

## SECTION 40 00 00 – PROCESS SYSTEMS INTEGRATION

### 1.01 SUMMARY:

#### A. Scope:

1. <sup>A16</sup>Integrated process control systems shall govern and handle the operation of the third set of lock complexes, and support the Transit of vessels in accordance with paragraph 1.01 D. of Section 01 81 26 (*Communications, Controls, Safety, and Security Systems*), and Section 01 92 00 (*Facility Operation*). <sup>A16</sup>
2. This Section shall be read in conjunction with the Sections listed in Table 40 00 00-1.

#### B. Related Sections:

| Table 40 00 00-1: <sup>A9</sup> Related Sections <sup>A9</sup> |                     |   |  |
|--|---------------------|---|--|
| 1.   | Section 01 40 00    | - | Quality Requirements   |
| 2.   | Section 01 81 26    | - | Communications, Controls, Safety, and Security Systems                       |
| 3.   | Section 01 92 00    | - | Facility Operation   |
| 4.   | Section 11 52 23    | - | Video Walls  |
| 5.   | Section 12 59 83    | - | Custom Systems Furniture   |
| 6.   | Section 25 11 00    | - | Data Processing Equipment  |
| 7.   | Section 27 10 00    | - | Structured Cabling Systems for Communications Inside Plant                   |
| 8.   | Section 27 11 16    | - | Cabinets, Racks, Frames, and Enclosures                                      |
| 9.   | Section 40 70 00    | - | Electrical Supervisory Control and Data Acquisition (SCADA) System           |
| 10.  | Section 40 91 00    | - | Primary Process Measurement Devices (Sensors and Instrumentation)            |
| 11.  | Section 40 94 43    | - | Programmable Logic Controllers (PLCs)  |
| 12.  | Section 40 95 13    | - | Process Control Hardware   |
| 13.  | Section 40 95 13.13 | - | Process Control Hardware for Locks Machinery Control Systems                 |
| 14.  | Section 40 95 13.16 | - | Process Control Hardware for Fire Fighting Control Systems (FFCSs)           |
| 15.  | Section 40 95 13.19 | - | Process Control Hardware for Electrical Distribution Control Systems (EDCSs) |
| 16.  | Section 40 95 13.22 | - | Wastewater Treatment Control Systems (WWTCSs)                                |
| 17.  | Section 40 95 73    | - | Control Cables   |
| 18.  | Section 40 96 45    | - | Process Control Software   |
| 19.  | Section 40 96 45.13 | - | Process Control Software for LMCSs   |
| 20.  | Section 40 96 45.16 | - | Process Control Software for FFCSSs  |
| 21.  | Section 40 96 45.19 | - | Process Control Software for EDCSs   |
| 22.  | Section 48 19 16    | - | Inverters  |

**C. Items to be Provided:**

1. Process control systems to be provided shall include, but not be limited to the specific functions and elements listed in Table 40 00 00-1, and shall be configured generally in accordance with Figure 40 00 00-1, Conceptual Process Integration Block Diagram.
2. Process control systems shall be provided with items listed elsewhere in the <sup>A17</sup>Contract including, <sup>A17</sup> but not limited to, the following:
  - a. Cables and accessories for local power distribution
  - b. Special tools, portable and workshop test equipment
  - c. <sup>A9</sup>Off-line simulator for play back and operator training, <sup>A9</sup> <sup>A5</sup> as specified in Section 40 96 45 (*Process Control Software*).<sup>A5</sup>
  - d. <sup>A5</sup>Training services for operation and maintenance staff including process control equipment as described in Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Paragraph 1.03.<sup>A5</sup>
  - e. Fault diagnostics with facilities for off-line analyses.
  - <sup>A9</sup>f. Input/output type and quantities depend on overall locks design and machinery.<sup>A9</sup>

