PIP PNE00002
Piping Material Specification Selection, Development, and Application Guidelines
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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1. Scope

This Practice provides guidelines for the selection, development, and application of piping material specifications and applicable standards for the design, fabrication, installation, examination and testing of piping systems for process facilities (e.g., refineries, chemical plants, terminals, and related facilities). This Practice applies to piping designed in accordance with ASME B31.1 or ASME B31.3.

2. References

Applicable parts of the following PIP Practice and industry codes and standards should be considered an integral part of this Guideline. The edition in effect on the date of contract award should be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP PNC00001 - Pipe Support Criteria for ASME B31.3 Metallic Piping
- PIP PNC0002 - Abbreviated Piping Terms and Acronyms
- PIP PNC0005 - Design of ASME B31.3 Metallic Piping Systems
- PIP PNCM0001 - Piping Line Class Designator System
- PIP PNCM0004 - Valve Commodity Codes Designator System
- PIP PNE00003 - Process Unit and Offsite Layout Guide
- PIP PNE00004 - Steam Trap Guidelines
- PIP PNE00012 - Piping Examination and Leak Testing Guide
- PIP PNEM0001 - Piping Service Index
- PIP PNF0200 - Vents, Drains and Instrument Connection Details
- PIP PNFJ8000 - Jacketed Piping Fabrication & Installation Details
- PIP PNFS0001 - Pipe Support Details
- PIP PNSC0001 - ASME B31.3 Metallic Piping Fabrication and Examination Specification
- PIP PNSC0011 - Installation of ASME B31.3 Metallic Piping
- PIP PNSC0021 - Leak Test of Piping Systems
- PIP PNSC0035 - Steam Tracing Specification
- PIP PNSC0036 - Installation of High Density Polyethylene (HPDE) Piping
- PIP PNSC0037 - Aboveground Reinforced Thermosetting Resin (RTR) Piping System Requirements
- PIP PNSM0105 - Purchasing Requirements for Gaskets
- PIP PNSM0110 - Procurement of Valves
- PIP PNSM0115 - Purchasing Requirements for Pipe
- PIP PNSM0116 - Purchasing Requirements for Fittings and Flanges
- PIP PNSM0120 - Purchasing Requirements for Bolting
2.2 Industry Codes and Standards

- American Petroleum Institute (API)
  - API SPEC 6D - Specification for Pipeline and Piping Valves
  - API STD 526 - Flanged Steel Pressure Relief Valves
  - API STD 527 - Seat Tightness of Pressure Relief Valves
  - API STD 594 - Check Valves: Flanged, Lug, Wafer and Butt-Welding
  - API STD 598 - Valve Inspection & Testing
  - API STD 599 - Metal Plug Valves - Flanged, Threaded and Welding Ends
  - API STD 600 - Steel Gate Valves - Flanged and Butt-Welding Ends, Bolted Bonnets
  - API STD 602 - Gate, Globe, and Check Valves for Sizes DN 100 (NPS 4) and Smaller for the Petroleum and Natural Gas Industries
  - API STD 603 - Corrosion-Resistant, Bolted Bonnet Gate Valves - Flanged and Butt-Welding Ends
  - API STD 607 - Fire Test for Quarter-Turn Valves and Valves with Nonmetallic Seats
  - API STD 608 - Metal Ball Valves - Flanged, Threaded, and Welding Ends
  - API STD 609 - Butterfly Valves: Double Flanged, Lug- and Wafer-Type
  - API STD 623 - Steel Globe Valves-Flanged and Butt-welding Ends, Bolted Bonnets

- American Society of Mechanical Engineers (ASME)
  - ASME Boiler and Pressure Vessel Code (B&PVC)
  - ASME A13.1 - Scheme for the Identification of Piping Systems
  - ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves
  - ASME B16.11 - Forged Fittings, Socket-Welding and Threaded
  - ASME B16.20 - Metallic Gaskets for Pipe Flanges
  - ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges
  - ASME B16.34 - Valves - Flanged, Threaded, and Welding End
  - ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard
  - ASME B16.9 - Factory-Made Wrought Buttwelding Fittings
  - ASME B31.1 - Power Piping
  - ASME B31.3 - Process Piping
  - ASME B36.10M - Welded and Seamless Wrought Steel Pipe
  - ASME B36.19M - Stainless Steel Pipe
  - ASME PCC-1 - Guidelines for Pressure Boundary Bolted Flange Joint Assembly
• American Society for Testing Materials (ASTM)
  – ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
  – ASTM A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
  – ASTM A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low Temperature Service
  – ASTM F704 - Standard Practice for Selecting Bolting Lengths for Piping System Flanged Joints

• Manufacturer’s Standardization Society (MSS)
  – MSS-SP-95 - Swage(d) Nipples and Bull Plugs
  – MSS-SP-97 - Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, Buttwelding Ends

