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|  | TECHNICAL SPECIFICATION | | Nº: I-ET-3010.2E-1200-200-P4X-001 | | | | | | | |
| | CLIENT: AGUP | | SHEET: 1 of 25 | | | | | | | |
| | JOB: HIGH CAPACITY FPSO - GAS EXPORTATION ALL ELECTRIC | | | | | | | | | |
| | AREA: ATAPU 2 AND SÉPIA 2 | | | | | | | | | |
| SRGE | TITLE: MINIMUM REQUIREMENTS FOR PIPING MECHANICAL DESIGN AND LAYOUT | | INTERNAL | | | | | | | |
| | | | | ESUP | | | | | | |
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1 SCOPE

- 1.1 This Technical Specification specifies the minimum requirements for the execution of the mechanical design of piping in offshore units, using as reference ASME Codes B31.3, B31.4, B31.8 and other applicable codes and standards.
- 1.2 This Technical Specification also complements the applicable codes, defining supplemental requirements and OWNER definitions.
- 1.3 This Technical Specification contains Technical Requirements and Recommended Practices.

2 REFERENCES

The following referenced documents and standards are indispensable for the application of this document, besides the Rules of Classification Society. For undated references, the latest edition at the date of contract signature applies, unless a specific date/edition is referenced in the contract or specified by the Classification Society rules.

2.1 OWNER documents

I-ET-3010.00-1200-200-P4X-003 – DESIGN, CONSTRUCTION AND ASSEMBLY OF FRP PIPING

I-ET-3010.00-1200-200-P4X-115 – REQUIREMENTS FOR PIPING FABRICATION, ASSEMBLY, INSPECTION AND COMMISSIONING

I-ET-3010.00-1200-200-P4X-116 – BOLTED JOINTS MANAGEMENT

I-ET-3010.00-1200-295-P4X-001 – REQUIREMENTS FOR PIG LAUNCHER AND RECEIVER DESIGN

I-ET-3010.00-1200-310-P4X-001 – API 610 CENTRIFUGAL PUMPS SPECIFICATION

I-ET-3010.00-1200-310-P4X-002 – POSITIVE DISPLACEMENT PUMPS SPECIFICATION

I-ET-3010.00-1200-451-P4X-001 – SHELL & TUBE HEAT EXCHANGERS SPECIFICATION

I-ET-3010.00-1200-456-P4X-001 – PLATE HEAT EXCHANGERS SPECIFICATION

I-ET-3010.00-1200-459-P4X-001 – PRINTED CIRCUIT HEAT EXCHANGERS SPECIFICATION

I-ET-3010.00-1200-540-P4X-001 – REQUIREMENTS FOR PRESSURE VESSELS DESIGN

I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS

I-ET-3010.00-1200-940-P4X-005 – CHEMICAL INJECTION POINTS

I-ET-3010.00-1200-955-P4X-001 – WELDING

I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING

I-ET-3010.2E-1200-200-P4X-001 – PIPING SPECIFICATION FOR HULL

I-ET-3010.2E-1200-200-P4X-004 – REQUIREMENTS FOR PIPING SUPPORT

I-ET-3010.2E-1200-200-P4X-006 – REQUIREMENTS FOR PIPING STRESS ANALYSIS

I-RL-3010.2E-1200-940-P4X-003 – DRAINAGE SYSTEM GUIDELINES

I-ET-3010.2E-1350-196-P4X-002 – ERGONOMIC REQUIREMENTS FOR HULL



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I-ET-3010.2E-1350-200-P4X-001 – HULL PIPING PRACTICE

I-ET-3010.00-1350-960-P4X-001 – DESIGN REQUIREMENTS - NAVAL ARCHITECTURE

I-ET-3010.2E-5410-253-P4X-002 - REQUIREMENTS FOR RIGID EXPANSION JOINTS (DRESSER TYPE)

2.2 Standards

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

API RP 551 – Process Measurement

API RP 686 – Recommended Practice for Machinery Installation and Installation Design

API STD 6A – Specification for Wellhead Equipment

API STD 520 – Sizing, Selection, and Installation of Pressure-relieving Devices Part II-Installation

ASME B16.5 – Pipe Flanges and Flanged Fittings

ASME B16.47 – Large Diameter Steel Flanges

ASME B16.48 – Line Blanks

ASME B31.3 – Process Piping

ASME B31.4 – Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

ASME B31.8 – Gas Transmission and Distribution Piping Systems

ASME B36.10 – Welded and Seamless Wrought Steel Pipe

ASME B36.19 – Stainless Steel Pipe

EEMUA 234 – 90/10 Copper nickel alloy piping for offshore applications Specification

ISO 21457 – Materials selection and corrosion control for oil and gas production systems

NR-13 – CALDEIRAS, VASOS DE PRESSÃO, TUBULAÇÕES E TANQUES METÁLICOS DE ARMAZENAMENTO

STANDARDS OF THE EXPANSION JOINT MANUFACTURERS ASSOCIATION

3 TERMS AND DEFINITIONS

For the purposes of this document, the following terms and definitions are applicable. For other general technical terms see I-ET-3010.00-1200-940-P4X-002.

3.1 Category M fluid service

Based on OWNER experience, sour service as defined by ANSI/NACE MR0175 / ISO 15156 shall not be considered Category M as per ASME B31.3.

3.2 EJMA

Expansion Joint Manufacturer Association



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3.3 Expansion bend

Piping configuration designed to absorb expansion and contraction.

3.4 FRP / GRP

Fiber reinforced plastic / glass reinforced plastic.

3.5 High pressure fluid service

Pressure ratings up to 10ksi shall not be considered High Pressure Fluid Service as defined in ASME B31.3. For higher pressures, OWNER approval is required.

3.6 Low temperature condition

Operation or transient condition when the temperature is below 0°C.

3.7 Mechanical design

A series of engineering activities and their product intended to present necessary and sufficient information for the acquisition, construction, operation and maintenance of piping systems belonging to petroleum facilities.

NOTE: for the purposes of this Technical Specification, mechanical design and detailed piping design shall be considered synonyms.

3.8 NPS

Nominal Pipe Size.

3.9 Piping

An assembly of pipes and accessories (valves, flanges, bends, fittings, etc.) intended for transporting process or utility fluids.

3.10 Piping system

An assembly of pipes used to convey fluids, interconnected to each other and/or to static or dynamic equipment, and subject to the same design conditions (temperature and pressure).

3.11 Pressure rating

Maximum allowable pressure at a given temperature.

3.12 Process piping

Piping interconnecting piping systems or equipment in the physical space defined by the process units, usually delimited by battery limits.

3.13 PSV

Safety relief valve.

3.14 Severe cyclic condition

As per ASME B31.3-2014: conditions applying to specific piping components or joints in which SE computed in accordance with para. 319.4.4 exceeds $0,8S_A$ (as defined in para. 302.3.5), and the equivalent number of cycles (N in para. 302.3.5) exceeds 7000; or other conditions that the designer determines will produce an equivalent effect.



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3.15 Small bore connection (SBC) / Small bore lines

Connections or lines having a nominal diameter equal to or smaller than NPS 2.

3.16 Sour service (H2S service)

Service with fluid that contains sufficient H2S to cause cracking of materials by the mechanisms addressed by ANSI/NACE MR0175 / ISO 15156.

3.17 Stress critical lines

Lines defined as critical according to I-ET-3010.2E-1200-200-P4X-006.

3.18 TSA

Thermal spray aluminum.

3.19 Utility piping

Piping carrying auxiliary fluids required for processing, storage and general services.

4 GENERAL CONDITIONS

4.1 Designer's Responsibility

4.1.1 The designer is responsible to assure that the engineering design of piping complies with the requirements of this this Technical Specification, applicable codes and standards, Classification Society Rules and legal conditions.

