PRESSURE VESSELS Part III: Design Loads, Wind & Seismic, Skirts, Legs, Saddles, Non-standard Flanges.

STUDY NOTES

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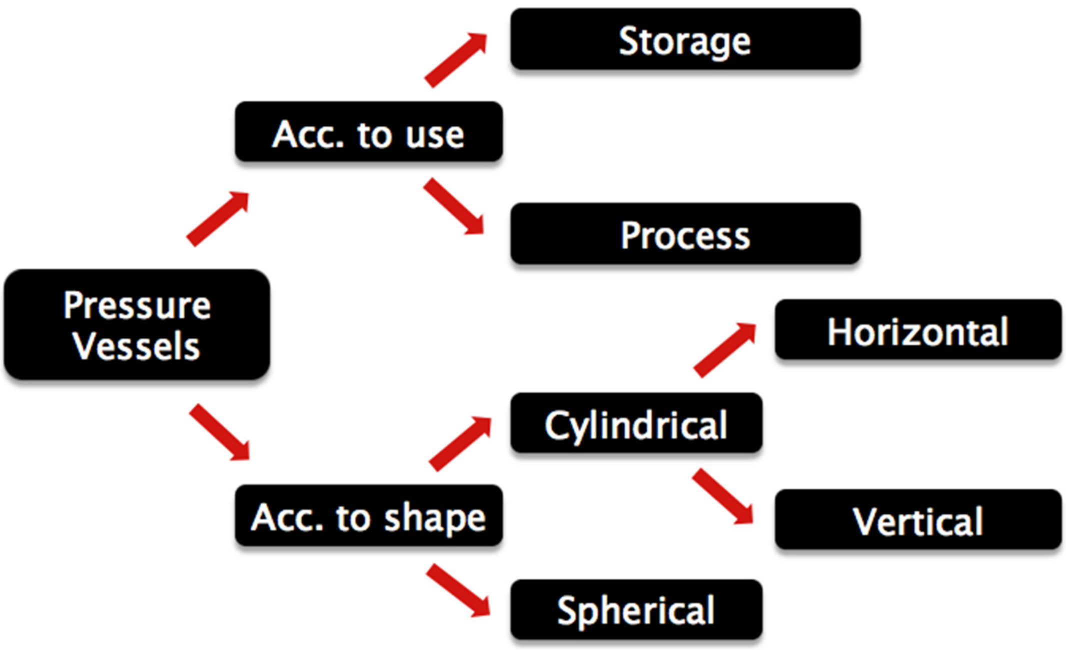
Introduction

A pressure vessel is considered as any closed vessel that is capable of storing a pressurized fluid, either internal or external pressure, regardless of their shape and dimensions. The cylindrical vessels, to which we refer in this volume, are calculated on the principles of thin-walled cylinders.

The first step in designing a container is choosing the best type for the service for which it is intended. **The factors influencing the choice of type are the function of the container, the location, the nature of the fluid that has to be stored, the temperature and operating pressure** and their ability to store the volume needed by the process.

Pressure vessels can be classified according to their intended service, temperature and pressure, materials and geometry. Different types of pressure vessels can be classified as follows:



According to the intended use of the pressure vessel, they can be divided into storage containers and process vessels.

The first classes are only used for storing fluids under pressure, and in accordance with the service are known as storage tanks.

Process pressure vessels have multiple and varied uses, among them we can mention heat exchangers, reactors, fractionating towers, distillation towers, etc.

