Engineering Standard

SAES-J-003 13 May 2013

Instrumentation - Basic Design Criteria

Document Responsibility: Instrumentation Standards Committee

Saudi Aramco DeskTop Standards

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Revised paragraphs are indicated in the right margin

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1 Scope

This Engineering Standard covers the basic requirements for the selection, design, and application of process instrumentation and control systems.

This entire standard may be attached to and made a part of purchase orders.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other Saudi Aramco Engineering Standards (SAESs), Saudi Aramco Materials System Specifications (SAMSSs), Industry Standards, codes, forms, and Saudi Aramco Standard Drawings (SASDs) shall be resolved by the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-103	*Metric Units of Weights and Measures*
SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-A-105	*Noise Control*
SAES-A-112	*Meteorological and Seismic Design Data*
SAES-B-054	*Access, Egress, and, Materials Handling for Plant Facilities*
SAES-J-004	*Instrumentation Symbols and Identification*
SAES-J-700	*Control Valves*

SAES-J-904	*FOUNDATION™ fieldbus (FF) Systems*
SAES-P-100	*Basic Power System Design Criteria*

Saudi Aramco Library Drawings

DD-950025	*Nameplate Details for Instrument Boards*
DD-950053	*Field Mounting Details for Instruments*

3.2 Industry Codes and Standards

American Society for Testing and Materials

ASTM A269	*Seamless and Welded Austenitic Stainless Steel Tubing for General Service*

National Association of Corrosion Engineers/International Organization for Standardization

NACE MR0175/ISO 15156	*Petroleum and Natural Gas Industries – Materials for Use in H_2S-Containing Environments in Oil and Gas Production*

Process Industry Practices

PIP PCCGN002	*General Instrument Installation Criteria*

International Society of Automation (ISA)

ISA-100.11a	*Wireless Systems for Industrial Automation: Process Control and Related Applications*

4 General

All continuous measurement electronic field instruments, and control valve positioners, shall be smart.

Electronic, smart or any positioners with potential ignition sources, shall not be used for applications where process gas is used as an actuating media instead on instrument air.

The design requirements for each type of instrument are covered by the individual standards and specifications.

The design and selection of process control and instrumentation systems should include consideration of the following:

- Application suitability
- Reliability and availability

- Quality
- Accuracy
- Repeatability
- Life cycle cost
- Previous acceptance as a stock item (i.e., savings on spares)
- Availability of spares beyond the end of the production run of the respective item
- Compatibility with existing equipment (i.e., a Plant Expansion)
- Flexibility of use
- Compatibility with the environment (climatic and electrical classification)
- Ease of maintenance (reduction of down-time)
- Ease of operation (confidence and familiarity of the operator)

Commentary Note:

The priority of the above aspects will depend on the application and equipment under consideration. Other pertinent factors and design issues that are not listed above should also be considered.

5 Measurement Units

All new facilities shall be designed for operation in English units.

Exception:

Upgrades or modifications to existing facilities may retain existing operating units unless otherwise specified in project documentation.

Subject	Fluid	SI Unit	English Unit
Length	N/A	M	ft
Mass	All	Kg	lb
Temperature	All	°C	°F
Flow (Notes 2 & 3)	Water Oil and in-plant process liquids Steam and steam condensate Gas (except GOSP Gas) GOSP Gas GOSP Crude Production	m^3/h, m^3/d m^3/h, m^3/d kg/h m^3/h, m^3/d m^3/d m^3/d	GPM (US), BPD BPH, BPD LB/H SCFM, SCFH, SCFD SCFD BPD
Level	All	mm, cm, m, % of range	in, ft, % of range
Pressure	All	kPa	Psig, psia
Vacuum	All	Pa, kPa	inches of H_2O inches of Hg
Pressure, Differential	All	kPa	psi inches of H_2O
Vibration	All	Micrometer	mil (0.001 inch)

Subject	Fluid	SI Unit	English Unit
Concentration	All	mole %, ppm, %w, %v kg/m^3	mole %, ppm, %w, %v PTB (Pounds per thousand barrels)
Viscosity, Kinematic Dynamic	All	 m^2/s Pa.s	 CST (centistoke) CP (centipoise)
Density	All	g/cm^3, g/liter, kg/m^3	lb/ft^3

Notes:

