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ADDENDUM 1

This addendum (Version 1.01) replaces Edition 1.0 published in March 2021.

NOTE: In addition to the updates listed below, minor editorial/typographical amendments may have been made.

List of updates

Clause/subclause	Description
2	References ISA 7.0.01 and NFPA 70:2023 added Reference ASTM F1387:2010 amended to ASTM F1387:2023
3	New terms 3.2 "facility", 3.3 "instrument process manifold", 3.6 "manufacturer" and 3.9 "small bore tubing system" Terms 3.2 *, 3.3 *, 3.4 *, and 3.5 * renumbered to 3.4, 3.5, 3.7 and 3.8
4.1	Subclause 4.1.2 amended New subclause 4.1.6
4.2	Subclause 4.2.1 amended New subclause 4.2.2 Subclause 4.2.2 * renumbered to 4.2.3
Table 1	Reference to footnote f added to column headers "Metric units" and "Imperial units" New columns "Allowable working pressure at 37,7 °C (barg)" and "Allowable working pressure at 100 °F (psig)" New footnote f
4.3.1	New subclauses 4.3.1.1, 4.3.1.2 and 4.3.1.3 Subclause 4.3.1.5 * deleted Subclauses 4.3.1.1 * through 4.3.1.4 * renumbered to 4.3.1.4 through 4.3.1.7
4.4.1	Subclauses 4.4.1.7 and 4.4.1.8 temperature values amended New subclause 4.4.1.9 Subclauses 4.4.1.9 * and 4.4.1.10 * renumbered to 4.4.1.10 and 4.4.1.11 Subclause 4.4.1.11 amended
4.4.2	Subclause 4.4.2.2 amended
4.4.3	New subclause 4.4.3.2 Subclauses 4.4.3.2 * and 4.4.3.3 * renumbered to 4.4.3.3 and 4.4.3.4 Subclause 4.4.3.4 amended New subclause 4.4.3.5 Subclause 4.4.3.4 * renumbered to 4.4.3.6 New subclause 4.4.3.7
4.4.4.1	Subclause title amended Subclause 4.4.4.1.2 * deleted Subclause 4.4.4.1.3 * renumbered to 4.4.4.1.2 and amended New subclauses 4.4.4.1.3 through 4.4.4.1.5

List of updates (*continued*)

Clause/subclause	Description
4.4.5	New subclause including subclauses 4.4.5.1 through 4.4.1.13
4.6	Subclause 4.6.1 amended New subclauses 4.6.3 and 4.6.4
4.7	Subclause heading 4.7.1 added New subclauses 4.7.2 and 4.7.3
Table 2	Table amended including new columns "Critical pitting temperature (CPT)", "Maximum temperature limits (chloride induced stress corrosion cracking (CISCC)) (internal/external)" and "Exclusions", and new footnote d
5.5	New subclause
Table 3	Table amended including new footnote c
6.1	Subclause 6.1.1 amended New subclauses 6.1.7 and 6.1.8 (including new NOTE)
6.2.1	New subclause 6.2.1.3 Subclauses 6.2.1.3 * through 6.2.1.6 * renumbered to 6.2.1.4 through 6.2.1.7 Subclause 6.2.1.6 amended New subclause 6.2.1.8 Subclause 6.2.1.8 * renumbered to 6.2.1.9 New subclauses 6.2.1.10 through 6.2.1.13 Subclause 6.2.1.9 * renumbered to 6.2.1.14 New subclause 6.2.1.15
6.2.2	Subclause 6.2.2.1 replaced (including new NOTE) Table 4 deleted New subclauses 6.2.2.3, 6.2.2.4 (including new NOTE) and 6.2.2.5 through 6.2.2.8
6.2.3	New subclauses 6.2.3.1 and 6.2.3.2 Subclause 6.2.3.1 * renumbered to 6.2.3.3 and amended Subclause 6.2.3.2 * renumbered to 6.2.3.4 New subclause 6.2.3.5 Subclause 6.2.3.3 * renumbered to 6.2.3.6 New subclauses 6.2.3.7 and 6.2.3.8 Subclause 6.2.3.4 * renumbered to 6.2.3.9 Subclause 6.2.3.5 * renumbered to 6.2.3.10 and amended Subclause 6.2.3.6 * renumbered to 6.2.3.11 New subclause 6.2.3.12 Subclause 6.2.3.7 * renumbered to 6.2.3.13 New subclauses 6.2.3.14 through 6.2.3.17, and 6.2.3.18 (including new NOTE)
6.3	New subclauses 6.3.4 through 6.3.6
6.4	Subclauses 6.4.1 and 6.4.2 amended Subclause 6.4.3 * deleted Subclause 6.4.4 * renumbered to 6.4.3 New subclause 6.4.4

List of updates (*continued*)

Clause/subclause	Description
7	Subclause 7.1 * renumbered to 7.3 and subclause 7.3 * renumbered to 7.7 Subclause 7.2 * renumbered to 7.1 and amended New subclauses 7.2 and 7.4 Subclauses 7.5 and 7.6 amended Subclause 7.4 * renumbered to 7.8 and amended New subclauses 7.9 and 7.10 (including new NOTE) Subclauses 7.6 * through 7.10 * renumbered to 7.11 through 7.14 Subclauses 7.11, 7.12 and 7.14 amended
8	Subclauses 8.1 and 8.2 amended New subclause 8.5 Subclauses 8.5 * through 8.8 * renumbered to 8.6 through 8.9 Subclauses 8.6 and 8.7 amended New subclauses 8.10 and 8.11
9	Subclauses 9.1 and 9.2 amended New subclauses 9.3 through 9.5
* Clause/subclause number from Edition 1.0.	

