International Association of Oil & Gas Producers

SPECIFICATION
S-718J

November
2021

Specification for Basic Process Measurement Instruments

NOTE This version (S-718J) of the specification document provides the justification statements for each technical requirement, but is otherwise identical in content to S-718.

JIP33
JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
0.3	November 2021	Issued for Public Review

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

Disclaimer

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2020).

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Introduction

The purpose of this specification is to define a minimum common set of requirements for the procurement of basic process measurement instruments for application in the petroleum and natural gas industries.

This specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.

JIP33 Specification for Procurement Documents
Technical Specification

This specification is to be applied in conjunction with the supporting procurement data sheet, information requirements specification (IRS) and quality requirements specification (QRS) as follows.

IOGP S-718: Specification for Basic Process Measurement Instruments

This specification defines the technical requirements for the supply of the equipment.

IOGP S-718D: Procurement Data Sheet for Basic Process Measurement Instruments

The procurement data sheet defines application specific requirements, attributes and options specified by the purchaser for the supply of equipment to the technical specification. The procurement data sheet may also include fields for supplier provided information attributes subject to purchaser's technical evaluation. Additional purchaser supplied documents may also be incorporated or referenced in the procurement data sheet to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-718L: Information Requirements for Basic Process Measurement Instruments

The IRS defines the information requirements, including contents, format, timing and purpose to be provided by the supplier. It may also define specific conditions which invoke information requirements.

IOGP S-718Q: Quality Requirements for Basic Process Measurement Instruments

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the data sheet or in the purchase order.

The terminology used within this specification and the supporting procurement data sheet, IRS and QRS is in accordance with ISO/IEC Directives, Part 2.

The procurement data sheet and IRS are published as editable documents for the purchaser to specify application specific requirements. The specification and QRS are fixed documents.

The order of precedence (highest authority listed first) of the documents shall be:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser defined requirements (procurement data sheet, IRS, QRS);

d) this specification.

1 Scope

1.1 Technologies

This specification defines the requirements for the design, sizing and selection, materials, inspection and testing, marking and preparation for shipment of basic process measurement instrumentation, for pressure ratings up to class 2500, covering the following technologies:

— electronic pressure and differential pressure transmitters (both with manifold and diaphragm seal options);

— electronic temperature transmitters;

— RTD, thermocouple and thermowell temperature elements;

— concentric sharp edge, conic, quadrant edge and eccentric orifice head flow meter elements and quick change assembly;

— venturi flow elements;

— ultrasonic flow, magnetic flow and vortex volumetric flow meter elements;

— coriolis mass flow meter elements;

— magnetic level transmitters;

— wet leg and diaphragm hydrostatic level transmitters;

— guided wave radar level transmitters;

— non-contact radar level transmitters.

Justification

Scope of supply is decided based on the agreed framing proposal from OpCos.

1.2 Boundaries

This specification covers instrumentation for the following applications:

— upstream production facilities excluding wellhead, drilling and subsea instrumentation;

— midstream transportation and storage (excluding pipelines to ASME B31.8);

— downstream refining and distribution.

This specification is applicable for instrumentation in the following special services:

— NACE compliance for H_2S and alkaline service;

— hydrogen service.

Justification

The operators agreed scope for the boundary conditions mostly commonly encountered for the instrumentation.

1.3 Exclusions

The following general requirements are excluded from this specification:

— wireless technology;

— internet of things (IoT);

— signal conditioners.

The following technologies are excluded from this specification:

— electronic remote pressure seals (for level measurement);

— multi-variable pressure transmitters;

— thermowells in vessels;

— skin-type thermocouples;

— magnetic temperature sensors;

— orifice flange, integral orifice run, flow nozzle, v-cone and multi-hole orifice head flow meter elements;

— turbine volumetric flow meter elements;

— gauge glass level indicators;

— hydrostatic bubbler level transmitters;

— displacer, nucleonic level, density profiler and ultrasonic level transmitters.

Justification

There is a vast range of instrumentation that could have been covered within the specification and the above are included, for the avoidance of doubt, where there could be some element of misunderstanding.

2 Normative references

The following publications are referred to in this document, the procurement data sheet (IOGP S-718D) or the IRS (IOGP S-718L) in such a way that some or all of their content constitutes requirements of this specification. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 551, *Process Measurement*

ASME BPVC, Section IX, *Welding, Brazing, and Fusing Qualifications*

ASME B1.20.1, *Pipe Threads, General Purpose, Inch*

ASME B16.5, *Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard*

ASME B31.3, *Process Piping*

ASME B40.200, *Thermometers, Direct Reading and Remote Reading*

ASME MFC-3M, *Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi*

ASME MFC-5.1, *Measurement of Liquid Flow in Closed Conduits Using Transit-Time Ultrasonic Flowmeters*

ASME MFC-5.3, *Measurement of Liquid Flow in Closed Conduits Using Doppler Ultrasonic Flowmeters*

ASME MFC-6M, *Measurement of Fluid Flow in Pipes Using Vortex Flowmeters*

ASME MFC-11, *Measurement of Fluid Flow by Means of Coriolis Mass Flowmeters*

ASME MFC-16, *Measurement of Liquid Flow in Closed Conduits With Electromagnetic Flowmeters*

ASME PTC 19.2, *Pressure Measurement – Instruments and Apparatus Supplement – Performance Test Codes*

ASME PTC 19.3 TW, *Thermowells*

ASTM B912, *Standard Specification for Passivation of Stainless Steels Using Electropolishing*

ASTM E230/E230M, *Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

ASTM E235/E235M, *Standard Specification for Type K and Type N Mineral-Insulated, Metal-Sheathed Thermocouples for Nuclear or for other High-Reliability Applications*

