Pressure Vessels

Website: www.ttetraining.ltd.uk

What is a Pressure Vessel?

A pressure vessel is a closed vessel
of any capacity consisting of one or more
independent chambers, any or each of
which is or may be subjected to,
internal or external pressure,
greater or lesser to atmospheric

PRESSURE VESSELS

Pressure vessels are the containers for fluids under high pressure.

They are used in a variety of industries like

- Petroleum refining
- Chemical
- Power
- Food & beverage
- Pharmaceutical

British Standards Design Codes

- Design and testing standards and a system of certification came about as the result initially of fatal boiler explosions.

- BS 5500: Former British Standard, replaced in the UK by a European Standard BS EN 1344 but retained under the name PD 5500 for the design and construction of export equipment.

The Law

All pressure vessels must be registered in an equipment file.

Each Vessel must have a unique number and a name plate with year of manufacture

Certificate of test registered in the equipment file. Also frequency of testing

MAIN COMPONENTS OF PRESSURE VESSEL

Following are the main components of pressure Vessels in general

Shell

Head

Nozzle

Support

Common Types of Pressure Vessels

The three very common type of pressure vessels are.

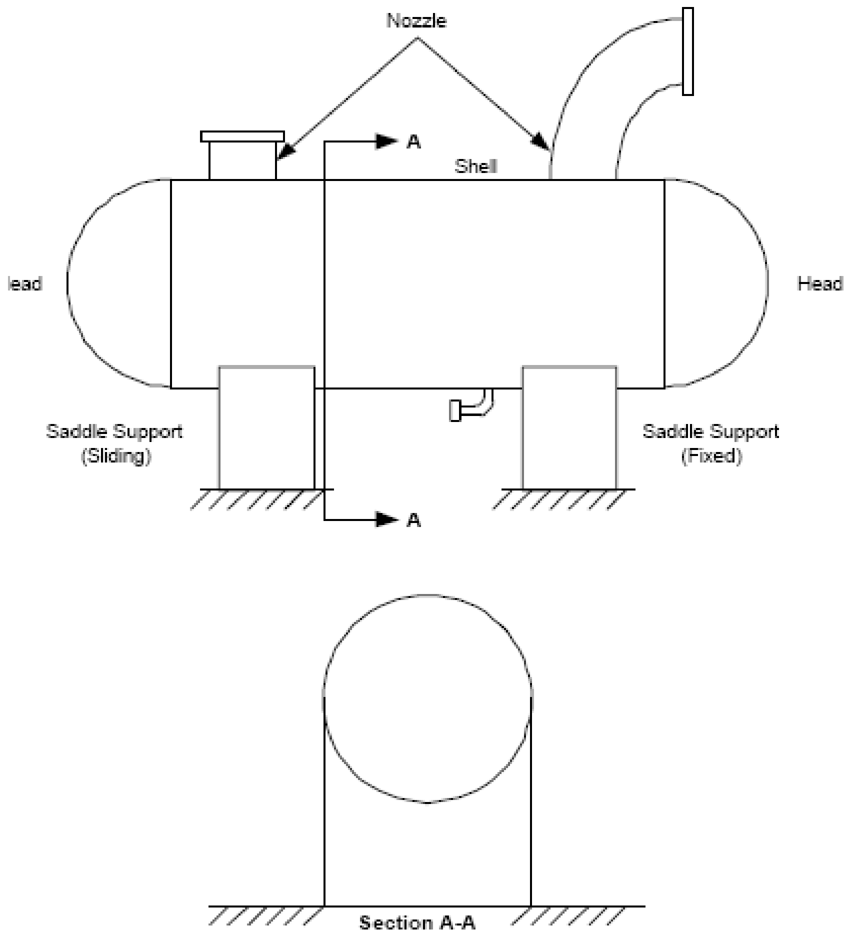
Horizontal Pressure Vessels

Vertical Pressure Vessels

Spherical Pressure vessels

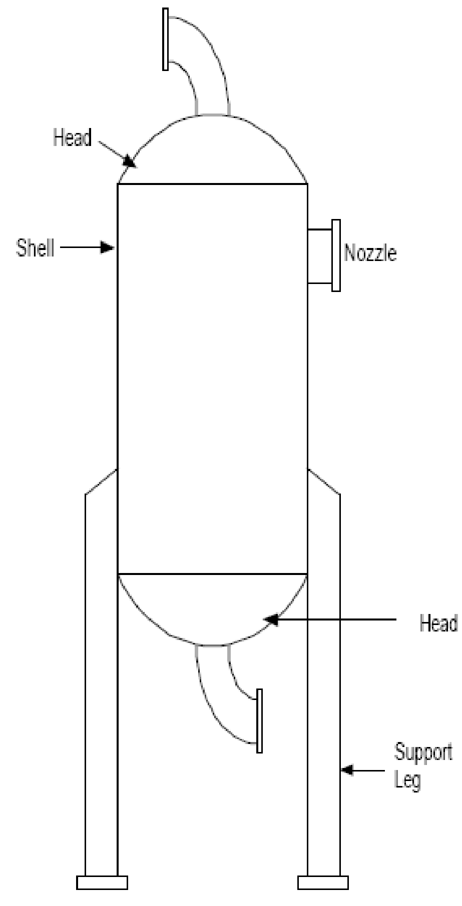
However there are many others some special types of vessel like Regeneration Tower, Reactors but these names are given according to their use only.