4.1.2 In case it is necessary to create or revise piping specsheets issued by OWNER, Designer shall submit them for OWNER review and approval. Once approved, CONTRACTOR shall issue a Technical Specification containing all piping specsheets used in the Project, for hull or for topside as applicable. This new Technical Specification will replace the original one. Modifications in relation to the previous specification shall be highlighted.

4.2 Design Conditions

4.2.1 Hull piping shall be designed according to ASME B31.3. Piping design shall also comply with NR-13 and Classification Society Rules.

4.2.2 Piggable lines shall comply with ASME B31.4 and/or B31.8 as applicable.

4.2.3 For fatigue assessment and requirements applicable to stress critical lines I-ET-3010.2E-1200-200-P4X-006 shall be complied with.

4.2.4 Unit shall be designed for an uninterrupted period of 30 years without dry-docking for maintenance.

4.2.5 Localized temperature reduction caused by flange leakage does not need to be considered as minimum design temperature.

4.2.6 The use of ASME Code Cases is subjected to OWNER previous approval.

4.2.7 Piping shall be designed to avoid categorization into severe cyclic service. [RECOMMENDED PRACTICE]

4.2.8 Design, construction and assembly of GRP piping shall comply with I-ET-3010.00-1200-200-P4X-003.

4.2.9 Design, construction and assembly Hull piping shall also comply with I-ET-3010.2E-1350-200-P4X-001.



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4.2.10(NOT APPLICABLE)

4.3 Materials

- 4.3.1 The piping specsheets of I-ET-3010.2E-1200-200-P4X-001 shall be adopted in the design.
- 4.3.2 In case it is necessary to create or revise piping specsheets, material selection shall be according to ISO 21457, and subjected to OWNER acceptance.
- 4.3.2.1 The materials of the piping specsheets prepared by the designer shall be those included in ISO, ASTM, ASME or API standards. Materials according to other standards may only be used if authorized by OWNER.
- 4.3.2.2 Following diameters shall not be used: NPS 3/8, NPS 3 ½, NPS 5, NPS 7 and NPS 22. Small sections of pipes or accessories are permitted for direct connection to the equipment. The nominal diameter of NPS 1 ¼ and NPS 2 ½ shall be used only for marine (hull) systems.
- 4.3.2.3 The dimensions of metallic pipes shall be those standardized in ASME B36.10 and ASME B36.19, for thicknesses within the limits of these standards. Cu-Ni piping dimensions shall be according to EEMUA 234.
- 4.3.3 Flanges for sour (H₂S) service, where the studs/bolts are exposed directly to atmosphere may use studs/bolts not for sour service. Typical flanged connections are ASME B16.5 / B16.47 with raised faces (RF) or ring-type join (RTJ), and API 6A type 6BX, not insulated nor covered. Compact flanges shall be studs suitable for sour service.
- 4.3.4 Material selection for low temperature conditions based on temperature reduction (stress ratio) according to Figure 323.2.2B/Table 323.2.2B of ASME B31.3 is not allowed. Except for controlled depressurization, necessary for system operation, where there is a written procedure, and where the stress ratio does not exceed 0,3. This condition must be considered in the stress analysis, with a report issued.

4.4 Piping Identification

- 4.4.1 All piping and process tubing shall be assigned with an identification code in accordance with I-ET-3010.2E-1200-200-P4X-001 as applicable. The identification of each piping shall be conspicuously shown on all drawings (such as flow diagrams, plans, and isometrics), lists, data sheets, and other design documents where the referenced piping appears or is mentioned.

4.5 Fabrication, assembly, test and commissioning

- 4.5.1 Piping welding shall be according to I-ET-3010.00-1200-955-P4X-001.
- 4.5.2 Welding inspection shall be according to I-ET-3010.00-1200-200-P4X-115.
- 4.5.3 Designer shall foresee facilities (such as flanged connection, inspection openings, removable spools etc.) to allow commissioning and inspection activities.
- 4.5.4 Fabrication, assembly, tests and commissioning shall also comply with I-ET-3010.00-1200-200-P4X-115.
- 4.5.5 Bolted flange joint assembly and management shall be according to I-ET-3010.00-1200-200-P4X-116.
- 4.5.6 The hydrostatic test pressure, for metallic and non-metallic piping, shall be at least 1,5 times the pressure rating of the piping specsheet, unless there is any component which maximum test pressure is lower than the test pressure cited above.



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4.5.7 Lines open to the atmosphere, such as vents or drains downstream of the last shutoff valve, need not be hydrostatically tested. Nevertheless, these lines shall be leak tested according to I-ET-3010.00-1200-200-P4X-115.

4.5.8 Piping system in Category D fluid service may be subjected to leak test (prior to initial operation) in accordance with paragraph 345.7 of ASME B31.3, in lieu of the hydrostatic leak test.

5 PIPING MECHANICAL CALCULATION REQUIREMENTS

5.1 Calculations Included in this Technical Specification

5.1.1 This chapter covers calculation of wall thickness for piping not specified in I-ET-3010.2E-1200-200-P4X-001.

5.1.2 For calculation of span between supports and forces on supports (for piping not subjected to stress analysis), see I-ET-3010.00-1200-200-P4X-004.

5.1.3 Stress analysis shall be according to I-ET-3010.2E-1200-200-P4X-006.

5.2 Calculation of Wall Thickness

5.2.1 The thicknesses of piping or fittings not covered or not defined by piping material standardizations of I-ET-3010.2E-1200-200-P4X-001 shall be calculated. The fitting thicknesses shall be in accordance with the corresponding pipe thickness.

5.2.2 The calculation of piping wall thickness due to internal or external pressure shall be performed as required by ASME Codes B31.3, B31.4 (Chapter IX) or B31.8 (Chapter VIII), according to the application field of each standard.

5.2.3 The thickness of piping shall also comply with Classification Society requirements.

5.2.4 Specific Considerations

5.2.4.1 The design pressure and design temperature values used for calculation of wall thickness shall be as set out by ASME Codes mentioned in 5.2.2.

5.2.4.2 Large diameter (NPS > 36) and thin wall piping (ratio D/t > 100) shall be analyzed regarding the collapse resistance to atmospheric pressure, in case there is occasional formation of vacuum in the piping. These pipes be adequately supported to avoid local buckling.

5.2.5 It shall be considered a minimum corrosion allowance of 1,6 mm applicable to all carbon steel and low steel alloy pipes, except when there is proper internal coating. Values above 1,6 mm shall be adopted when more severe operating conditions of the piping justify this procedure, technically and economically. In case of threaded connections, an extra thickness shall be added to this value to compensate the thread notch. This value shall be equal to the external radius of pipe minus the minimum radius of thread at pipe end. The extra thicknesses shall be based in the minimum lifetime of 30 years for carbon steel, steel alloy and stainless steel, except when a different lifetime is specified.

5.2.6 Tolerances inherent to fabrication processes and material specification shall be considered when selecting the commercial thickness of the pipe.