Specification for Small Bore Tubing and Fittings

Revision history

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1.01	November 2025	Addendum 1
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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 design, material selection, installation, testing and inspection, marking of small bore tubing, small bore tubing system components and small bore piping for application in the petroleum and natural gas industries.

This specification follows a common document structure comprising the three 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 quality requirements specification (QRS) and information requirements specification (IRS) as follows.

IOGP S-716: Specification for Small Bore Tubing and Fittings

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

IOGP S-716Q: Quality Requirements for Small Bore Tubing and Fittings

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 purchase order.

IOGP S-716L: Information Requirements for Small Bore Tubing and Fittings

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.

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

The IRS is published as an editable document 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 (QRS and IRS);
- d) this specification.

1 Scope

This specification provides the requirements for the design, material selection, installation, inspection, testing and marking of the following items covering offshore and onshore environments:

- a) Small bore tubing sizes up to 50 mm (2 in) for:
 - 1) process impulse lines, pneumatic lines, hydraulic lines, analyzer and sample take off tubing;
 - 2) trace heating.
- b) Small bore tubing system components for use with ASME B31.3 piping systems up to class 2500 in accordance with ASME B16.5 (42.5 Mpa @ < 38 °C (6170 psig @ < 100 °F) based on carbon steel systems):
 - 1) tube fittings;
 - 2) instrument air manifolds;
 - 3) instrument tubing valves;
 - 4) miscellaneous items such as tube clamps and valves for flushing rings or bleed rings.
- c) Instrument nipples.

This specification excludes the following items:

- subsea small bore tubing and fittings;
- welded tube and tube fittings for welded tubes, Joint Industry Council fittings, flexible hoses;
- piping systems designed in accordance with ASME B31.1 and ASME B31.3;
- non-metallic multi tubes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the references document (including any amendments) applies.

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

ANSI/NACE MR0175/ISO 15156, Parts 1 to 3, Petroleum, petrochemical, and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production

API Standard 598:2016, *Valve Inspection and Testing*

ASME B1.20.1:2013, *Pipe Threads, General Purpose (Inch)*

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

ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*

ASME B31.3, *Process Piping*

ASTM A269/A269M, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*

ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*

ASTM A479/A479M, *Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels*

ASTM A632, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service*

ASTM A789/A789M, *Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service*

ASTM B68/B68M, *Standard Specification for Seamless Copper Tube, Bright Annealed*

ASTM B75/B75M, *Standard Specification for Seamless Copper Tube*

ASTM B165, *Standard Specification for Nickel-Copper Alloy Seamless Pipe and Tube*

ASTM B338, *Standard Specification for Seamless and Welded Titanium and Titanium Alloy Tubes for Condensers and Heat Exchangers*

ASTM B423, *Standard Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloy (UNS N08825, N08221, and N06845) Seamless Pipe and Tube*

ASTM B444, *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloys (UNS N06625 and UNS N06852) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Pipe and Tube*

ASTM B622, *Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube*

ASTM B677, *Standard Specification for UNS N08925, UNS N08354, and UNS N08926 Seamless Pipe and Tube*

ASTM B706, *Standard Specification for Seamless Copper Alloy (UNS No. C69100) Pipe and Tube*

ASTM B729, *Standard Specification for Seamless Nickel-Iron-Chromium-Molybdenum-Copper Nickel Alloy Pipe and Tube*

ASTM F1387:2023, *Standard Specification for Performance of Piping and Tubing Mechanically Attached Fittings*

ISA 7.0.01, *Quality Standard for Instrument Air*

ISO 5208:2015, *Industrial valves — Pressure testing of metallic valves*

ISO 8573-1:2010, *Contaminant and purity classes*

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

MSS SP-99, *Instrument Valves*

NFPA 70:2023, *National Electrical Code*

3 Terms and definitions

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

3.1

direct-mount

supported directly by the process pipe

3.2

facility

place, building or piece of equipment designed, built, installed and operated for processing, treating and separating oil and gas from exploration to distribution

3.3

instrument process manifold

process connection system that isolates, vents and equalizes a variety of pressures including absolute, gauge and differential measurement applications

Note to entry: Instrument process manifolds are commonly close-coupled to the instrument and allow for isolation, controlled venting, testing and calibration.

3.4

interchanging

replacing of any individual component of a tube fitting, i.e. body, nut, front ferrule and back ferrule with another tube fitting

3.5

intermixing

mixing of a single part, i.e. a body or a group of parts together

Note to entry: Nut, front ferrule and back ferrule from a tube fitting to another tube fitting.

3.6

manufacturer

company, including subcontractors, that carries out operations (e.g. forming, heat treatment, welding, machining) to produce a finished product

3.7

marine

offshore

nearshore

installations sited in oceans, seas, bays, estuaries and other high salinity water bodies including land up to 1 kilometre (0,6 miles) from shore

3.8

onshore

inland installations sited more than 1 kilometre (0,6 miles) from shore

3.9

small bore tubing system

system that consists of tubing, tube fittings, instrument air manifolds, instrument tubing valves, instrument process manifolds and miscellaneous items such as tube clamps and valves for flushing rings or bleed rings

4 Design

4.1 General

4.1.1

The tubing system shall be designed for the following:

- process fluid;
- process pressure (design range);
- process temperature (design range);
- environmental conditions in accordance with project-specific requirements.

4.1.2

Compression fittings shall be as follows:

- sourced from a single manufacturer across the project;
- for modifications, aligned with the existing facility.

4.1.3

Intermixing of tube fittings from different manufacturers shall not be acceptable.

4.1.4

Interchanging of tube fittings from different manufacturers shall not be acceptable.

4.1.5

Mixing of different wall thickness tubing within the same diameter tubing run shall not be acceptable.

