ASME B31 | PIPING SYSTEMS FOR INDUSTRIAL PLANTS

Online Training: Lesson 1
Codes and Design Criteria

Study Notes

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Introduction

A piping system is a typically closed network of pipes, fittings and valves designed for transporting fluids.

The vast majority of piping systems act as pressurized conduits, in other words, the fluid wets the entire inner cross-sectional area of the pipe. This is true except for sanitary or storm drains, which are open-channel flow applications. These pipes are designed to flow partially full.

![Roman Aqueduct, V Century A.C.](image)

The need for using piping systems arises from the fact that the point of storage or flow capture is distant from the place where the liquid product it is required.

Pipes have been used for thousands of years to transport fluids. Over the course of history, many civilizations developed pipe systems to transport water for drinking or irrigation. Bored stone, wood, clay and lead were popular materials for building the first piping systems. However, the commercial manufacture of pipes for industrial applications only dates back to the late 19th century. This is when a new generation of metal pipes were developed, such as to withstand growing pressures related to the use of steam.

Modern piping systems are used to transport all known liquid or gaseous fluids, from pulp and slurries to compressed gases, covering the whole range of pressure and temperature used in industrial applications, from the absolute vacuum to pressures up to 400 MPa and from absolute zero to the melting temperature of metals.
Circular pipes are the most frequently used, since this shape provides not only the greatest structural strength but also the largest cross section for the same outer perimeter than any other shape. The term “pipe” used in this study notes always refers to a closed conduit, of circular cross-section with a constant inner diameter, unless specifically noted.

Piping systems could be classified as follows:

- Domestic Use
  - Drainage
  - Water, CNG
  - Heating
- Industrial Use
  - Power
  - Petrochemical
  - Transportation

*Classification of piping Systems.*

*Erection of a piping system in a petrochemical plant.*
Penstock of a Hydraulic Power Plant.
1. **Applicable codes**

On a practical level, the North American industry has imposed its codes and standards as a system of design conditions, in the chemical, petrochemical, nuclear, and other sectors. This applies not only to pipes, but also to fittings, valves and other elements used to join or assemble pipes under pressure. Therefore, in projects related to the above applications, these rules and codes are usually mandatory.

**Piping codes** define the requirements of design, fabrication, use of materials, tests and inspection of pipes and piping systems – in other words, **what the designer needs to do**.

A code has a limited jurisdiction. Although a code is not law, it can be adopted into law.

**Piping standards** define application design and construction rules and requirements for piping components as flanges, elbows, tees, valves etc. – in other words, **how to do it**.

**The Organizations which issue codes and standards and practical recommendations** are listed below:

- American Iron and Steel Institute: AISI
- American National Standards Institute: ANSI
- American Petroleum Institute: API
- American Society of Civil Engineers: ASCE
- American Society of Mechanical Engineers: ASME
- American Society for Nondestructive Testing: ASNT
- American Society of Testing Materials: ASTM
- American Welding Society: AWS
- American Water Works Association: AWWA
- Manufacturers Standardization Society of Valves and Fitting Industry Standard Practices: MSS-SP
- National Association of Corrosion Engineers: NACE
- National Fire Protection Association: NFPA
- Pipe Fabrication Institute: PFI
- Plastic Pipe Institute: PPI
- Society of Automotive Engineers: SAE
- Deutsches Institut für Normung: DIN
- European Standard: EN
In all cases, there is a periodic review of these codes and standards, which is carried out to include changes to the piping systems characteristics, based on the evolving best practices in the industry, as well as on-going research.

**Codes & standards editions to be used in the design of piping systems are those specified in the project contract; this is usually the latest edition issued at the time the contract was signed. Therefore, mention should always be made of the year of publication / edition as a complement to its name.**

**Standards unification**

Currently there has been a unification of codes and standards. The ANSI, ASTM and most MSS-SP standards were absorbed by ASME. The content of the standards has not changed, only the designation.

For example: in the past, the "Welded and seamless Wrought Steel Pipes" pipe specification was designated as ANSI B36.10, the current designation is ASME B36.10.
1.1) American Society of Mechanical Engineers | ASME

The codes from the American Society of Mechanical Engineers or ASME, which are used for the design of pipe systems are as follows:

- B31.1: Power piping
- B31.2: Fuel gas piping
- B31.3: Process piping
- B31.4: Pipeline transportation systems for liquid hydrocarbons and other liquids
- B31.5: Refrigeration piping and heat transfer components.
- B31.8: Gas transmission & distribution piping systems
- B31.9: Building services piping
- B31.11: Slurry transportation piping systems
1.2) **American Petroleum Institute | API**

The **American Petroleum Institute or API Standards**, which are often used in pipe designs, are:

- API 5L: Specification for line pipe
- API 6D: Pipeline valves, end closures, connectors and swivels
- API 6F: Recommended practice for fire test for valves
- API-327: Aboveground storage tanks standard
- API-570: Piping inspection code
- API-593: Ductile iron plug valves – flanged ends
- API-598: Valve inspection and test
- API-600: Steel gate valves
- API-601: Metallic gasket for refinery piping
- API-602: Compact design carbon steel gate
- API-603: Corrosion resistant gate valves
- API-604: Ductile iron gate valves – flanged ends
- API-605: Large diameter carbon steel flanges
- API-607: Fire test for soft-seated ball valves
- API-609: Butterfly valves
- API-610: Centrifugal pumps for petroleum
- API-617: Axial and centrifugal compressors, and expander-compressors
- API-661: Air-cooled heat exchangers for general refinery service
- API-682: Pumps-shaft sealing for centrifugal & rotary pumps
- API 1104: Standard for welding pipeline and facilities
- API-2000 Venting atmosphere and low pressure storage tank
2.4) **Hydraulic and pneumatic test**

These tests are non-destructive examinations, which aim to verify the integrity of the system.

During the test, the system is subject to a pressurized liquid (usually water), for a pre-established period of time. The temperature of the water, the environment and the chemical composition of the water are factors that are usually forgotten, but very important.

Whenever possible, hydraulic tests should be performed instead of pneumatic. Some reasons against choosing a hydrostatic test include:

- Liquid freezing due to site temperature
- Start of corrosive processes in the pipe due to exposure to water

The requirements for piping tests are contained in ASME B31 Code. In the case of the B31.1 and B31.3 code, the value of the hydrostatic test is 1.5 times the design pressure.

On the other hand, for the B31.4 and B31.8 codes, the hydrostatic test pressure is 1.25 times the design pressure. However, in some cases, customer specifications contain their own requirements for testing, including their own formulas for determining pressure.

Should a piping system be installed in the European Union, the pressure equipment directive must be complied with, which establishes a test pressure of 1.43 times that of design.

Considering that the stresses induced during the test are temporary and at a temperature different from the design temperature, they cannot be compared with the allowable stresses for design conditions. For these cases, the ASME B31 Code indicates that the stresses induced by the tests (hydrostatic and / or pneumatic) will be compared with a stress equivalent to 90% of the yield strength of the material.