• Pipe Fabrication Institute (PFI)
  – PFI-ES1 - Internal Machining and Solid Machined Backing Rings For Circumferential Butt Welds
  – PFI-ES2 - Method of Dimensioning Piping Assemblies
  – PFI-ES3 - Fabricating Tolerances
  – PFI-ES4 - Hydrostatic Testing of Fabricated Piping
  – PFI-ES5 - Cleaning of Fabricated Piping
  – PFI-ES7 - Minimum Length and Spacing for Welded Branch Connections
  – PFI-ES11 - Permanent Marking on Piping Materials
  – PFI-ES16 - Access Holes, Bosses, and Plugs for Radiographic Inspection of Pipe Welds
  – PFI-ES20 - Wall Thickness Measurement by Ultrasonic Examination
  – PFI-ES21 - Internal Machining and Fit-up of GTAW Root Pass Circumferential Butt Welds
  – PFI-ES22 - Recommended Practice for Color Coding of Piping Materials
  – PFI-ES24 - Pipe Bending Methods, Tolerances, Process and Material Requirements
  – PFI-ES26 - Welded Load Bearing Attachments to Pressure Retaining Piping Materials
  – PFI-ES29 - Internal Abrasive Blast Cleaning of Ferritic Piping
  – PFI-ES31 - Standard for Protection of Ends of Fabricated Piping Assemblies
  – PFI-ES32 - Tool Calibration
  – PFI-ES34 - Temporary Painting/Coating of Fabricated Piping
  – PFI-ES35 - Nonsymmetrical Bevels and Joint Configurations for Butt Welds
  – PFI-ES37 - Standard for Loading and Shipping of Piping Assemblies
  – PFI-ES39 - Fabricating Tolerances for Grooved Piping Systems
3. Definitions

material specification: A document that describes specific physical or chemical properties or manufacturing methods that a material is to be in accordance with in order to qualify for designation under the specification

owner: The party who owns the facility wherein the piping system will be used

piping material specification (PMS): A document that defines compatible piping, valves, flanges, fittings, gaskets, and bolting materials for a particular pressure-temperature rating class and set of material specifications. Additional design related information is typically shown in a PMS as pressure-temperature rating tables and branch reinforcing tables.

4. General

4.1 All materials should be in accordance with the material specifications shown in the piping materials specifications (PMS) whether shown in a PIP Practice or owner’s PMS or addenda.

4.2 The documents listed in Section 2 provide the basis for acceptable design practice for piping systems used in the conveyance of gas, liquid, and vapor process and utility streams; and define the minimum requirements for the design, selection, specification, procurement, and installation of piping materials for these systems.

5. Design Considerations

5.1 Determinations concerning fitness for purpose and particular matters or application of this Practice to a particular project or engineering situation should not be made solely on information contained in this Practice. Because the suitability of any practice, guide or standard to any particular project requires the exercise of professional judgment and is dependent upon various conditions unique to each project, appropriate professionals should be consulted before applying or acting on any material contained in or suggested by this Practice or documents referenced herein.

5.2 Unless specifically designed for higher temperatures, steam-out design should be based on the premise that process piping and equipment are not at any time subject to steam pressures greater than 3.5 barg (50 psig) or metal temperatures greater than 149ºC (300°F).

5.3 Design for elevated temperatures for piping systems should include consideration of temperature limitations for any components, elastomers, coatings, or other associated systems that could be impacted.
5.4 Minimum ambient temperature at the facility location should be considered when setting
the minimum design, because it can affect the selection of materials.

5.5 Flanges should be matched in both class rating and facing (e.g., flat face flanges should
not be used with raised face flanges or Class 150 flanges should not be used with Class
300 flanges).

5.6 Permanent records of all flexibility analyses should be maintained by owner as part of
process safety information or an engineering records library.

6. Material Specifications

6.1 Piping and component materials should be in accordance with published ASTM
standards as listed or referenced in ASME B31.1 or ASME B31.3, as appropriate.

6.2 The selection of a material grade for a piping system should be determined through the
use of process knowledge, operating experience, the appropriate metallurgical corrosion
data, or material compatibility charts.

6.3 Often, multiple material selections are suitable for a particular service or application with
some materials offering superior performance to others. It is the responsibility of the
engineering design team to determine the specific materials of construction considering
environmental/safety/health (EHS) risk, mechanical integrity, reliability, and cost.

7. Piping Material Specifications (PMS)

7.1 Piping material specifications define the material and rating class for listed components that
are compatible with each other for the service stated in owner’s PMS and/or PIP Practices.

7.2 PMS provide complementary information necessary to execute the design process.

7.3 PMS do not represent a complete engineering solution and should not be used as a
substitute for an appropriate design process using the codes and standards referenced in
Section 2.