**1.02 REFERENCES:**

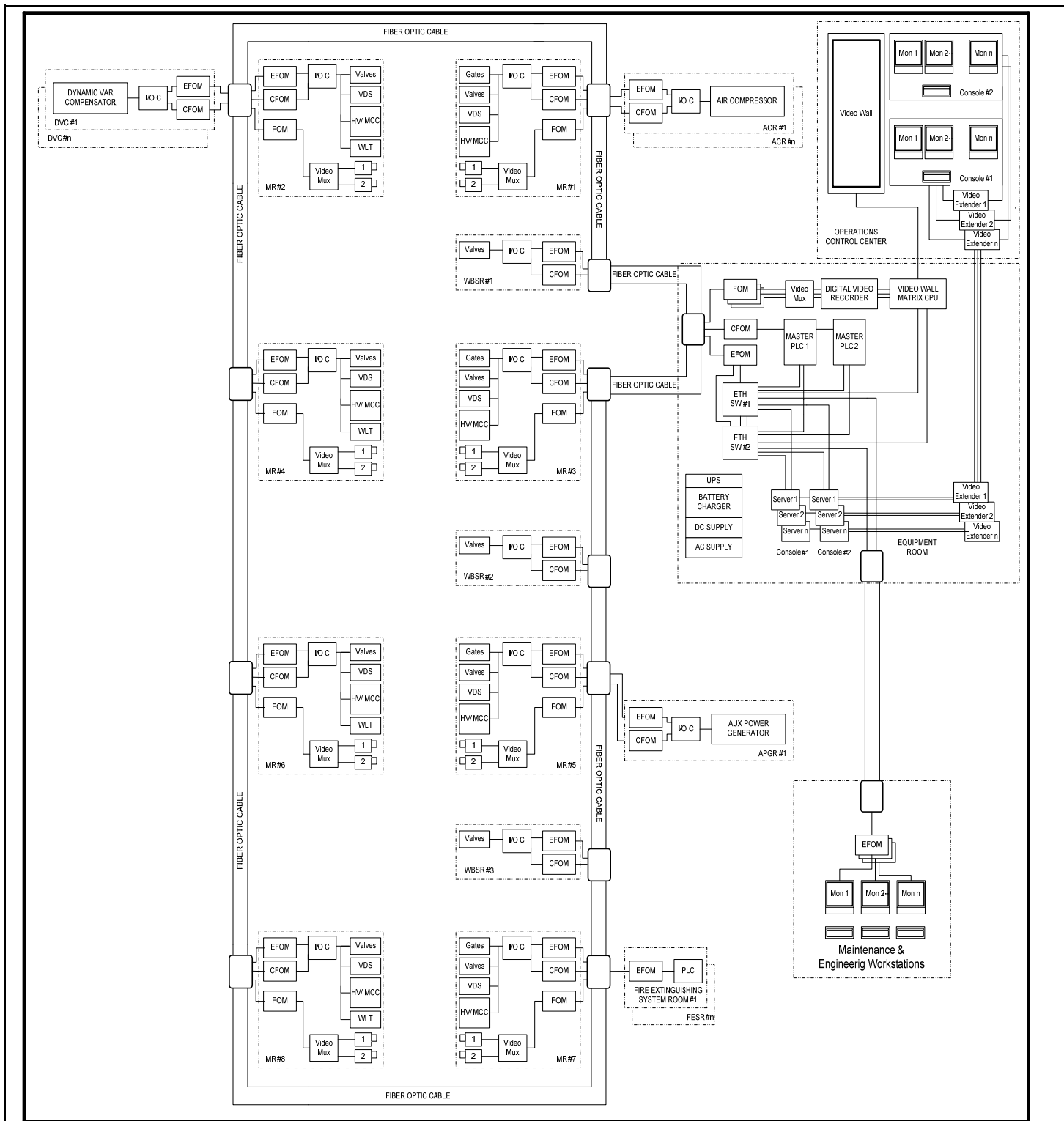
- A. **Applicable Publications:** Refer to Paragraph 1.02 of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*).
- B. **Conceptual Drawings:** The following drawings are furnished as <sup>A17</sup>information, and the Contractor is referred to the final paragraph of Sub-Clause 5.1 of the Conditions of Contract: <sup>A17</sup>

| <b>Table 40 00 00-2: Process Integration Reference Drawings (see Volume VI, Part 1)</b> |  |
|---|--|
| ACP VF Number   | Description  |
| <sup>A7</sup> VF-1700-118-157 <sup>A7</sup>   | Control System Architecture Proposal                     |
| <sup>A7</sup> VF-1700-118-159 <sup>A7</sup>   | Control System Architecture Basic Configuration          |
| <sup>A7</sup> VF-1700-118-160 <sup>A7</sup>   | Control System Architecture Final Configuration Proposal |

**1.03 REQUIREMENTS:**

**A. General:**

1. The Contractor shall meet all applicable requirements of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Paragraph 1.03.



**Figure 40 00 00-1:** Conceptual process integration block diagram, where CFOM = FOM for IEC 61158 type 2 (ODVA ControlNet), EFOM = FOM for Ethernet, and IOC = input/output concentrator. CFOMs and EFOMs shall provide technology diversity (ODVA ControlNet and Ethernet/IP) as well as route diversity.

2. In order to simplify change management, the process control system (PCS) at each lock complex shall be a centralized control system with all the corresponding processors installed in the equipment room of the main control building.
3. <sup>A9</sup>All plant I/O shall be collected by local I/O concentrators and sent to central processors by means of networking. The number of I/O points or tags depends on the contractor design.<sup>A9</sup>

**B. Communications:**

**1. General:**

- a. Backbone fiber optic cabling shall be in accordance with Section 27 10 00 (*Structured Cabling Systems for Communications Inside Plant*).
- b. Watchdogs shall watch communications in one second base.