ASTM E608/E608M, *Standard Specification for Mineral-Insulated, Metal-Sheathed Base Metal Thermocouples*

ASTM E1137/E1137M, *Standard Specification for Industrial Platinum Resistance Thermometers*

BS 476-7, *Fire tests on building materials and structures Part 7.Method of test to determine the classification of the surface spread of flame of products*

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60381-1, *Analogue signals for process control systems – Part 1: Direct current signals*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60584-1, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 60584-3, *Thermocouples – Part 3: Extension and compensating cables – Tolerances and identification system*

IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

IEC 61326-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61326-3-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications*

IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61515, *Mineral insulated metal-sheathed thermocouple cables and thermocouples*

IEC 61518, *Mating dimensions between differential pressure (type) measuring instruments and flanged-on shut-off devices up to 413 BAR (41,3 MPa)*

IEC 62305 (all parts), *Protection against lightning – Part 1: General principles*

IEC 62402 , *Obsolescence management*

IEC 62828 (all parts), *Reference conditions and procedures for testing industrial and process measurement transmitters*

IOGP S-563, *Material Data Sheets for Piping and Valve Components*

IOGP S-705, *Supplementary Specification to API Recommended Practice 582 Welding Guidelines for Welding of Pressure Containing Equipment and Piping*

IOGP S-715, *Supplementary Specification to NORSOK M-501 Coating and Painting for Offshore, Marine, Coastal and Subsea Environments*

ISA 50.00.01, *Compatibility of Analog Signals for Electronic Industrial Process Instruments*

ISO 261, *ISO general purpose metric screw threads — General plan*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

ISO 5167-2, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 2: Orifice plates*

ISO 5167-4, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 4: Venturi tubes*

ISO 10790, *ASTM E235/E235M — Standard Specification for Type K and Type N Mineral-Insulated, Metal-Sheathed Thermocouples for Nuclear or for Other High-Reliability Applications*

ISO 12764, *Measurement of fluid flow in closed conduits — Flowrate measurement by means of vortex shedding flowmeters inserted in circular cross-section conduits running full*

ISO 12944-5, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems*

ISO 12944-6, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods*

ISO/TR 15377, *Measurement of fluid flow by means of pressure-differential devices — Guidelines for the specification of orifice plates, nozzles and Venturi tubes beyond the scope of ISO 5167*

ISO 15614, *Specification and qualification of welding procedures for metallic materials — Welding procedure test*

ISO 17089-2, *Measurement of fluid flow in closed conduits — Ultrasonic meters for gas — Part 2: Meters for industrial applications*

ISO 20456, *Measurement of fluid flow in closed conduits — Guidance for the use of electromagnetic flowmeters for conductive liquids*

ISO 21457, *Petroleum, petrochemical and natural gas industries — Materials selection and corrosion control for oil and gas production systems*

ISO 23936-1, *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 1: Thermoplastics*

ISO 23936-2, *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 2: Elastomers*

MSS SP-99, *Instrument Valves*

NACE MR0175/ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production*

NACE MR0103/ISO 17945, *Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments*

NAMUR NE 43, *Standardization of the Signal Level for the Failure Information of Digital Transmitters*

NAMUR NE 107, *Self-Monitoring and Diagnosis of Field Devices*

NEMA 250, *Enclosures for Electrical Equipment (1000 Volts Maximum)*

NFPA 70, *National Electrical Code*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org.obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
capillary
tube used to provide high integrity connection between the diaphragm seal (process connection) and the sensing element (transmitter)

3.2
diaphragm seal
chemical seal
remote seal
flexible material located at the process connection to isolate the capillary line fill fluid from the process fluid while permitting the transmission of pressure through to the fill fluid contained within the capillary

3.3
impulse line
instrument tubing connection provided between the process isolation valve and the measuring element

4 Common requirements

4.1 System design

4.1.1 Design codes

Basic process measurement instrumentation shall comply with the following standards:

— IEC 62828 (all parts);

— IOGP S-563;

— ISO 21457;

— ISO 23936-1;

— ISO 23936-2.

Justification

Provides a basis of the code compliance for the instrumentation being supplied.

4.1.2 Configuration

4.1.2.1

Transmitters shall permit re-ranging without requiring re-calibration.

Justification

Re-calibration is a more complex task (and requires equipment that is only available in the workshop) and the option to omit it when re-ranging is required removes an additional task from the operations team when only re-ranging is required.

4.1.2.2

Instrumentation shall be preconfigured with the following data:

— tag number;

— failure mode;

— operating range;

— units of measure.

Justification

This provides the minimum configuration needed for the instrument to be functionally ready to be installed and operated.

4.1.2.3

Instrumentation configuration shall be via the specified communication protocol.

Justification

Enforces standardisation of tool used to interface with the instrumentation and furthermore those tools used shall have full functionality to configure all parameters within the instrument.

4.1.2.4

The communication protocol shall be backward compatible.

Justification

Any change to the communication protocol will have no impact to the purchasers configuration from an earlier version / revision.

4.1.2.5

Instrumentation shall be supplied as single assemblies.

Justification

Ensures that it is supplied complete and tested as a single unit.

4.1.3 Electronics

4.1.3.1

Transmitters shall have an integral local display.

Justification

Allows visibility of the measured variable and other settings locally to the instrument.

4.1.3.2

Transmitter integral displays shall be configured to display the measured variable and unit of measure.

Justification

Supports the goal of minimal interaction with the field instrument by the operator in the field since default display provided. Additionally, the units are configured to the range and units stated on the datasheet.

4.1.3.3

Transmitter housings shall rotate and have the facility to be locked in position at any point about that rotation.

