SECTION 40 91 00 – PRIMARY PROCESS MEASUREMENT DEVICES

1.01 SUMMARY:

A. **Scope**: [A17]This Section covers the performance requirements, design, installation, testing, and commissioning of complete chemical, electrical, hydro-meteorological, sewage/wastewater treatment, and miscellaneous sensors and instrumentation, as required for process control systems (PCSs) as part of the Works.[A17] This Section of the Employer's Requirements shall be read in conjunction with the Sections listed in Table 40 91 00-1.

B. **Related Sections**:

Table 40 91 00 – 1: Related Sections

[A16]1.	Section 01 10 00	-	General Project Requirements.[A16]
[A19]2.	Section 01 81 13	-	Filling and Emptying Systems.[A19]
[A17]3.	Section 01 81 19	-	Lock Gates.
4.	Section 01 81 26	-	Communications, Control, Safety, and Security Systems.
[A19]5.	Section 01 86 13	-	Plant – Mechanical Systems and Equipment[A19]
6.	Section 01 89 19	-	Sanitary Sewer / Wastewater.
7.	Section 26 13 00	-	Medium Voltage Switchgear.
8.	Section 26 24 19	-	Motor Control Centers.
9.	Section 26 29 23	-	Variable Frequency Drives.
10.	Section 26 33 00	-	Direct Current Equipment.
11.	Section 35 12 00	-	Vessel Detection Systems (VDSs).
12.	Section 40 00 00	-	Process Systems Integration.
13.	(deleted)		
14.	Section 40 94 43	-	Programmable Logic Controllers (PLCs).
15.	Section 40 95 13	-	Process Control Hardware.
16.	Section 40 95 13.13	-	Process Control Hardware for Locks Machinery Control Systems.
17.	Section 40 95 13.16	-	Process Control Hardware for Fire Fighting Control Systems (FFCSs).
18.	Section 40 95 13.19	-	Process Control Hardware for Electrical Distribution Control Systems (EDCSs).
19.	Section 48 19 16	-	Inverters.[A17]

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**:

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

2. All sensors and instrumentation shall,

   a. Use 24 VDC power (unless self-powered), and shall not require batteries.

   b. Units shall have high accuracy, repeatability, and long operating life. Also, units shall have negligible creep, hysteresis, temperature effects, and vibration related errors, as applicable.

3. Enclosed input/output (I/O) shall not require extra protection devices. Non-enclosed I/O shall require that all signals to be terminated in adequate terminal blocks which have built-in protection elements for the purpose of protecting the PLC modules or dry contacts from undesirable electrical conditions originating outside the enclosure, such as over voltage surges, cross-circuit shorts, inductive element feedback, electromotive feedback, other arc promoting load conditions, or any other damaging electrical phenomena.

4. If possible, all sensors shall be self-calibrating or calibration-free.

5. Flow rates shall be measured by transducers where required, i.e., FFCSs. Where transducers are not required, flow may also be inferred by pump m^3/s (gpm). The Employer does not require flow measurement for LMCSs.

6. The Employer finds acceptable handling Sequence of Events (SOE) for electrical variables from multifunction sensors instead of via EDCSs. In such cases, data shall be downloadable later for post-mortem review.

[A10]7. To be useful, metrics shall be automated, informative, and objective.[A10]

B. **Equipment and Materials**:

1. **Air Quality Transducers**:

   a. Transducers shall measure whether the combination of air gases in confined spaces is suitable for breathing by humans. Sampling rate shall be adjustable from continuous polling up to once per hour.

   b. Units shall be stationary and suitable for deciding when to push or pull air automatically in confined spaces, tentatively at 1,500 cfm.

   c. Units shall be wired to nearest I/O concentrator by means of any of the listed fieldbuses in accordance with [A8]Subparagraph 1.03 B.4.[A8], Fieldbuses.

2. [A17]**Daylight Sensors**: At the control house at each Lock facility, Pacific and Atlantic, two high performance, weatherproof, and rugged daylight sensors photocells shall be provided. [A17] Discrete process value shall be available to the nearest I/O concentrator.