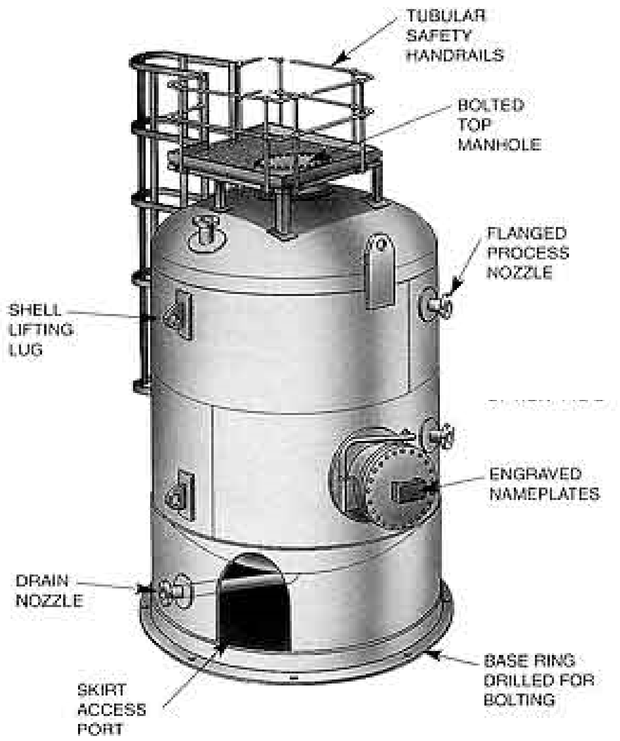
According to the shape, pressure vessel may be cylindrical or spherical. The former may be horizontal or vertical, and in some cases, may have coils to increase or lower the temperature of the fluid.

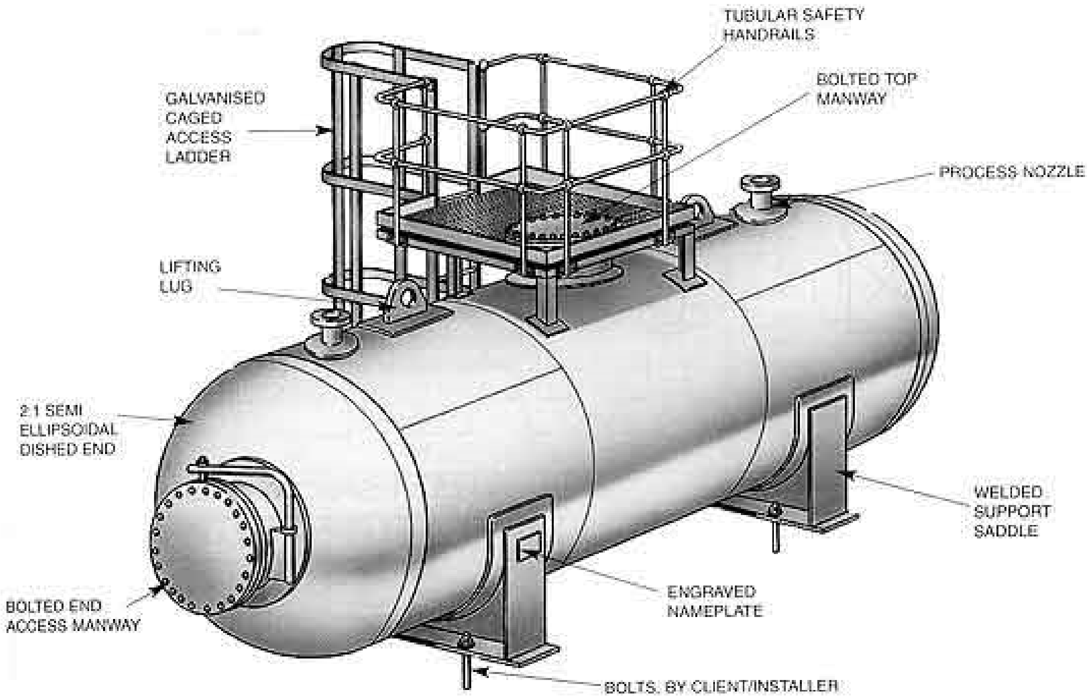
Spherical pressure vessels are usually used as storage tanks, and are recommended for storing large volumes.

Since the spherical shape is the "natural" form bodies adopt when subjected to internal pressure, this would be the most economical way to store pressurized fluids. However, the manufacture of such containers is much more expensive compared with cylindrical containers.