**2. Communication Protocols:**

**a. Lower Layer Protocols:**

- 1) CENELEC EN 50325-2, IEC 61158 type 2, or Ethernet/IP (Ethernet Industrial Protocol) shall be used for all motor starters, variable frequency drives, and remote field I/O blocks.
- 2) When available, highway addressable remote transducer (HART) protocol shall be used for all analog sensors connected to a PLC.
- 3) When used, DNP3 protocol shall be in this layer and encapsulated in EtherNet/IP.

- b. **Middle Layer Protocol:** Shall be redundant IEC 61158 type 2 or Ethernet/IP for PLCs and input / output (I/O) racks. Proprietary protocols are unacceptable for this. Redundancy requirements imply two network interface cards (NICs) at each equipment.

**c. Top Layer Protocol:**

- 1) This layer shall have redundant EtherNet/IP for all local or remote central consoles, engineering and maintenance workstations, all server types and PLC communications. Ethernet shall be 100 Mbps or faster, and gigabit (1 Gbps) or better if available.
- 2) This layer shall also have redundant IEC 61158 type 2 communications between PLCs and RIOs. Ethernet/IP and IEC 61158 type 2 shall be redundant to each other. Ethernet/IP shall

be the default network, and shall failover to IEC 61158 type 2 upon failure of both Ethernet/IP channels.

- 3) Redundancy requirements imply two NICs or LAN ports at each equipment.

d. **ODVA Common Industrial Protocol (CIP):** CIP shall be used as follows:

- 1) As a single media-independent platform that provides seamless communication from the plant floor through the enterprise with a scalable and coherent architecture.
- 2) To integrate I/O control, configure devices, and collect data transparently across multiple networks, regardless of the network type. Such networks shall include, but not be limited to, IEC 61158 type 2, CENELEC EN 50325-2, and Ethernet/IP.
- 3) For network integration, allowing complete integration of control with information, multiple CIP Networks, and Internet technologies.

e. **Other:**

- 1) IEC 61158 type 2, CENELEC EN 50325-2, or Ethernet/IP shall be used to communicate with field instrumentation, as specified in this section.
- 2) Should the proposed PLCs, RIOs, and other applicable control devices not handle IEC 61158 type 2 and/or CENELEC EN-50325-2 in native form, the Contractor shall provide gateways or other appropriate means as required to maintain both of these communications protocols for field instrumentation. Such gateways and items shall not decrease the data baud rate nor slow down the Employer processes.

C. **Coordination:**

1. The Contractor is required to cooperate intensively with the mechanical Subcontractors.

D. **Equipment for Exteriors:** All PCS equipment to be used in the Works either above ground or submerged shall be designed such that:

1. The equipment itself and all mechanical housings, supporting brackets and hardware:
  - a. Shall be certified for use in tropical coastal marine climate (resistance to temperature, corrosion, water, sun rays, and pollution considered) and have a minimum level of protection in accordance with IEC 60529 (even for equipment that will normally not be submerged): IP 68 whenever available, IP 67 otherwise.

- b. <sup>A5</sup>Shall not require replacement for a minimum of 10 years when specified maintenance is performed.<sup>A5</sup>
  - 2. Electrical and electronic equipment shall be mounted, connected, and protected so as to be highly resistant to lightning effects.
- E. **Ergonomic Studies:** The <sup>A10</sup>Contractor <sup>A10</sup> shall carry out specific ergonomic studies of the process in accordance with Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), in order to <sup>A9</sup>achieve locks<sup>A9</sup> operators efficiency and operation safety.
- F. **Fiber Optic Cabinet/Enclosures:** Shall be in accordance with Section 27 11 16 (*Cabinets, Racks, Frames, and Enclosures*).
- G. **Interface Requirements:**
  - 1. The Contractor shall be required to coordinate, integrate and interface the designs and construction methods and techniques with that of the communications and control systems for which the integrated process systems forms part, as described in Sections 01 81 26 (*Communications, Control, Safety, and Security Systems*) and 01 40 00 (*Quality Requirements*).
  - 2. The Contractor shall develop and maintain an interface and integration management regime for use throughout the <sup>A17</sup>service life of the systems. <sup>A17</sup> This shall be done in accordance with design conferences specified in Section 01 81 26 (*Communications, Control, Safety, and Security Systems*).
  - 3. The Contractor shall coordinate the systems and <sup>A10</sup>sub-systems listed <sup>A10</sup> in Tables 40 00 00-1 and 40 00 00-3 to ensure that communications, control, safety, and security systems are fully integrated and compliant with all requirements of the Contract.
- H. **Networking:**
  - 1. PCS network topology shall ensure the network does not encounter a single point of failure where:
    - a. The failure of one node will disable other nodes on the same ring or network segment, or
    - b. The failure of one ring or network segment will disable two or more machinery acting as backup to one another.
  - 2. Where Ethernet/IP and IEC 61158 type 2 are used to communicate IOCs and PLCs, redundant Ethernet shall be the default, and failover to IEC 61158 type 2 shall take place automatically upon failure of both Ethernet/IP data communications links. Upon restoration of Ethernet/IP links, IEC 61158 type 2 links shall failover to Ethernet/IP automatically.