3. **Encoders and Resolvers**: These requirements shall apply to all instances of measuring rotation of moving machinery as a means of calculating machinery position.

   a. [A19]Wherever encoders are used, they shall have built-in CENELEC EN 50325-2 fieldbus, IEC 61158 type 2 fieldbus, or Ethernet/IP interface, and shall use this interface to send data to a PLC or an I/O concentrator.[A19] Using encoders that require additional high speed counter modules shall not be acceptable.

   b. Provided that the needed data resolution is adequate for the application, resolvers may be used as an acceptable alternative to encoders. Resolvers communicate their data by means of a 4 to 20 mA current loop within a fixed rotation range in terms of number of turns.

4. **Fieldbuses**:

   a. [A19]**IEC 61158 type 2 Fieldbus:**

      1) This fieldbus shall be primarily used for communications between processors, or between a processor and an I/O concentrator.

      2) This fieldbus may also be used to communicate any processor or I/O concentrator with any other device that does not have CENELEC EN 50325-2 or highway addressable remote transducer (HART) or Ethernet I/P connectivity.

      3) Ethernet/IP may be used instead of this fieldbus, and the Employer encourages this change. [A19]

   b. [A19]**CENELEC EN50325-2 Fieldbus**:

      1) This fieldbus shall be primarily used for communications between a device or sensor with a processor or I/O concentrator.

      2) This fieldbus shall be used typically to monitor and control all possible process variables available in variable frequency drives, motor starters, encoders or other sub-I/O concentrators.

      3) Ethernet/IP or IEC 61158 type 2 may be used instead of this fieldbus, and the Employer encourages this change. [A19]

   c. **Direct I/O**: All input and output signals shall be copper wired directly to an I/O concentrator.

d. [A19]**DUG DNP Version 3.0 or Higher**: All electrical power intelligent electronic devices (IEDs), shall communicate using DNP 3.0 or higher protocol, encapsulated over Ethernet. [A19]

e. [A19]**Ethernet I/P**: An Ethernet I/P communications module in the I/O concentrator shall be used to communicate any other device that does not have CENELEC EN 50325-2 or HART connectivity. [A19]

f. **Highway Addressable Remote Transducer (HART)**:

1) All instruments or sensors used shall output a 4 to 20 mA current loop analog signal enabled with HART protocol in accordance with [A10] HFC KIT-13,[A10] except for specialty or proprietary instruments that cannot be replaced (as validated by the Employer's Representative) by standard devices enabled with HART communications.

2) A HART scanner module in the I/O concentrator shall be used to monitor and configure all smart instruments or sensors.

[A5]5. **Level Switches**:

a. Units shall be capacitive, non-moving, and suitable for detecting water leaks and whether water level in an area exceeds a predefined warning level.

b. Units shall have a SPST dry contact alarm output for each switch. The Employer prefers units with no less than two outputs. [A5]

6. **Flow Transducers**:

a. Units shall be differential pressure to current (DPI) transducers with the following or better characteristics:

Table 40 91 00 – 2: Flow Transducer Characteristics

Accuracy		± 0.15% of span
Effects	Hysteresis	± 0.05% of span
	Static Pressure	±0.45% of span for combined zero and span per 70 bar
	Supply Voltage	±0.01% of span
	Temperature	±0.25% of span for combined zero and span per 28°C
Housing		NEMA 4X
Materials	Reduction coupling or adapter flange	Carbon Steel or bronze, size as required
	Bolting	Carbon Steel
	Fill Fluid	Silicon oil

Table 40 91 00 – 2: Flow Transducer Characteristics		
	Head Gaskets	Teflon
	Mounting Bracket	Zinc-plated carbon steel, horizontal or vertical mounting on a 50 mm (2 in) pipe on for wall mounting
	Process Barrier Diaphragms	316L ss
	Process Head	Carbon Steel
	Adapter Fitting	Carbon steel or bronze
Output		4-20 mADC factory calibrated, two wire analog output
Overpressure		207 bar (3,000 psi) or 1.5 times the upper range limit, whichever is the highest
Power Supply		As recommended by the manufacturer and reviewed by the Employer's Representative

7. **Hydrogen Monitors**: Shall have a normally open alarm contact that closes upon exceeding safe hydrogen level in the air of a closed room.