1. SI Units shall conform to SAEP-103, Metric Units of Weight & Measures.
2. Flowrate given in units per day is based on operating day, e.g., BPOD. This is to be differentiated from flow rate per calendar day, e.g., BPCD, which is used for plant design, and takes into account the operating factor (less than unity) of the plant. Thus, BPCD = BPOD * (operating factor).
3. Saudi Aramco-defined standard conditions for process flow measurement and gas custody metering are as follows:

	SI Unit	English Unit
Pressure	101.56 kPa (abs)	14.73 psia
Temperature	15.56°C	60°F

Standard conditions for liquid custody metering are as follows:

	SI Unit	English Unit
Pressure	101.325 kPa (abs)	14.696 psia
Temperature	15.00°C	60°F

6 Gas as an Instrument Supply

Sour gas shall not be used in lieu of instrument air. Gas with less than 10 ppm H_2O, 10 ppm CO_2 and 5 ppm H_2S may be used with prior written approval by the Supervisor, Instrumentation Unit, Process Automation Systems Division, Process & Control Systems Department.

7 Signal Ranges and Communications Protocols

7.1 Acceptable field transmission signals for grass root projects are 3-15 psi, FOUNDATION™ fieldbus, or 4-20 mA with superimposed HART. Vendor proprietary digital protocols are acceptable for plant expansions when matching existing instrumentation. In the context of this standard, field transmission signals are defined as signals from field devices to a control system, or signals from a control system to field devices.

HART communication protocol shall not be used for plant control.

FOUNDATION™ fieldbus based instrumentation and control systems shall meet the requirements specified in SAES-J-904.

Use of any other communication protocol requires prior written approval of the General Supervisor, Process Automation Systems Division, Process & Control Systems Department.

7.2 Wireless instrumentation shall not be utilized in any safety, control (open or close loop, start/stop, open/close, etc.) or critical monitoring applications. Wireless instrumentation may, however, be considered for asset management or non-critical monitoring applications provided the following conditions are met:

7.2.1 The wireless installation is primarily non-critical asset management or non-time critical process monitoring applications only.

Commentary Note:

Non-critical applications are typically meant for increased performance or diagnostics. Monitoring applications that may be classified as non-critical are those with the following characteristics:

a) A signal loss of two to three days continuous can be tolerated without compromising safety or impacting plant operation.

b) A battery change of up to a frequency of once every two years can be accommodated into the routine operation/maintenance of the device.

c) Response time of once is every 10 seconds.

7.2.2 A letter of concurrence shall be signed by the project manager, the proponent manager, and LPD representative, to declare the non-criticality of the process for which a wireless solution is to be proposed. The letter shall specify each device to be connected to the wireless network.

7.2.3 All wireless devices and gateways shall be fully ISA 100.11a compliant and stamped by the Wireless Compliance Institute (WCI).

7.2.4 The wireless gateways shall be hardwired to the control system, compatible with the host system, and connected with redundant links. Gateway and instrumentations shall be procured from the same vendor.

7.2.5 All wireless devices, repeater/routers, gateways, and space between them shall reside within Saudi Aramco premises. Wireless signals shall not propagate outside Saudi Aramco facilities as per government directives.

7.2.6 The design shall not pose any security holes to the control system or any Saudi Aramco networks.

7.2.7 The detailed design package, including material specifications, shall be reviewed and approved by General Supervisor, Process Automation Systems Division/ P&CSD.

8 Environmental Conditions

8.1 Temperature

Instruments and control systems shall operate continuously under the following ambient air temperatures without any degradation of the manufacturer's guaranteed performance:

	Indoor Air Conditioned (2)	Outdoor Sheltered (1)(2)(3)	Outdoor Unsheltered (2)(3)
Maximum	35°C (95°F)	55°C (131°F)	65°C (149°F)
Minimum	10°C (50°F)	0°C (32°F)	0°C (32°F)

Notes:

1) "Sheltered" refers to permanent, ventilated enclosures or buildings, or permanently fixed sunshades with a top and three sides.
2) For instruments which dissipate internal heat and are installed in custom engineered enclosures (e.g., enclosures not included in the original manufacturer's temperature certification), an additional 15°C shall be added to the above maximum temperatures. An example, for "indoor air conditioned" installation, the equipment must perform at 35 + 15 = 50°C. Similarly, for the "outdoor unsheltered" case, the equipment shall be designed for a maximum operating temperature of 65 + 15 = 80°C.
3) For the outdoor installations only, the designer can take credit for forced or passive cooling to eliminate or reduce the 15°C heat rise. For example, if vortex coolers are used, the heat removal capacity of the coolers may be subtracted from the generated heat. No more than 15°C reduction in temperature will be given as credit. The designer shall substantiate his claim by providing the support data and calculations.