HORIZONTAL PRESSURE VESSEL



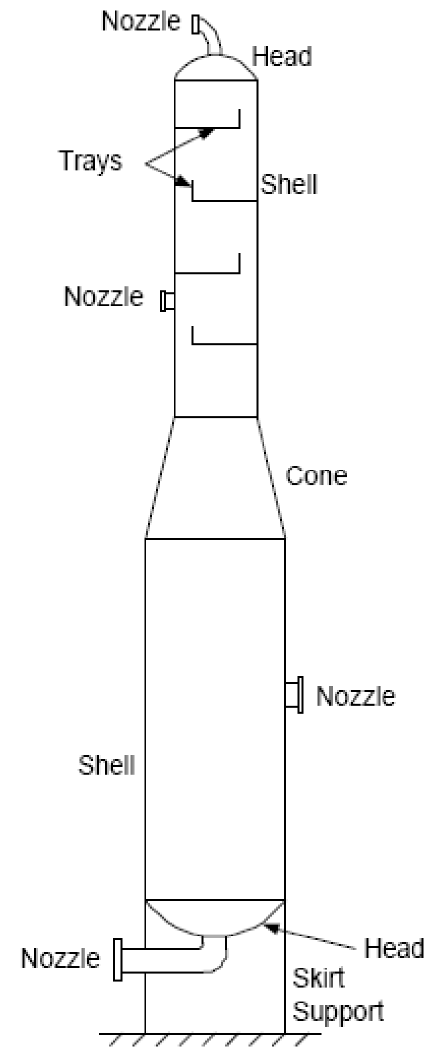
VERTICAL PRESSURE VESSEL

The max. Shell length to diameter ratio for a small vertical drum is about 5 : 1



TALL VERTICAL TOWER

Constructed in a wider range of shell diameter and height. They can be relatively small in dia. and very large (e.g. 4 ft dia. And 200 ft tall distillation column.
They can be very large in dia. and moderately tall (e.g. 3 ft dia. And 150 ft tall tower).
Internal trays are needed for flow distribution.

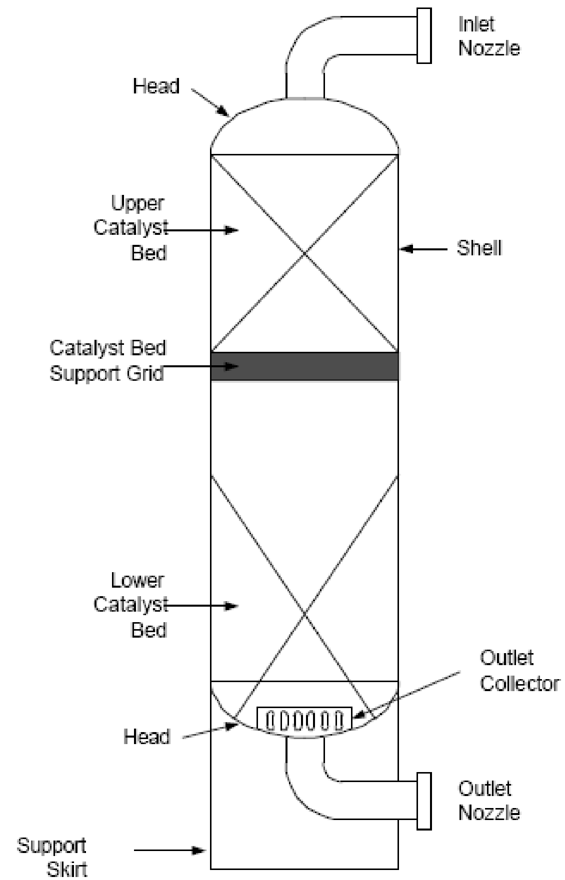


VERTICAL REACTOR

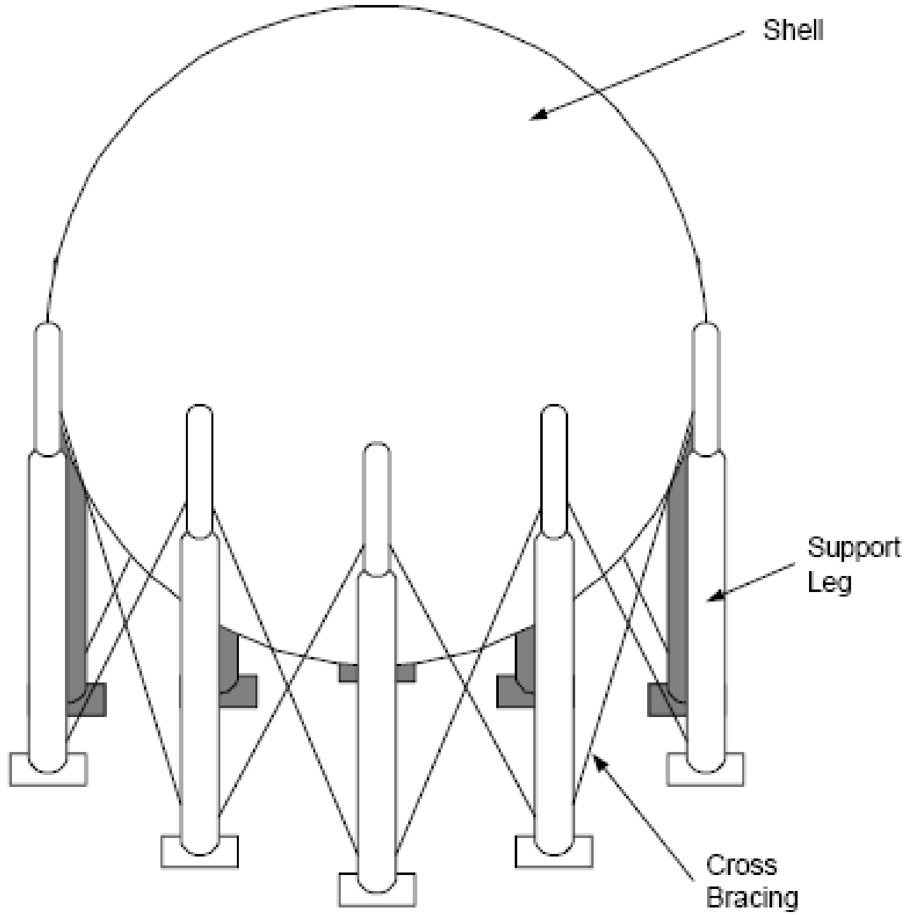
Figure shows a typical reactor vessel with a cylindrical shell.