Justification

Allowing the LCD display to be rotated in a single plane supports operations and maintenance by allowing the display to be positioned at the optimal angle.

4.1.3.4

Transmitter displays shall have manual rotation adjustment.

Justification

Allows display to be oriented in the optimum angle for operator viewing.

4.1.3.5

Transmitter displays shall be provided with independent adjustments for span and zero.

Justification

Allow the operator in the field to carry out calibration activities without the need of other remote intervention such as hand held communicator or control room.

4.1.3.6

Failure or removal of a transmitter integral local display shall have no effect on the output signal.

Justification

Ensures display does not affect availability of instrument function.

4.1.3.7

Instrumentation shall maintain configuration settings on loss of power.

Justification

Supports availability of the installation by minimising operator support.

4.1.3.8

Instrumentation with external power supplies shall have the facility to be electrically isolated.

Justification

Safety design to ensure operator in the field can remove power to the device.

4.1.3.9

Transmitters shall have an ungrounded shield terminal.

Justification

Requirement detailed for shielded cabling for the field cable. This terminal is only used as a termination point since the overall design concept would require the shield to be left open in the field so as not to form a ground loop. As example, generally the options for temperature would be: 7 terminals - 4 TC (caters both single and duplex), 2 field, 1 shield 9 terminals - 6 RTD 4-wire (caters both single and duplex), 2 field, 1 shield Note: 4-wire RTD catered also by 7 terminals - 4 RTD (single element only), 2 field, 1 shield

4.1.3.10

Screw terminals shall be provided for wire connections.

Justification

Screw terminals are the standard well proven form of cable termination.

4.1.3.11

Electrical connections shall be reverse polarity protected.

Justification

Provides protection to the transmitter electronics.

4.1.4 Safety integrity

Safety instrumented function transmitters shall be provided with a SIL certificate from an independent, internationally recognized organization.

Justification

A third party independent assessment body provides an impartial review and will ensure validity of the certification provided.

4.1.5 Cyber security

4.1.5.1

Device type manager and device description files shall be obtained directly from the original equipment manufacturer.

Justification

The source coding files shall be obtained from the equipment manufacturer to minimise the risk of uploading corrupt code.

4.1.5.2

Device type manager and device description files shall be digitally signed by the original equipment manufacturer.

Justification

Signed files are required to ensure authenticity.

4.1.5.3

Device type manager and device description files shall be verified with the original equipment manufacturer.

Justification

Provided files shall have verification provided by OEM e.g. encrypted keys, to ensure authenticity of the files.

4.1.5.4

Instrumentation shall be protected against inadvertent changes to the configuration and parameters.

Justification

The electronics configurations need to be protected from unauthorised access and prevent inadvertent changes to the configuration and parameters by both software authorisation and hardware protection (e.g. switch or jumper) type tools.

4.1.6 Ingress protection

The ingress protection for the instrumentation housing and termination enclosures shall be IP66 or NEMA 4X.

Justification

Industry agreed minimum IP rating for externally mounted electronics and is commonly accepted and designed for by suppliers.

4.2 Performance

4.2.1

Instrument hardware, firmware and software shall be supported for 10 years from order placement.

Justification

Timescale provided is industry good practice to ensure that sufficient time is available for support of instrument to ensure minimum impact to maintenance team. In reality there can be 5 years between order placement and instrument being commissioned leaving only a small time period of use hence validation of suppliers plans is critical. Also note that the transmitter hardware and firmware will be supported by the supplier in terms of services and spare parts.

4.2.2

Transmitters shall have a vibration level resistance of "Field with general application or pipeline with low vibration" in accordance with IEC 62828-1:2017, Table 4.

Justification

Vibration limits are stated in API RP 551 which in turn references IEC 60770-1. However, IEC 60770 has been withdrawn and replaced with IEC 62828 hence requirement.

4.3 Mechanical construction

4.3.1 Metallurgy and soft goods

4.3.1.1 Wetted materials

4.3.1.1.1

Wetted part materials shall be minimum 316 stainless steel.

Justification

Minimum material selection of 316SS provides increase corrosion resistance for the standard offering.

4.3.1.1.2

316 stainless steel shall not be used in chloride-containing process fluids.

Justification

Use of 316 ss in chloride environments can cause pitting and stress corrosion cracking.

4.3.1.1.3

Alloy C-276 (UNS N10276) sensor elements shall be used when in contact with chloride-, amine- or ammonium-containing process fluids.

Justification

Material selection stated mitigates against the potential impact of the identified corrosive environments encountered in O&G industry.

4.3.1.1.4

Copper and copper alloys shall not be used for parts exposed to sour service process fluids.

Justification

copper and copper alloys can suffer accelerated corrosion in sour environment.

4.3.1.1.5

For hydrogen services, the diaphragm shall be designed to resist hydrogen embrittlement.

Justification

To mitigate against the risk of hydrogen atom permeation across the sensor. Over time the hydrogen can permeate into the fill fluid causing zero and span shifts. In extreme cases a hydrogen bubble can form in the fill fluid causing the diaphragm to rupture.

4.3.1.1.6

Silver, mercury and alloys containing silver or mercury shall not be used for wetted parts.

Justification

Mercury use is prohibited due to its health effects. It also has the ability to cause liquid metal embrittlement. Silver alloys are sometime used for brazing parts together and may cause galvanic corrosion for some materials/environments combinations.

4.3.1.2 Pressure-retaining parts

4.3.1.2.1

Pressure-retaining bolting and nuts shall be in accordance with IOGP S-563.

Justification

The critical nature of the pressure retaining bolting and reference to S-563 ensures that the correct material is selected for the service.