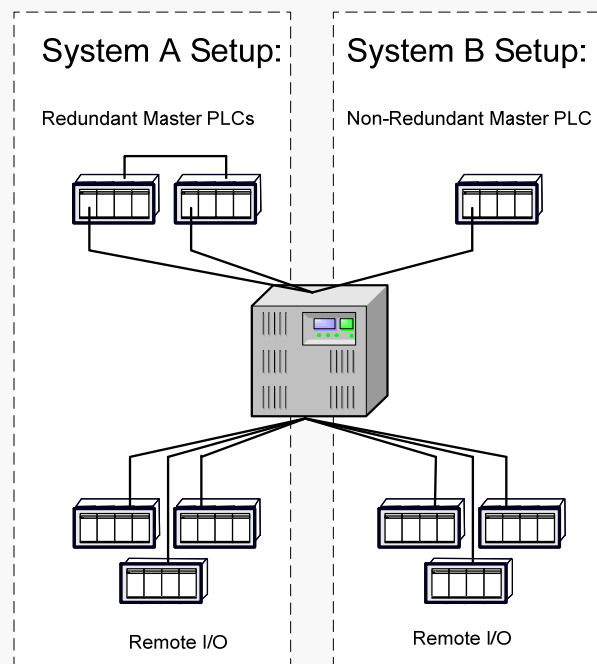
**I. Process Control Requirements:**

1. Unless otherwise specified, remote control and supervision of each lock operations shall be from dedicated, independent, and isolated control systems at the Atlantic lock complex and at the Pacific lock complex. <sup>A9</sup>Furthermore, no automation work is required for existing locks under this Contract.<sup>A9</sup>
2. The third set of locks control facilities shall supervise all shipping movements on the third lane of the Panama Canal locks system. Such supervision shall normally be automatic and with the minimum amount of intervention by the operating personnel during normal operations. Override capability shall be provided to enable semi-automatic or manual control of the third lane of <sup>A17</sup>the Canal locks <sup>A17</sup> system during degraded or emergency circumstances.
3. All commands initiated by controllers shall generate an immediate change in the display to indicate that the command has been received and this change shall be such that pending commands are distinguishable from completed commands so as not to induce any ambiguous recognition on the part of the controller and potential unsafe operation.
4. The detailed requirements for each of the control systems are contained in the Sections listed in Table 40 00 00-1.
5. Process control systems shall be efficient, safe, and reliable. <sup>A16</sup>Depending on design, the Contractor may choose to provide redundant hardware for PCSs whose requirements do not require hardware redundancy.<sup>A16</sup>
6. All master PLCs shall be application redundant **as a software solution**. In an application redundant scheme, the functions of a failed PLC shall be performed by **one of the remaining working PLCs, with FFCS master PLC as the last choice**. Figure 40 00 00-2 illustrates a possible way of achieving this.  
<sup>A9</sup>Application redundancy does not imply physical I/O switching devices.<sup>A9</sup>

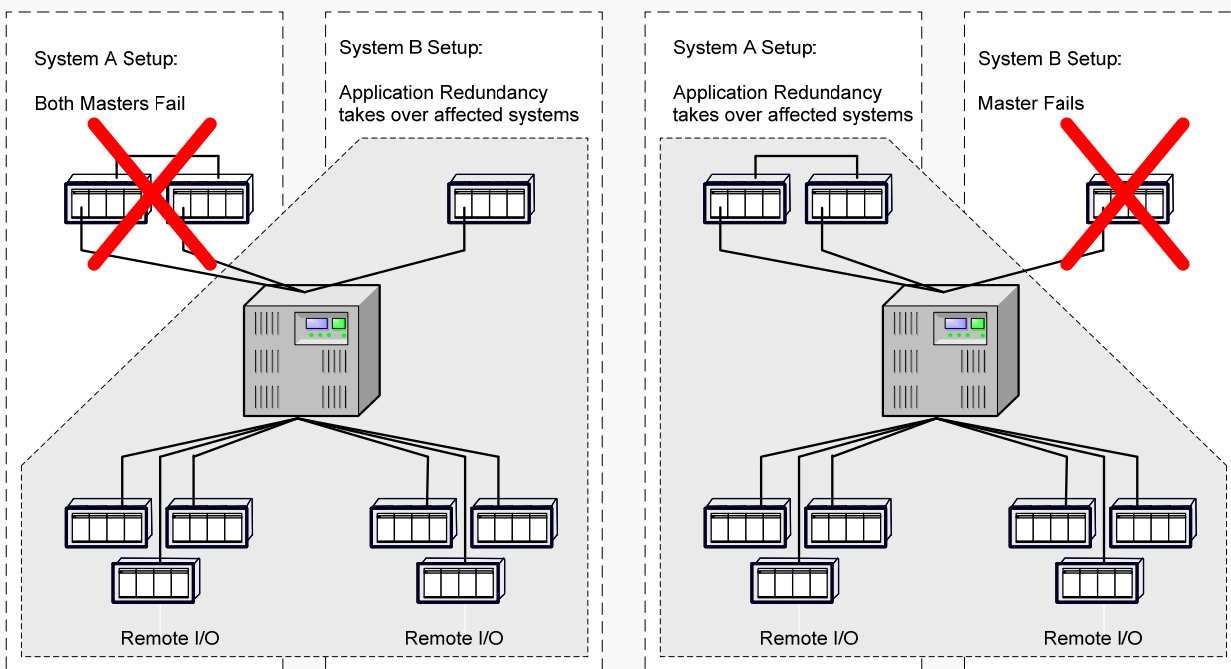
## Application Redundancy Concept:

