

SECTION 40 95 13 – PROCESS CONTROL HARDWARE

1.01 SUMMARY:

- A. **Scope:** This Section covers the performance requirements, design, supply, installation, and commissioning of complete process control systems (PCSs) for the [Works](#). This Section of the Employer's Requirements shall be read in conjunction with the Sections listed in Table 40 95 13-1.
- B. **Related Sections:**

Table 40 95 13-1: Related Sections			
1.	Section 01 81 26	-	Communications, Control, Safety, and Security Systems
2.	Section 09 69 00	-	Raised Access Floors
3.	Section 11 52 23	-	Video Walls
4.	Section 12 59 83	-	Custom System Furniture (ref. Consoles)
5.	Section 25 11 00	-	Data Processing Equipment (DPE)
6.	Section 26 43 13	-	Transient Voltage Surge Suppressors
7.	Section 27 10 00	-	Structured Cabling Systems for Communications Inside Plant
8.	Section 27 11 16	-	Cabinets, Racks, Frames, and Enclosures
9.	Section 27 21 00	-	Data Communications Equipment (DCE)
^{A10} 10.	Section 27 31 33	-	Radio-Telephone Communications Console Systems ^{A10}
^{A10} 11. ^{A10}	Section 27 53 13	-	Time Synchronization Systems
^{A10} 12.	Section 28 16 46	-	Vehicular Control Systems ^{A10}
^{A10} 13.	Section 28 23 00	-	Closed Circuit Video Systems ^{A10}
^{A10} 14. ^{A10}	Section 33 82 00	-	Cabling for Underground Communications Outside Plant
^{A10} 15. ^{A10}	Section 35 10 00	-	Waterway and Marine Signaling and Control Equipment
^{A10} 16. ^{A10}	Section 35 12 00	-	Vessel Detection Systems (VDSs)
^{A10} 17. ^{A10}	Section 40 00 00	-	Process Systems Integration
^{A10} 18. ^{A10}	Section 40 91 00	-	Primary Process Measurement Devices (Sensors and Instrumentation)
^{A10} 19. ^{A10}	Section 40 94 43	-	Programmable Logic Controllers
^{A10} 20. ^{A10}	Section 40 95 13.13	-	Process Control Hardware for Locks Machinery Control Systems
^{A10} 21. ^{A10}	Section 40 95 13.16	-	Process Control Hardware for Fire Fighting Control Systems (FFCSs)
^{A10} 22. ^{A10}	Section 40 95 13.19	-	Process Control Hardware for Electrical Distribution Control Systems (EDCSs)
^{A10} 23. ^{A10}	Section 40 95 13.22	-	Wastewater Treatment Control Systems
^{A10} 24. ^{A10}	Section 40 95 73	-	Control Cables
^{A10} 25. ^{A10}	Section 40 96 45	-	Process Control Software
^{A10} 26. ^{A10}	Section 48 19 16	-	Inverters

1.02 REFERENCES:

- A. **Applicable Publications:** Refer to Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Paragraph 1.02.

1.03 REQUIREMENTS:

A. **General Requirements:**

1. **General:**

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

2. **Operator Interface:** Shall be CNI ControlNet enabled touch sensitive screens in accordance with Section 25 11 00 (*Data Processing Equipment*).

3. **Remote Users:**

- a. Physical access to remote workstations shall be restricted for authorized personnel only.
- b. Fiber optic links to these workstations shall also be protected against tampering.

B. **Equipment and Hardware:**

1. **Cabinets:** Units for machinery control shall be in accordance with Section 27 11 16 (*Cabinets, Racks, Frames, and Enclosures*).

2. **Cable Pathways:** Shall be in accordance with Section 27 05 28 (*Communications Pathways for Inside Plant*).

3. **CCVS Equipment:** Shall be furnished in accordance with Section 28 23 00 (*Closed Circuit Video Systems*), including the following:

- a. CCVS control panels and keypads.
- b. CCVS cameras with pan / tilt / zoom (PTZ) and dome.
- c. Video matrix switcher(s).

4. **Computer Video Extenders:** Shall be in accordance with Section 25 11 00 (*Data Processing Equipment*).

5. **Console Desks:**

- a. Consoles shall be in accordance with Section 12 59 83 (*Custom Systems Furniture*).
- b. Central control console Infrastructure shall be as follows:
 - 1) **General:** For each central control console, six monitors shall be furnished for the operation side of the console and six for the maintenance side.
 - 2) **Maintenance Side:** Shall include, but not be limited to, four single desktop monitors for power distribution station, and two machinery diagnostic stations.
 - 3) **Operation Side:** Shall include, but not be limited to, three single desktop monitors for lockage operations station (one monitor per level), one automatic identification system (AIS) scheduling station, one water level monitoring station, and one office workstation.

