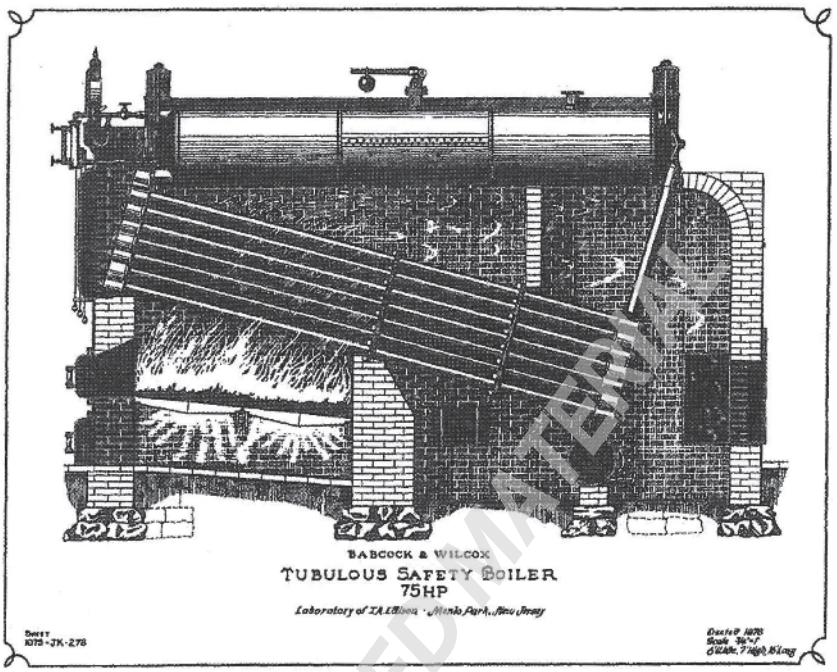


Old timers. *Source*: (Top) Courtesy Babcock & Wilcox Company; (bottom) Courtesy Nooter Corporation.

# 1

# History and Organization of Codes

## 1.1 Use of Process Vessels and Equipment

Throughout the world, the use of process equipment has expanded considerably. In the petroleum industry, process vessels are used at all stages of oil processing. At the beginning of the cycle, they are used to store crude oil. Many different types of these vessels process the crude oil into oil and gasoline for the consumer. The vessels store petroleum at tank farms after processing and finally serve to hold the gasoline in service stations for the consumer's use. The use of process vessels in the chemical business is equally extensive. Process vessels are used everywhere.

Pressure vessels are made in all sizes and shapes. The smaller ones may be no larger than a fraction of an inch in diameter, whereas the larger vessels may be 150 ft. or more in diameter. Some are buried in the ground or deep in the ocean; most are positioned on the ground or supported on platforms; and some actually are found in storage tanks and hydraulic units in aircraft.

The internal pressure to which the process equipment is designed is as varied as the size and shape. Internal pressure may be as low as 1 in. water-gage pressure or as high as 300 000 psi or more. The usual range of pressure for monoblock construction is about 15 to about 5000 psi, although there are many vessels designed for pressures below and above that range. The American Society of Mechanical Engineers (ASME) Boiler and Pressure Code, Section VIII, Division 1 [1], specifies a range of internal pressure from 15 psi at the bottom to no upper limit; however, at an internal pressure above 3000 psi, the ASME Code, VIII-1, requires that special design considerations may be necessary [1]. However, any pressure vessel that meets all the requirements of the ASME Code, regardless of the internal or external design pressure, may still be accepted by the authorized inspector and stamped by the manufacturer with the ASME Code symbol. Some other pressure equipment, such as American Petroleum Institute (API) [2] storage tanks, may be designed for and contain internal pressure not more than that generated by the static head of fluid contained in the tank.

## 1.2 History of Pressure Vessel Codes in the United States

Through the late 1800s and early 1900s, explosions in boilers and pressure vessels were frequent. A firetube boiler explosion on the Mississippi River steamboat *Sultana* on April 27, 1865, resulted in sinking of the boat within 20 minutes and the death of 1500 soldiers who were going home after the Civil War. This type of catastrophe continued unabated into the early 1900s. In 1905, a destructive explosion of a firetube boiler in a shoe factory in Brockton, Massachusetts (Figure 1.1) killed 58 people, injured 117 others, and caused $400 000 in property damage. In 1906, another explosion in a shoe factory in Lynn, Massachusetts, resulted in death, injury, and extensive property damage. After this accident, the Massachusetts governor directed the formation of a Board of Boiler Rules. The first set of rules for the design and construction of boilers was approved in Massachusetts on August 30, 1907. This code was three pages long!