PLC software capability where all Masters share the same software. Under normal conditions, only application relevant subroutines remain active. Under failure conditions of other Masters, Relevant subroutines become active and all systems are maintained in operation.

### Normal Operation



### Operation under Master Failure



**Figure 40 00 00-2:** Application Redundancy Concept with Redundant IEC 61158 type 2 (ODVA ControlNet) and Ethernet/IP

7. The non-redundant master PLC for the FFCS and other master PLCs residing in the main control building and connected to the same secure network shall be



application redundant with the redundant master PLCs of the LMCS. Thus, if the FFCS (or other) master PLC fails, the LMCS master PLCs shall take over the operation of the FFCS (or other), and vice-versa.

8. PCSs shall be open and allow future programmable logic controller's (PLC's) extensions by the simple connection of new devices on the appropriate Network.
9. PCS shall be able to expand in the future to handle a fourth lane without having to replace components of the third lane.
- <sup>A9</sup>10. Whenever controlled motors are equipped with temperature sensors, PCSs shall protect motors against damage due to over-temperature.<sup>A9</sup>

**J. Qualifications of Contractor, Manufacturers, Subcontractors, and System Integrators:**

1. **Item Availability:** Unless otherwise specified, all materials and equipment to be provided for PCSs shall be commercially available and field proven for no less than 4 years, excluding beta testing time.
2. <sup>A9</sup>**System Integrator:** Shall<sup>A9</sup> prove design competence in process control integration, and experience in similar process integration system projects for a period of 10 years or longer<sup>A9</sup>, including canals and/or factory automation projects with robotics<sup>A9</sup>.
3. **Personnel:**
  - a. The Contractor shall ensure that all process integration works shall be executed by experienced personnel, in that:
    - 1) All process integration system designs shall be prepared by competent process control and integration personnel.
    - 2) All process control system testing shall be executed by well-trained and qualified personnel under the leadership of an experienced process integration-testing manager.
  - b. The Contractor shall submit the curriculum vitae of the lead and / or senior process integration design manager and the process integration commissioning manager to the Employer's Representative for review, prior to the commencement of the design and test and commissioning phases of the Works.
  - c. <sup>A9</sup>The process integration design manager shall prepare and maintain design documentation that will fully communicate the design objectives and intent throughout the design phase. The objective of the documentation is to allow the testing, commissioning, and taking-over staff to have full benefit of what the design team planned for, considered, assumed, calculated, and concluded, and why the conclusions were made. This documentation is to be submitted to the Employer's

Representative periodically – no less frequently than upon completion of each phase of the design – to ensure the information has been effectively retained. The ideal situation would be for the integration design manager to oversee testing and commissioning of the process systems. In the event that does not occur, the design records shall be available to the commissioning manager.<sup>A9</sup>

4. **Workmanship:** The Contractor shall ensure that the design, purchasing, manufacture, and installation of the integrated process control system meet the following:

- a. The full range of climatic conditions defined in Volume III, Part 7 of the Employer’s Requirements, and
- b. <sup>A16</sup>The full range of Employer’s Requirements and that the final system as delivered is fully fit for purpose, safe, available, reliable, and maintainable.<sup>A16</sup>

**K. Redundancy:**

1. Rolling gate pairs and other redundant controllable devices shall have communications, control, and power diversity.
2. This shall include route diversity for cabling, and the use of separate IOCs, MCCs, and PLCs, as applicable.