Pressure vessel parts

The following two sample vessels are presented: vertical and horizontal. In both cases the main parts are shown:



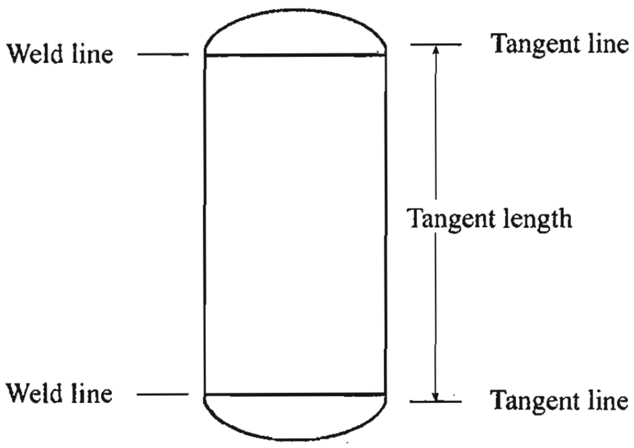


Geometry definition

To define the geometry of a pressure vessel, the inner diameter of the equipment and the distance between tangent lines is used.

The inner diameter should be used, since this is a process requirement.

- **Welding line**: point at which the head and shell are welded
- **Tangent line**: point at which the curvature of the head begins



Depending on the head fabrication method, heads come with a straight skirt.

To set the length of the pressure vessel (regardless the type of heads), the distance between tangent lines is used since this distance is not dependent on the head manufacturing method. It is very rare that the weld and tangent lines coincide.

1. Material selection

The ASME Code does not recommend or suggest any material for any application. The code merely states what materials are allowed and the requirements they must comply with.

Fortunately, in most cases, there are reference publications (such as the National Association of Corrosion Engineers - NACE,), which allow the material selection for almost every application. There will always be a case that is not covered by any of these publications; this is when a materials specialist comes into action.

1.1) Corrosion

In technical terms, corrosion is defined as the deterioration or destruction of a metallic material, caused by electrochemical attack from the surrounding environment.

The lifetime of equipment in different industries is often reduced as a result of corrosion, which is why special attention has been given to its study, achieving significant results with respect to the detection and control.

In practical terms, it is almost impossible to eliminate corrosion; the effective work of engineering in this field is more towards controlling than eliminating it. Hence the importance of understanding the mechanisms of corrosion to take them into account at the design stage of the equipment.

All metals and alloys are susceptible to corrosion, not all materials are useful for all applications; for example: gold corrodes rapidly under the influence of mercury, but has excellent resistance to corrosive attack from the atmosphere; on the other hand, steel is highly resistant to mercury attack, but gets corroded exposed to the atmosphere.

Fortunately, there is a wide range of metals that can perform satisfactorily in specific media, also different methods of corrosion control that greatly reduce the problem are available.

Production stoppages often occur in plants because of corrosion, causing direct and indirect economic and in the worst cases human losses.

Economic loss could arise due to:

1) Equipment replacement

2) Safety coefficients and over design

3) Production stoppage

4) Product contamination

Among the aspects that generate social impact and casualties are:

1) Fires, explosions, toxic products release

2) Environmental pollution

3) Depletion of non-renewable natural resources, both metals and fuels used to manufacture equipment. Naturally social and human aspects also have economic consequences, so it is difficult to name all the reasons for the study of corrosion and its control.

1.1.1) <u>Corrosion types</u>

When corrosion is present in the plant equipment, it is essential to establish a methodology to counteract this problem. The solution will depend, among other things, on the knowledge of the various types corrosion can appear. The following types of corrosion described can be present in most pressure vessels.

Uniform corrosion

Uniform or general corrosion acts evenly on a metal surface, which in most cases can be controlled providing a range of admissible corrosion thicknesses. This information is provided by laboratory tests to be considered in the design of equipment.