6. **Domain Controllers:** Shall be furnished as required.

7. ^{A11}**Electrical (non-PLC) Relay Logic Circuitry:**

- a. The Contractor shall furnish electrical relay logic external to IOCs and PLCs, as required to provide backup for local machinery operation in case of total communications and/or PLC failure, and to accomplish safe shutdown in emergencies.
- b. Light indicators, push buttons, relays, sensors, and watchdog timers used in PLC based local controls shall be shared with relay logic external to IOCs (or slave PLCs) whenever possible, to minimize possible duplication of local control hardware.^{A11}

8. **Equipment Racks:** Shall be furnished in accordance with Section 27 11 16 (*Cabinets, Racks, Frames, and Enclosures*) for the following equipment:

- a. Equipment rack monitoring.
- b. Fiber optic modem banks.
- c. Fiber optic patch panels.
- d. Master PLCs.
- e. Power distribution: monitored Circuit Breakers (CBs) and load balancing.

9. **Ethernet Data Switches:** Data switches shall be in accordance with Section 27 21 00 (*Data Communication Equipment*).
10. **Fiber Optic Modems (FOMs):** Shall be in accordance with Section 27 21 00 (*Data Communications Equipment*).
11. **Fiber Optic Patch Cords:** Shall be furnished as required.
12. **Fiber Optic Patch Panels:** Shall be furnished for the following:
 - a. Backbone
 - b. Machinery
 - c. Self healing rings
13. **Fiber Optic Terminations Enclosures:**
 - a. Backbone patch panels
 - b. Machinery patch panels
 - c. Self healing ring patch panels
14. **Firewalls:** Shall be provided as required to minimize security vulnerabilities and shall be in accordance with Section 27 21 00 (*Data Communications Equipment*).
15. ^{A8}**Time Receivers:** Shall be in accordance with Section 27 53 13 (*Time Synchronization Systems*).^{A8}
16. **Input/Output Concentrators (IOCs):** Shall be in accordance with Section 40 94 43 (*Programmable Logic Controllers*).
17. **Instrumentation:**
 - a. **Electrical Power Distribution and Motor Control Center (MCC) Instrumentation:** Shall be in accordance with Section 40 95 13.19 (*Process Control Hardware for EDCSs*).
 - b. **Locks Foam Concentrate / Water Systems:** Shall also be in accordance with Section 40 95 13.16 (*Process Control Hardware for FFCSSs*).
 - c. **Machinery Instrumentation:** Shall be in accordance with Section 40 91 00 (*Primary Process Measurement Devices*).
 - d. **Programmable Logic Controllers (PLCs):** Shall be in accordance with Section 40 94 43 (*Programmable Logic Controllers*).

- e. **VDS Semaphores:** Shall be in accordance with Section 35 10 00 (*Waterway and Marine Signaling and Control Equipment*).
 - f. **Vehicular Control Systems and Traffic Lights:** Shall be in accordance with Section 28 16 46 (*Vehicular Control Systems*).
 - g. **Water Level Measurement Well Instrumentation:** Shall be in accordance with Section 40 91 00 (*Primary Process Measurement Devices*).
 - h. **Other Instrumentation:** Shall be furnished as required to meet these Employer's Requirements.
- 18. **Keyboards and Pointing Devices:** Shall be in accordance with Section 25 11 00 (*Data Processing Equipment*).
 - 19. **Keyboard / Video / Mouse (KVM) Switches:** Shall be in accordance with Section 25 11 00 (*Data Processing Equipment*).
 - 20. **Monitors:** Shall be in accordance with Section 25 11 00 (*Data Processing Equipment*).
 - 21. **Monitor Support Structure:** Shall be in accordance with Section 12 59 83 (*Customs Systems Furniture*).
 - 22. **Printers:**
 - a. Printers shall be dedicated for PCS use and in accordance with Section 25 11 00 (*Data Processing Equipment*).
 - b. One color laser unit shall be furnished for each main control building, one color laser unit shall be furnished for each engineering user location (one Pacific and one Atlantic locks).
 - c. ^{A10}One monochrome (black ink) laser unit shall be furnished for each one of the following maintenance shops: Atlantic, Gatun, Miraflores, and Pacific Locks. ^{A10}
 - 23. **Programmable Logic Controllers (PLCs):** Shall be in accordance with Section 40 94 43 (*Programmable Logic Controllers*).
 - 24. **Radio-Telephone Console Systems:** Shall be in accordance with Section 27 31 33 (*Radio-Telephone Communications Console Systems*).
 - 25. **Raised Access Floor:** Shall be in accordance with Section 09 69 00 (*Raised Access Flooring*).