5.2.7 The specified thickness shall not be less than the thicknesses described in Table 1.

Table 1 - Minimum Structural Piping Wall Thicknesses

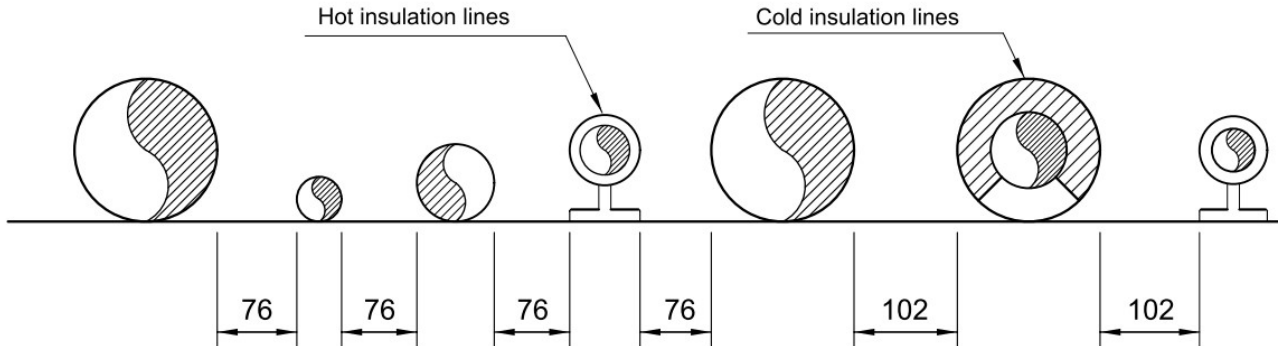
| NPS | SERVICE | Carbon and low alloy steel | Alloys and Stainless steels |
|----------|---|----------------------------|-----------------------------|
| ½ to 1 ½ | Utilities, sea water and produced water | SCH 80 | SCH 40S |
| ½ to 1 ½ | Hydrocarbon | SCH 160 | SCH 40S |
| 2 to 6 | All | SCH 40 | SCH 40S |
| 8 to 10 | All | 0,25" | SCH 40S |
| 12 to 24 | All | 0,25" | SCH 40S |
| 26 to 30 | All | 0,312" | 0,375" |
| 32 to 44 | All | 0,375" | 0,375" |

6 GENERAL PIPING ARRANGEMENT

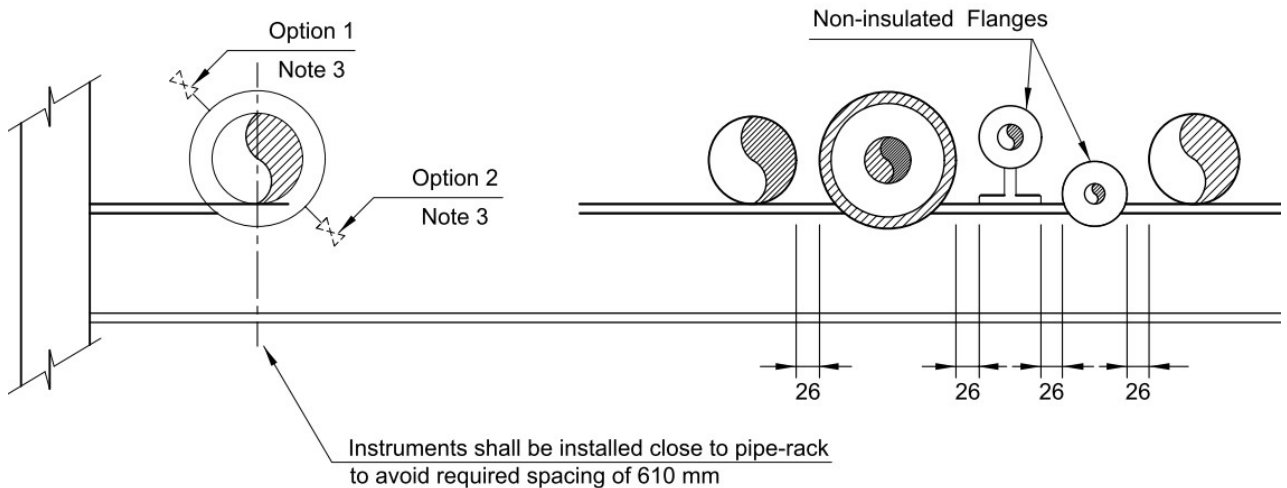
- 6.1.1 The piping layout shall be the most economical as far as process, assembly, operation, safety, and maintenance needs are concerned.
- 6.1.2 The pipe rack shall have at least 10% space for future expansion.
- 6.1.3 The minimum height above the floor for piping shall be at least 300 mm, measured from the outside bottom of the pipe, except for small diameter lines. This height shall always be increased, when necessary, for the installation of accessories on the bottom part of the pipes such as, for example, legs for collecting condensate and drains with valves.
- 6.1.4 Piping shall form parallel groups, with the same elevation of the outside bottom of pipe (bottom elevation). Whenever possible, these parallel groups shall have an orthogonal design direction (bow-stern or port-starboard), or vertical direction. Piping operating at high temperatures should be placed externally to the group of parallel pipes and at the highest point of the pipe rack to facilitate the placement of expansion bends. Heavier pipes shall be located at the lowest elevation of the pipe rack and closer to the pipe rack columns. Groups of parallel horizontal pipes shall have different elevations for different directions. Piping branching off to various units or to equipment on one side or the other of a central pipe rack shall preferably be located at the center of the pipe rack. For economic reasons, large diameter pipes or those made of special materials may be dealt with differently from the ones described above.
- 6.1.5 Within processing areas, the interconnection between different modules should be restricted to the pipe racks. The pipe rack's walkways, maintenance routes and escape routes shall be clear of piping. Pipe sections close to the floor level are permitted, provided they do not obstruct the equipment handling way and escape routes. Due to process or economic reasons, properly supported piping installed at high points directly interconnecting equipment is permitted.
- 6.1.6 Pipes on elevated pipe racks should be arranged in such a way that the small diameters lines lie between 2 large diameter lines, allowing the former to rest on the latter, thereby reducing the need for intermediate supports.
- 6.1.7 All elevated piping shall be designed in such a manner not to obstruct access for people. Piping shall not rest on platforms or walkways with low rigidity.
- 6.1.8 The spacing between parallel pipes shall be at least the values given in Figure 1. For crossings at 45°, see Figure 2. Spacing between piping and other elements, such as structures, shall not be less than

half of the values indicates on Figure 1. In all cases, the displacements that may occur on piping due to thermal expansion shall be considered.

Non-flanged piping



Flanged piping



NOTE 1: dimensions in mm.

NOTE 2: movements due to thermal expansion shall be calculated for each piping.

NOTE 3: use Option 1 for removal of gas/steam and Option 2 for liquids.

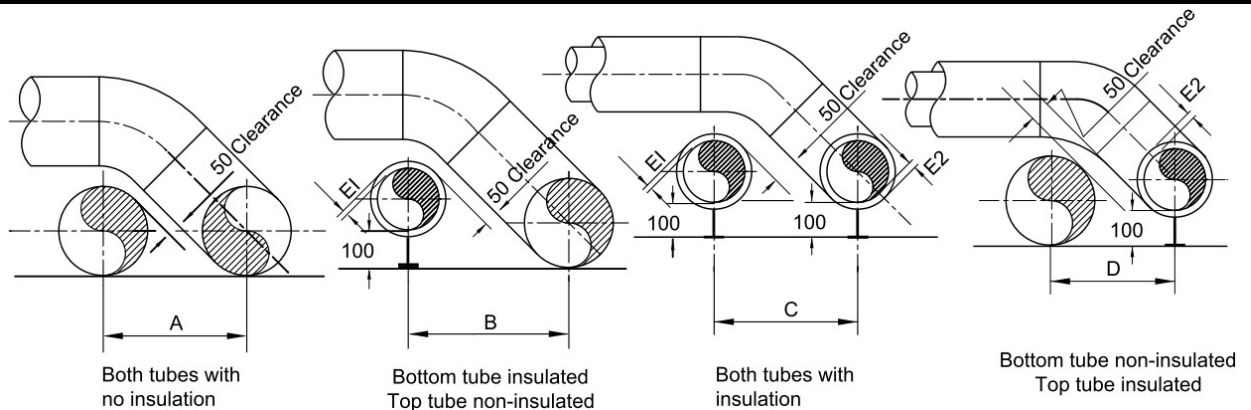
Figure 1 - Spacing between parallel pipes

6.1.9 When routing the piping, special attention shall be paid to those cases where certain conditions are required by the process, such as slope, absence of high points, symmetry, and minimum head loss.