4.3.1.2.2

Exposed and non-exposed bolting shall comply with NACE MR0175/ISO 15156 or NACE MR0103/ISO 17945 when the instrument is designated in sour service.

Justification

Pressure containing bolting is considered to be not in contact with the process medium. However, there have been instances where, should the containment be broken, then the liquid can migrate to the bolting and over time attack the bolt/nut material particularly if under insulation. On this basis, because of this risk, the material shall align with whether NACE is needed.

4.3.1.2.3

Cadmium-plated bolting shall not be used.

Justification

Plating is not acceptable primarily for HSSE reasons given it's high toxicity.

4.3.1.3 Housing materials

4.3.1.3.1

Housing material for use in offshore applications shall be minimum 316 stainless steel.

Justification

Depending on the use there are options ranging from FRP (plastic), aluminium, 316SS, with 316SS being probably the most popular offering an optimum combination of corrosion resistance and robustness at low cost.

4.3.1.3.2

Instrumentation shall not contain mercury, asbestos or ceramic fibres.

Justification

Hazardous substances.

4.3.1.3.3

Instrumentation shall be UV resistant.

Justification

Any instrument enclosure including the display screen needs to be UV resistant to protect the instrument integrity and prevent degradation. If Material and LCD glass is not UV resistant the plastic on the LCD screen will be impossible to read.

4.3.1.4 Soft goods

4.3.1.4.1

The selection and evaluation of elastomeric seals for explosive decompression shall be in accordance with ISO 23936.

Justification

Selection guide to supplier for suitable material to prevent the explosive decompression phenomena on pressure containing parts.

4.3.1.4.2

Nitrile rubber o-rings shall not be used in hydrocarbon applications.

Justification

Hydrocarbons can attack nitrile rubber (e.g. Buna-N) and hence not to be used in hydrocarbon services.

4.3.2 Painting and coating

4.3.2.1

Instrumentation installed in coastal, marine or offshore environments shall have a coating system applied in accordance with IOGP S-715.

Justification

Installing equipment in saline environments can lead to aggressive corrosion of the exposed material surfaces. The IOGP specification referenced provides prescriptive details to the supplier for coating systems and how to apply.

4.3.2.2

The coating system applied to instrumentation installed in onshore or non-marine environments shall be selected in accordance with ISO 12944-5.

Justification

Provides code requirements for coating when instrumentation is to be located onshore / non marine.

4.3.2.3

Onshore and non-marine environment coating systems shall be qualified in accordance with ISO 12944-6.

Justification

Provides code requirements for coating when instrumentation is to be located onshore / non marine.

4.3.3 Tag and name plates

4.3.3.1

Tag and name plate information shall be stamped or engraved.

Justification

Experience demonstrates that illegibility causes problems.

4.3.3.2

Tag and name plate font size shall be at least 3 mm ($^{1}/_{8}$ in).

Justification

Minimum font size requirement to ensure legibility.

4.3.3.3

Tag and name plates shall be 316 stainless steel.

Justification

316 stainless steel provides a balance between a resilient material to the wide range of environmental conditions whilst at the same time cost effective.

4.3.3.4

Name plates shall include the following information:

— manufacturer's name;

— model, type and serial number;

— operating voltage;

— hazardous area certification details;

— date of manufacture;

— beta ratio – venturi flow meter only;

— internal diameter of pipe – venturi flow meter only;

— material of construction – venturi flow meter only;

— flow direction – venturi flow meter only.

Justification

Minimum agreed requirements for information to be contained on the nameplate to allow the instrument to be clearly identified during the production process and also when in the field to identify the tag and base technical parameters.

4.3.3.5

Tag plates shall be secured to the transmitter or remote indicator with 316 stainless steel tie wire.

Justification

Ensures the integrity of the wire used to affix the tag plate.

4.3.3.6

Name plates shall be affixed with 316 stainless steel rivets or screws.

Justification

Material and fixing point to be specified for durability as per existing industry best practice.

4.3.4 Cable entry

4.3.4.1

Unused electrical ports shall be fitted with plugs certified to the specified hazardous area classification.

Justification

Ensuring that no openings remain exposed on completion of the manufacture and so maintain the IP rating and hazardous area certification of the unit. The risk is uncertified plugs could be used which are of lower quality and could compromise the integrity of the unit.

4.3.4.2

Terminals within the head shall be clearly marked "+", "−", "earth" or "ground", as appropriate.

Justification

Supports installation and troubleshooting.

4.4 Inspection and shop tests

4.4.1 Pressure testing

4.4.1.1

Pressure-containing parts shall be hydrostatically tested in accordance with the material specification.

Justification

Code requirement for pressure testing of pressure containing parts. In general pressure containing parts will be hydrostatically tested to ASME B16.5 but the individual material datasheets (i.e. the relevant datasheet for the selected material from ASME/ASTM) to be followed.

4.4.1.2

The complete instrument assembly shall be hydrostatically pressure tested at a pressure of 1.5 times the 38 °C (100 °F) rating rounded off to the next higher 1 bar (25 psi) increment.

Justification

There are potentially multiple pressure containing parts in the instrument assembly and the process of pressure testing as one will ensure integrity of the final assembly. The tests are in accordance with the system hydrostatic testing requirements in ASME B16.5

4.4.1.3

Assemblies of pressure-containing components shall remain assembled on completion of the hydrostatic test.

Justification

Ensures that the item is tested as a single fully functional unit. An example of this would be manifolds used on hydrostatic pressure applications which are supplied operational with transmitter.

4.4.2 Nondestructive examination

4.4.2.1

Nondestructive examination of pressure-containing parts or of parts in contact with the process fluid shall be in accordance with IOGP S-563.