**L. Service Requirements (referenced to utility services):**

1. <sup>A10</sup>Integrated <sup>A10</sup> process control system shall consist of the sub-systems listed in Table 40 00 00-1 and these shall also be integrated into the overall systems <sup>A10</sup>covered by <sup>A10</sup> Table 40 00 00-3.

| Table 40 00 00-3: Other Systems |   |                                  |
|---------------------------------|---|----------------------------------|
| Reference                       |   | Specification Title              |
| Division 27                     | - | Communications                   |
| Division 33                     | - | Utilities                        |
| Division 35                     | - | Waterway and Marine Construction |

**M. Systems Integration:**

1. The Contractor shall ensure that the overall communications and controls systems design, supply, installation and commissioning are coordinated with, but not limited to the following:
  - a. Spatial and installation requirements for equipment cabinets and housings.
  - b. Common cable routes, trough/trench, tray trunking requirements for all types of cables to be used, fill rates, screening requirements, heat dissipation, and bending radius.

- c. Common power supply integration to ensure that adequate power at the various voltages is provided to all equipment at common locations, and that the rating of the primary power supplies for the building services power supply is adequate for the equipment to be supplied under the <sup>A10</sup>Contract, with 25% or larger spare capacity. <sup>A10</sup>
- d. Capacity of the backbone fiber optic cable systems being provided by the Contractor is adequate to meet the requirements for the process control and monitoring systems being supplied under this Contract plus the spare capacity required for future expansions as described in these Contract documents.
- e. Ensure that the grounding, lightning, EMI (electromagnetic interference), and RFI (radio-frequency interference) protection systems are compatible, and that <sup>A10</sup>the connection of <sup>A10</sup> process control and monitoring systems to services and facilities provided by other suppliers within the communications and control systems scope of the Works shall not result <sup>A10</sup>in degradation <sup>A10</sup>in performance, safety, or reliability of the process control and monitoring systems.

<sup>A9</sup>N. **Operations:** Shall be in accordance with Section 40 96 45.xx series. <sup>A9</sup>

#### 1.04 DESIGN CRITERIA/SYSTEM PERFORMANCE:

##### A. **General:**

- 1. **Problem to be Solved:** PCSs shall solve the following business needs:
  - a. Provide reliable control systems, connections, and programming as required to operate the third set of locks in a fail safe manner.
  - b. Provide fail-safe main power shutdown and automatic restart upon power restoration.
  - c. Seamless integration of commercial hardware and software applied for process, machine, and motion control with real time and historical process data feedback in an intuitive and useful format for administrative, engineering, operations, and maintenance authorities.
  - d. Seamless integration of process control system with existing Employer's Computerized Maintenance Management System (CMMS) to automatically generate maintenance work orders based on machinery or equipment condition and operating hours.
  - e. Coordination with other project construction and installation tasks with a timely installation and deployment.
  - f. <sup>A9</sup>Online storage and retrieval of historical data for no less than one year. <sup>A9</sup>

- g. Whenever feasible, measure variables and report as required to determine response times and verify compliance of tests on completion.

2. **Restrictions to be Considered:**

- a. <sup>A9</sup>A The Contractor may replace PLC hardware and software with respect to PCS reference items in Table 01 81 26-7 only upon meeting the requirements of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Subparagraph 1.05 B.<sup>A9</sup>
- b. CMMS shall be whatever software the Employer is using at the time of installation (to be selected). <sup>A10</sup>The Contractor will be notified upon CMMS selection.<sup>A10</sup>

B. **Design Criteria:** Notwithstanding the Contractor's obligations detailed in Sections 01 40 00 (*Quality Requirements*) and 01 81 26 (*Communications, Controls, Safety, and Security Systems*), and Paragraph 1.02 of this Section, the design and implementation of PCSs shall comply with applicable international standards, codes and regulations in accordance with the Employer's Requirements. In particular, the provision of safety critical functions and equipment shall comply with appropriate international process control practices for ship control and navigation within an inland waterway, which shall be nominated by the Contractor and reviewed by the health and safety manager and by the Employer's Representative.

- 1. The Contractor shall ensure all safety critical and vital functions and equipment are designed to eliminate failures of hardware and software errors which could leave the system and/or equipment at a state where further valid commands or instructions can be made on the faulty system or equipment, resulting in an unsafe or dangerous condition. The Contractor shall present its fail-safe concepts in the design documents submitted for the review by the Employer's Representative.
- 2. System assurance documents and activities specific to the process control systems shall be prepared as required to support the system level requirements specified in the Employer's Requirements Section 01 40 00 (*Quality Requirements*) systems assurance.
- 3. Process control systems software engineering activities on the safety critical functions and equipment shall also be carried out in compliance with Section 01 40 00 (*Quality Requirements*) and the associated supporting documentation provided.
- 4. Software shall be clearly separated in system data and application data. The Contractor shall identify both in the design documents.
- 5. <sup>A17</sup>Process control equipment shall be specified and designed for 15 years of design life from the date of Taking-Over Certificate. The duty life of commercially supplied industrial computers shall be 6 years, however, the