4.1.6

The small bore tubing design review conducted prior to construction shall consider the following:

- correct installation for the application and process conditions;
- correct tubing, tube fittings and valves for the application;
- correct tube clamps for the application;
- potential static and dynamic loads;
- maintenance accessibility (e.g. repair and testing);
- operations accessibility (e.g. indication and equipment operation);
- reduction in tube fittings and leak points (i.e. failure mode minimization).

4.2 Sizing

4.2.1

A project shall not mix metric and imperial tubing and fitting sizes.

4.2.2

A project shall align the use of metric or imperial tubing and fittings based on the selection previously made for existing facilities.

4.2.3

The minimum wall thickness for tubing shall be in accordance with Table 1.

Table 1 — Tube size

Metric units ^{c, f}			Imperial units ^{c, f}		
Tube outside diameter ^d (mm)	Minimum nominal wall thickness ^{a, b} (mm)	Allowable working pressure at 37,7 °C (barg)	Tube outside diameter ^d (in)	Minimum nominal wall thickness ^{a, b} (in)	Allowable working pressure at 100 °F (psig)
3	0,8	670	1/8	0,028	8500
—	—	—	3/16	0,049	10200
6	1,2 e	540	1/4	0,049 e	7500
8	1,2	390	5/16	0,049	5800
10	1,2	300	3/8	0,049	4800
12	1,2	250	1/2	0,049	3700
14	1,5	270	—	—	—
16	1,5	230	5/8	0,065	4000
18	1,5	200	3/4	0,065	3300
22	2,2	260	7/8	0,083	3600
25	2,2	230	1	0,083	3100
30	2,8	240	1 1/4	0,109	3300
38	3,5	240	1 1/2	0,134	3400
50	5,0	270	2	0,180	3600

^a Pressure ratings of different wall thicknesses shall be determined based on the design criteria defined in ASME B31.3.

^b Higher wall thicknesses can be specified by the user or can be selected by the package supplier or contractor where required.

^c Tube sizes indicated for imperial and metric shall not be treated as a direct conversion from imperial to metric.

^d The tube sizes indicated are commonly available for SS 316 or SS 316L tubes. Some tube sizes may not be available for other materials such as 6 Mo, 25 Cr. Duplex, Alloy 625, Alloy 825 and Titanium Gr. 2.

^e For pneumatic signal lines, 6 mm tubing diameter with 1 mm WT (1/4 in tubing diameter with 0,035 in WT) is acceptable.

^f Tubing sizes and wall thicknesses shall comply with this table for their respective service and pressure ratings, unless an alternative (e.g. P&IDs, data sheets) is provided.

4.3 Small bore tubing

4.3.1 Tubes

4.3.1.1

Ends of finished tubing shall be free from burrs.

4.3.1.2

Finished internal tubing surfaces shall be free from dirt, oil, scale, corrosion, fine chips and manufacturing machining debris.

4.3.1.3

Tubing shall be free from scratches and degreased.

4.3.1.4

Tubing shall be seamless, i.e. coiled or stick form.

4.3.1.5

Tubing shall be fully annealed.

4.3.1.6

Tubing shall not exceed the maximum acceptable hardness specified by the fittings manufacturer.

4.3.1.7

The tubing material, material grade and wall thickness shall be the same from source to destination.

NOTE The wall thickness of branch tubing may be less than the wall thickness of the main header tubing if the branch tubing size is less than the main header size.

4.3.2 Trace heated tube bundles

4.3.2.1

The tubing bundle outer jacket shall be flame retardant, ultraviolet resistant, hydrolytically stabilized, low smoke-halogen free, chloride free and abrasion resistant.

4.3.2.2

The tubing bundle outer jacket shall be selected for the operating temperature.

4.3.2.3

Tubing bundle insulation shall be non-hygroscopic.

4.3.2.4

Heat traced tubing, ends of pre-insulated tubing bundles into boxes, cabinets and bulkheads shall:

- be installed using the manufacturer's approved heat shrink boot and procedures; or
- utilize heat shrink entry seals for penetrations.

4.3.2.5

Tubing bundle ends shall:

- be installed using the manufacturer's approved heat shrink boot and procedures; or
- utilize heat shrink entry seals for penetrations.

4.4 Small bore tubing system components

4.4.1 General

4.4.1.1

Compression tube fittings shall be flareless, double-ferrule type.

4.4.1.2

Compression tube fittings for the selected tube size and wall thickness combination shall be used up to design pressures not exceeding ASME B16.5 class 2500 pressure ratings.

4.4.1.3

Tubing shall be de-rated in accordance with the tube manufacturer's charts or formula for the service design pressure and temperature limits.

4.4.1.4

NPT (national taper pipe thread) thread engagement shall conform to ASME B1.20.1:2013, Table 2, column 7.

4.4.1.5

In panels, elbow fittings shall only be used:

- for tubing terminations where the tubing manufacturer's recommended minimum bending radius is not achievable; or
- to facilitate component removal.

4.4.1.6

Compression fitting nut or body threads shall have an anti-galling coating.

4.4.1.7

Polytetrafluoroethylene or graphite packing shall be used for design temperatures up to 200 °C (390 °F) for instrument tubing valves.

4.4.1.8

Graphite packing shall be used for design temperatures greater than 200 °C (390 °F) for instrument tubing valves.

4.4.1.9

Packing materials, seal materials and other soft materials shall be compatible with the process media.

4.4.1.10

Unused vent and drain ports shall be fitted with design-rated plugs or caps.

4.4.1.11

Plugs and caps shall be made of the same material as the tube fittings.

4.4.2 Instrument air manifolds

4.4.2.1

Air manifolds shall be fabricated using at least 25 mm (1 in) diameter pipe.