26. **Servers:**

a. **General:**

- 1) Units shall be in accordance with Section 25 11 00 (*Data Processing Equipment*).
- 2) Servers shall be adequate for the following purposes:
 - a) **Historical Data Server:** Database and reporting
 - b) HMI application servers
 - c) **PCS Communication Server:** Running OPC servers, RS-FactoryTalk directory, and Factory Talk security.
 - d) **RSMACC Server:** Security, change management, audit, network and device health monitoring

b. **Database Servers:**

- 1) Operation commands and indication historical database
- 2) Maintenance events and process values historical database

c. **HMI Application Servers:**

- 1) Machinery control station (MCS)
- 2) Machinery diagnostics station (MDS)
- 3) Fire fighting control system (FFCS)
- 4) Power distribution station (PDS)
- 5) Water level display (WLD)

27. **Video Walls:** Shall be in accordance with Section 11 52 14 (*Video Walls*).

28. **Workstations:**

- a. Units shall be in accordance with Section 25 11 00 (*Data Processing Equipment*).
- b. Units shall be furnished as required for each main control building, one unit shall be furnished for each engineering user location (one Pacific and one Atlantic locks), and ^{A10}one unit for each maintenance shop (one for Atlantic, Gatun, Miraflores, and Pacific Locks, respectively). ^{A10}

C. **Software:** Shall be in accordance with Section 40 96 45 (*Process Control Software*).

D. Installation:

1. **Consoles:** Shall be furnished in operator rooms of main control buildings.
2. **Fiber Optic Cables:** Shall be identified in accordance with Section 40 95 73 (*Control Cables*) including, but not being limited to, the following:
 - a. Network backbone cables
 - b. Self healing Ethernet and ControlNet ring cables
3. **Workstations:**
 - a. **Engineering Workstations:** Shall be located at the nearest existing locks (Gatun and Miraflores), main office, at the engineering section.
 - b. **Maintenance Shop Workstations:** Shall be located at the existing locks maintenance shops as well as in the new maintenance buildings.
 - c. **Software Deployment Workstations:** Shall be located at the existing locks, LAN manager office.
 - d. **Software Development Workstations:** Shall be located in the existing locks, main office, at the engineering section.

E. Equipment Location Layout:

1. **Computer Server Rooms:** The master PLC arrangement shall be installed in 483 mm (19 inch) wide racks, located in the equipment room below the control room. The computers and servers servicing control stations shall also be installed in these racks. Other closed circuit video system (CCVS), firefighting, and PCS equipment, and other related hardware shall be installed in adjacent racks.
 - a. **Monitoring of Equipment Room Equipment:** An I/O concentrator shall collect equipment room I/O for the LMCS master PLCs. LMCS shall supply equipment room I/O to any other PCS as required.
 - b. **Rack Layout:** The rack layout shall be designed and organized in a logical manner that allows wiring flow and equipment organization, aimed at easy identification, location of equipment, and troubleshooting. Each rack shall have a unique numbered label placed at the top center of the rack. Each group of components on each rack shall also be labeled with a group identification (ID), where the ID is related to the rack section and each major component is also labeled with a component ID that is indicative of the related controlled machinery or equipment. The racks may be generally organized as follows:

- 1) **Equipment Racks for Support of Console #1:** Shall include application servers, open ^{A9}process^{A9} control (OPC) servers, workstations, video extenders, keyboard-video-mouse (KVM) matrix switch, domain controller #1, history servers, and others.
 - 2) **Equipment Racks for Support of Console #2:** Shall include application servers, OPC servers, workstations, video extenders, KVM matrix switch, domain controller #2, history servers, and others.
 - 3) **Equipment Racks for Other Requirements:** Shall include ^{A10}no less than 25% ^{A10} spare space.
 - 4) **Fiber Optic Modem Banks:** Fiber optic modems, CNI ControlNet fiber optic modems.
 - 5) **Fiber Optics Termination Patch Panels:** Backbone fiber termination and patch cord patch panels to link equipment room equipment.
 - 6) **Mastering PCS Hardware:** LMCS master PLCs, FFCS non-redundant PLC, I/O concentrator for monitoring equipment room equipment.
 - 7) **Network Communications:** Ethernet data switches, local area network (LAN) patch panels.
 - 8) **PCS Power Supply Management:** Direct current/direct current (DC/DC) converters, power supplies, power distribution breakers, bridge rectifiers, and others.
2. **Machinery Rooms:** ^{A10}Each machinery room with machinery components shall include I/O concentrators (or slave PLCs as applicable) in the telecommunication closets/rooms to report I/O to the master PLCs (and OPC servers as applicable), as required for power switchboards and motor control centers. ^{A10}
- a. The control system at these machinery rooms shall provide four general functions:
 - 1) Collect I/O for the master PLCs and operate and monitor all machinery room related machinery.
 - 2) Conduct automated maintenance tests, aimed at diagnosing failures, testing critical component availability, and calibrating HART sensors and other transducers as much as possible.
 - 3) Detect a communication loss with the mastering control and after an adjustable timeout, operate the machinery in emergency safe mode.