Contractor shall specify such equipment in the design documents and provide recommendations for future upgrade by the Time for Completion.<sup>A17</sup>

6. The design and provision of process control equipment shall take into account the results of the ergonomic studies to be carried out as specified in the Employer's Requirements Section 01 81 26 (*Communications, Controls, Safety, and Security Systems*) and Section 01 40 00 (*Quality Requirements*).
7. The Contractor shall ensure that the provision and configuration of the integrated process control systems is consistent with the proposals for future expansion and modification of <sup>A17</sup>the Canal, as <sup>A17</sup>described in the Employer's Requirements.
8. The Contractor shall carry out EMC investigations in the vicinity of the <sup>A17</sup>Works prior to carrying out design work, in order to avoid any EMC problems with communications between the existing Panama locks systems and those to be proposed for the Works. <sup>A17</sup> Particular consideration shall be given to medical instruments, air traffic control, military communications and mobile phones. The usage of wireless communications shall be also compliant the relevant regulations of the Panamanian *Autoridad Nacional de los Servicios Públicos* (ASEP).
9. The Contractor shall analyze the hazards of possible Disaster and the risk mitigation of the <sup>A17</sup>Works <sup>A17</sup>in accordance with this Section. Risk assessment shall identify safeguarding performance requirements and lock-out/tag-out procedures. Also, the Contractor shall use risk assessment process through system design process for engineered safety and to minimize lost time, incident rate, and residual risk.
10. <sup>A3</sup>Fiber optics communications networks shall be designed incorporating bypasses and splitters as required so that de-energizing a node does not affect negatively all other active nodes. <sup>A3</sup> <sup>A9</sup>Such bypasses and splitters shall allow the implementation of distributed systems based on the proposed PLC platform.<sup>A9</sup>

**C. Process Control Systems Performance:**

1. Performance shall be as specified on other Sections of this division. In general, the Contractor shall prove the solutions and equipment designed are:
  - a. Reliable, with calculation of general mean time between failures (MTBF) of the solutions.
  - b. Safe (SIL level), in accordance with Subparagraph 1.03 K.7.d. of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*).
  - c. Fit to environmental conditions of use (i.e., degree of protection of enclosure, and tropical – marine adequacy).
2. As PCS manufacturers always improve their products, process control devices are rapidly obsolescent. Where equipment, devices, and facilities are clearly

specified in the documents of this division or other division of the Employer's Requirements, the Contractor may suggest solutions or products:

- a. More suitable to the purpose, up to date, robust, and with better performance (reliability, availability, and safety considered), and
  - b. Less expensive.
3. The control system at machinery rooms shall provide three general functions:
- a. Collect I/O for the master PLCs and operate and monitor all machinery room related machinery.
  - b. Provide electrical circuit logic (non-PLC) as control backup, capable of the basic functions that shall operate the machinery in local emergency mode and in the case of communication loss.
  - c. Detect a communication loss with master PLCs and after an adjustable timeout, operate the machinery to safe shutdown position. In the case of valves, this position is closed. In the case of gates, this position is stopped. In all other machinery, i.e. fire fighting and electrical distribution, the PCS shall act according to the last operator command.
4. **Official Date and Time:** Server and workstation clock time/date shall be global positioning system (GPS), U.S. GNSS satellite time, updated via network time protocol (NTP) protocol.
5. **Power On and Ready Times:**
- a. After a power shutdown, all equipment under this scope shall automatically power on and be ready for normal lockage operations in 4.5 minutes or faster.
  - b. Upon power up, PCS shall first validate actual machinery position and update machinery indication, before any machinery becomes available for operation.

**1.05 SUBMITTALS:** <sup>A17</sup>Notwithstanding the general <sup>A17</sup> <sup>A16</sup>requirements with respect to submittals contained in Section 01 33 00 (Submittal Procedures), the Contractor shall provide design and construction documentation in accordance with Section 01 81 26 (*Communications, Controls, Safety, and Security Systems*), Paragraph 1.05 <sup>A16</sup>.

A. <sup>A16</sup>**Within 91 Days from Commencement Date:** <sup>A16</sup>

1. An interface management plan, which shall detail how the Contractor shall manage all physical interfaces between the various designers, manufacturers, constructors, quality management representatives, health and safety management representatives, and third parties to ensure that the Contractor achieves a “fully coordinated”, “fit for purpose”, and safe Canal transportation system.

2. An integration management plan which shall detail how all of the electrical and mechanical support systems shall be integrated to ensure that they enable the <sup>A17</sup>Works <sup>A17</sup> to provide a fully functional Canal transportation system that meets the operational objectives of Section 01 92 00 (*Facility Operation*).
3. These plans shall be regularly updated, and include the above stakeholders as well as newly involved persons in the <sup>A17</sup>Works <sup>A17</sup> as soon as they are known. Also, the plans shall be coordinated in design conferences in accordance with Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Subparagraph 1.05 D.