7.4 The selection or development of a PMS is part of the piping design process as shown in
the work flow diagram, Figure 1.

8. PMS Selection

8.1 Figure 2 shows the work flow process for determining a suitable PMS for use for a
particular service.

8.2 The work flow includes determining the metallurgy and elastomers, flange rating class,
end connections, and desired corrosion allowance using the references shown.
8.3 To select the final PMS, a search of the PIP Practices or owner’s PMS index should be performed. A PMS that matches the criteria should be selected or a closely matching PMS may be selected and supplemented with addenda showing the variances.

8.4 The order of preference for PMS selection is PIP Practices and then owner’s PMS.

8.5 It is the responsibility of the engineering design team to ensure that all PMSs are suitable for the service.
8.6 If suitable matches are not available for the PMS search criteria, the PMS information can be developed using the work process provided in Section 9.
9. PMS Information and Development

9.1 If a suitable existing PMS is not available, the information for the completion of a piping system design may be developed and, if this information is to be applied to other designs or stored for future use, it may be documented in the format of a PMS.

9.2 A work process for developing PMS information is shown in Figure 3.

Figure 3. PMS Development Work Process
9.3 Figure 3 shows the sequence of steps and resource information required to develop the information that is typically provided in a PIP or owner’s PMS. The work process includes a sequence of steps to determine the following:

a. The process design which defines the process stream, operating conditions, and valve types

b. Metallurgy, fluid service category, pressure rating class, flanges and bolts, the fittings, nipples, wall thickness, gaskets, branch connections, and valve trim and mechanical features

9.4 This work process does not require a pre-defined PMS.

9.5 This work process should provide a code compliant design that is in accordance with Recognized and Generally Accepted Good Engineering Practice (RAGAGEP).

10. PMS Application Considerations

10.1 *PIP PNEM0001*, Table 1 format should be used for the Piping Service Index.

10.2 Caution should be used when applying a PMS to a piping system to ensure the following:

a. None of the components have a temperature or pressure rating that is less than shown in the PMS rating table

b. The strength of the pipe or any component is not exceeded

10.3 Elastomers in valves and gasket materials can have temperature limits that are not suitable for the full pressure temperature range listed. Elastomers should also be checked for compatibility with the service media. Elastomers that fail by explosive decomposition after being exposed to pressurized gas should not be used.

10.4 If superimposed on the static internal pressure stress, external or hydrodynamic loads may impose stresses that can result in exceeding the strength of the piping system.

10.5 Some components (e.g., sight glasses, valves, fittings, expansion joints, or any other interconnected items) may have pressure and temperature ratings less than shown in the PMS table and should be verified before use.

11. PMS Naming Convention

11.1 A naming convention in accordance with *PIP PNCM0001* should be used for all PMS whether as addenda or standalone specifications.

11.2 The use of a PIP-compliant naming convention should not preclude the use of a facility specific alias as a secondary means to designate a PMS. If an alias is used, the facility should maintain a cross reference listing to identify the relationship between the PIP compliant PMS name and its associated alias.
12. Component Requirements

12.1 Bolted Flange Joints

12.1.1 Gaskets

12.1.1.1 Gasket materials should be in accordance with the requirements for the corresponding process stream or as specified in the PMS for the piping system.

12.1.1.2 Gaskets should be in accordance with ASME B16.20 or ASME B16.21 as applicable.

12.1.2 Bolts

12.1.2.1 Bolting should be in accordance with the following standards as applicable:

a. Example: Carbon steel: ASTM A193, Grade B7 stud bolt with two ASTM A194, Grade 2H heavy hex nuts

b. Example: Stainless steel: ASTM A193, Grade B8, Class 2 stud bolt with two ASTM A194, Grade 8 heavy hex nuts

12.1.2.2 If exposure to specific external environmental conditions can lead to accelerated deterioration of carbon steel (e.g., corrosion under insulation), stainless steel bolts or coated carbon steel bolts should be used, particularly for joints where early detection of bolt damage is unlikely.

12.1.2.3 If specifying stainless steel bolts and nuts, caution should be used to ensure that an EHS risk analysis considers all the potential damage mechanisms because some mechanisms may increase the overall risk of failure sufficient to offset the potential mitigating effects gained by using stainless steel.

12.1.2.4 Stainless steel bolts and nuts may not be suitable in operating environments where the potential for environmental stress corrosion cracking exists.

12.1.2.5 The galling potential of stainless steel bolted assemblies and the impact this may have on proper assembly for initial torque and post startup re-torque should be considered.

12.1.2.6 If external corrosion resistance is required, hot dipped galvanized ASTM A193, Grade B7 stud bolts are not recommended as an alternative to stainless steel bolts. Galvanized B7 bolts are not recommended, because the galvanizing process generates hydrogen which collects at root of the thread and this may cause hydrogen embrittlement. The hydrogen embrittlement may cause failure in service. Teflon coated B7 bolts may be considered for providing sufficient protection from external corrosion.