4.4.2.2

The material of air manifolds and their valves and plugs shall be minimum SS 316.

4.4.2.3

Air manifolds shall have a ball valve at least 12 mm ($\frac{1}{2}$ in) in size for each individual air consumers.

4.4.2.4

Individual air consumers shall be sized to meet the required response time and pressure drop.

4.4.2.5

Air manifolds shall have a drain valve at least 12 mm ($\frac{1}{2}$ in) in size.

4.4.2.6

Air manifold drain valves shall be fitted with a rated plug for condensate draining.

4.4.2.7

Valves for air consumers shall be lockable.

4.4.2.8

Spare taps installed on the instrument air manifolds shall be fitted with a rated valve and rated plug.

4.4.3 Instrument tubing valves

4.4.3.1

Instrument tubing valves shall be ball or needle type.

4.4.3.2

Needle valves shall be metal-to-metal hard-seated type.

4.4.3.3

The instrument tubing valves maximum allowable leakage rates for closure tests shall be in accordance with API Standard 598:2016, Table 5 or ISO 5208:2015, Table 4, Rate A.

4.4.3.4

In addition to primary isolation (e.g. provided by piping, others), impulse lines shall have a test and calibration manifold with vents and drains implemented with the instrument.

NOTE Primary isolation is achieved by piping primary isolation valves.

4.4.3.5

Manifold valves shall be fitted with a bonnet locking mechanism (e.g. pins and screws).

4.4.3.6

Instrument tubing valves or manifold valves shall not be used for piping or process primary isolation purposes.

4.4.3.7

Packing for services above 200 °C (400 °F) shall be flexible graphite with carbon/graphite end rings.

4.4.4 Miscellaneous items

4.4.4.1 Tubing clamps

4.4.4.1.1

Tubing clamps shall use ultraviolet resistant and flame-retardant polymer with SS 316 mounting hardware.

4.4.4.1.2

Tubing clamps shall be an anti-corrosion design and free draining, and promote air circulation in marine environments.

4.4.4.1.3

The use of metal-on-metal clamps shall be prohibited for installation, support or routing of tubing.

4.4.4.1.4

Tubing clamp design shall allow the tubing to be inspected without disassembly.

4.4.4.1.5

Tubing clamp design shall be based on maximum operating temperature limits of the tubing.

4.4.4.2 Instrument valves for flushing or bleed rings

When a flushing ring is used, the ring shall be provided with one valve in the 12 o'clock position and one valve in the 6 o'clock position.

4.4.5 Process analyzer

4.4.5.1

Process analyzer systems that measure trace components (e.g. moisture, organic sulphur compounds, mercury) shall use electropolishing/inert treatment techniques (e.g. chemical vapour deposition or silica coatings) for tubing in the flow path to prevent adsorption, desorption or reactivity.

4.4.5.2

For single-digit parts per million trace analysis and lower, wetted components (e.g. tubing, regulators, filters) shall be treated in accordance with 4.4.5.1 to maintain sample integrity.

4.4.5.3

When electropolishing techniques are used for tubing, the tubing material shall be minimum SS 316L in accordance with ASTM A632.

4.4.5.4

When electropolishing techniques are used for tubing, the tubing shall be cleaned in accordance with the cleanliness requirements specified in ASTM A632.

4.4.5.5

Tubing that requires coating for improvement of measurement methods or for corrosion prevention shall be either bent prior to application of coating or bent to the minimum bend radius defined by the coating manufacturer.

4.4.5.6

Electrically-traced tubing shall be used for heating purposes when required (e.g. at dew point, in temperature-sensitive streams).

4.4.5.7

Steam tracing of tubing bundles for analyzer applications shall only be used when electrical tracing is not feasible (e.g. in high temperature applications).

4.4.5.8

Heat-traced pre-manufactured insulated tubing bundles shall be the preferred method for insulating sample tubing between the sample conditioning system and analyzer.

NOTE The use of insulating jackets (e.g. fibreglass wraps) to insulate cold tubing connections (i.e. not insulated or electrically heated connections) should be either minimized or, when possible, avoided.

4.4.5.9

Analyzer sample tubing to and from the sample conditioning system shall use continuous, single-run tubing (i.e. without splices of the pre-insulated tubing bundle) or tubing with insulation.

4.4.5.10

Sample bottle connections in analyzer systems, with fittings designed to be remade as part of a high-frequency maintenance routine (e.g. multiple times per year), shall use vacuum coupling fittings or similar fittings with replaceable seating gaskets.

4.4.5.11

Analyzer tubing shall be identified with the tag number and the service.

4.4.5.12

Installation of coated tubing systems (e.g. bending, tools employed, techniques and minimum bending radius) shall be performed by personnel certified by the coating manufacturer's approved product training program or an equivalent industry training program.

4.4.5.13

Process analyzer sample tubing shall be leak tested only, using one of the methods from ISA 7.0.01 or another accepted leak test method.

4.5 Instrument nipples

4.5.1

Stainless steel nipples shall be manufactured from seamless pipe in accordance with ASTM A312/A312M or from wrought bar in accordance with ASTM A479/A479M.

4.5.2

Close nipples without a hex head shall not be used.

4.5.3

Nipples used for direct-mount installations shall be minimum ½ in, Sch 80.

4.6 Insulation

4.6.1

Where tracing is used, the tubing and tubing bundle shall be insulated.

4.6.2

Prefabricated traced and insulated tubing bundles shall be used for heat tracing applications.

4.6.3

Insulation placed at tubing joints shall be removable and uniquely identified to enable inspection.

4.6.4

Tubing systems shall allow for instrument maintenance without damaging the insulation.