6.1.10 The trim of the vessel (ship) shall be considered when routing piping with slope, as required by I-RL-3010.2E-1200-940-P4X-003. See I-ET-3010.00-1350-960-P4X-001 – DESIGN REQUIREMENTS - NAVAL ARCHITECTURE for trim angles

6.1.11 All piping shall be arranged in such a manner as to allow fast and safe access to equipment, valves, sample connections and instruments, for maintenance as well as operation. Piping and supports shall be located in such a way as to allow all removable parts to be easily dismantled and removed.

6.1.12 Whenever possible, all discharge nozzles of pump assemblies shall be aligned.



NOTE 1: the minimum allowable clearance is 50 mm between pipes. If a larger clearance is required, the distances A, B, C and D shall be increased.

NOTE 2: E1 and E2 are the thermal insulation thicknesses.

NOTE 3: dimensions in mm.

Figure 2 - Minimum Distances for Crossings at 45°

6.1.13 Expansion bends shall be routed in two plans, to allow the location of adjacent pipes. In case of lines with continuous slope, lines that cannot have high points, flare lines, lines subjected to formation of liquid or steam pockets, among others, the expansion bend routings shall be on the horizontal plan. Expansion loops in the vertical plane shall be avoided.

6.1.14 Following branches shall be installed on top of main line:

- a) Branches connected to PSV discharge lines;
- b) Branches for chemical injection;
- c) Branches for utilities containing gaseous fluid;
- d) Branches of deluge system.

6.1.15 Branches for utilities with liquid fluid, from header to customer, shall be installed on bottom of main line, except for tank cleaning lines.

6.1.16 Changes in direction shall meet the requirements set forth in 6.1.16.1 to 6.1.16.3.

6.1.16.1 Changes in pipe direction shall be made using bends, elbows, tees, crosses or by bending the pipe itself. The use of flanged tees shall be minimized.

6.1.16.2 Miter bends are not allowed.

6.1.16.3 In all of the above cases, when the bend does not have a long radius, the drawings shall indicate which bend was used.

6.1.17 Short radius elbows shall not be used for piping subject to multiphase flow.

6.1.18 The use of flanges shall be minimized and shall be usually allowed only for connecting valves, pressure vessels, tanks, pumps or other equipment. Pipes that need to be frequently disassembled for cleanup or inspection and those having an internal lining may be flanged.

6.1.19 Insulated piping systems shall be designed with sufficient space around inline valves, equipment, flanges, etc. to allow for installation of insulation boxes or perforated sheets.

6.1.20 Enough straight length of pipes shall be provided between blanks, flanged valves and/or flanged equipment to allow studs/bolts disassembly.

6.1.21 Enough straight length of pipes shall be provided between flanges and gussets, reinforcements of branches or penetration pieces, to allow studs/bolts disassembly.

6.1.22 All flanges shall be placed in a manner allowing vertical or North-South design lines to pass through the middle of the interval between 2 bolt holes (see Figure 3).

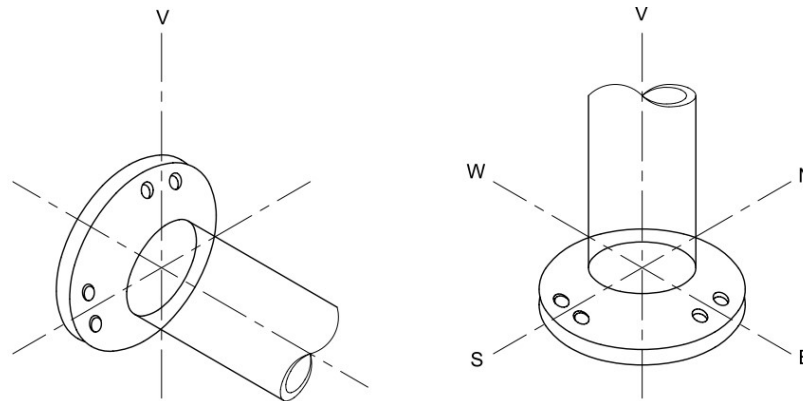


Figure 3 – Position of flange bolt holes

6.1.23 For pipes having a diameter of NPS 30 or larger, carrying liquid or subject to dynamic forces or whose head loss is critical, branches may be made to 45° with respect to the flow direction. [Recommended Practice]

6.1.24 Hook-up piping spools shall have excess material for field adjustment in the three orthogonal directions. When required organic coating by the piping specification, the hook-up spool shall be flanged and the coating shall be applied only post module lifting, after spool fit-up and welding.

6.1.25 Chemical injection lines arrangement shall comply with I-ET-3010.00-1200-940-P4X-005.

6.1.26 Hydrocarbon lines shall not pass through or under accommodation. Hydrocarbon lines adjacent to the accommodation module can be accepted, as long as they are seamless and have no flanges, valves or other non-welded connections. In this case, a risk analysis is necessary.

6.1.27 Piping containing liquids should not pass through rooms containing electrical panels, transformers, telecommunication, control equipment, or essential equipment (emergency generators, fire pumps, essential electrical panels, etc.) except piping for condensed water the coils of machines with air condensation. If deemed necessary, these lines shall be all-welded and without potential leaking points, e.g., flanges, valves, drains, vents, etc. Pipelines carrying liquids at a high flow or pressure should not be installed adjacent to these rooms. Any piping subject to condensation must be insulated or provided with a drainpipe.

6.1.28 The pipes and ducts in the accommodation areas must run in specific trunk for this purpose and must have access for inspection and maintenance. The distribution branches must provide access to the valves, including those of the sewage collection system.

6.1.29 The straight piping sections upstream and downstream from orifice flanges shall comply with API RP 551. Easy access shall be provided to orifice flanges.

6.1.30 Personal protective shields are preferable to thermal insulation on hot lines where personal protection is required.

6.1.31 Blanks shall be according to ASME B16.48. For larger diameters, not included in the scope of B16.48, paddle blanks and paddle spacers should be used, with dimensions according to ANNEX A. Blanks and



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spacers shall be used preferable rather than figure-8 (spectacle blind) for combination of class and sizes above those listed in Table 2.

Table 2 – Maximum recommended size for figure-8 (spectacle blind)

| Class | Size (NPS) |
|-------|------------|
| 150 | 14 |
| 300 | 10 |
| 600 | 8 |
| 900 | 6 |
| 1500 | 6 |
| 2500 | 4 |

6.1.32 Changes of direction in drainage system shall use tees rather than elbows to allow cleaning.

7 LAYOUT OF PIPING CONNECTED TO EQUIPMENT

7.1 General Requirements

- 7.1.1 Piping connected to any type of equipment (e.g., pumps, compressors, flare ignition system, flame arrester, valves etc.) shall comply with requirements of equipment manufacturer. Manufacturer requirements override the ones in this Technical Specification.
- 7.1.2 On intake piping of any machine (such as pumps, turbines and compressors) a temporary strainer shall be provided, except when there is a permanent strainer on the piping. The temporary strainer shall be installed in such a manner as to allow it to be easily placed and removed.
- 7.1.3 The forces and moments caused by the piping on nozzles of any machine (due to thermal expansion, dead weight, or any other case) shall be below the allowable limits provided by the manufacturers of those machines. The values provided in API STD 610 and API STD 617 may be taken as a preliminary indication.
- 7.1.4 Piping shall be designed in such a way that vessels and equipment can be easily blocked for maintenance without posing any risks. Blocking shall be done by means of block valves or blanks placed at strategic points of the piping, and easily accessed from the ground or from any platform or operating floor. Blanks shall be depicted on engineering process diagrams.
- 7.1.5 The design shall provide means to allow blanks to be inserted or rotated such as: adjustable supports, valve or spool removal, or enough piping flexibility. Sufficient flexibility in the piping system shall also be assured for removal of valves and other inline items. Particular attention shall be paid to items with metallic seal rings, such as ring type joint flanges, compact flanges or clamp connectors. Items that protrude axially into the pipe (e.g., conical strainers) will normally require break out spools. Break out spools shall be as short as possible.
- 7.1.6 When no provision is made for these blanks, the piping layout shall allow valves or other components to be removed for the installation of blind flanges, caps or plugs.
- 7.1.7 Chemical injection skid shall be as near as possible to injection points, to reduce length and welds to be inspected.
- 7.1.8 For parallel equipment trains, with a parallel layout within the same area, piping arrangement may be mirror imaged to get easy access to common maintenance areas.