The process fluid undergoes a chemical reaction inside a reactor.

This reaction is normally facilitated by the presence of a catalyst which is held in one or more catalyst beds.



SPHERICAL PRESSURIZED STORAGE VESSEL



SHELL

It is the primary component that contains the pressure.

Pressure vessel shells are formed form of different plates that are welded together to form a cylinder structure that has a common rotational axis.

The shell end are mainly either dished, spherical or conical in shape.

These cylindrical shells are constructed in a wide range of diameter and lengths.

The shell sections of a tall tower may be constructed of different materials, thickness and diameters due to process and phase change of process fluid.

Some shells can be spherical in shape these and can be very strong but have limited use.

HEAD

All the pressure vessels must be closed at the ends by heads (or another shell section).
Heads are typically curved rather than flat.
The reason is that curved configurations are stronger and allow the heads to be thinner, lighter and less expensive than flat heads.
Heads can also be used inside a vessel and are known as intermediate heads.
These intermediate heads are separate sections of the pressure vessels to permit different design conditions.

NOZZLE

A nozzle is a cylindrical component that penetrates into the shell or head of pressure vessel.

They are used for the following applications.

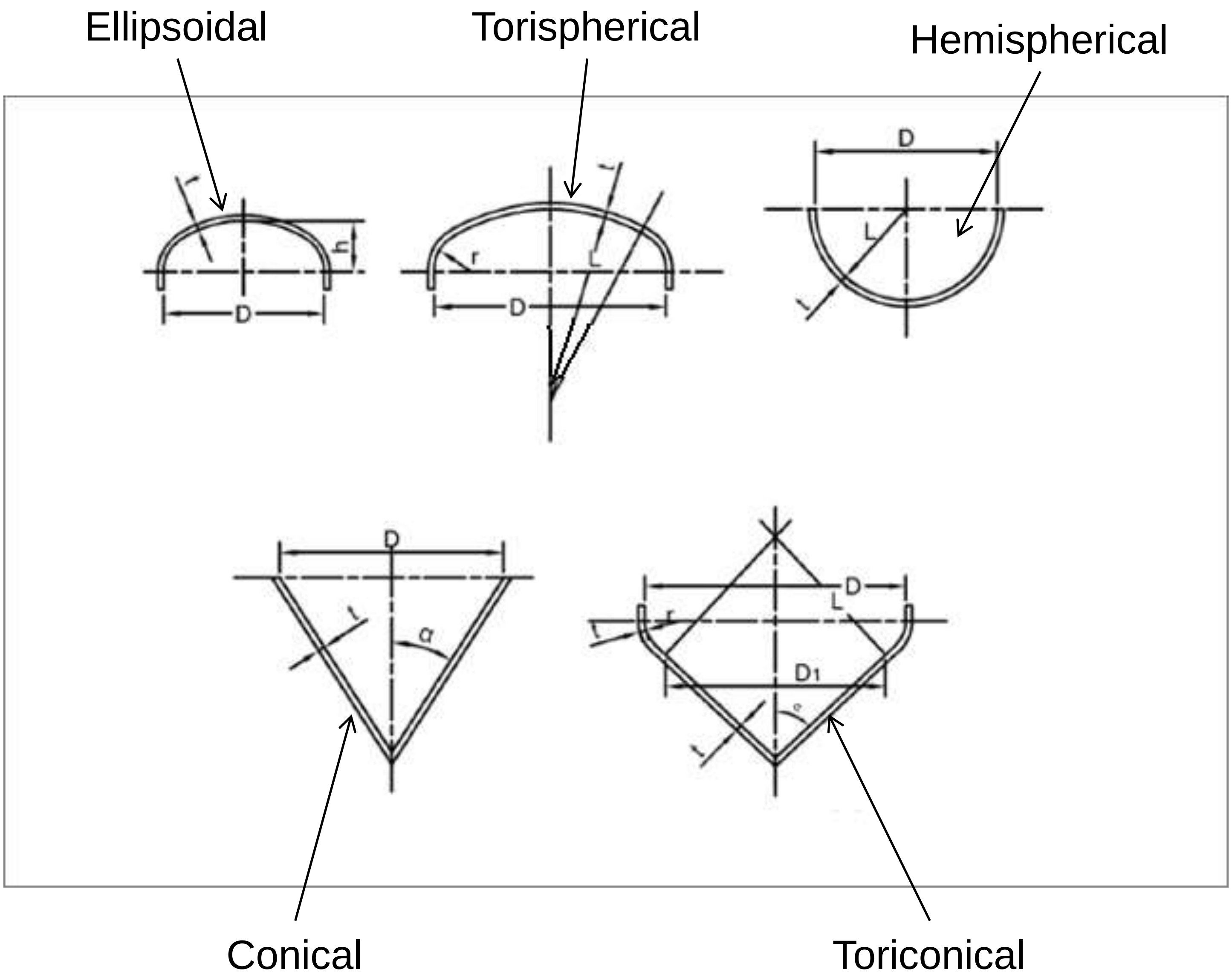
Attach piping for flow into or out of the vessel.
Attach instrument connection (level gauges, Thermowells, pressure gauges).

Provide access to the vessel interior at MANWAY.
Provide for direct attachment of other equipment items (e.g. heat exchangers).