- 4) Provide electrical circuit logic (non-PLC) as control backup, capable of the basic functions that will operate the machinery in local emergency mode.
 - b. Each machinery room shall include a NEMA 4X touch screen operator interface that provides locally the operation and maintenance functions for each and all equipment in the machinery room.
 - c. In the case of machinery actuators located ^{A10}outside machinery rooms, each actuator location shall have a NEMA 4X weatherproof control box for maintenance operation. Such control boxes shall be connected to the I/O Concentrator of the corresponding machinery room. ^{A10}
3. **Main Control Building:**
- a. The PCS shall include redundant control consoles located in the control room of the Locks. Each control console left side shall handle operation HMIs, while the right shall handle maintenance and firefighting HMIs.
 - b. Ergonomic analysis is required in accordance with Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Paragraph 1.03 I.

1.04 DESIGN CRITERIA / SYSTEM PERFORMANCE:

A. General:

1. Problem to be Solved:

- a. Provide reliable and long life controls and indication to locks operators of all machinery and equipment, main and auxiliary, required to perform an efficient and safe lockage operation.
- b. Acquire data from status and telemetry devices.
- c. Process data on field devices and present it to multiple operators on various customized displays and system generated reports.
- d. Perform remote control of locks machinery upon operator command and semi-automatic sequences, considering defined interlocks and making decisions based on programmed logic.
- e. Maintain a copy of the data base and current data in backup devices configured in hot-standby or better.

2. Restrictions to be Considered: (reserved)

B. Design Criteria:

1. **General:** PCSs shall be designed to meet the following:
 - a. All applicable requirements of CNI ControlNet, IEC 61158 as well as ISA 84, 95, and 99.
 - b. Clear and accurate indications in real time of the status of all locks machinery.
 - c. Records of the analogical and calculated values, events and alarms with the possibility of sorting, zooming, and archiving.
 - d. Safe operating conditions for the people and for the navigation, including avoiding floods in locks and downstream, avoid draining Gatun Lake, achieving target water levels, and compensating for differences in water when operating in different chamber lengths.
 - e. Enhanced operator interface.
 - f. Automating mission critical locks operations in real time 24 hours per day.
 - g. Decrease of the shutdown time for maintenance and repair.
 - h. Minimization of the staffing requirements.
 - i. Pass information to Employer's computerized maintenance management system (CMMS) for predictive and preventive maintenance purposes.
2. **Monitored and Controlled Machinery:** The following machinery shall be included in the design for control, instrumentations, monitoring, data logging, and remote reset capabilities from the main control building at the control consoles. Other machinery and equipment may also be required to be monitored and controlled, depending on Contractor's overall design.
 - a. **Rolling Gates:** Shall include the following:
 - 1) Gate position monitor
 - 2) Gate flotation and buoyancy
 - 3) Gate recess dewatering
 - 4) Equalization valves (if used)
 - 5) Rolling track cleaning system
 - 6) Visual aids to navigation
 - 7) Pedestrian crossing alarms
 - 8) Vehicular crossing

- b. Culvert and conduit valves
 - c. LMCS equipment and signaling
 - d. **Lock Transit Direction Signaling:** Rotating arrow at approach wall ends.
 - e. Power generators
 - f. Elevators
 - g. Locks complex air compressors
 - h. Fire fighting control system
 - 1) Monitor nozzles
 - 2) Motor / pump starters
 - 3) Motorized valves and pipework
 - i. Power distribution system
 - j. Crossunder tunnel flood monitors.
3. **Non-Vital Function PCS:** Non-Vital PCS shall not require master PLCs. If a PLC is recommended to perform the function of a master, then a slave PLC may be used as a non-redundant master PLC. HMIs may also perform the function of a master and communicate directly with slave PLCs. Non-Vital function PCSs are:
- a. EDCS
 - b. FFCS
4. **Vital Function PCSs:** Shall be designed to be controlled by using master PLCs as the primary control equipment. Master PLCs shall communicate with I/O concentrators, slave PLCs or open process control (OPC) servers as needed. Human-machine interfaces (HMIs) shall communicate with master PLCs and slave PLCs as needed. LMCS is a vital function PCS.