8. [A8]**I/O Concentrators (IOC)** [A8]: Shall be used as a local I/O collector, and may contain any combination of the fieldbuses in [A8]Subparagraph 1.03 B.4.[A8]

9. **Intelligent Electronic Devices (IEDs)**:

   a. [A17]IEDs shall consist of any devices incorporating one or more processors with two-way communication capability to receive and send data/control from/to an external source (such as electronic multifunction meters, digital relays, and controllers).

   b. IEDs shall be primarily used for power distribution process monitoring and control, and shall use DNP 3.0 or higher communication protocol.

   c. Whenever possible, IEDs shall be used instead of transducers for EDCS.[A17]

10. **Level Transducers for Liquids**:

   a. When used for water level measurement, these sensors shall be called water level transducers (WLT). WLTs shall be used for flotation control requirements of rolling gates, in accordance with Section 01 81 19 (*Lock Gates*). [A16]The following requirements apply to all liquid level measurements: [A16]

      1) [A19]Sensors shall be IP68 compliant per IEC 60529, light weight, non-contact, corrosion resistant, installed top side of measuring wells, 10 mm or better accuracy, an algorithm to eliminate

reflection and wave effects, and have two 4-20 mA outputs.[A19] The units shall have a highly directional parabolic dish, with frequency and size as required.

2) Process value output shall be continuous and smooth, maintaining at least the minimum specified accuracy requirements throughout the measuring range.

3) Sensor support structure shall be rigid and constructed of light weight, corrosion resistant materials.

11. **Limit Switches**:

a. Applicable to all Locks moving machinery, all limit switch functions that require startup, cruise and slow down speed control, shall employ acceleration, deceleration, and stop limit switches, to ensure adequate startup, cruise, slowdown and full stop of machinery without over travel.

b. All such limit switch function devices shall be inductive proximity switches, or other non-contact sensing devices, IP-68 compliant per IEC 60529, and with factory molded connector and cable, with long enough cable length to reach the controls enclosure and terminated at appropriate terminal blocks.

c. Limit switches shall operate correctly under submerged or other environmental conditions.

12. [A19]**Measurement Devices for Electrical Distribution PCS**:[A19]

a. **General**: These devices shall primarily use DNP 3.0 or higher protocol for communications, and shall be connected to an I/O concentrator, where all the device's features shall be available for PLC use. Where convenient, Ethernet communications may be used to service the device's open process control (OPC) server features, if needed.

b. **Power Monitoring Protection Devices**: Shall comply with the requirements of Section 26 24 19 (Motor Control Centers).

c. **Power Quality Analyzing Protection Devices:** Shall comply with the requirements of Sections 26 13 00 (Medium Voltage Switchgear) and 26 29 23 (Variable Frequency Drives).

13. [A19] **(deleted)** [A19]

14. **Pressure Transducers**:

a. Units **s**hall be process pressure-to-current (PPI) transducers with 4-20 mA output.

b. Quality shall be similar to that of flow transducers of Table 40 91 00-2.

[A5]15. **Sensors for Rolling Gates (RGs):** Shall be as required for the functions specified on Subparagraph 1.04 B.6. The type and nature of such sensors largely depend on Contractor design which shall consider centering, maintainability, and positioning issues, and shall minimize the possibility of unsafe RG position and conditions. [A5]

16. **Vessel Detection Sensors**:

a. Sensors for vessel presence and position detection shall be suitable to multiple vessel hull colors, shapes, and sizes, as applicable, and shall operate reliably considering the presence of one or more tug near the vessel as per Section 35 12 00 (*Vessel Detection Systems*).

b. Such sensors shall detect black paint from a vessel's structure without confusing with fog.

17. **Wastewater/Sewage Treatment Sensors**:

a. The Contractor shall provide sensors as required for wastewater/sewage treatment process variables that can be measured online, including, but not being limited to, dissolved oxygen and Ph. Variables that require taking samples and analyzing them for hours or days are not required to have sensors under this Section of the Employer's Requirements.

b. These process variables shall be in accordance with Section 01 89 19 (*Sanitary Sewer / Wastewater*).