Justification

The material data sheet (as provided in S-563) provides prescriptive details of what NDE is required for each part.

4.4.2.2

Nondestructive examination of non-pressure-containing parts or of parts not in contact with the process fluid shall be in accordance with the material standard specification.

Justification

The standard material specification (e.g. as defined in the ASTM/ASME/ENI/ISO material 'standard specification') provides minimum requirements.

4.5 Preparation for shipment

4.5.1

Instrumentation internal surfaces shall be free from test fluids, cleaning agents, particles and organic substances.

Justification

Ensures no matter remains on internals which could degrade and damage internal material.

4.5.2

Threaded openings shall have temporary plugs.

Justification

Protects internals by preventing ingress of moisture, dirt or any other contaminant.

4.5.3

Temporary plugs shall be distinguishable from permanent plugs.

Justification

Ensures the correct plugs are removed and also that once in operation only certified plugs remain in place.

4.5.4

Flange faces shall be protected.

Justification

Protection to the flange face shall prevent damage during shipment ensuring integrity of the facing surfaces.

4.5.5

Flange openings shall be sealed.

Justification

Sealing of the flange opening prevents entry of foreign material to the internals and also prevent damage (which could be to diaphragm seal or internals of an instrument).

4.5.6

The design of the covers shall prevent the instrumentation from being installed without prior removal of the covers.

Justification

Potential a safety issue if process fluid is prevented from registering with the installed instrument or could cause internal damage or malfunction.

5 Pressure and differential pressure transmitters

5.1 General

5.1.1

Pressure instrumentation shall be designed and tested in accordance with the following standards:

— ASME B16.5;

— ASME PTC 19.2;

— IEC 60381-1;

— IEC 61326-1;

— IEC 61326-3-1;

— IEC 61508;

— IEC 61518;

— IEC 62305 (all parts);

— IEC 62402;

— IOGP S-715;

— ISA 50.00.01;

— ISO 12944-5;

— ISO 12944-6;

— MSS SP-99;

— NAMUR NE 43;

— NAMUR NE 107.

Justification

Provides a basis of the code compliance for the instrumentation being supplied.

5.1.2

Pressure instrumentation supplied in accordance with US standards shall comply with the following standards:

— ASME *BPVC*, Section IX;

— ASME B1.20.1;

— NEMA 250;

— NFPA 70;

— UL 94.

Justification

Provides a basis of the code compliance for the instrumentation being supplied. These are used in addition to those stated in the general section and the general pressure section.

5.1.3

Pressure instrumentation supplied in accordance with non-US standards shall comply with the following standards:

— BS 476-7;

— IEC 60079 (all parts);

— IEC 60529;

— ISO 15614 (all parts);

— ISO 261.

Justification

Provides a basis of the code compliance for the instrumentation being supplied. These are used in addition to those stated in the general section and the general pressure section.

5.1.4

Pressure and differential pressure transmitter response time shall be less than 1 s.

Justification

Overall the response time is the sum of the dead time plus the time constant added together. A minimum of 1 second provides a basis to ensure stability.

5.1.5

Pressure transmitters shall have an accuracy of ±0,1 % of the calibrated span.

Justification

Provides a basis of the minimum accuracy requirements for the instrumentation being supplied

5.2 Instrument protection

5.2.1

Diaphragm seal assembly capillary material shall be 316 stainless steel.

Justification

The capillaries are isolated from the process fluid and hence material selection can generally rely on standard 316 SS material.

5.2.2

Diaphragm seal assembly capillaries shall have flexible armoured tubing.

Justification

Armour prevents damage to the capillary.

5.2.3

Diaphragm seal assembly capillaries shall be coated with PVC or polyethylene.

Justification

The coating provides human protection from the armour and also prevents ingress of foreign matter into the armour.

5.2.4

Diaphragm seal assembly capillaries shall be filled and welded to the seals and the instrument.

Justification

Ensures the diaphragm seal is a complete assembly.

5.2.5

Diaphragm seal material shall be minimum 316 stainless steel.

Justification

The diaphragm seal is in contact with the process fluid and hence material selection is critical.

5.2.6

Diaphragm seal capillary fill fluid shall not be pyrophoric.

Justification

Pyrophoric liquids such as Sodium potassium (NaK) will explode if the liquid comes into contact with air. On this basis any liquid from this category is not acceptable for use.

5.2.7

Diaphragm seals shall be permanently marked with the seal fluid used and the specific gravity of the seal fluid.

Justification

For incidents or troubleshooting at the middle of the night information must be available easily to make troubleshooting easier. Also for spare parts and maintenance having the sg in the markings will reduce the likelihood of errors occurring.

5.3 Instrument process manifolds

5.3.1

Manifold valve bonnets shall have a locking pin.

Justification

Pin prevents inadvertent dis-assembly of needle valve leading to removal of the valve bonnet.

5.3.2

Manifold valve process connections shall be flanged type for direct mounted installation.

Justification

The threaded connections are prone to leakage and hence integral tubing connectors or oval flange connection on manifold.

5.3.3

Manifold valve bonnets shall be fitted with colour-coded ring labels in accordance with API Recommended Practice 551.

Justification

The valve handle and bonnet color code requirements are identified for correct operation. This is recommended by API RP 551; 2016 edition, section 8.7.4.

5.3.4

Manifold valves shall be fabricated from bar stock material.

Justification

Suited to bar stock due to compact size and also will minimise NDE.

5.3.5

Manifold valves shall be directly mounted on the transmitter.

Justification

In order to have less connection points which acts as a source of leakage in tubing system.

5.3.6

Five-valve manifolds shall be single equalization valve pattern in accordance with API Recommended Practice 551.