C. **System Performance:**

1. **Communications Loss with Machinery:**
- a. Should a critical machinery, one whose failure to operate can adversely impact the lockage operations, loose communication with operator control, the machinery shall enter an emergency safe mode and, after an adjustable timeout, operate on its own to safe shutdown position.
 - b. Under emergency safe mode, and assuming power is available,

- 1) Safe shutdown position is “closed” for valves, and “stopped” for gates. In all other machinery, i.e. firefighting and electrical distribution, the PCS shall act according to the last operator command.
- 2) If redundant machinery is available, it too shall shutdown to safe position.

2. **Emergency Features:**

a. **Communications Failure:**

- 1) Whenever a communications failure occurs, an alarm shall be set at the machinery diagnostics station (MDS) HMI, and operations shall continue normally. For more information on the MDS, refer to the LMCS topology in Figure 40 95 13.13-1.
- 2) If enough simultaneous failures occur and communications between master PLC control and a mechanical room fails, an alarm shall be set in both operations HMI and MDS HMI. Failed communications with the machinery room shall result in a safe shutdown of all related machinery.
- 3) **Control System Failure:** If the control system fails, the backup electrical circuit logic at the mechanical room shall allow the local operation of the machinery in local emergency mode.

b. **Machinery Failure:**

- 1) If the machinery fails to operate, the PCS shall set a shut down alarm in both the operation and MDS HMIs.
- 2) The description of the diagnosed fault at the mechanical room's operator and the locks operator interfaces shall be in plain English. MDS HMI shall act as a help desk by showing a more detailed display.

c. **Power Failure:**

- 1) ^{A10}The corresponding MDS HMI alarm shall be set and operations shall continue normally upon any of the following occurrences:
 - a) When primary power source fails and secondary power remains,
 - b) When secondary power source fails and primary power remains, or

- c) When all but one DC power unification bridge rectifiers fail.^{A10}
 - 2) If enough simultaneous failures occur and power to the control system fails, PLC masters shall store all critical data in non-volatile memory.
- 3. **Normal Control System Behavior:**
 - a. **Mastering Configurations:**
 - 1) In the case of LMCS, a master PLC configuration (redundant) shall serve as the mastering device. Upon failure of both masters, the FFCS non-redundant master PLC shall take over, due to application redundancy.
 - 2) In the case of the FFCS, a non-redundant master shall serve as the mastering device. Upon failure, the LMCS master PLCs shall take over due to application redundancy^{A10} (see Figure 40 00 00-2).^{A10}
 - 3) In the case of EDCS, the EDCS HMI shall serve as the mastering device.
 - b. In a master PLC configuration, system parameters and HMI parameters stored in the master PLC shall be mirrored between the redundant master pair. If a master fails, the other shall operate seamlessly with the currently active parameters.
 - c. Both control stations in the control room shall operate in parallel and simultaneously. Each control station shall have the ability to operate the entire lock facility on its own. Either station shall be able to shutdown without affecting the operation of the other station.
 - d. Any member of the redundant pair of domain controllers, application servers, tag servers, OPC or security servers shall be capable of shutting down without affecting the operation.
 - e. All communication links shall be tested at regular intervals. Periodicity shall be as fast as possible without reaching the limit of simultaneous communications allowed. Failed links shall set an alarm at the MDS HMI.
 - f. While machinery is idle, all machinery indication shall be read at regular intervals. Reading shall be validated and invalid readings shall be retested. After retesting, if reading remains invalid an alarm shall be set at the MDS HMI. If position reading is invalid or unavailable, a warning alarm shall also be set at the operations HMI.

- b. ^{A8}PCSs shall have the highest security level in conformance with NERC cyber security standards, and shall use virtual LANs (VLANs) if and as applicable. Data transmission to/from the boundaries of the PCSs over public network shall use secure virtual private networks (VPNs). ^{A8}

1.05 SUBMITTALS: Shall be in accordance with Section 40 00 00 (*Process Systems Integration*), Paragraph 1.05.

1.06 QUALITY ASSURANCE: Shall be in accordance with Section 40 00 00 (*Process Systems Integration*), Paragraph 1.06.

END OF SECTION

A10 **THIS PAGE NOT USED** A10