18. **Water Level Measurement Wells**:

a. Wells shall be designed and constructed along Locks Chamber walls considering desirable behavior suitable for water level measurement.

b. The design performance shall provide for:

1) Minimizing lagging or leading of the well's water level with respect to the actual level of the body of water being measured.

2) Where the body of water is a lake or sea, the depth of the well shall be sufficient to enable measurement of the lowest expected level of the body of water, plus 1 meter (3.028 ft).

3) Where the body of water is a Lock Chamber, the depth of the well shall be sufficient to enable measurement of the lowest level of the Chamber floor.

4) No obstructions or protrusions shall be acceptable in the well shaft.

c. Well shafts shall have enough dimensions to allow personnel access for maintenance if needed.

d. Wells shall include provisions to:

1) Prevent floating debris from entering the shaft.

2) Prevent overflow in the highest possible levels of the body of water.

3) Contain splashes.

4) Accommodate and manage the effects of water pressure transients.

5) Facilitate replacement of measurement equipment.

19. **Water Quality Sensors**:

a. At each Lock facility, Pacific and Atlantic, water quality sensors shall be provided to measure salinity, dissolved oxygen, pH, turbidity, fluorescence, in parts per million (ppm) with a resolution of 0.1 ppm, or better, with a suitable full scale range.

b. [A16]This sensor shall also measure water pressure in decibars, temperature in degrees Celcius and specific conductance in micromhos per cm, with the characteristics described in Table 40 91 00 – 3, Water Quality Sensor Characteristics. [A16]

Table 40 91 00 – 3: Water Quality Sensor Characteristics

	Full Scale Range	**Resolution**
Specific Conductivity	0 to 70 millimho/cm	0.1 micromho/cm
Temperature	[A16]-5 to 35°C	0.1°C [A16]
Pressure	> 100 m depth in decibars	0.002% full scale

c. Transducers shall be permanently installed at two depths per installation, on both the lake and sea side of the locks, with a continuous 24 VDC power source. Measurements shall be at adjustable depths, ranging from 1 m below water surface to 1 m above the lake or sea bed. Installation design shall allow for ease of maintenance and replacement.

d. Process values and available control functions shall be available to the nearest I/O concentrator.

e. Sensor shall be suitable to operate continuously under salt, fresh and brackish water, 100 m (300 feet) deep or more.

[A16]f. Water quality sensors shall also meet the requirements of Section 01 10 00 (*General Project Requirements*), paragraph 1.03 H. 3. [A16]

20. **Wind Speed and Direction Sensors**:

a. [A8]High performance rugged wind sensors shall be provided to measure wind speed and direction, providing two 4-20 mA outputs (one for wind speed and one for wind direction). Units shall be provided with a corrosion resistant construction, avoiding use of slip rings and brushes for increased reliability/availability. Wind speed sensors shall be a multiple blade helicoid propeller with a full scale of 40 m/s.[A8]

b. Process values and available control functions shall be available to the nearest I/O concentrator.

21. [A19]**Water Slope Sensors:** Shall measure longitudinal and transversal water slopes in lock chambers, and shall meet the requirements of Section 01 81 13 *(Filling and Emptying System)* [A19].

C. **Installation**:

1. **General**:

a. Devices shall be located where normal operation cannot damage or negatively affect them.

b. Devices shall be installed so that these can be easily removed and replaced for maintenance without needing lock downtime.

c. Unless otherwise specified, transducers shall be installed above normal water levels in the area of measurement.

d. [A19]Measurement devices calibration and precision shall be verified in accordance with the recommendations of the corresponding manufacturer. Whenever feasible, every device shall be verified with no less than two readings near the extremes of the operating range (one near the low end and one near the high end) and one near mid range. [A19]

2. **Air Quality Transducers**:

a. Units shall be permanently installed in confined spaces, including but not being limited to, the following: cable galleries (e.g., below switchgear in electrical rooms), Crossunders, passageways (i.e., to lock gate flotation tanks), tunnels, valve pits, and vertical shafts.

b. Remote reading shall be provided to the "*División de Esclusas y Mantenimiento de Instalaciones*" (OPE) via the Employer's intranet.

c. [A19]These transducers shall be connected to LMCSs so that confined spaces are ventilated as follows:

1) Automatically, depending on the transducer readings, or

2) Manually, the default configuration per Section 01 86 13 *(Plant – Mechanical Systems and Equipment)*. [A19]

3. [A5]**Level Switches**

a. [A17]Each Crossunder shall have at least two units. [A17]

b. Units shall be connected to the corresponding LMCS (for alarm purposes) as well as EAA Water SCADA system (for status monitoring and valve control purposes. [A5]

4. **Flow Transducers:** Shall be installed as required to monitor liquid flow in FFCSs pipes.