In 1911, Colonel E. D. Meier, the president of the ASME, established a committee to write a set of rules for the design and construction of boilers and pressure vessels. On February 13, 1915, the first ASME Boiler Code was issued. It was entitled "Boiler Construction Code, 1914 Edition." This was the beginning of the various sections of the ASME Boiler and Pressure Vessel Code, which ultimately became Section I, *Power Boilers* [3].

The first ASME Code for pressure vessels was issued as "Rules for the Construction of Unfired Pressure Vessels," Section VIII, 1925 edition. The rules applied to vessels over 6 in. in diameter, volume over 1.5 ft [3], and pressure over 30 psi. In December 1931, a Joint API–ASME Committee was formed to develop an unfired pressure vessel code for the petroleum industry. The first edition

*Structural Analysis and Design of Process Equipment,* Third Edition. Maan H. Jawad and James R. Farr.

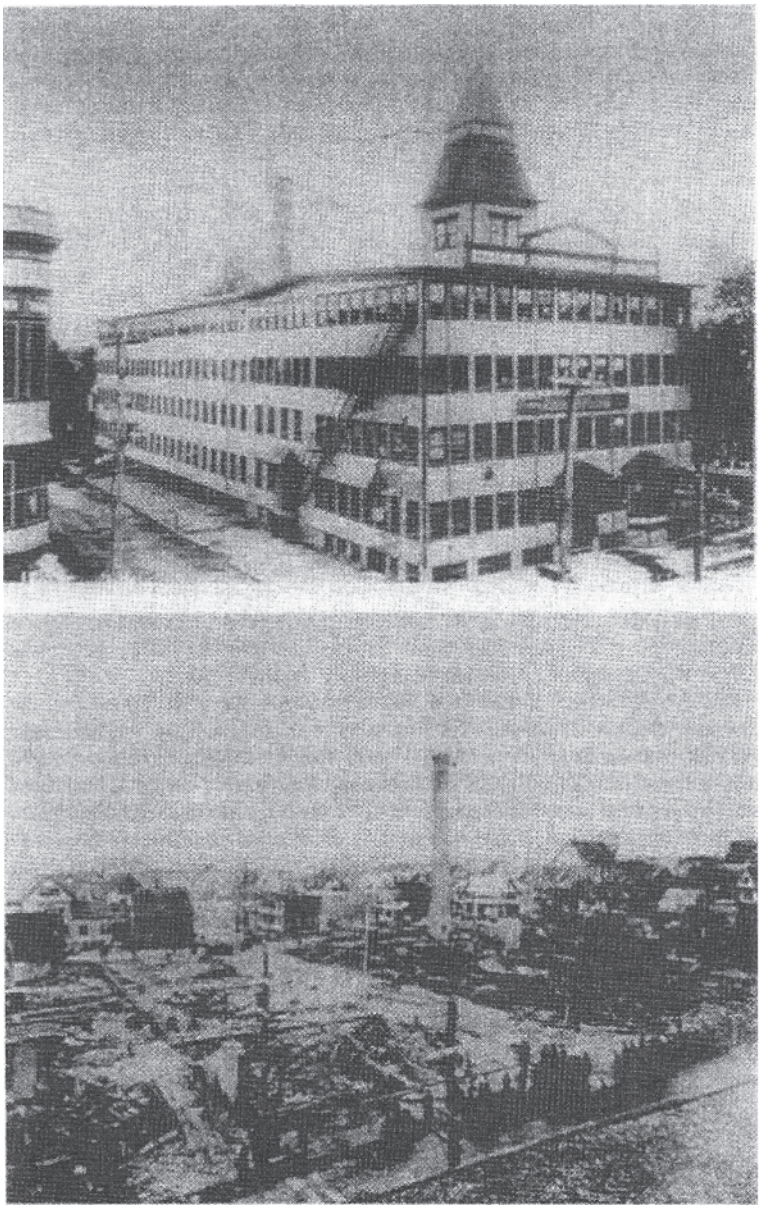

**Figure 1.1** Firetube boiler explosion in shoe factory in Brockton, Massachusetts in 1905. *Source*: Courtesy Hartford Steam Boiler Inspection and Insurance Co., Hartford, Ct.