4.7 Vibration and thermal effects

4.7.1

The tubing system shall be designed to withstand the stresses due to vibration, thermal variation or the movement of the attached equipment.

4.7.2

If the fluid process characteristics (e.g. condensing, freezing, hydrate formation, viscosity greater than 200 cP) are affected by the ambient temperature, impulse lines shall be heat traced or insulated.

4.7.3

Tubing systems shall not be used where vibration is greater than 10 mm/s (0.39 in/s).

5 Material selection

5.1

The tubing material shall be selected from Table 2.

Table 2 — Material selection

Material	ASTM grade	UNS number	Recommended tube hardness ^b	PREN	Critical pitting temperature (CPT)	Maximum temperature limits (chloride-induced stress corrosion cracking (CISCC)) (internal/external) ^d	Typical applications ^c	Exclusions ^c
SS 316 or SS 316L	A269/A632	S31600/S31603	HRB 80	23	10 °C (50 °F) where pitting corrosion may occur	<ul style="list-style-type: none"> 60 °C (140 °F) where CISCC may occur Can be extended up to 450 °C (842 °F) for non-marine, non-corrosive environments and without use of clamps 	1) Environments where chloride build up does not occur or indoor conditioned environments for services such as air, hydraulic, nitrogen, hydrocarbons, fresh water, and glycol 2) Instrument air, heating, ventilation, and air conditioning (HVAC) and inert gases 3) Dual certified tubes 4) Tubing with minimum 2,5 % molybdenum content to minimize CISCC and pitting corrosion	Marine environments where chloride build up occurs
SS 317 or SS 317L	A269/A632	S31700/S31703	HRB 80	24	30 °C (86 °F) where pitting corrosion may occur	<ul style="list-style-type: none"> 60 °C (140 °F) where CISCC may occur 	1) Dual certified SS 317 / SS 317L in lieu of SS 316 / SS 316L can be used to enhance resistance to stress corrosion cracking	Marine environments where chloride build up occurs
Alloy 254 (6Mo)	A269	S31254	HRB 80	42	55 °C (131 °F) where pitting corrosion may occur	<ul style="list-style-type: none"> 100 °C to 120 °C (212 °F to 248 °F) where CISCC may occur For aerated chlorinated seawater systems with crevices, maximum operating temperature limit 20 °C (68 °F) 	1) External marine atmospheric environments 2) External corrosive environments, CISCC, pitting and crevice corrosion 3) Sour service ^a	
Alloy 6HN	A269	N08367	HRB 80	42	65 °C (149 °F) where pitting corrosion may occur	<ul style="list-style-type: none"> 100 °C to 120 °C (212 °F to 248 °F) where CISCC may occur For chlorinated seawater systems with crevices, maximum operating temperature limit 20 °C (68 °F) 	1) External marine atmospheric environments 2) Severe corrosive environments, CISCC, pitting and crevice corrosion 3) Increased resistance to pitting, crevice corrosion and CISCC when compared to alloy 254 4) Sour service ^a	

Table 2 (continued)

Material	ASTM grade	UNS number	Recommended tube hardness ^b	PREN	Critical pitting temperature (CPT)	Maximum temperature limits (chloride-induced stress corrosion cracking (CISCC)) (internal/external) ^d	Typical applications ^c	Exclusions ^c
25Cr super duplex SS	A789/A789M	S32750/S32760	HRC 32	40-45	80 °C (176 °F) where pitting corrosion may occur	<ul style="list-style-type: none"> 90 °C to 110 °C (194 °F to 230 °F) where CISCC may occur For chlorinated seawater systems with crevices, maximum operating temperature 20 °C (68 °F) 	1) Marine environments 2) Sour service ^a 3) Severe corrosive environments	
Alloy 400	B165	N04400	HRB 75	N/A		<ul style="list-style-type: none"> 150 °C (302 °F) where CISCC may occur 	1) Resistance to acid, alkali, seawater, organic intermediates 2) Marine environments 3) Chemical plants, including environments using sulfuric acid and hydrofluoric acid 4) Severe internal/external corrosive environments	Environments where fluids are contaminated with amine, ammonia and/or mercury
Copper alloy (tungum alloy)	B706	C69100	HRB 80	N/A		<ul style="list-style-type: none"> 60 °C (140 °F) where CISCC may occur 	1) Marine environments 2) Gas pipework systems (oxygen and inert gases) 3) Cryogenic applications	Environments where fluids are contaminated with H ₂ S and mercury, acetylene and/or ammonia Sensitivity to chlorine-containing environments
Alloy 625	B444	N06625	HRB 93	51		<ul style="list-style-type: none"> For chlorinated seawater systems with crevices, maximum operating temperature 30 °C (86 °F) 	1) Marine environments 2) Sour service ^a 3) Chlorides on external environments 4) Glycol	
Alloy 825	B423	N08825	HRB 90	32		<ul style="list-style-type: none"> No restriction on external CISCC 	1) Treated sea water 2) Phosphoric acid, sour gas and oil wells 3) Sour service ^a 4) Marine environments	
Titanium Gr.2	B338	R50400	HRB 85	N/A		<ul style="list-style-type: none"> 100 °C to 120 °C (212 °F to 248 °F) where CISCC may occur For chlorinated seawater systems with crevices, maximum operating temperature 85 °C (185 °F) 	1) Sodium hypochlorite 2) Chlorinated seawater systems 3) Sour service ^a 4) Marine environments	Sodium hypochlorite applications for operating temperature up to 50 °C (122 °F)

Table 2 (continued)