7.2 Piping Connected to Pumps

- 7.2.1 The piping arrangement shall be such as to allow for easy and free access for pump operation and maintenance, as well as for removal of the pump and driver, minimizing disassembly on piping to the greatest extent possible. Figure 4 shows some typical arrangements.

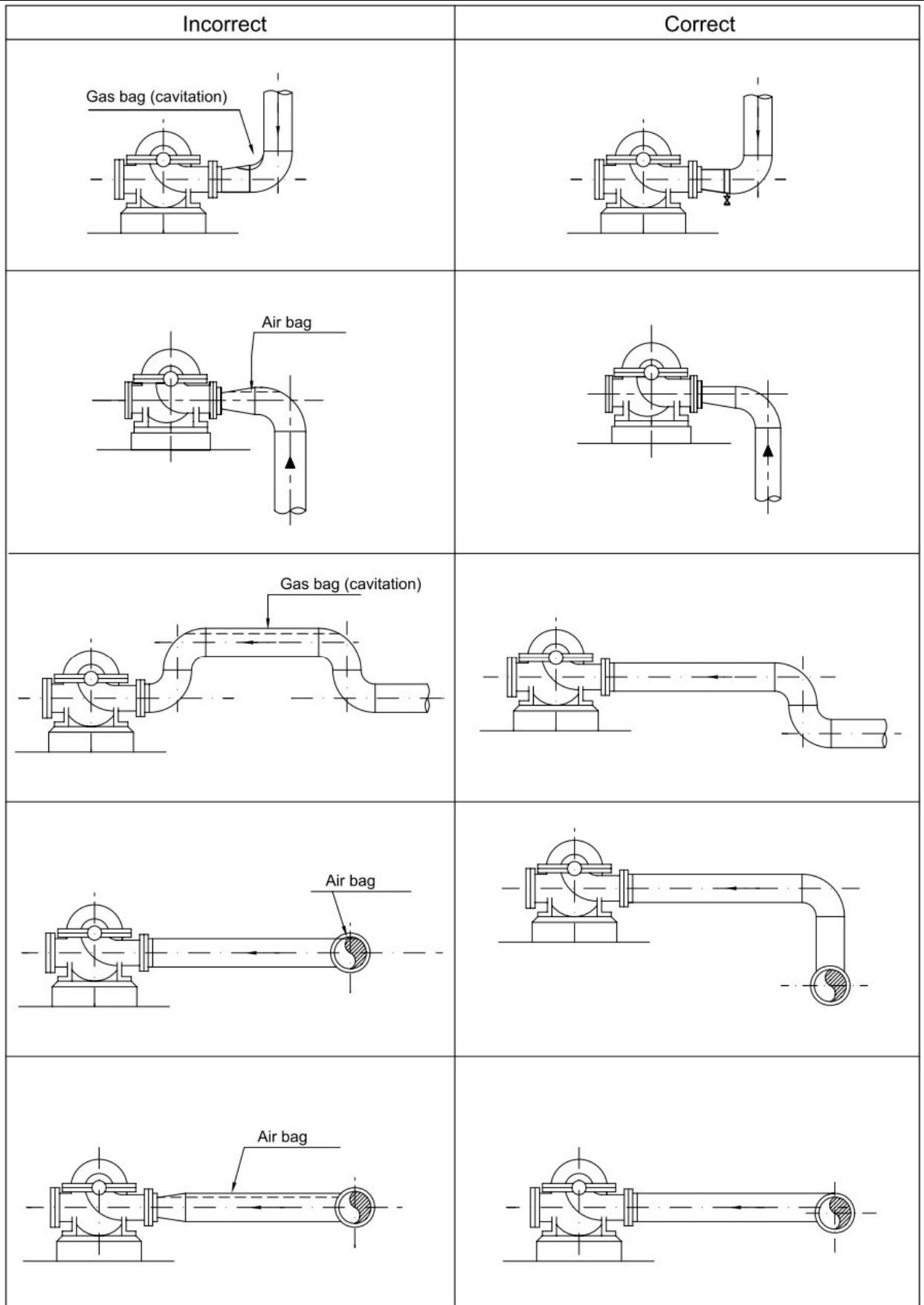


Figure 4 – Typical arrangements (sketch) of pump suction lines



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7.2.2 The layout of the suction pipes must be as short and straight as possible, without high or low points, considering the necessary flexibility required for the lines. Unless otherwise specified by pump manufacturer, a minimum pipe length of 5 x NPS (five times the nominal pipe diameter) shall be provided without components that cause disturbance to the flow, such as tees, short radius elbows, permanent filters and reduced-bore valves. Example of components that do not disturb the flow: full bore valves, reductions and long radius elbows.

7.2.3 Pump operation valves shall be easily accessible, avoiding operation by drive chains or extension rods.

7.2.4 Drains shall be provided upstream from suction valves at the lowest point and downstream from check valves at the discharge point, to allow full drainage and pipe cleaning operations with pumps blocked.

NOTE: When it is possible to drain the suction piping through the pump, a drain upstream from the suction valve may be dispensed. [Recommended Practice]

7.2.5 Installation of valves close to pumps shall comply with the following criteria:

- a) pumps with flooded suction or parallel pumps suctioning from the same header line: mandatory installation of a block valve close to the suction nozzle of each pump; this valve is not recommended for pumps with non-flooded suction, and that are not in parallel with other pumps;
- b) pumps with non-flooded suction: mandatory installation of a check valve (foot valve) at the free end of the suction line, sufficiently immersed in the liquid of the suction tank;
- c) discharge piping (in all cases): mandatory installation of a block valve close to the discharge nozzle of each pump;
- d) pumps discharging to a higher static level or parallel pumps discharging to the same header line: installation of a check valve close to the discharge nozzle of each pump, in addition to the block valve in enumeration c). Non-slam check valves shall be used for pumps with greater than 185 kilowatt (250 horsepower) nominal driver rating or NPS 12 or greater piping.

7.2.6 Special care shall be taken with respect to piping connected to positive displacement pumps, to avoid undesirable vibrations in the systems.

7.2.7 When the diameter of the pump nozzle is smaller than the piping connected to the nozzle, Table 3 should be used for the sizing of valves close to the pump. [Recommended Practice]

Table 3 - Valve Sizing

| Nozzle | Nominal nozzle diameter | Minimum Nominal valve diameter |
|-----------|---|---|
| Suction | One diameter smaller than the piping | Same diameter as the piping |
| | 2 or more nominal diameters smaller than the piping | One diameter smaller than the piping |
| Discharge | Smaller than the piping | One nominal diameter larger than the nozzle |

7.2.8 When the diameter of the suction piping is larger than the pump intake nozzle, the reduction placed adjacent to the pump shall be in accordance with Figure 4.