Justification

The separate vent or test valves can be more helpful during operation & maintenance activity.

5.3.7

The needle valve packing in manifold valves shall be PTFE for design temperatures less than or equal to 232 °C (450 °F).

Justification

The needle valve packing shall be PTFE for design temperatures below 232 °C (450 °F) with graphite based packing for 232 °C (450 °F) and above.

5.3.8

The needle valve packing in manifold valves shall be graphite-based packing for temperatures greater than 232 °C (450°F).

Justification

The needle valve packing shall be PTFE for design temperatures below 232 °C (450 °F) with graphite based packing for 232 °C (450 °F) and above.

6 Temperature instrumentation

6.1 General

6.1.1

Temperature instrumentation shall comply with the following standards:

- ASME B16.5;
- ASME B40.200;
- ASME PTC 19.3TW;
- ASTM B912;
- ASTM E230/E230M;
- ASTM E235/E235M;
- ASTM E608/E608M;
- ASTM E1137/E1137M;
- IEC 60381-1;
- IEC 60584-1;
- IEC 60584-3;
- IEC 60751;
- IEC 61326-1;
- IEC 61326-3-1;
- IEC 61508;
- IEC 61515;
- IEC 62305 (all parts);
- IEC 62402;
- IOGP S-715;
- ISA 50.00.01;
- ISO 10790;
- ISO 12944-5;
- ISO 12944-6;
- NAMUR NE 43;
- NAMUR NE 107.

Justification

Provides a basis of the code compliance for the instrumentation being supplied in addition to those listed in the general section.

6.1.2

Temperature instrumentation supplied in accordance with US standards shall comply with the following standards:

— ASME B1.20.1;

— NEMA 250;

— NFPA 70.

Justification

Provides a basis of the code compliance for the instrumentation being supplied. These are used in addition to those stated in the general section and the general temperature section.

6.1.3

Temperature instrumentation supplied in accordance with non-US standards shall comply with the following standards:

— IEC 60079 (all parts);

— IEC 60529;

— ISO 261.

Justification

Provides a basis of the code compliance for the instrumentation being supplied.

6.1.4

Temperature transmitters shall have configurable linearization.

Justification

Linearization models are a close fit but configuration is required to optimise the linearity. This clause provides the function for localised customised linearisation for temperature transmitter in addition to linearisation being performed at the control system.

6.1.5

The thermal connection between the thermowell tip and tip-sensitive elements shall be maintained with mechanical loading.

Justification

Ensures thermal contact is made of the element with the tip (end of the thermowell) e.g. spring loaded.

6.1.6

Temperature transmitters shall have an accuracy of ±0,1 % of the calibrated span.

Justification

Provides a basis of the minimum accuracy requirements for the instrumentation being supplied.

6.1.7

Temperature transmitter assemblies shall be designed with nipple-union-nipple fittings.

Justification

The n-u-n fitting allows adjustment of the transmitter fitting to connect the element into the thermowell.

6.1.8

The temperature transmitter and the head shall be permanently connected by a stainless steel chain.

Justification

Chain will ensure that even if dropped from hand during maintenance it will remain local.

6.1.9

Temperature transmitter assemblies shall have duplex elements.

Justification

Standardisation of design.

6.2 Thermocouples

Thermocouples shall be supplied ungrounded.

Justification

The grounded thermocouple loop has a faster response time to temperature change, but the disadvantages lay in that the hot end, grounded to the sheath, exposing the circuit to transient earth loops and this causes noise on the circuit.
The ungrounded thermocouple response time to temperature change is slower than the grounded thermocouple. In this circuit the hot end will not have been directly coupled to the ground, so therefore regarded as isolated from the ground, by mineral insulation. The advantage being, that the loop will no longer have the same transient noise on the circuit, as the grounded thermocouple.

6.3 Resistance temperature devices

6.3.1

RTD transition pieces shall be hermetically sealed.

Justification

Prevents ingress of moisture within the sheath where it could degrade those elements within.

6.3.2

RTD heads shall have an integral terminal block with a shield terminal.

Justification

Integral block provides a compact solution and the extra shield terminal allows for the shield of the 3-wire RTD to be taken down to a terminal (although the shield will remain isolated to prevent earth ground loop).

7 Flow instrumentation

7.1 General

7.1.1

Flow instrumentation shall comply with the design standards in Table 1.

Justification
Ensure code compliance with relevant standards.

Table 1 — General standards applicable to flow instrumentation

Standard number	Venturi	Coriolis	Magnetic	Ultrasonic	Vortex	Orifice
ASME B16.5	X	X	X	X	X	
ASME B31.3	X					
ASME MFC-3M	X					X
ASME MFC-5.1				X		
ASME MFC-5.3				X		
ASME MFC-6M					X	
ASME MFC-11		X				
ASME MFC-16			X			
IEC 60381-1	X	X	X	X	X	
IEC 61326-1	X	X	X	X	X	
IEC 61326-3-1	X	X	X	X	X	
IEC 61508	X	X	X	X	X	
IEC 62305 (all parts)	X	X	X	X	X	
IEC 62402	X	X	X	X	X	
IOGP S-705	X	X	X	X	X	
IOGP S-715	X	X	X	X	X	
ISA 50.00.01	X	X	X	X	X	
ISO 5167-1	X					X
ISO 5167-2						X
ISO 5167-4	X					
ISO 12764					X	
ISO 12944-5	X	X	X	X	X	
ISO 12944-6	X	X	X	X	X	
ISO/TR 15377						X
ISO 17089-2				X		
ISO 20456			X			
NAMUR NE 43	X	X	X	X	X	
NAMUR NE 107	X	X	X	X	X	

7.1.2

Flow instrumentation supplied in accordance with US standards shall comply with the design standards in Table 2.