5. **Hydrogen Monitors**: Shall be installed in every battery room of Section 26 33 00 (*Direct Current Equipment*) and the alarm contact shall be connected to the EDCS of Section 40 95 13.19 (*Process Control Hardware for Electrical Distribution Control Systems*).

6. **Intelligent Electronic Devices (IEDs):** Shall be connected to a local area network (LAN) or an I/O concentrator in every applicable site, i.e., substation and equipment/machinery rooms.

7. **Limit Switches:** Shall be used to de-accelerate, stop, and prevent over-travel and extreme over-travel of controllable devices.

8. **Pressure Transducers**:

a. PPI transducers shall be installed as required to monitor pressure in FFCS pipes.

b. A single PPI transducer shall suffice for the entire pipe assembly between two actuated valves, as long as no manual valves or other potentially flow restricting components are present. In such cases, more than one transducer shall be required to monitor pressure in all pipe segments.

9. **Vessel Detection Sensors:** Shall be installed as shown in Figure 40 91 00-1, preferably above water level.

10. **Water Level Transducers (WLTs):**

a. Transducers shall be installed on top of water level measurement wells, in accordance with Figure 40 91 00-1.

b. [A19]Level transducer calibration and precision shall be verified comparing LMCS readings against elevation marking rulers in the corresponding locks chamber wall. [A19]

11. **Wind Speed and Direction Transducers**:

    a. One anemometer shall be provided for each end of the locks, with data for use by the locks and the Employer's Personnel (pilots).

    b. One anemometer shall be provided for a nearby isolated area, with data for use by the Employer's "*Sección de Recursos Hídricos*" (EACR)'s ALERT hydro-meteorological system.

12. [A5]**Sensors for Rolling Gates (RGs):** Shall be installed above water whenever possible for ease of maintenance. [A5]