12.2 Steam Traps

12.2.1 Steam traps should be selected in accordance with PIP PNE00004.

12.2.2 Each steam trap should have a non-corrosive permanent tag marked with an assigned unique identification number to facilitate maintenance (e.g., track location, service, performance, repair history).
12.3 Valve Specifications

12.3.1 Applicable Standards

12.3.1.1 Valves should be in accordance with the following documents or equivalent standards as appropriate for the type and intended use:

- **API STD 526**
- **API STD 527**
- **API STD 594**
- **API STD 598**
- **API STD 599**
- **API STD 600**
- **API STD 602**
- **API STD 603**
- **API STD 608**
- **API STD 609**
- **API STD 623**
- **API SPEC 6D**
- **ASME 16.10**
- **ASME B16.34**

12.3.1.2 The PIP Practices listed in Section 12.3.1.1 provide descriptions for a wide variety of valves. If new valves are required, the PIP valve description format should be used.

12.3.2 Valve Naming and Tagging

12.3.2.1 A naming convention in accordance with **PIP PNCM0004** should be used for all valve specifications whether as addenda or standalone specification. This does not preclude the use of an alias as a secondary means to designate the valve specification.

12.3.2.2 The use of a PIP compliant naming convention should not preclude the use of a facility specific alias as a secondary means to designate a valve specification. If an alias is used, the facility should maintain a cross reference listing to identify the relationship between the PIP compliant valve specification name and its associated alias.

12.3.2.3 All valves should be tagged in accordance with **PIP PNSM0110**.

12.3.3 Valve Application Recommendations

12.3.3.1 Extended body gate valves may be used at vent, drain, and instrument connections.

12.3.3.2 Full port valves should be used in suction lines to pumps and inlet/outlet piping to/from relief devices.

12.3.3.3 If environmental fugitive emissions control is required, or process or personnel safety hazards are of concern, gate and globe valves in sizes less than or equal to NPS 2 may have welded bonnet or bellows seal construction to eliminate a potential leak point.
13. **Procurement**

13.1 Procurement for piping and component systems should be in accordance with PIP PNSM0105, PIP PNSM0110, PIP PNSM0115, PIP PNSM0116, and PIP PNSM120.

13.2 All procurement should be in accordance with terms and conditions of a valid contract or owner’s requirements.

14. **Fabrication and Installation**

14.1 **Fabrication**

Fabrication of piping and component systems should be in accordance with the guidelines provided in the following standards and PIP Practices:

- ASME B31.1
- ASME B31.3
- PFI-ES1
- PFI-ES2
- PFI-ES3
- PFI-ES4
- PFI-ES5
- PFI-ES7
- PFI-ES11
- PFI-ES16
- PFI-ES20

14.2 **Installation**

Installation of piping and component systems should be in accordance with PIP PNSC0001, PIP PNSC0006, PIP PNFJ8000, and ASME PCC-1.

14.3 **Post Weld Heat Treatment (PWHT)**

14.3.1 **Based on Material**

14.3.1.1 Post weld heat treatment should be in accordance with ASME B31.3 or ASME B31.1.

14.3.1.2 ASME B31.3, Paragraph 331.1.3 or ASME B31.1, Paragraph 132.4 should be consulted for additional guidelines on the thickness to be used for applying PWHT.

14.3.1.3 Attachment welds to piping that require PWHT should be heat treated, unless the weld size is restricted in accordance with the applicable code, ASME B31.3, Paragraph 331.1.3 (b) (1) and (2), such that stress relief is not required.

14.3.1.4 If PWHT is required for process or service conditions (e.g., amine, caustic, cyclic load, etc.), attachment welds should be PWHT.

14.3.2 **Post Weld Heat Treatment Based on Service**

14.3.2.1 PWHT or hardness control should be performed for all carbon steel piping in rich amine and lean amine services regardless of operating temperature.
14.3.2.2 PWHT should be performed for all carbon steel piping exposed to caustic water solutions or mixtures of such solutions with hydrocarbons. If heat tracing (steam or electric) is provided for caustic piping and equipment to keep the caustic in solution, the potential of overheating should be considered.

14.3.2.3 Other services that require PWHT should be specified in the engineering design.

15. Examination and Testing

Examination of piping and component systems should be in accordance with PIP PNE00012, PIP PSNC0001, and PIP PNSC0021.

16. Service Color Coding and Marking

16.1 The paint or tape color coding standard for identification of piping systems by service should be in accordance with ASME A13.1 or equivalent industry standard. Project specific color coding should be avoided.

16.2 To prevent confusion and the potential for cross-connection errors arising from multiple color coding standards for process piping, continued consistency within a facility location should be maintained rather than changing to an industry standard.