8.2 Contaminants

Installations shall be designed for operation in an environment with contaminant levels as defined in the Ambient Air Quality Section of SAES-A-112.

8.3 Humidity

Indoor humidity design basis shall be 20% to 80% relative humidity.

Outdoor design basis shall be 5% to 95% relative humidity (non-condensing).

8.4 Noise

Instruments that generate noise shall be selected so that the effect on the environment is limited in accordance with SAES-A-105.

Control valve installations shall meet the noise requirements specified in SAES-J-700.

8.5 Offshore and Nearshore Environment

Equipment which is not enclosed or hermetically sealed, but is situated offshore or nearshore, shall be protected against corrosion and operational failure due to wind-borne sea water spray and the accumulation of wetted salt (NaCl). Nearshore is defined as any outdoor, onshore location within one kilometer from the shoreline of the Arabian Gulf; all of the Ras Tanura Refinery and Terminal; and within three kilometers from the shoreline of the Red Sea.

8.6 Instrument Certification for Classified Area

All instrumentation devices intended for operation in classified areas shall be certified per SAES-P-100, "Basic Power System Design Criteria."

9 Fail Safe Design Requirements

Unless otherwise specified in other standards, all discrete instrumentation such as switches, solenoids, relays, etc., shall be designed so that they are energized during normal operation and should de-energize to initiate a shutdown, an alarm or any other control action.

10 Instrument Installations

All instrumentation installations shall comply with this standard and the relevant instrumentation standards. Where there is a conflict between this standard and any of the relevant standards, the more specific relevant standard shall govern. All instrumentation installations in sour service shall comply to NACE MR0175/ISO 15156.

10.1 Instrument Mounting Locations

10.1.1 Field instruments shall be mounted as close as possible to the process connection to minimize the length of instrument impulse lines. Where practically possible, the length of the impulse line should not exceed 6 m (20 ft.)

10.1.2 Instruments shall not protrude into or obstruct access ways so as to inhibit area personnel egress.

10.1.3 All instrumentation and associated control equipment shall be readily accessible from grade, platform, fixed walkway, fixed stairway or a fixed ladder. Local indicating instruments shall be visible from where related equipment is operated or primary instruments are tested or calibrated.

10.1.4 Instruments mounted outside a handrail shall be located to allow maintenance from the walking/working surface without reaching through or leaning over the handrail. The distance from the platform shall be per SAES-B-054.

10.1.5 Instruments shall be located to allow performance of routine services with unobstructed access.

Commentary Note:

Clearances shall be provided for the removal of covers and cases and the opening of doors and enclosures. Access for appropriate lifting equipment shall be provided when necessary for control valves or other large in-line instruments.

10.1.6 Pressure and D/P instruments in liquid or condensable vapor service shall be self-venting (i.e., mounted below the process connections) with all impulse lines sloping downward approximately 1:12 -minimum toward the instrument. Pressure and D/P instruments in gas service shall be self-draining (i.e., mounted above the process connections) with all lines sloping downward approximately 1:12 minimum toward the process connection.

10.1.7 Instrument impulse lines shall not be pocketed. Where practically possible, horizontal tube connections (manifold with horizontal taps) shall be used.

10.2 Instrument Process Connections

10.2.1 A line class root or isolation valve shall be provided at each process connection. This valve shall be specified and provided by the piping discipline.

10.2.2 All process connected instruments shall be equipped with block and bleed mechanism to allow isolation, drainage and maintenance.

10.2.3 Pressure and differential pressure transmitters shall be equipped with manifold assemblies.

10.2.4 Instrument process connections shall conform to the requirements specified in the relevant instrumentation standards and standard drawings.

10.3 Instrument Support

10.3.1 Direct-reading instruments such as gauges shall be supported by piping, panel board or equipment.

10.3.2 Except for close-coupled instrument, all field instruments should be mounted on instrument supports designed for that purpose.