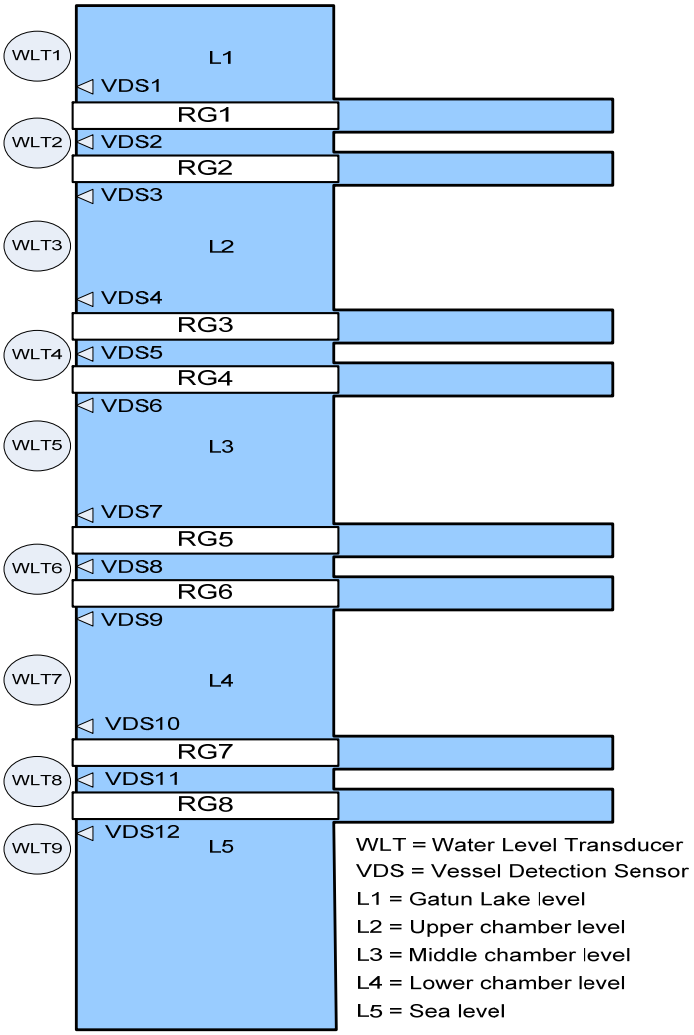

Figure 40 91 00-1: WLTs and VDSs in Lock Chamber Areas

[A19]13. **Water Slope Sensors:** Shall be temporarily or permanently installed in all lock chambers. As a minimum, such sensors shall be made available during the tests on completion period. [A19]

14. **Photocells**: Shall point towards the north.

1.04 DESIGN CRITERIA/ SYSTEM PERFORMANCE:

A. **General**:

1. **Problem to be Solved**:

a. Simplified, seamless integration of commercial hardware and software making maintenance easy and training requirements minimal.

b. Use of standard equipment, controllers, devices and instrumentation across the Locks complex to detect machinery alarms, position, status, and values of specified parameters.

c. Use of standard fault tolerance and common failure mode avoidance concepts applied across the locks complex.

2. **Restrictions to be Considered**:

[A16]a. Insofar as practicable, instrumentation, sensors, and transducers shall not require divers for installation, inspection, and maintenance. [A16]

B. **Machinery Sensors**:

1. **Main Sensors for Electromechanical Machinery**: Shall include as a minimum:

Measurement (each)	**Measurement Method**
Main breaker status	Breaker auxiliary contacts
Motor breaker status	Breaker auxiliary contacts
Phase-loss / reversal relay alarm	Device alarm output
Control 24VDC distribution CBs	Feedback line to I/O rack input
DC power supply temperature	DC power supply analog outputs
DC power supply current	DC power supply analog outputs
DC power supply voltage	DC power supply analog outputs
Redundant 24VDC output	Feedback line to I/O RACK input
120VAC TVSS alarm	Device alarm output
[A19]Motor: All control and data available from motor starter or VFD, via CENELEC EN 50325-2 fieldbus, IEC 50325-2 fieldbus, or Ethernet/IP [A19]	
Motor running	Motor auxiliary contacts
[A19] (deleted) [A19]	
Motor voltage Vab and Vcb	Analog transducer output
Motor current Iab and Icb	Analog transducer output
Wire rope (pulling cable) slack and rupture	Discrete output
Operational position	Absolute analog position transducer output
	[A19]or Absolute encoder using CENELEC EN 50325-2 fieldbus, IEC 61158 type 2 fieldbus, or Ethernet/IP [A19]

Measurement (each)	Measurement Method
	or resolver using analog transducer output
	Deceleration inductive proximity switch (open)
	Stop inductive proximity switch (open)
	Deceleration inductive proximity switch (close)
	Stop inductive proximity switch (close)

2. **Machinery Sensors for Hydraulic Machinery**: Shall include the following as a minimum:

Measurement (each)	Measurement Method
Main 480VAC breaker status	Breaker auxiliary contacts
Motor breaker status	Breaker auxiliary contacts
Phase-loss/ reversal relay alarm	Device alarm output
Control 24VDC distribution CB	Feedback line to I/O rack input
DC power supply temperature	DC power supply analog outputs
DC power supply current	DC power supply analog outputs
DC power supply voltage	DC power supply analog outputs
Redundant 24VDC output	Feedback line to I/O rack input
120VAC TVSS alarm	Device alarm output
Motor:	[A19]All control and data available from motor starter or VFD, via CENELEC EN 50325-2 fieldbus, IEC 61158 type 2 fieldbus, or Ethernet/IP [A19]
Motor running	Motor auxiliary contacts
Motor temperature	Analog transducer output
Motor bearing temperature	Analog transducer output
[A19] (deleted) [A19]	
Pump gpm (if variable)	Pump analog output
Pump output pressure	Adjustable settings, high pressure switch
Pump output filter dirty alarm	Device alarm output
Cylinder rod pressure	Pressure transducer
	Adjustable settings, high pressure switch
Cylinder bore pressure	Pressure transducer
	Adjustable settings, high pressure switch
Cylinder position	Absolute analog position transducer output
	[A19]Or absolute encoder using CENELEC EN 50325-2 fieldbus, IEC 61158 type 2 fieldbus, or Ethernet/IP [A19]
	Or resolver using analog transducer output
	Deceleration inductive proximity switch (open)
	Stop inductive proximity switch (open)