Material	ASTM grade	UNS number	Recommended tube hardness ^b	PREN	Critical pitting temperature (CPT)	Maximum temperature limits (chloride-induced stress corrosion cracking (CISCC)) (internal/external) ^d	Typical applications ^c	Exclusions ^c
Alloy C276	B622	N10276	HRB 90	45-75		<ul style="list-style-type: none"> No restriction on external CISCC For chlorinated seawater systems with crevices, maximum operating temperature 50 °C (122 °F) 	1) Marine environments 2) HF Acid non-aerated 3) Corrosive conditions 4) Oxidizing and reducing chemicals (e.g. ferric/cupric chlorides, chlorine, formic acids, and hypochlorite solution) 5) Sour service ^a 6) Chlorinated seawater systems 7) High-temperature sea water service	
Alloy 904L	A269/B677	N08904	HRB 80	35-43	45 °C (113 °F) where pitting corrosion may occur	<ul style="list-style-type: none"> 30 °C (86 °F) where CISCC may occur For chlorinated seawater systems with crevices, maximum operating temperature 10 °C (50 °F) 	1) Marine environments 2) Sour service ^a	Process and pneumatic services
Alloy 20	B729	N08020	HRB 95				1) Sulfuric acid, caustic, sour gas, acid gas, organic acids, chlorinated hydrocarbons, sludge acids 2) Sour service ^a	Marine environments where chloride build up occurs
Copper	B68/B75	C12200	60 on Rockwell 15T scale				1) HVAC tubing	Process and pneumatic services Environments where fluids are contaminated with H ₂ S, mercury, acetylene and/or ammonia

^a The definition of sour service remains the responsibility of the end user. Tubes used in sour service shall meet the requirements in accordance with ANSI/NACE MR0103, ISO 17945 or ANSI/NACE MR0175/ISO 15156.

^b If hardness compatibility between tubing and tube fittings can be demonstrated, higher tubing hardness above the recommended hardness can be used. Refer to the fitting manufacturer for maximum hardness compatibility requirements. See 4.3.1.3.

^c For tubing clamp requirements, see 4.4.4.1.

^d The temperature limits and material applications provided represent typical values and are for guidance only.

5.2

The tubing system component materials shall be selected from Table 3.

5.3

For sour service, tubing system component materials shall be in accordance with ANSI/NACE MR0103 or ISO 17945 or ANSI/NACE MR0175/ISO 15156, Parts 1 to 3.

5.4

Operating and ambient temperature limits of the applications shall be in accordance with ISO 21457 for the selected tubing material.

5.5

Where tubing and fittings are made from dissimilar materials, the temperature and environmental limits of the lower grade material shall apply for material selection.

Table 3 — Material compatibility

Tube			Compatible material	
Material ^a	ASTM grade	UNS number	Tube fitting ^{a, b, c}	Instrument isolation valves ^{a, b}
SS 316/SS 316L	A269/A632	S31600/S31603	6Mo or SS 316	SS 316
SS 317/SS 317L	A269/A632	S31700/S31703	SS 316	SS 316
Alloy 254 (6Mo)	A269/A632	S31254	6Mo or SS 316	6Mo or SS 316
Alloy 6HN	A269/A632	N08367	Alloy 6HN or SS 316	Alloy 6HN or SS 316
25Cr Super Duplex SS	A789/A789M	S32750/S32760	25Cr Super duplex SS	25Cr Super duplex SS
Alloy 400	B165	N04400	Alloy 400	Alloy 400
Copper Alloy	B706	C69100	SS 316	SS 316
Alloy 625	B444	N06625	Alloy 625	Alloy 625
Alloy 825	B423	N08825	Alloy 825 or SS 316	Alloy 825 or SS 316
Titanium Gr.2	B338	R50400	Titanium Gr. 2 or Titanium Gr. 4	Titanium Gr. 2 or Titanium Gr. 4
Alloy C276	B622	N10276	Alloy C276	Alloy C276
Alloy 904L	A269/B677	N08904	SS 316	SS 316
Alloy 20	B729	N08020	Alloy 20	Alloy 20
Copper	B68/B75	C12200	Brass B16/B453 or SS 316	Brass B16/B453 or SS 316
^a SS 316 material shall not be used in marine environments. ^b Temperature and environmental limits of the lower grade material shall be applied for material selection when dissimilar material combination is selected within a tubing run. ^c Where multiple materials are identified for the fittings, refer to Table 2 for limitations and exclusions.				

6 Installation

6.1 General

6.1.1

Tubing shall not be used as load bearing supports including structural supports and overhung masses.

6.1.2

Tubing and tubing bundles shall be supported using tube clamps or alternate methods recommended by the manufacturer.

6.1.3

Threads shall not be seal welded.

6.1.4

Instrument tubing shall be removable without disassembly of pipes or equipment.

6.1.5

Impulse line tubing shall have a minimum gradient of 1:12 towards the instrument for liquid service.

6.1.6

Impulse line tubing shall have a minimum gradient of 1:12 towards the process for gas service.

6.1.7

Repairs on the existing tubing system shall be based on the methods applied previously, unless a risk assessment is performed to apply other methodologies.

6.1.8

Impulse tubing shall be routed to prevent creation of pockets or traps.

NOTE High and low points are prone to plugging where liquid, vapour or sediment can get trapped and introduce an error into the instrument reading.

6.2 Small bore tubing system installation

6.2.1 Tube routing

6.2.1.1

Tubing containing hydrocarbons, toxic and corrosive fluids shall not be routed to electrical buildings, equipment rooms or control rooms.

6.2.1.2

Tubing and tubing bundles shall be routed separately from cables.

6.2.1.3

Tubing and tubing bundles that penetrate walls, enclosures or panels shall use bulkhead union fittings, cable transit modules or equivalent solutions.