Pressure Vessel Types and Vessel End Shapes

These are the main types of cylindrical (closed ends) vessel used:-

- Conical
- Elliptical and semi Elliptical (Torispherical)
- Rectangular (flat end)
- Hemispherical
- Ellipsoidal
- Toriconical


Ellipsoidal
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Semi Elliptical pressure vessels

Conical

Torispherical

Semi Ellipsoidal

Rectangular

Spherical

SUPPORT

Support is used to bear all the load of pressure vessel, including earthquake and wind loads.

There are different types of supports which are used depending upon the size and orientation of the pressure vessel.

It is considered to be the non-pressurized part of the vessel.

TYPES OF SUPPORTS

SADDLE SUPPORT:

Horizontal drums are typically supported at two locations by saddle support.

It spreads over a large area of the shell to prevent an excessive local stress in the shell at support point.

One saddle support is anchored whereas the other is free to permit unstrained longitudinal thermal expansion of the drum.

TYPES OF SUPPORTS

LEG SUPPORT:

Small vertical drums are typically supported on legs that are welded to the lower portion of the shell.
The max. ratio of support leg length to drum diameter is typically 2 : 1
Reinforcing pads are welded to the shell first to provide additional local reinforcement and load distribution.
The number of legs depends on the drum size and loads to be carried.
Support legs are also used for Spherical pressurized storage vessels.
Cross bracing between the legs is used to absorb wind or earth quake loads.

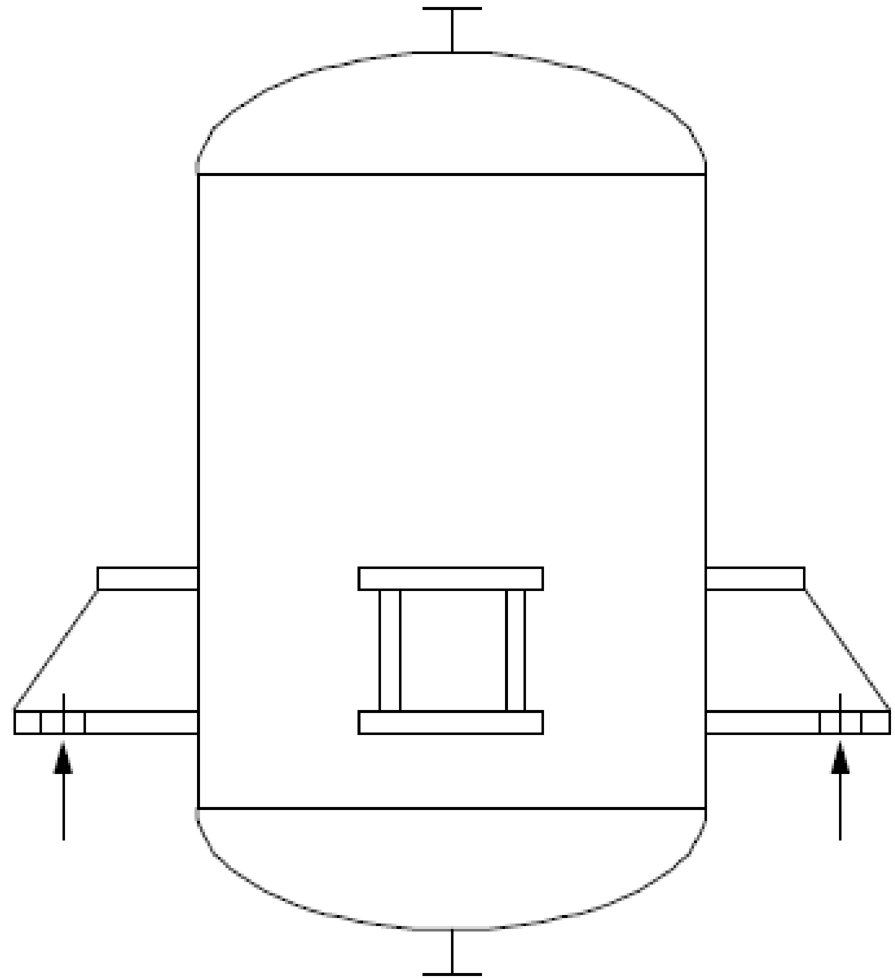
TYPES OF SUPPORTS

LUG SUPPORT:
Vertical pressure vessels may also be supported by lugs.

The use of lugs is typically limited to pressure vessels of small and medium diameter (1 to 10 ft)

Also moderate height to diameter ratios in the range of 2:1 to 5:1

The lugs are typically bolted to horizontal structural members in order to provide stability against overturning loads.



TYPES OF SUPPORTS

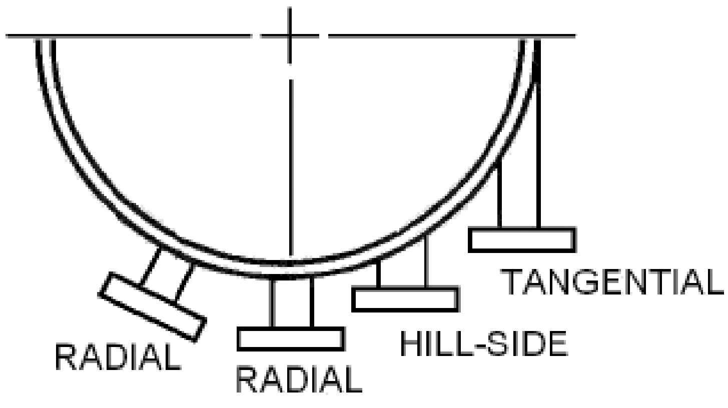
SKIRT SUPPORT:

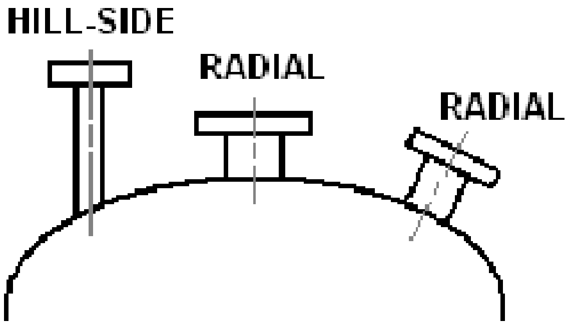
Tall vertical cylindrical pressure vessels are typically supported by skirts.

