complete, up-to-date set of wiring drawings and a PAC register list for the test point, for review throughout the test.
- C. The CONTRACTOR shall schedule the factory test after receiving approval of the factory test procedures submittal. One test shall be conducted for the complete system. A minimum of five 8-hour days will be budgeted for the test. The CONTRACTOR shall provide a qualified technician to assist with testing for the entire duration of the factory test.
- D. Test Procedure: The factory test shall be conducted in accordance with the previously submitted and approved test procedures. The test procedures shall include written descriptions of how individual tests shall be performed and shall incorporate testing the following features as a minimum. All testing shall be completed in one continuous factory test which shall extend over 5 continuous days.
1. Power Failure: External power to enclosures and/or workstations shall be turned off and back on in order to test the operation of the DC battery back-up system.
 2. The panel fabricator shall provide one technician for the 5 days of the test to assist the ENGINEER in testing the panel.
- E. Test Report: The CONTRACTOR shall record the results of all factory testing on preapproved test forms which the OWNER's and ENGINEER's representatives shall sign. A copy of the completed test forms and a report certifying the results shall be provided to the ENGINEER within 10 days of completing the test.
- F. Rework and Retest: If the PACS does not operate as required, the CONTRACTOR shall make whatever corrections are necessary, and the failed part of the tests shall be repeated. If, in the opinion of ENGINEER's representative, the changes made by the CONTRACTOR for such a correction are sufficient in kind or scope to effect parts

of system operation already tested, then the effected parts shall be retested also. If a reliable determination of the effect of changes made by the CONTRACTOR cannot be made, then the ENGINEER's representative may require that all operations be retested. The CONTRACTOR shall bear all of its own costs for the factory test, including any required retesting.

- G. All of the travel and per diem costs for factory testing and retesting shall be borne by the CONTRACTOR.
 - 1. For factories within a 50-mile radius of the project site, no travel or per diem costs will be charged by the OWNER's representative and ENGINEER of record.
 - 2. For factories outside of a 50-mile radius of the project site, the CONTRACTOR shall pay air travel costs, vehicle rental costs, lodging, and meals, for two people for the duration of each visit required to witness the factory tests. The vehicle rental, lodging, and meal allowance shall be \$225 per person per day.

3.3 CALIBRATION, TESTING, AND INSTALLATION

- A. Calibration: All analog inputs and outputs of the PAC shall have their calibration checked at a minimum of two points to verify consistency with the balance of the analog loop. This calibration check shall be done in conjunction with the analog loop tests in Section 40 90 00 – Process Control and Instrumentation Systems. Operator Interfaces and PAC registers shall both be verified for correctness.
- B. The CONTRACTOR shall submit to the ENGINEER a system testing completion report when each process system and all aspects of the configuration software have been successfully tested as described herein. The report shall note any problems encountered and what action was required to correct them. It shall include a clear and unequivocal statement that the process systems have been thoroughly tested and are complete and functional in accordance with all Specification requirements.

END OF SECTION 40 95 00