6.2.1.4

Tubing system installation shall not prevent the removal of instruments, maintenance of equipment or calibration of instruments.

6.2.1.5

Where impulse tubing length is more than 6 m (20 ft), a dynamic analysis shall be performed to measure the response time.

6.2.1.6

Where impulse tubing length is more than 6 m (20 ft), a risk assessment which includes minimizing tubing fittings by using coils and bundles or providing accessibility to tubing and tubing fittings for maintenance and repair, shall be performed for potential leaks.

6.2.1.7

Tubing shall be routed using tray, angle or channel.

6.2.1.8

Tubing systems shall not be run-in or secured in trays containing electrical conducting cables.

6.2.1.9

Tubing shall be routed through grating or chequer plate if the removal of the grating or chequer plate does not require isolation or disassembly of tubing installation.

6.2.1.10

Tubing shall not be routed through service access areas or impede walkway and egress routes.

6.2.1.11

Field tubing shall enter the panel from the side, rear or bottom, unless otherwise accepted by the end user.

6.2.1.12

Tubing shall be of the same material, grade and wall thickness through the entire continuous tubing run, from source to end connections, including side branches.

6.2.1.13

Tubing shall not be supported from or secured to the conduit.

6.2.1.14

If tubing or tubing bundles are pre-insulated, tubing runs shall be continuous between:

- tubing junction boxes and shelters; or
- tubing junction boxes and field enclosures.

6.2.1.15

A spare space of 20 % minimum of the total bulkhead fittings (e.g. panel, wall, terminating plate) shall be provided for initial installation and anticipated future expansion .

6.2.2 Supports**6.2.2.1**

For horizontal and vertical runs of tubing, spacing for supports shall be 1 m (3 ft) and within 150 mm (6 in) of tangents or changes of direction.

NOTE For tubing sizes equal to and greater than 12,7 mm ($\frac{1}{2}$ in) with a long bend radius, support distance at bends or tangents may be increased.

6.2.2.2

Tubing shall not be supported from handrails or ladders.

6.2.2.3

For marine environments, the tubing tray material shall be 316 SS or a non-metallic corrosion-resistant material.

6.2.2.4

For marine environments, the tubing tray support hardware (i.e. nuts and bolts to connect trays together and threaded bars with washers and nuts) material shall be 316 SS.

NOTE Painted structural steel, channels or angles can be used by exception (e.g. package systems such as turbine machinery).

6.2.2.5

Where above-ground routing is not possible, underground routing shall be encased in a non-metallic conduit sleeve and sealed at both ends.

6.2.2.6

Where above-ground routing is not possible, underground routing shall be uniquely marked and documented.

6.2.2.7

Structural steel shall not be mechanically drilled or hydraulically punched for tubing fasteners.

6.2.2.8

Metallic tubing trays shall be grounded in accordance with NFPA 70:2023, Article 392 or an equivalent code.

6.2.3 Tubing installation**6.2.3.1**

Deformed, scratched or damaged tubes shall not be used.

6.2.3.2

Installed tubing shall be free from mechanical defects (e.g. scratches, dents, ovality).

6.2.3.3

Personnel responsible for tubing system design, fabrication, installation and inspection shall be certified by the fittings manufacturer's approved product training program and have hands-on experience with recommended interval for recertification assessment.

6.2.3.4

Tubing and fittings make-up shall be prepared and marked in accordance with the fitting manufacturer's recommendations.

6.2.3.5

Where specified for marine environments, when construction and assembly are completed, external tubing systems shall be pickled, passivated or cleaned.

6.2.3.6

Marking pens containing chloride or sulfur shall not be used.

6.2.3.7

Tubing shall be arranged to facilitate tracing, troubleshooting and maintenance (see Figure 1).

6.2.3.8

Tubing shall be installed to account for normal equipment movement, maintenance, thermal expansion and acoustic-induced vibrations.

6.2.3.9

Parallel runs of tubing shall be installed in accordance with the example method shown in Figure 1.

6.2.3.10

The tube fitting manufacturer's approved tools (e.g. gap inspection gauge, roller benders, depth marking tool, tubing cutter, deburring tool) shall be used for tubing and fitting assembly.

6.2.3.11

The tubing manufacturer's recommended bending radius shall be followed.

6.2.3.12

Single bends shall be made in one plane.

6.2.3.13

Installed spare tubes in tube bundles shall be capped.

6.2.3.14

Tubing fittings shall be free from mechanical defects (e.g. galled or deformed threads).

6.2.3.15

Instrument pneumatic tubing shall be routed overhead or provided with low-point collections and drains.

6.2.3.16

Tubing systems shall be terminated at a bulkhead or panel using a bulkhead fitting at the edge of the skid or modular equipment.

6.2.3.17

The centreline dimension between bulkhead connections shall be a minimum of 38 mm (1½ in) on both the vertical and horizontal planes.

6.2.3.18

Interface installations using dissimilar materials between piping, instrumentation, tubing and fittings, or where leakage current exists shall use one of the following:

- insulating flange gaskets;
- isolation kits;
- dielectric tube fittings and union isolation kits.

NOTE Examples include where galvanic corrosion, cathodic protection or high-voltage grids exist.