A support skirt is a cylindrical shell section that is welded either to the lower portion of the vessel shell or to the bottom head (for cylindrical vessels).

The skirt is normally long enough to provide enough flexibility so that radial thermal expansion of the shell does not cause high thermal stresses at its junction with the skirt.

Types of Nozzle Mounting Attachment for Vessels





Types of Nozzle Attachment

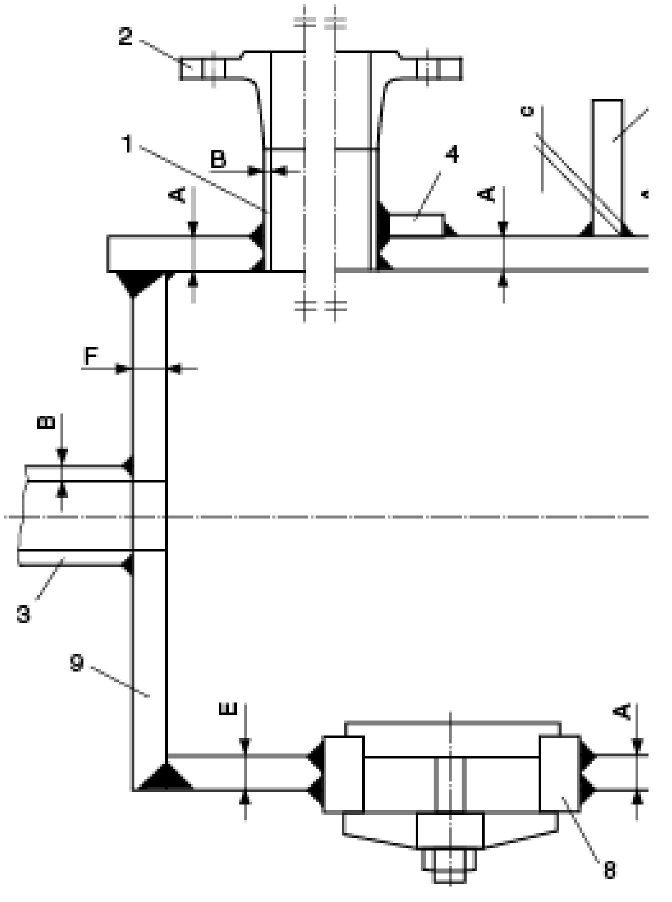
Nozzle attachment to shell of a vessel.

Set-on.

Set-through.

Set-through with compensating ring.

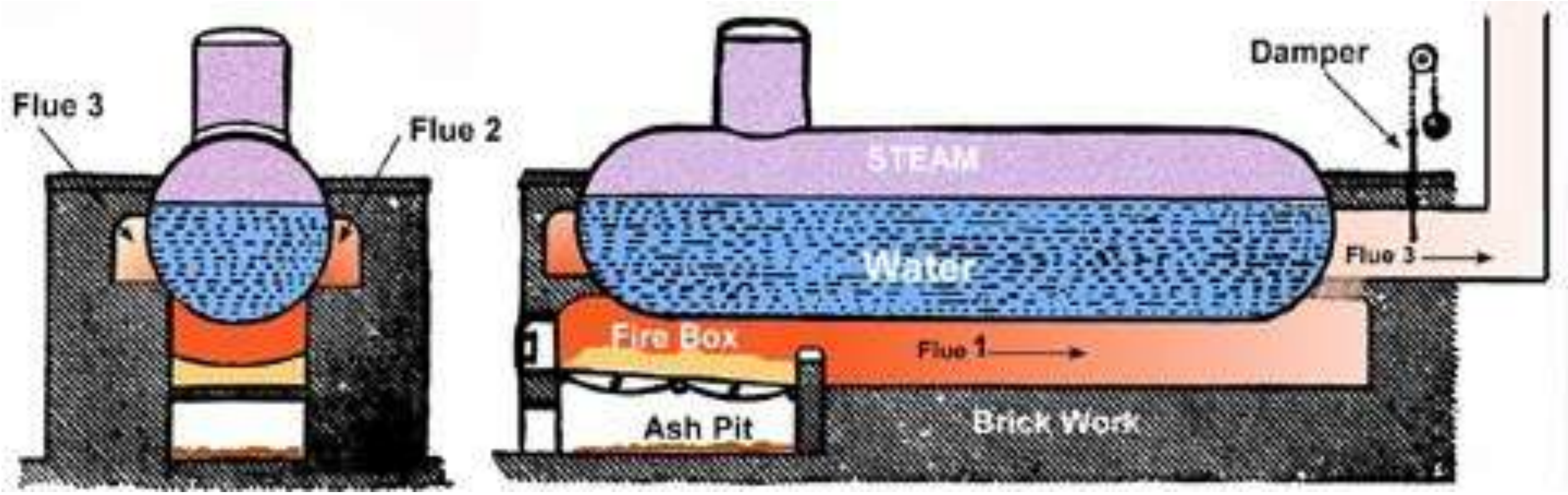
Note the compensating ring is nearly always drilled and tapped for tell-tale leak decision or for pressure test