Measurement (each)	Measurement Method
	Deceleration inductive proximity switch (close)
	Stop inductive proximity switch (close)
	Shut off valve limit switches
Shut off valve position	Directional valve limit switches
Directional valve position	Valve analog output
Proportional valve position	Discrete or analog transducer output
Reservoir oil Level	Analog transducer output
Reservoir oil temp	Analog transducer output
Moisture / water in oil	Analog transducer output or PLC compatible protocol
Oil particle counter	
Local gate open alarms	Discrete output
Local gate closure alarms	Discrete output

3. **Main Sensors for Electrical Distribution System**: Shall include as a minimum:

Measurement (each)	Measurement Method
Power quality	DNP 3.0 or higher protocol
Power measurement	DNP 3.0 or higher protocol
Electronic reverse overcurrent relays	DNP 3.0 or higher protocol
Protective high voltage relays	DNP 3.0 or higher protocol
main circuit breakers	Breaker auxiliary contacts
Circuit breakers	Breaker auxiliary contacts

4. **Redundant Sensors for Electromechanical Machinery**:

   a. [A19]For each motor, a rms current sensing shall be provided, as a backup means of validating machinery is in motion.[A19]

   b. Also, redundancy shall be implemented for operational position sensing by using an analog position transducer as main and four limit switches with adjustable position supports as backup. See Section 40 96 45.13 (*Process Control Software for LMCS*) for more requirements for position system redundancy.

   c. Other redundancy shall be provided as required, following the above concepts for critical process values.

5. **Redundant Sensors for Hydraulic Machinery**:

   a. Redundancy shall be implemented for pressure sensing by using an analog pressure transducer as main and an adjustable setting pressure switch as backup.

   b. Also, redundancy shall be implemented for operational position sensing by using an analog position transducer as main and four limit switches

with adjustable position supports as backup. See Section 40 96 45.13 (*Process Control Software for LMCS*) for more requirements for position system redundancy.

c. Other redundancy shall be provided as required, following the above concepts for critical process values.

6. **Sensors for Rolling Gates (RGs)**:

a. Sensors shall be as required for track cleaning, ballast/floating control, dewater recess pump, and lubrication (if automated).

b. [A17]Weight sensors shall be provided for RG wagons or mechanisms to monitor whether operating equipment, rollers, and tracks are withstanding normal or excessive loads in accordance with the requirements of Section 01 81 19 (Lock Gates), and to control RG buoyancy. [A17]

[A5]c. Sensors shall also be provided to continuously detect whether it is safe to move rolling gates. [A5]

C. **Other Sensors**:

1. **Flood Monitors**: Shall allow the corresponding LMCS to continuously monitor whether water level in all Crossunders exceeds a warning level to be determined be the Employer's Representative.

2. **Water Quality**: Measured variables shall be for continuous monitoring from the Employer's "División de Agua" (EAA) SCADA systems.

1.05 SUBMITTALS:

A. Submittals shall be in accordance with Section 40 00 00 (*Process Systems Integration*), Paragraph 1.05.

B. [A19]All CENELEC EN 50325-2 and IEC 61158 type 2 fieldbus conformant items shall have an Open DeviceNet Vendors Association (ODVA) test laboratory certification. [A19]

C. The Contractor shall provide a list of recommended spare parts, including make and model, and main technical characteristics.

1.06 QUALITY ASSURANCE:

A. Quality shall be in accordance with Section 40 00 00 (*Process Systems Integration*), Paragraph 1.06.

B. Calibration of each measurement device shall be certified and verified.

C. Warranty.

END OF SECTION

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