Comment: *Attention should be paid to process instruments that are close - coupled (installed directly on the piping). Effects of instrument size and weight as well as heat or vibration in piping systems should be carefully evaluated.*

10.3.3 When pipe stand is used as an instrument support, it should be made of a prefabricated, 2-inch, schedule 40 pipe. The pipe stand should be hot-dipped galvanized. The top of the pipe shall be plugged or sealed to prevent water entry.

10.3.4 Pipe stands shall be securely anchored. For typical details, refer to Library Drawing # DD-950053, Field Mounting Details for Instruments.

10.4 Instrumentation Tagging

10.4.1 All instruments shall have engraved phenolic/Bakelite-laminated nameplates showing instrument tag numbers. The nameplates shall be installed with stainless steel screws. Using glue to install nameplates is not acceptable.

Exception:

For local gauges, thermocouple termination heads and other field mounted instruments, where it is impractical to screw the nameplate to the instrument, stainless steel chain connection, for the nameplate to the instrument is acceptable.

10.4.2 Panel mounted instruments shall be provided with two nameplates, one on the front and one on the back; rack mounted instruments should have front mounted nameplates only.

10.4.3 For RTD and thermocouple heads, stainless steel nameplates that are chained to the head may be used.

10.4.4 All field junction boxes, other instrumentation enclosures and process automation cabinets shall be equipped with nameplates.

10.4.5 The tagging scheme shall be per SAES-J-004.

10.4.6 A typical construction of the instrument nameplate can be found in Library Drawing # DD-950025, sheets 1 & 2.

11 Instrument Piping and Tubing

11.1 Instrument Piping

When piping is used for process connection, the piping specification and installation shall follow the relevant piping standards. From the root valve to the instrument, the instrument piping specification, material of construction, pressure rating, fittings, and valves shall meet or exceed applicable piping specifications for the process service.

11.2 Instrument Tubing

11.2.1 When tubing is used for process connection, the process sensing tubing (impulse line), fittings, and instrument valves shall be compatible with the process medium. The tubing and fittings shall be made of the same material. As a minimum, the tubing shall be Type 316 seamless, annealed stainless steel per ASTM A269, ½-inch OD x 0.035-inch wall thickness, hardness Rockwell B80 maximum.

11.2.2 As a minimum, pneumatic signal (3-15 psig signals) tubing shall be Type 316 seamless, annealed stainless steel per ASTM A269, ¼-inch OD x 0.035-inch wall thickness, hardness Rockwell B80 maximum. The minimum design pressure shall be 150 psig.

11.2.3 Tube fittings shall be, as a minimum, 316 stainless steel and shall be compression type. Interchange of tube fittings or fitting parts from different manufacturers in a specific plant is not allowed.

11.3 Instrument Piping and Tubing Support

11.3.1 Instrument process piping and tubing shall be supported as necessary to maintain structural integrity.

11.3.2 All instrument piping and tubing between the instrument and process equipment or pipeline shall be properly supported to prevent strain on the instrument, equipment, and piping connections. The supports shall be designed so that the effect of any equipment vibration is eliminated.

11.3.3 Tubing shall not be routed along or supported from handrails.

11.3.4 Tubing supports should be spaced not more than four feet apart.

11.3.5 In locations where mechanical damage is likely, tubing may be installed in dedicated structural channel, angle, or in trays.

11.3.6 Tubes and tube bundles and their support channels and trays shall not be supported from process or utility piping.

11.3.7 Tubing channels or trays shall not be supported by bolting to transmitter brackets or control valves.

11.3.8 Tubing shall be installed in a manner that allows for calibration of instruments and easy removal of adjacent instruments, equipment, and tubing.

11.4 Heat Tracing

Heat tracing of tubing shall be per PIP PCCGN002, General Instrument Installation Criteria, paragraph 7.2.

11.5 Fire Protection

Stainless steel tubing (ASTM Types 304, 316, 321) does not require fireproofing.

Revision Summary

6 September 2011	Revised the "Next Planned Update." Reaffirmed the contents of the document, and reissued with minor revision.
25 March 2012	Minor revision to clarify the requirement for the nameplates for field instruments.
31 December 2012	Minor revision to limit wireless instrumentation to ISA 100.11a.
13 May 2013	Minor revision to clarify the plant wireless instrumentation installation requirements.