was issued in 1934. For the next 17 years, two separate unfired pressure vessel codes existed. In 1951, the last API–ASME Code was issued as a separate document [4]. In 1952, the two codes were consolidated into one code – the *ASME Unfired Pressure Vessel Code*, Section VIII. This continued until the 1968 edition. At that time, the original code became Section VIII, Division 1, *Pressure Vessels*, and another new part was issued, which was Section VIII, Division 2, *Alternative Rules for Pressure Vessels*.

The ANSI/ASME Boiler and Pressure Vessel Code is issued by the ASME with approval by the American National Standards Institute (ANSI) as an ANSI/ASME document. One or more sections of the ANSI/ASME Boiler and Pressure Vessel Code have been established as the legal requirements in 47 of the 50 states in the United States and in all the provinces of Canada. Also, in many other countries of the world, the ASME Boiler and Pressure Vessel Code is used to construct boilers and pressure vessels.

In the United States, most piping systems are built according to the ANSI/ASME Code for Pressure Piping B31. There are a number of different piping code sections for different types of systems. The piping section that is used for boilers in combination with Section I of the ASME Boiler and Pressure Vessel Code is the Code for Power Piping, B31.1 [5]. The piping section that is often used with Section VIII, Division 1, is the

code for Chemical Plant and Petroleum Refinery Piping, B31.3 [6].

## 1.3 Organization of the ASME Boiler and Pressure Vessel Code

The ASME Boiler and Pressure Vessel Code is divided into many sections, divisions, parts, and subparts. Some of these sections relate to a specific kind of equipment and application; others relate to specific materials and methods for application and control of equipment; and others relate to care and inspection of installed equipment. The following sections specifically relate to the design and construction of boiler, pressure vessel, and nuclear components:

Sections.

(I) Rules for Construction of Power Boilers
(II) Materials
Part A. Ferrous Material Specifications
Part B. Nonferrous Material Specifications
Part C. Specifications for Welding Rods, Electrodes, and Filler Metals
Part D. Properties
(III) Rules for Construction of Nuclear Facility Components
Division 1.
Subsection NB. Class 1 Components.
Subsection NC. Class 2 Components.
Subsection ND. Class 3 Components.
Subsection NE. Class MC Components.
Subsection NF. Supports.
Subsection NG. Core Support Structures.
Division 5. High-Temperature Reactors.
(IV) Rules for Construction of Heating Boilers
(VIII) Rules for Construction of Pressure Vessels
Division 1.
Division 2. Alternative Rules.
Division 3. Alternative Rules for Construction of High Pressure Vessels.
(X) Fiber-Reinforced Plastic Pressure Vessels
(XII) Rules for Construction and Continued Service of Transport Tanks

A new edition of the ASME Boiler and Pressure Vessel Code is issued every 2 years. A new edition incorporates all the changes made to the previous edition. The new edition of the code becomes mandatory when it appears.

Code Cases [7] are also issued periodically after each code meeting. They contain permissive rules for materials and special constructions that have not been sufficiently developed to include them in the code itself. Finally, there are Code Interpretations [8]. These are in the form of questions and replies that further explain the items in the code that have been misunderstood.

## 1.4 Organization of the ANSI B31 Code for Pressure Piping

In the United States, the most frequently used design rules for pressure piping are the ANSI B31 Code for Pressure Piping. This code is divided into many sections for different kinds of piping applications. Some sections are related to specific sections of the ASME Boiler and Pressure Vessel code as follows:

B31.1 Power Piping
B31.3 Process Piping
B31.4 Pipeline Transportation Systems for Liquids and Slurries
B31.5 Refrigeration Piping and Heat Transfer Components
B31.8 Gas Transmission and Distribution Piping Systems
B31.9 Building Services Piping
B31.12 Hydrogen Piping and Pipelines

The ANSI B31 Piping Code Committee prepares and issues new editions and addenda with dates that correspond with the ASME Boiler and Pressure Vessel Code and addenda. However, the issue dates and mandatory dates do not always correspond with each other.