B. <sup>A16</sup>**Within 119 Days from Commencement Date:** <sup>A16</sup>

1. Critical path method (CPM) diagram, including estimated dates for design conferences
2. A communications, control, security and safety (CCSS) system wide intermediate design description, including a block diagram with similar or better detail to Figure 40 00 00-1 (*Conceptual Process Integration Block Diagram*)
3. Major components descriptive literature
4. Quality assurance and control plans
5. From this point on, all submittals here described shall be updated monthly, if and where changes apply, as the design progresses into final form. Presenting changes shall include a change list consisting of item number and description.

C. **Design:** Shall include, but not be limited to, the following:

1. Application programs
2. Business continuity plan (BCP)
3. **Calculations:** The following calculations shall consider how long it takes for a communications session to close:
  - a. <sup>A11</sup>**PLC Communications:** <sup>A11</sup>
    - 1) Estimated maximum common industrial protocol (CIP) connections used versus total available
    - 2) Estimated maximum programmable controller communications commands (PCCC) connections used versus total available
    - 3) Estimated maximum connections used of other type versus total available
  - b. Server and workstation network communications worst case traffic analysis

- c. Estimated central processor unit (CPU) loading for PLCs and application servers for different levels of activity
- d. Estimated loading of PLC processor buffer memory, and maximum number of simultaneous communication connections
- e. PCS reliability/availability
- 4. Certifications, including ISO 20000 for PCS hardware and software manufacturers
- 5. CPM diagram, with monthly updates
- 6. Data base, including structure and related processing scripts
- 7. Descriptive literature
- 8. Disaster recovery plan (DRP), preferably in accordance with NIST SP 800-34
- 9. Drawings, including shop drawings for control cabling and devices, and process integration diagrams (PIDs) of the total systems (including locks, gates, and valves).
- 10. Fail safe considerations
- 11. Governance recommendations for PCSs
- 12. Interlocks for safe operation, considering required response times and speed profiles of movable controlled devices
- 13. IT security methods
- 14. Macros
- 15. Protection methods for corrosion, ESD, fungus/humidity, lightning/surge, power distortion and harmonics, RFI/EMI, thermal, and vibration
- 16. RAMS report on the design
- 17. Recommended policies and practices, preferably in accordance with BSI 7799
- 18. Response times
- 19. Risk [assessment in](#) accordance with one or more of the following: IEC 61508, [IEC 61511](#), IEC 62061, [ISO 13849-1](#), and NIST SP 800-30
- 20. Security certifications, preferably in accordance with NISP SP 800-37
- 21. Security controls recommended, preferably in accordance with NIST SP 800-53



22. Security logs' formats
  23. Sequence of operations for all operating conditions
  24. Specifications
  25. Spare communications, I/O, and memory.
  26. Speed profiles of movable controlled devices, including up/down ramps and steady speeds.
  27. Strengths, weaknesses, opportunities, and threats (SWOT) analysis.
  28. Systems development plans.
- D. **Design<sup>A17</sup> Phase<sup>A17</sup> Final Details:** See Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Subparagraph 1.03 D.
- E. **Right after Factory Quality Control Tests (FQCT):**
1. FQCT reports
- F. **Upon Receipt of Shipped Items in Panama:**
1. Instruction manuals for administration, installation, maintenance, and operation.  
<sup>A16</sup>Operations manuals shall describe the details of algorithms and sequences for automatic and semi-automatic controls.<sup>A16</sup>
  2. Packing lists
- G. **Prior to Issuance of Taking over Certificate:**
1. As-built drawings
  2. List of recommended spare parts
  3. Software licenses
  4. Test reports
  5. Training services
- 1.06 QUALITY ASSURANCE:** Shall include the following in accordance with Section 01 81 26 (*Communications, Controls, Safety, and Security Systems*), Paragraph 1.06:
- A. **General:** The Contractor shall comply with all quality requirements as defined in Section 01 40 00 (*Quality Requirements*), and with the specific requirements listed herein.

1. Certifications of compliance
2. Quality assurance and control plans
3. **Testing Reports:**
  - a. FQCT.
  - b. Factory inspection tests (FIT)
  - c. Final field inspection tests (FFIT)
4. **Training Services:** Shall be for no less than 30 collaborators of the Employer's Personnel (most of them shall be instructors). Training in Panama shall be in three sessions of no less than 40 hours per session.
5. Spare parts
6. **Systems Assurance:** The Contractor shall comply with the systems assurance requirements detailed on Section 01 40 00 (*Quality Requirements*), Paragraph 1.07, and deliver the final failure modes effects criticality analysis (FMECA) and reliability documentation in a format compatible with the Employer's CMMS.
7. Technical support
8. Warranty

**END OF SECTION**