Justification

Ensure code compliance with relevant standards.

Table 2 — US standards applicable to flow instrumentation

Topic	Standard number	Venturi	Coriolis	Magnetic	Ultrasonic	Vortex
Welding (offline)	ASME *BPVC,* Section IX	X				
Threads	ASME B1.20.1	X	X	X	X	X
Integrity	NEMA 250	X	X	X	X	X
Hazardous area	NFPA 70	X	X	X	X	X
NOTE Standards and topics not relevant to orifice plates.						

7.1.3

Flow instrumentation supplied in accordance with non-US standards shall comply with the design standards in Table 3.

Justification

Ensure code compliance with relevant codes.

Table 3 — Non-US standards applicable to flow instrumentation

Topic	Standard number	Venturi	Coriolis	Magnetic	Ultrasonic	Vortex
Hazardous area	IEC 60079 (all parts)	X	X	X	X	X
Integrity	IEC 60529	X	X	X	X	X
Threads	ISO 261	X	X	X	X	X
Welding (offline)	ISO 15614 (all applicable parts)	X				
NOTE Standards and topics not relevant to orifice plates.						

7.1.4

Flow elements shall be marked with the flow direction.

Justification

Incorrect orientation of the meter when placed in line could at best introduce errors into the measurements and at worst stop the meter from operating.

7.1.5

The accuracy of flow instrumentation shall comply with Table 4.

Justification

Provides a basis of the accuracy requirements for the instrumentation being supplied

Table 4 — Flow instrumentation accuracy

Technology	Accuracy
DP flow	3 % of span
Ultrasonic	± 1 % of full scale flow
Coriolis	± 1 % of full scale flow
Electromagnetic	± 1 % of full scale flow
Vortex	± 1 % of full scale for liquid flow ± 2 % of full scale for gas flow

7.2 Head meters, orifice

7.2.1

Orifice plate metering shall be minimum 50 mm (2 in) in size.

Justification

The Reader-Harris calculations as detailed in ISO 5167-2 is only valid for pipe ID >=50mm.

7.2.2

Orifice plate material shall be minimum 316 stainless steel.

Justification

316 SS is considered the minimum austenitic stainless steel grade for this application by the majority of operators. It offers better corrosion resistance than 304 SS, whose use is also discouraged by API RP 551.

7.2.3

Orifice plate handles shall be engraved on the upstream side with the following information:

— "INLET";

— instrument tag;

— bore size;

— plate material;

— plate type;

— line size;

— flange rating;

— manufacturer's name.

Justification

Minimum requirement needed to be visibly marked on handle.

7.2.4

Orifice plate information shall be visible without the removal of insulation.

Justification

Potential safety issue should operator need to retract insulation in order to read details.

7.2.5

The orifice plate differential pressure range for sizing shall be between 0 to 250 mbar (100 in H_2O).

Justification

Optimum differential pressure range across the orifice plate.

7.2.6

The orifice plate tab shall be in line with the drain or vent hole.

Justification

Ensures correct orientation of the handle in relation with the vent or drain hole.

7.3 Volumetric meters

7.3.1 Ultrasonic flow meters

7.3.1.1

Ultrasonic flow meters with insertion probes shall have a probe retraction mechanism.

Justification

Retraction mechanism will allow in-stream probe maintenance without the requirement for isolation of the flow meter and removal.

7.3.1.2

A clamp-on ultrasonic instrument couplant pad or couplant lubricant shall be selected dependent on process pipe temperature.

Justification

The selection of the correct compound shall minimise errors when signal transitions between the flow meter and pipe.

7.3.2 Magnetic flow meters

7.3.2.1

Magnetic flow meter liners shall not deteriorate or be eroded by process flow conditions.

Justification

Field experience has shown the magnetic flowmeter liners are susceptible to wear and hence extra caution is required when carrying out the selection process.

7.3.2.2

When the pipe is empty of liquid, the magnetic flow meter shall signal an alarm.

Justification

When the measuring tube is completely filled, the measuring electrodes are connected to each other and against the reference point of the EMF via the process liquid. The resistance between the measuring electrodes or from one electrode to a reference point is a factor of the conductivity of the process liquid. This resistance is lower with a completely filled measuring tube than with an empty measuring tube. When the measuring tube of a mechanical flowmeter is empty, its flow indicator indicates the value 0 and flow totalising stops. This is not the case with an EMF device, where the electrodes are no longer in contact with the process liquid and are open. The electrode circuit has high impedance when the tube is empty making it susceptible to electrical interference and coupling from the surroundings which can lead to error flow readings and totalised values. On this basis magnetic flow meters shall always be kept liquid full, including during no-flow conditions. Should a vapour enter then it would lead to the electrodes being exposed and then alarm raised.

7.3.2.3

Magnetic flow meter tubes, electrodes and grounding rings shall be minimum 316 stainless steel.

Justification

Minimum material grade to be chosen providing the optimum material characteristics.

7.3.3 Vortex flow meters

The vortex flow meter minimum design flow shall be greater than 10 % of the meter's inherent low flow cut-off.

Justification

Provides a deadband between the meter stopping operating and the minimum flow needed to be measured.

7.4 Coriolis mass flow meters

Coriolis flow meters shall have fully rated secondary containment.

Justification

The code does not require secondary containment so long as design is compliant. Secondary containment should be provided in all situations. Coriolis meters are prone to rupture of the tubes.

8 Level instrumentation

8.1 General

8.1.1

Level instrumentation shall comply with the design standards in Table 5.

Justification

Ensure code compliance with relevant standards.