Steam Boilers

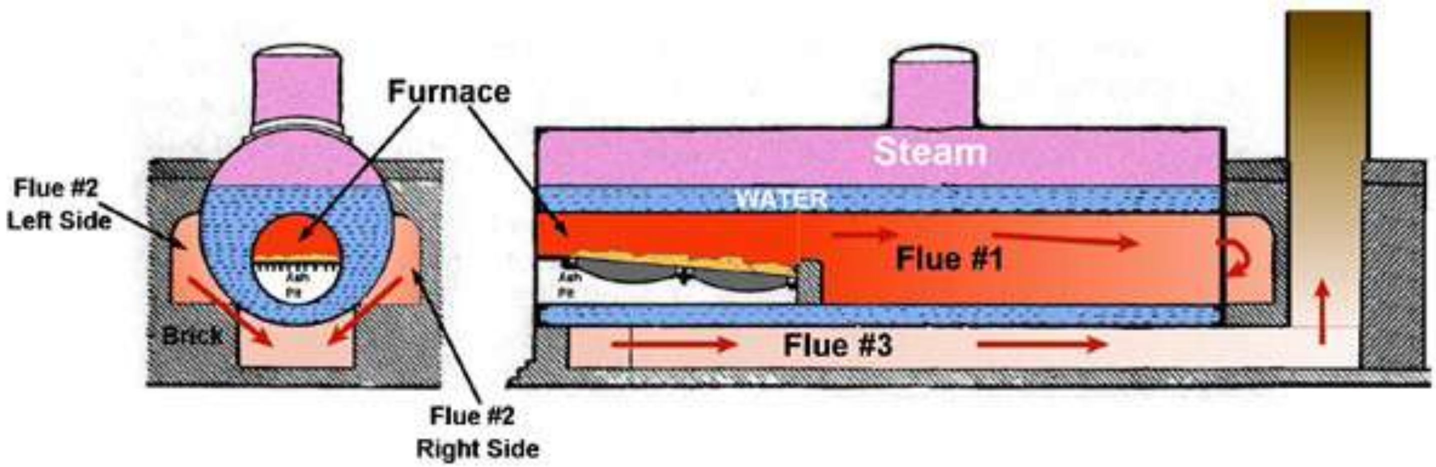
Among the vessels with the most potential are the steam raising equipment (Boilers) Steam is used throughout industry as it has an enormous capacity to store energy and do work. But because of both the heat and pressure they contain they have to be constructed and maintained to very high standards and operated with great care.

Boiler Evolution



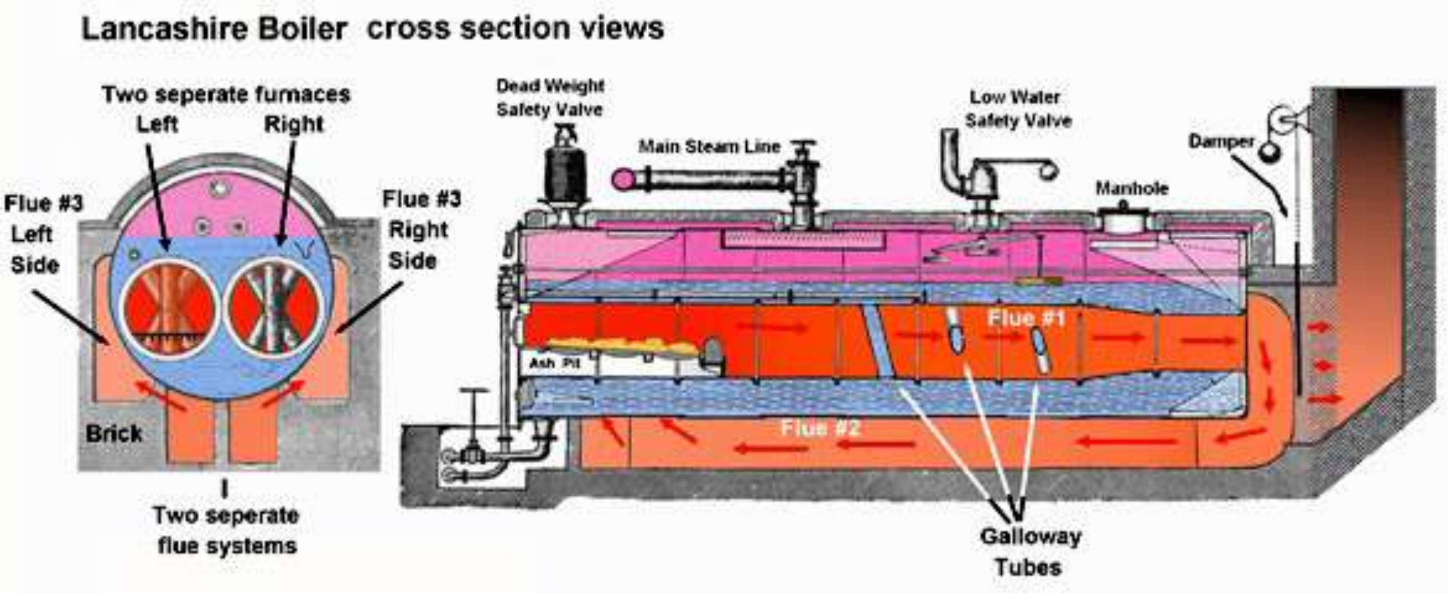
The first advancement in boiler design came with the invention of the Plain Cylinder Boiler.