7.2.9 Branches for two or more pumps operating in parallel, suctioning from the same header line, as well as for double suction centrifugal pumps, shall be as symmetrical as possible, with the same head loss, to prevent preferential flow through a branch.

7.2.10 Positive displacement pumps shall be provided with a bypass and a vent valve at the discharge with the same pump flow capacity.

7.2.11 Discharge piping of dosing pumps shall meet the requirements stipulated by the pump manufacturer.



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7.2.12 Piping design and layout shall comply with API 610, API 674, I-ET-3010.00-1200-310-P4X-001 and I-ET-3010.00-1200-310-P4X-002 as applicable.

7.3 Diesel Engines

7.3.1 Piping shall not be run directly over diesel engines, exhaust piping or any position where leaking fuel oil can impinge onto hot parts.

7.4 Piping Connected to Turbines

7.4.1 The same requirements and recommendations of 7.2.1 and 7.2.3 are applicable.

7.4.2 When two or more turbines share a control valve, block valves shall be provided at the intake nozzle of each turbine. Block valves shall also be provided at the discharge of each turbine.

7.5 Piping Connected to Vessels

7.5.1 Piping shall be arranged in such a manner as not to obstruct access for operation, maintenance and tests. All manhole covers as well as other removable parts of the vessels shall be left completely unobstructed.

7.5.2 Manway hinges/davits shall be oriented such that the cover opens away from ladders/stairs and instrument access.

7.5.3 Piping shall run at least 300 mm away from external surface of pressure vessels or its external insulation.

7.5.4 For vertical vessels, nozzles connected to piping and instruments shall be grouped together preferably in one or two sectors properly chosen on the vessel shell.

7.5.5 All valves shall be accessible for operation from the floor or platform.

7.5.6 Forces imposed by piping on vessel nozzles (due to thermal expansion, weights etc.) cannot cause stresses larger than those stresses allowed by I-ET-3010.00-1200-540-P4X-001. Nozzle displacements due to thermal expansion of the vessels shall be considered.

7.6 Piping Connected to Heat Exchangers

7.6.1 Forces imposed by piping on heat exchangers nozzles (due to thermal expansion, weights etc.) cannot cause stresses larger than those allowed on the nozzles shown in I-ET-3010.00-1200-540-P4X-001 I-ET-3010.00-1200-451-P4X-001, I-ET-3010.00-1200-456-P4X-001 and I-ET-3010.00-1200-459-P4X-001, as applicable. Nozzle displacements due to thermal expansion of the heat exchangers shall be considered.

7.6.2 Piping shall be arranged to allow removal of tube bundles, channel and shell covers without disassembly of piping. It means there shall be no piping in the area in front of the channel cover, within the space needed for tube bundle removal. There shall also be sufficient space left in the entire perimeter of equipment to allow bolts to be dismantled. If required, include a pair of flanges (maintenance spool) in piping connected to the top nozzle of the channel to facilitate the dismantling and enable the removal of the channel during maintenance shutdowns.

7.6.3 Provision shall be made in the piping design for an area for cleaning operations, with water taps, electrical outlets, access to machines, and lighting.

7.6.4 Cooling water piping connected to heat exchangers shall be arranged in such a way as to prevent water from being drained by the outlet piping in the event of a feed failure.

7.6.5 The arrangement shall provide for blocking (even in series) and bypass piping whenever heat exchangers are subject to individual in-service maintenance.



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7.6.6 In the case of heat exchangers stacked one on top of the other, blanks shall be provided to allow individual hydrostatic testing of the equipment.

7.7 Piping Connected to Compressors

7.7.1 The arrangement of compressor piping shall facilitate dismantling of the housing and removal of inside parts.

7.7.2 Low points in suction lines shall be avoided, and piping shall be as straight as possible to avoid surge and head loss problems. Whenever necessary, provision shall be made for removal of accumulated condensate and dirt. Suction lines shall preferably have an upward flow. Air intakes for air compressor shall be located away from windows, steel stacks, vents, or any other source of air contamination, and shall not be positioned at a point that restricts suction.

7.7.3 Piping connected to the compressor shall not transmit excessive forces due to weights and thermal expansion, according to the provisions in 7.1.3. Supports or expansion joints shall be provided to minimize the effects of pulsation and vibrations. Supports shall be conveniently spaced to prevent vibrations. Piping shall preferably not have supports on the compressor foundation block.

7.7.4 Compressor operation valves shall be accessible from the floor or platforms.

7.7.5 Condensate drained from each pressure stage shall be collected by independent piping. When there is a single condensate piping, proper means shall be provided to prevent the high-pressure condensate from returning to the lower pressure stages.

7.7.6 Pulsation damper vessels shall be placed as close as possible to the compressor discharge and, if necessary, at the suction line.

7.7.7 Suction line filters shall be provided.

7.7.8 Steam traps shall be installed at low points of compressed air distribution piping.

7.7.9 Piping design and layout shall comply with API RP 686.

8 VALVES

8.1 General Considerations

8.1.1 Valves position shall comply with I-ET-3010.2E-1350-196-P4X-002.

8.1.2 All valves shall be installed in such a way as to facilitate operation and allow dismantling or removal when necessary. Lever operated valves shall be installed with sufficient clearance to allow the lever to be operated. Motorized valves shall also have access for manual operation.

8.1.3 Control valve to be installed in other position than with stem/shaft pointing upward requires previous approval from manufacturer.

8.1.4 For valves located beneath platforms or decks, extension stems may be used.

8.1.5 Valves shall be oriented in such a way as to ensure that in all positions (open to close) their stems or levers will not obstruct or prevent passage of operation and maintenance personnel.

8.1.6 No valve shall be placed with its stem in vertical direction pointing downward, except Category 3 valves as per I-ET-3010.2E-1350-196-P4X-002.

8.1.7 Block valves shall be installed as near as possible from run lines, to reduce length of dead legs.

8.1.8 Reducers in conjunction with control or safety relief valves shall be located directly upstream/downstream the valve.



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8.1.9 Permanent access to valves that are likely to be operated only rarely (less than once per year) may be omitted with OWNER approval. In these cases, CONTRACTOR shall demonstrate that the valves are positioned such that access from temporary facilities can be obtained in a safe and proper way. The temporary facilities shall be included as volumes in the 3D computer assisted design model to ensure space reservation.

8.1.10 Actuator dimensions and weight shall be obtained from manufacturer or certified drawing, not from catalogs.

8.1.11 Valves identified in P&IDs as LC (locked close) or LO (locked open) shall be installed with a warning label according to annex A of PE-3BUZ-00123 and with a locking device, which might consist of:

- Steel cable or a metallic clamp, whose materials are sufficiently resistant, and which can only be broken intentionally and with the use of a tool, or;
- A chain with padlock, a padlock, or other commercial device that mechanically locks the valve actuator and prevents it from being actuated, or;
- A valve interlock system.

8.2 Safety Relief Valves

8.2.1 Piping containing liquids shall be provided with safety relief valves in the sections between two block valves.

8.2.2 Safety relief valves shall preferably discharge to the top of a collecting pipe. This collecting pipe cannot have low points. Piping between the PSV and the collector shall have a constant downward slope towards the collector, to prevent liquid accumulation so that the design relieving capacity of any of the pressure-relieving devices is not reduced. Mechanical design of piping connected to PSV must meet the requirements of API STD 520 PT II.

8.2.3 Discharge from any PSV to atmosphere shall be located in such a way as not to reach personnel or equipment.

8.2.4 Safety relief valves shall be located close to the piping or equipment to be protected. When this is not possible, the head loss in the valve inlet piping shall be checked in accordance with API STD 520 PT I.