The metal thickness will “wear off” uniformly over time, which is the most common and least dangerous form of corrosion. Other than the detached material, debris, blocking the normal operation of the equipment, this case presents no major complications.

The corrosion range is expressed in mils of penetration per year, which can be controlled in the equipment through regular ultrasonic inspection to monitor that the range of allowable corrosion is not exceeded, thus avoiding undesirable consequences.

The corrosive environment is the most important factor governing corrosion. Acidity, temperature, concentration, relative movement of metal surfaces, aeration and the presence or absence of inhibitors or accelerators are variables that should always be considered. These often interact in complex ways, resulting in the phenomenon of uniform corrosion.

For metals subject to uniform corrosion in a chemical environment, the following ranges of acceptance are set:

1) Excellent corrosion rate of less than 5 mils per year. Metals in this category are suitable for the manufacture of critical parts such as heat transfer tubes.

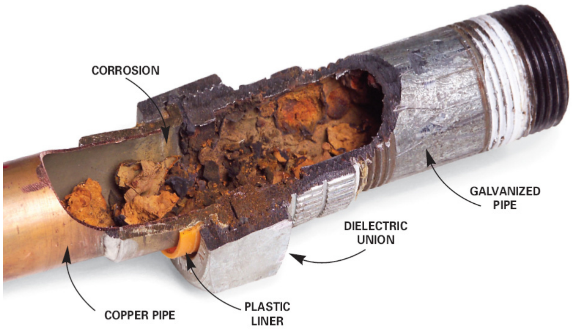
2) Satisfactory: corrosion rate of 50 mils per year. Metals in this range are generally suitable for the production of non-critical parts. A specific range of corrosion is predicted from the design, such as general elements of a heat exchanger.

3) Unsatisfactory corrosion rate greater than 50 mils per year.

Uniform corrosion can be originated due to a chemical or electrochemical reaction, it can be said that controlling this undesired phenomenon essentially lies in the proper selection of the material in relation to the surrounding environment, or using corrosion inhibitors, anti-corrosive paints or some other methods.

Galvanic corrosion

The diversity of fluids handled in industrial plants requires the use of a variety of metals and alloys that are often in physical contact between them. **The contact or engagement of metals with different electro-negativity produces significant corrosion rates when the fluid is of electrolytic nature. An electric discharge is caused between the metals, also known as "galvanic corrosion".**



The potential difference between two metals or alloys is directly related to the degree of galvanic corrosion that can be reached, with the most active metal acting as the anode and thus corroding itself, while the more noble metal acts as the cathode, gaining material.

It is important to point out that the area of the metal exposed to the electrolyte environment is also directly related to the degree of galvanic corrosion that could be generated, so, it should be noted that as the cathode area increases relative to the anodic area, the corrosive attack becomes more severe.

Next, some alternatives to control galvanic corrosion are indicated, which may be used one by one or combined:

1) If possible avoid the use of materials of different nature.

2) When metals of different kind are used, use insulation materials (coatings).

3) Install sacrificial anodes to protect the anodic areas of the equipment.

Corrosion due to erosion

When the corrosive attack is generated on a metallic surface due to the flow velocity and producing mechanical wear, this is called erosion.

This attack is normally noticed as pitting shallow and smooth, with directional distribution due to the path of the flow, followed by the aggressive agent flowing on the metal surface.

Erosion is increased at high speed, turbulence, shock, etc. It can often be seen

7. Bibliography

This document has been compiled using different books and references. The most important ones are:

- **Boiler and Pressure Vessel Code: ASME II, part D**
  ASME V
  ASME VIII, División 1
- **Pressure Vessel Design Manual – DENNIS MOSS**
- **Pressure Vessel Handbook - EUGENE MEGYESY**
- **Pressure Vessel Design Handbook – HENRY BEDNAR**
- **Modern Flange Design Bulletin 502 – TAYLOR FORGE**