## 1.5 Some Other Pressure Vessel Codes and Standards in the United States

In addition to the ANSI/ASME Boiler and Pressure Vessel Code and the ANSI B31 Code for Pressure Piping, many other codes and standards are commonly used for the design of process vessels in the United States. Some of them are as follows:

ANSI/API Standard 620. *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, American Petroleum Institute (API), Washington, D.C.

ANSI/API Standard 650. *Welded Steel Tanks for Fuel Storage*, American Petroleum Institute, Washington, D.C.

ANSI-AWWA Standard D100. *Welded Carbon Steel Tanks for Water Storage*, American Water Works Association (AWWA), Denver, Colorado.

UL 644. *Standard for Container Assemblies for LP-Gas*, 9th ed., Underwriters Laboratories, Northbrook, Illinois.

*Standards of Tubular Exchanger Manufacturers Association*, 9th ed., Tubular Exchanger Manufacturer's Association, New York.

*Standards of the Expansion Joint Manufacturers Association*, 10th ed., Expansion Joint Manufacturer's Association, New York.

A number of standards are available in the United States for repairing and altering existing boilers and pressure vessels. Frequently, the repairs and alterations involve design considerations that are outside the scope of ASME Sections I and VIII. Some of these standards are as follows:

*National Board Inspection Code*. National Board of Boiler and Pressure Vessel Inspectors, Ohio.

*Fitness-for-Service*. API 579–1/ASME FFS-1, American Society of Mechanical Engineers, New York.

*Pressure Vessel Inspection Code*. API-510, American Petroleum Institute, Washington, D.C.

## 1.6 Worldwide Pressure Vessel Codes

In addition to the ASME Boiler and Pressure Vessel Code, which is used worldwide, many other pressure vessel codes have been legally adopted in various countries. Difficulty often occurs when vessels are designed in one country, built in another country, and installed in still another country. This is often the case.

The following list is a partial summary of some of the various codes used in different countries:

**Australia**. Pressure Equipment: AS 1200. Standards Association of Australia. Sydney, Australia.

**China**. Pressure Vessel Standard GB 150. China National Institute of Standardization (CNIS). Beijing, China.

**European Union**. Countries belonging to the European Union (EN) including France, Germany, Italy, and the United Kingdom use the European Pressure equipment Directive (PED) for the design of boilers and pressure vessels. Hence, Standard EN 12953 is used for boilers and Standard EN 13445 is used for pressure vessels. Local codes are also used when specific rules are not covered by these two standards. These include CODAP in France, A. D. Merkblatter in Germany, and BS 5500 in the United Kingdom.

**Japan**. In Japan, the Japanese Industrial Standard for pressure vessels is JIS B 8265, 8266, and 8267. For boilers, the standard is JIS B 8201.

More complete details, discussions of factors of safety, and applications of the codes mentioned are given in Section 2.12.

## References


1 (2017). *ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels*. New York: American Society of Mechanical Engineers.

2 API Standard 620 (2013). *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*," ANSI/API Std. 620. Washington, D.C.: American Petroleum Institute.

3 (2017). *ASME Boiler and Pressure Vessel Code, Section I, Rules for Construction of Power Boilers*. New York: American Society of Mechanical Engineers.

4 API-ASME Code (1951). *Unfired Pressure Vessels for Petroleum Liquids and Gases*, 5ee. New York: American Society of Mechanical Engineers and American Petroleum Institute.

5 ASME Code for Pressure Piping B31 *Power Piping*, ANSI/ASME B31.1,. New York: American Society of Mechanical Engineers.

6 ASME Code for Pressure Piping B31 *Chemical Plant and Petroleum Refinery Piping*, ANSI/ASME B31.3. New York: American Society of Mechanical Engineers.

7 *ASME Boiler and Pressure Vessel Code, Code Cases, Boilers and Pressure Vessels*. New York: American Society of Mechanical Engineers.

8 ASME Boiler and Pressure Vessel Code *Interpretations* (issued periodically). New York: American Society of Mechanical Engineers.


## Further Reading


Steel Tanks for Liquid Storage. In: *Steel Plate Engineering Data*, 1976the, vol. 1. Washington, D.C: American Iron and Steel Institute.