8.2.5 The PSV discharge piping shall be properly supported considering discharge thrust load, vibrations and other dynamic effects inherent in the flow type. Easy access shall also be provided for maintenance of these valves.

8.2.6 Block valves installed at inlet or discharge lines of a PSV shall be provided with a device against inadvertent blocking.

8.3 Control Valves (Regulating and On-off)

8.3.1 Control valves shall be located as near as possible to the relevant equipment to which they apply, unless otherwise specified.

8.3.2 Sufficient space shall be left for dismantling and maintenance of actuator and valve stem/shaft.

8.3.3 Control valves shall be, whenever possible, located at floor level, in an easily accessible location.

8.3.4 Level control valves in vessels shall be installed in such a manner as to allow the level gauge to be visible during the operation of the bypass line-regulating valve.

8.3.5 Control valves operated by a local controller shall be located within the visual range of the controller to enable the operation of the valve to be observed while adjustments are made on the controller.



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8.3.6 Proper supports shall be provided for lines with control valves to avoid vibrations.

8.3.7 Elbows and tees connections shall be placed at least 2 x NPS straight run upstream (with a minimum of 300 mm) and 6 x NPS straight run downstream (with a minimum of 500 mm) of control valves, except otherwise specified by valve manufacturer.

8.4 Check valves

8.4.1 Check valves should be installed, preferably, in horizontal lines. They may be installed in vertical lines providing the flow is upwards and valve type is suitable for this type of installation. Usually, lift check valves shall not be installed in vertical lines. Draining of the downstream side shall be provided.

8.4.2 In services where two dissimilar check valves (non-slam and dual plate) are required to be installed next to each other, the non-slam check valve shall be installed upstream of the dual plate check valve. In addition, the check valves shall not be installed directly against each other.

8.5 Butterfly valves

8.5.1 Butterfly valves close to centrifugal pumps shall be installed with stem/shaft orthogonal to pump shaft.

8.5.2 Butterfly valves close to elbow, tee or eccentric reducer, shall be installed with stem/shaft in the same plane of elbow/tee/eccentric reducer.

8.5.3 Concentric butterfly valves shall be installed with no gaskets between valve and flanges.

8.5.4 For installation of concentric (category A) butterfly valves, valve manufacturer's installation instructions, including bolt torque, shall be followed.

9 BELLOWS EXPANSION JOINTS

9.1.1 The use of expansion joints shall be avoided whenever possible, and a route with changes in direction in the plane or in space is preferred, so that the piping has its own flexibility and does not cause loads or stresses greater than allowable values on equipment.

9.1.2 When expansion joints are used, the system shall be properly supported, anchored, and guided in a manner to ensure joints will not be subjected to the weight of piping or any forces or stresses greater than allowable values.

9.1.3 All expansion joints (except swivel joints) shall be obligatorily placed between two anchor points or axial stops, and between those points there can only be one expansion joint.

9.1.4 All expansion joints shall be supplied flanged (spool type).

9.1.5 All expansion joints shall have its tie rods designed to resist a load equal to a hydrostatic thrust force caused by a pressure of 1.5 times the maximum allowable pressure of the piping.

9.1.6 Piping arrangement and supports shall comply with EJMA or MANUFACTURER requirements.

9.1.7 Shipping devices, which shall be removed after installation, shall be painted yellow and indicated on expansion joint documentation.

9.1.8 Expansion joints shall be located in accessible areas, in order to allow inspection and maintenance.

9.1.9 Rigid expansion joints (Dresser type) shall comply with I-ET-3010.2E-5410-253-P4X-002 - REQUIREMENTS FOR RIGID EXPANSION JOINTS (DRESSER TYPE).



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10 PIPING SUPPORTS

10.1.1 Piping supports shall comply with I-ET-3010.00-1200-200-P4X-004.

10.1.2 When there is the possibility of removing items to provide calibration, maintenance or commissioning (e.g., PSVs, in-line instruments, strainer spools, channels, etc.) the supports shall be installed in such a way that the line is still properly supported after the item is removed. Supports installed on removable items shall be avoided.

11 VENTS, DRAINS, INSTRUMENT CONNECTIONS AND SMALL-BORE BRANCHES

11.1.1 The installation of vents at all high points and drains at all low points is mandatory for any piping, if those required by the P&IDs are not sufficient/suitable.

11.1.2 Drainage system shall comply with requirements of I-RL-3010.2E-1200-940-P4X-003.

11.1.3 Drains, vents and instrument connections arrangement shall be according to Annex C of I-ET-3010.2E-1200-200-P4X-001.

11.1.4 Welded supports should be installed preferably rather than Brace/clamp supports. For lines connected to positive displacement pump and compressor or to overboard control valves welded braces shall be used..

11.1.5 Typical layout configuration for small bore connections that may not be removed, e.g., drain, vent and instrument connection, shall be presented in the Piping Stress and Flexibility Analysis Technical Specification. As minimum, it shall be indicated the typical configurations with support and the maximum length without supports for each configuration and piping class. As recommended practice:

11.1.5.1 The typical configuration shall consider that any mass at the free end of a cantilever should be supported from the main pipe, in both directions perpendicular to the axis of the small-bore connection.

11.1.5.2 The typical configuration for unsupported length of SBC shall be as shorter as possible.

11.1.5.3 The typical configurations shall guarantee 5Hz as minimum natural frequency.

11.1.6 Small bore connections in lines with multiphase flow or subjected to vibration (e.g., lines connected to positive displacement compressor or in high-pressure water injection system) shall use sweeplet or insert weldolet connection rather than sockolet.

11.1.6.1 These branches shall be supported in two planes, connected between the small-bore pipework and the main pipe. Under no circumstances may these connections be braced from local structure such as steelwork, decks or bulkheads.

11.1.6.2 Supports shall have sufficiently stiffness. The support should be at least as stiff as the connection to be of any effect.

11.1.6.3 Design of support weld shall consider fatigue strength.

11.1.6.4 Any fastenings used shall be designed to be effective under vibration (e.g., bolted clamps include anti-vibration washers/lock nuts).

11.1.6.5 For examples of small-bore connection configurations and supports see T5 and T11 from Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework. [RECOMMENDED PRACTICE]

11.1.7 For other systems than those in 11.1.6 the use of supports in small bore branches shall be evaluated to prevent static and dynamic failure.



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11.1.8 For small bore piping running with a large span between structural supports, when the support is installed to a parent pipe of relatively small diameter (i.e., typically less than NPS 6) the effect of the added mass could affect the response of the parent pipe; this influence shall be clearly evaluated.

11.1.9 The diameter of small-bore branches and connections should be maximized to increase the stiffness of the arrangement.

12 ADDITIONAL REQUIREMENTS FOR DESIGN PRESENTATION

The design deliverables are those defined in the contract.

The purpose of this section is to present additional requirements applicable to the content of some documents.

12.1 Line List

12.1.1 The line list shall include, besides process information, the following data (extracted from database):

- The fluid class according to NR-13. In order to facilitate the identification of lines applicable to NR-13, fluid classes shall be grouped as A/B or C/D;
- The inspection class according to I-ET-3010.00-1200-200-P4X-115;
- The external coating code (N/A = not applicable; the paint scheme number according to I-ET-3010.00-1200-956-P4X-002; or TSA);
- The fluid service or condition according to ASME B31.3 (D = category D; ET = elevated temperature; HP = high pressure; M = category M; N = normal; SC = severe cyclic condition);
- Color code.