The Cornish Boiler



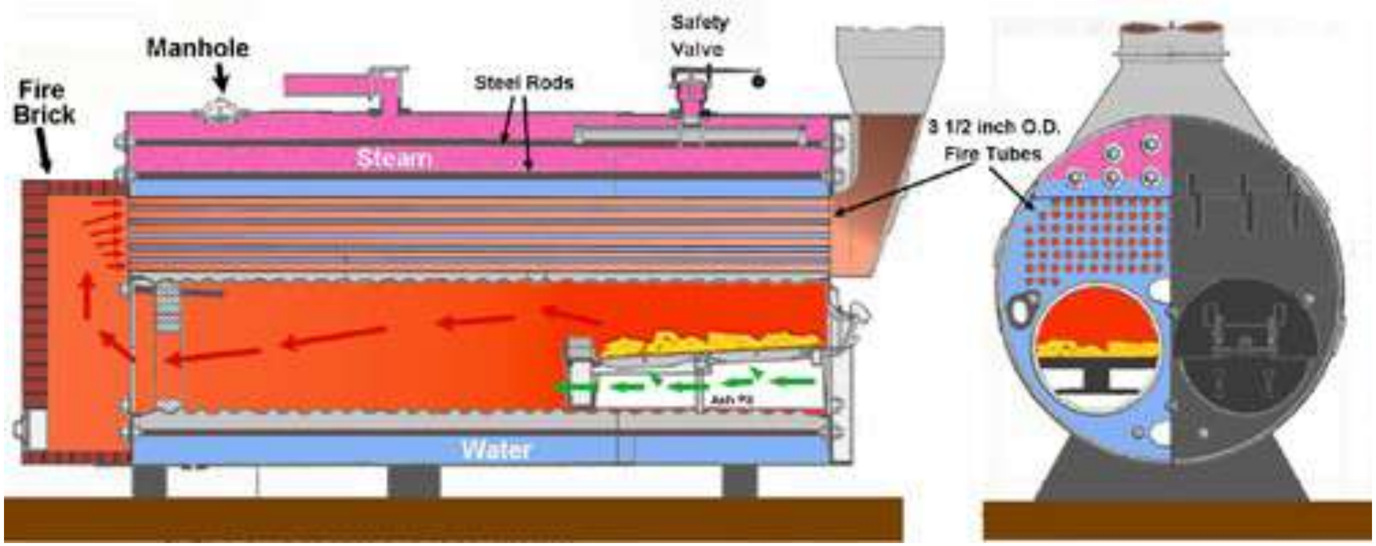
This greatly increased the amount of heat transferred to the water.

The Lancashire Boiler



The combustion takes place in 2 flue systems thereby increasing the amount of heating of the sides of the cylinder.

The Scotch Boiler (2-pass)

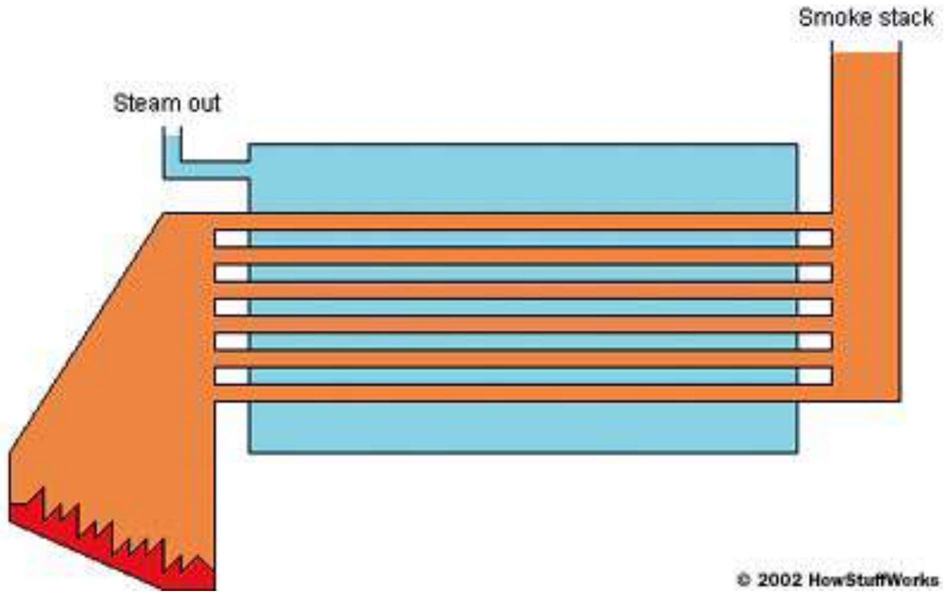


The water tank is made from corrugated plates to improve its strength and increase its surface area. Because of the larger water surface exposed to the heat more heat is transferred to the water.

Boiler classification

There are two approaches in boiler design: fire tube and water tube. The goal in all cases is to maximize the heat transfer between the water and the hot gases heating it.

Fire-tube boilers



The fire, or hot flue gases from the burner, is channeled through tubes that are surrounded by the water to be heated.