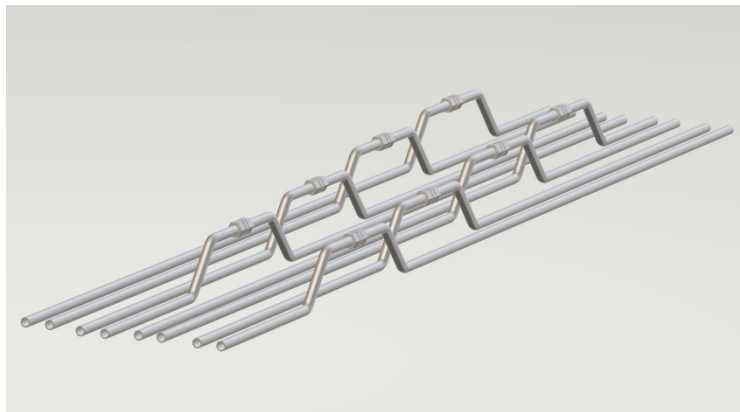


Figure 1 — Parallel runs of tubing runs

6.2.4 Tube bundles**6.2.4.1**

Spacing between multiple traced tube bundles shall follow the tube bundle manufacturer's recommendation.

6.2.4.2

Clamps or tie-wraps that exert point pressures shall not be used.

6.3 Small bore piping components installation specific to instruments

6.3.1

Fittings and nipples used at piping-instrument interfaces shall comply with ASME B16.11.

6.3.2

ASME B16.11 hex-style bushings and flush bushings shall not be used.

6.3.3

Flush or hollow hex pipe plugs shall not be used.

6.3.4

Tubing fitting sizes shall match piping connections.

NOTE Matching tubing fitting sizes and piping connections minimizes the use of reducers and creation of stress riser points.

6.3.5

Tubing schematics shall be provided on the panel for troubleshooting and maintenance purposes.

6.3.6

Where plugging is expected and rodding-out facilities are provided, tubing and tubing connections shall be routed to facilitate maintenance.

6.4 Thread sealing

6.4.1

Sealant and lubricant for threaded instrument connections shall be in accordance with the requirements of the process service (e.g. pressure, temperature and process material compatibility).

6.4.2

Thread sealant applied on stainless steel fittings shall have anti-seize properties.

6.4.3

Sealants shall be applied and cured in accordance with the manufacturer's instructions.

6.4.4

For temperatures above 200 °C (400 °F), sealant and lubricant on tube fitting threads shall be in accordance with the tube fitting manufacturer's recommendations.

7 Inspection and testing

7.1

Positive material identification shall be performed prior to installation of tubing.

7.2

Incoming material quality control shall be performed on the minimum specified sample size of one destructive sample per heat treat code.

7.3

A visual inspection and dimensional check shall be performed on the assembled tubing installations.

7.4

Tubing shall be visually and mechanically inspected prior to application of insulation.

7.5

Assembly testing using the tube fitting manufacturer's recommended tools (e.g. gap inspection gauge - Go / No Go gauge, if applicable) shall be performed.

7.6

The sample size for the inspection and testing specified in this clause shall be confirmed prior to commencement of inspection.

7.7

Pneumatic leak testing for tubing installations shall be carried out in accordance with ASME B31.3.

7.8

Hydrostatic leak testing for tubing installations, excluding Category D fluids, shall be carried out in accordance with ASME B31.3.

7.9

For Category D fluids, minimum leak testing shall be performed using process service and liquid leak detection methods.

7.10

Service leak testing shall be a pneumatic test followed by application of soapy water to the external surfaces of impulse tubing, tubing fittings and connections, with no visible air bubbles.

NOTE See 7.3 for pneumatic testing requirements.

7.11

Service testing after dismantling and re-assembly shall be performed on assembled tubing installations.

7.12

Compression fittings for each tubing material and size combination shall be type test qualified for the standard performance tests in accordance with ASTM F1387:2023, 13.1 and Table 3.

7.13

Instrument tubing valves shall be type test qualified in accordance with MSS SP-99.

7.14

Tubing shall be thoroughly cleaned and dried after all cutting and forming have been completed.

8 Marking

8.1

Process, analyzer sample, pneumatic and hydraulic tubing shall be tagged at a span of 25 m (82 ft).

8.2

Tag plates shall be affixed at entry or exit locations of the penetrations when the tubes are passing through a deck, wall, enclosure and panel.

8.3

Tag plates shall be SS 316.

8.4

Tag plates shall be tied using SS 316 zip ties or wires.

8.5

Tubing runs associated with safety instrumented systems shall have at least one of the following characteristics:

- tagged at the isolation points;
- tagged at the process and at the instrument;
- installed in separate tubing trays.

8.6

Tube marking shall be spaced at intervals in accordance with the selected tubing ASTM material standards.

8.7

In addition to 8.6, tubing shall be continuously marked with the following as a minimum:

- tube outside diameter;
- tube wall thickness;
- material (UNS code);
- manufacturer's name;
- lot number;
- heat treatment number, if heat treated.

8.8

Fitting bodies and nuts shall be marked with either the manufacturer's name, material, size and heat code traceability or with the manufacturer's part number.

8.9

Front and rear ferrules shall be marked with the manufacturer's name and material unless the marking is not feasible due to the size.

8.10

Heat-traced tubing shall be marked with the type of heat tracing used.

8.11

Heat-shrinkable identification marking sleeves and adhesive labels shall be prohibited for small bore tubing installations exposed to marine environments.

9 Preservation and packing

9.1

Incomplete tubing runs or loose components and fittings shall be protected using caps or plugs for shipping.

9.2

Loose non-bent tubes shall be packaged together in a protective sleeve (e.g. PVC tube) for shipping to prevent mechanical damage, ingress of moisture and contaminants.

9.3

Tubing and tube fittings shall be segregated and labelled with the metallurgy, size and wall thickness.

9.4

Tubing and tube fittings shall be stored in a protected and access-controlled environment.

9.5

Tubing and fittings shall be protected from construction activities and environmental factors until final commissioning using the following methods:

- tubing protective covering;
- instrument air tubing ends capped if connections have not been completed.

Bibliography

- [1] ASME B31.1, *Power Piping*



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