Table 5 — General standards applicable to level instrumentation

Standard number	Gauge	Hydrostatic	Guided wave radar	Non-contact radar
ASME B16.5	X	X	X	X
ASME B31.3	X			
ASME PTC 19.2		X		
IEC 60381-1	X	X	X	X
IEC 61326-1	X	X	X	X
IEC 61326-3-1	X	X	X	X
IEC 61508		X	X	X
IEC 61518		X		
IEC 62305 (all parts)	X	X	X	X
IEC 62402	X	X	X	X
IOGP S-705	X		X	X
IOGP S-715	X	X	X	X
ISA 50.00.01	X	X	X	X
ISO 12944-5	X	X	X	X
ISO 12944-6	X	X	X	X
NAMUR NE 43	X	X	X	X
NAMUR NE 107	X	X	X	X

8.1.2

Level instrumentation supplied in accordance with US standards shall comply with the design standards in Table 6.

Justification

Ensure code compliance with relevant standards.

Table 6 — US standards applicable to level instrumentation

Topic	Standard number	Gauge	Hydrostatic	Guided wave radar	Non-contact radar
Welding (offline)	ASME *BPVC,* Section IX	X	X	X	X
Threads	ASME B1.20.1	X	X	X	X
Hazardous area	NFPA 70	X	X	X	X
Integrity	NEMA 250	X	X	X	X
Fire retardant	UL 94		X		

8.1.3

Level instrumentation supplied in accordance with non-US standards shall comply with the design codes in Table 7.

Justification

Ensure code compliance with relevant codes.

Table 7 — Non-US standards applicable to level instrumentation

Topic	Standard number	Gauge	Hydrostatic	Guided wave radar	Non-contact radar
Fire retardant	BS 476-7		X		
Hazardous area	IEC 60079 (all parts)	X	X	X	X
Integrity	IEC 60529	X	X	X	X
Threads	ISO 261	X	X	X	X
Welding (offline)	ISO 15614 (all applicable parts)	X	X	X	X

8.1.4

The accuracy of level instrumentation shall comply with Table 4.

Justification

Provides a basis of the accuracy requirements for the instrumentation being supplied.

Table 8 — Level instrumentation accuracy

Technology	Accuracy
DP	± 0,1 % of specified span
Radar non-contact	± 3 mm (0,12 in) with an overall operating accuracy within ± 5 mm (0,2 in)
Radar GWR	± 5 mm (± 0,2 in)

8.1.5

Purchaser-provided level sketches shall be used to size and select the level instrumentation.

Justification

Level sketches provide a lot of additional information to support the sizing and selection of the level instrument and should support the datasheet in this task.

8.2 Magnetic level gauges

8.2.1

Magnetic level gauges shall use flag-type indicators.

Justification

The flag type indicators provide a clear indication of the process level.

8.2.2

Magnetic level gauges shall have a hermetically-sealed 316 stainless steel indicator housing the flags.

Justification

The process of providing it hermetically sealed will protect the moving parts and materials from the external environment.

8.2.3

Magnetic level gauge flags shall be replaceable without the need to isolate the gauge.

Justification

Ensures maintenance on the instrument scales would not affect availability of the system it is connected to.

8.2.4

Individual magnetic level gauge indicator segments shall be interlocked to prevent colour change due to external forces.

Justification

Ensures that external forces such as vibration will not allow the reading to change from representing the level in the chamber.

8.2.5

Magnetic level gauge internals shall be removable through the bottom flange.

Justification

Design to ensure that all internals can be removed and replaced from the bottom. The bottom point is noted since this is a more convenient access point allowing gravity to act on the internals to position at low point.

8.2.6

Magnetic level gauges shall have float stop springs in the bottom and top of the float chamber.

Justification

The springs will reduce the impact when float reaches either extreme position and minimise wear on the float.

8.2.7

The magnetic level gauge float and chamber design shall ensure that the float movement is not affected by process conditions.

Justification

Minimum space allowance to allow process not to interfere with the natural buoyancy effect of the float. Note: Sometimes float chamber size may be one size larger than that normally used with the selected float. This option allows a larger space between the float and the float chamber, thus permitting some particles to exist without causing the float to stick. For cryogenic operations near the vapor pressure (such as propane chillers), flashing, or outgassing service, this option allows excess vapors to pass between the float and the chamber wall without causing the float to move excessively.

8.2.8

Magnetic level gauge scale markings shall be indelibly stamped or engraved.

Justification

Ensures that scale is readable for the life of the instrument.

8.2.9

The magnetic level gauge scale element shall be integrally illuminated.

Justification

The element is just a steel plate and so can be difficult to read the scale.

8.3 Guided wave radar transmitter

Guided wave radar flexible cable for the sensor probe shall be used for applications exceeding 1 830 mm (6 ft) in length.

Justification

Practical solution for longer probes and for any applications where shipping, installation, and/or removal of a rigid probe would be difficult or impractical, with prior Owner approval.

8.4 Non-contact radar transmitter

8.4.1

Non-contact radar echo curves shall be provided.

Justification

The curves allow calibration of device.

8.4.2

Software used to display or interpret the non-contact radar echo curves shall be provided.

Justification

Without diagnostic software the interpretation of the curves is not possible

Registered Office
City Tower
Level 14
40 Basinghall Street
London EC2V 5DE
United Kingdom

T +44 (0)20 3763 9700
reception@iogp.org

Brussels Office
Avenue de Tervuren 188A
B-1150 Brussels
Belgium

T +32 (0)2 790 7762
reception-europe@iogp.org

Houston Office
15377 Memorial Drive
Suite 250
Houston, TX 77079
USA

T +1 (713) 261 0411
reception-americas@iogp.org

www.iogp.org