12.2 Isometrics

12.2.1 Each isometric drawing shall contain only one entire line.

12.2.2 Before starting the execution of isometrics, a typical isometric shall be submitted to OWNER, for comments.

12.2.3 All supports (welded or not) shall be indicated in the isometric with the respective tag.

12.2.4 The isometric shall include following data (extracted from 3D model), as minimum:

- The inspection class according to I-ET-3010.00-1200-200-P4X-115;
- The external coating code (N/A = not applicable; the paint scheme number according to I-ET-3010.00-1200-956-P4X-002; or TSA) and color code;
- The identification code of pipe material and fittings (see Annex B of I-ET-3010.2E-1200-200-P4X-001);
- Valve tag (same shown in P&ID) and valve code (from piping specsheet) ;
- Spools tags;
- Supports tags;
- Isometrics list number.

12.2.5 Isometrics shall contain additional information on basic quantitative items, such as weight and area, required for general thermal insulation, painting and coating services.



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| TITLE: | MINIMUM REQUIREMENTS FOR PIPING MECHANICAL DESIGN AND LAYOUT | | INTERNAL | |
| | | | ESUP | |

12.3 Specifications of Unlisted Components

12.3.1 It shall be issued data sheets, drawings, calculation reports and specifications of all piping components and sub-components that do not fully comply with a standard.

12.3.2 Examples of unlisted components are (not limited to):

- a) Flanges (including its gasket or seal joint) beyond the scope of ASME B16.5, ISO 27509 or API 6A, or those whose geometry differs from the standard;
- b) Valves beyond the scope of ASME B16.34, API 6D, API 6A or other applicable standard;
- c) Non-symmetrical piggable "Y" connections.

12.4 API 6A Flanges

It shall be issued drawings with API 6A flanges dimensions, including details for welding.

If the nominal bore of the welding end is different from the nominal bore of the pipe the flange shall be taper bored from the weld end according to API 6A.

However, requirements for minimum wall thickness shall apply.

13 RECOMMENDED STANDARDS [RECOMMEDED PRACTICE]

API RP 14E - Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems.

API RP 686 - Recommended Practice for Machinery Installation and Installation Design

Energy Institute - Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework, items T5, T11 and T13.

ISO 13703 - Petroleum and natural gas industries - Design and installation of piping systems on offshore production platforms.

NORSOK L-002 - PIPING DESIGN, LAYOUT AND STRESS ANALYSIS.

ANNEX A

Materials and coating, as applicable, shall be according to the piping specsheet.

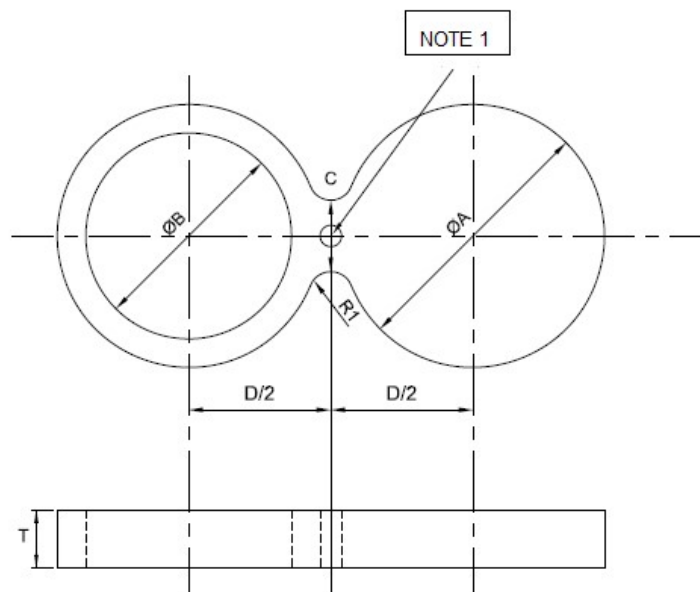
Dimensions shall be according to Table 4, Table 5, Figure 5 and Figure 6. Other dimensions according to ASME B16.47 Series A flanges.

Table 4 – Dimensions (mm) of paddle blanks and paddle spacers class 150

| NPS | A | B | C | D | G | H | R1 | R2 | T, min. |
|-----|------|------|-----|--------|-----|------|------|----|---------|
| 26 | 771 | 654 | 140 | 806,4 | 220 | 25,4 | 29,9 | 20 | 35 |
| 28 | 828 | 705 | 140 | 863,6 | 220 | | 29,9 | | 37 |
| 30 | 879 | 756 | 140 | 914,4 | 230 | | 28,1 | | 40 |
| 32 | 936 | 807 | 140 | 977,9 | 230 | | 28,1 | | 42 |
| 34 | 987 | 858 | 150 | 1028,7 | 230 | | 28,1 | | 45 |
| 36 | 1045 | 908 | 150 | 1085,8 | 250 | | 30,6 | | 48 |
| 38 | 1108 | 959 | 150 | 1149,4 | 250 | | 30,6 | | 50 |
| 40 | 1158 | 1010 | 150 | 1200,2 | 250 | | 30,6 | | 53 |
| 42 | 1143 | 1061 | 115 | 1257,3 | 260 | | 19,3 | | 55 |

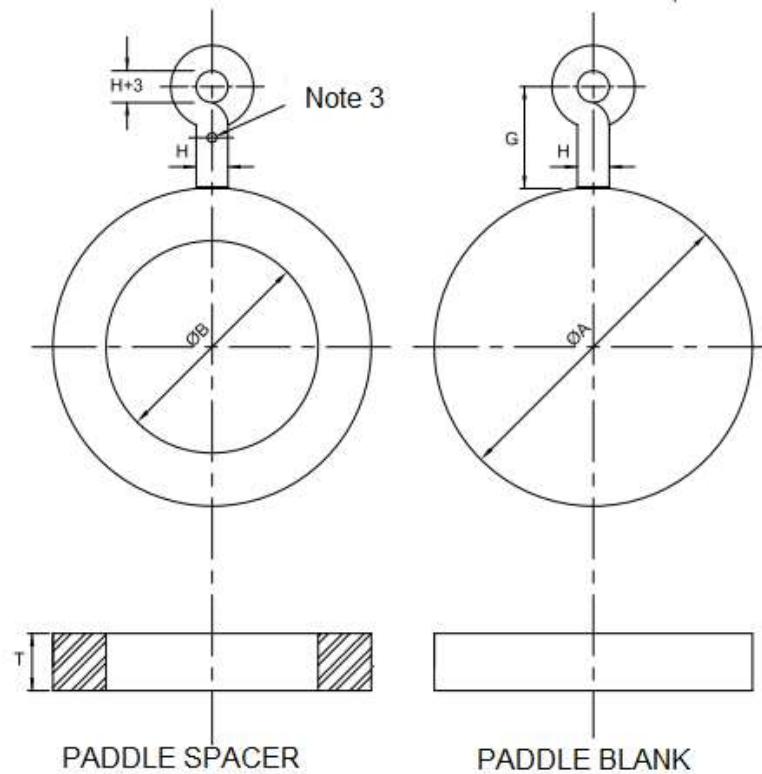
Table 5 – Dimensions of paddle blanks and paddle spacers class 300

| NPS | A | B | C | D | G | H | R1 | R2 | T, min. |
|-----|------|------|-----|--------|-----|------|------|----|---------|
| 26 | 832 | 654 | 130 | 876,3 | 260 | 25,4 | 33 | 20 | 57 |
| 30 | 949 | 756 | 155 | 997 | 260 | | 37 | | 66 |
| 36 | 1114 | 908 | 155 | 1168,4 | 280 | | 38,6 | | 79 |
| 42 | 1194 | 1061 | 150 | 1206,5 | 270 | | 34,9 | | 92 |



Note 1: Hole diameter shall be equal to the diameter of the flange holes.

Figure 5 – Figure-8 dimensions



Note 3: 6 mm hole to identify the paddle spacer.

Figure 6 - Paddle spacer and paddle blank dimensions