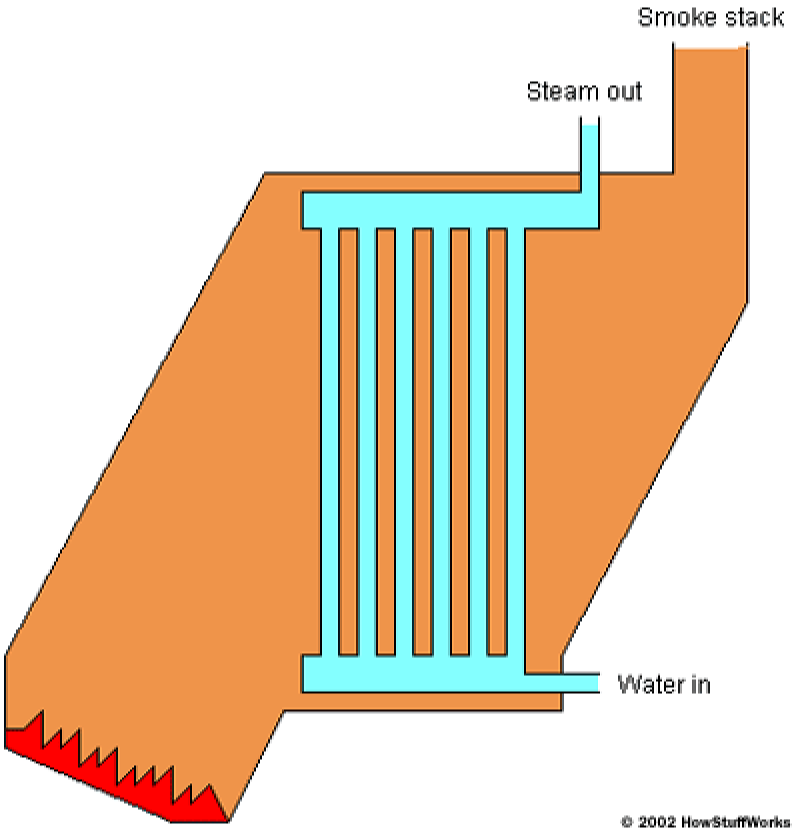
Advantages:

- Relatively inexpensive
- Easy to clean
- Compact in size
- Available in sizes from 600,000 btu/hr to 50,000,000 btu/hr
- Easy to replace tubes
- Well suited for space heating and industrial process applications

Disadvantages:

- Not suitable for high pressure applications 250 psig and above
- Limitation for high capacity steam generation
- In a fire-tube boiler, the entire tank is under pressure, so if the tank bursts it creates a major explosion.

Water-tube boilers



A Watertube design is the exact opposite of a fire tube.

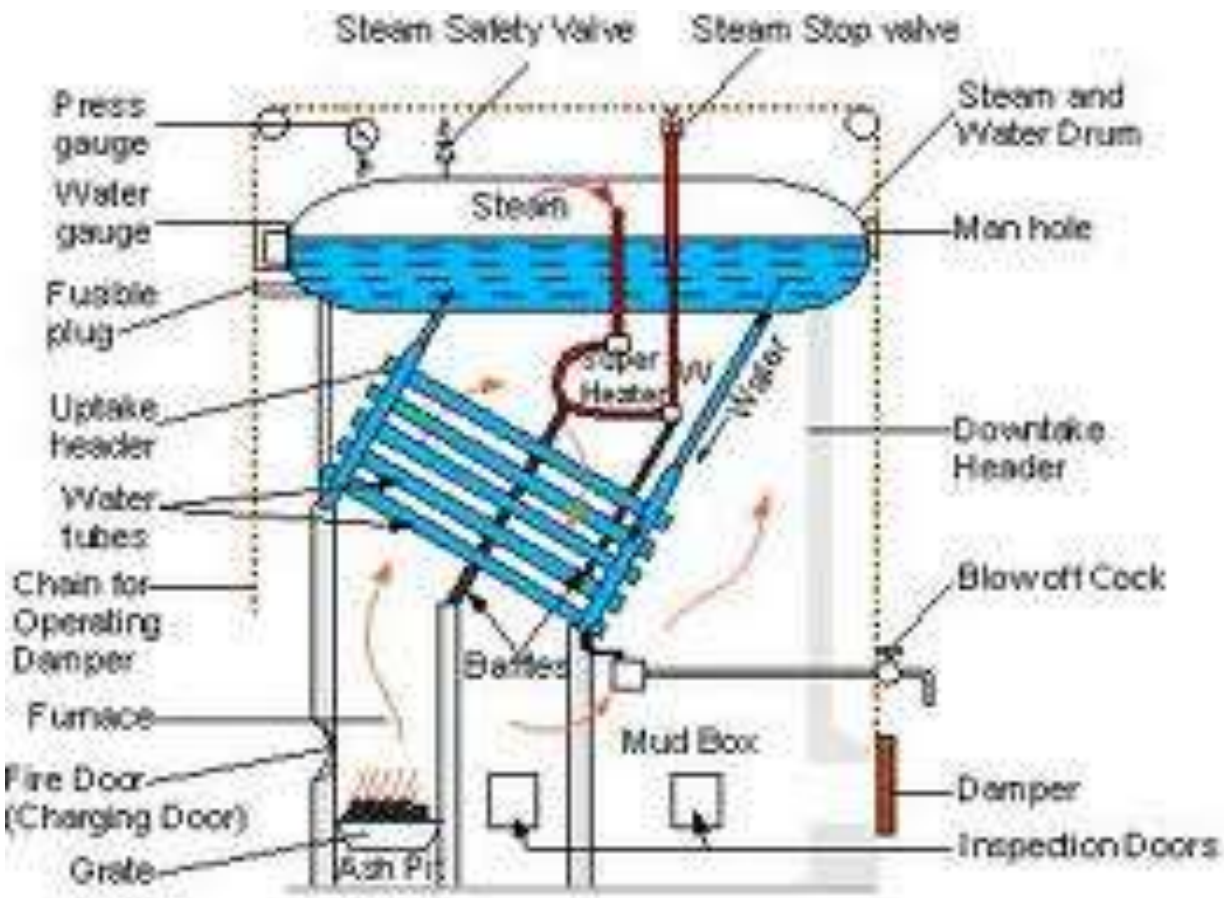
Advantages:

- Available in sizes that are far greater than the firetube design. Up to several million pounds per hour of steam.
- Able to handle higher pressures up to 5,000 psig
- Recover faster than their firetube cousins
- Have the ability to reach very high temperatures

Disadvantages:

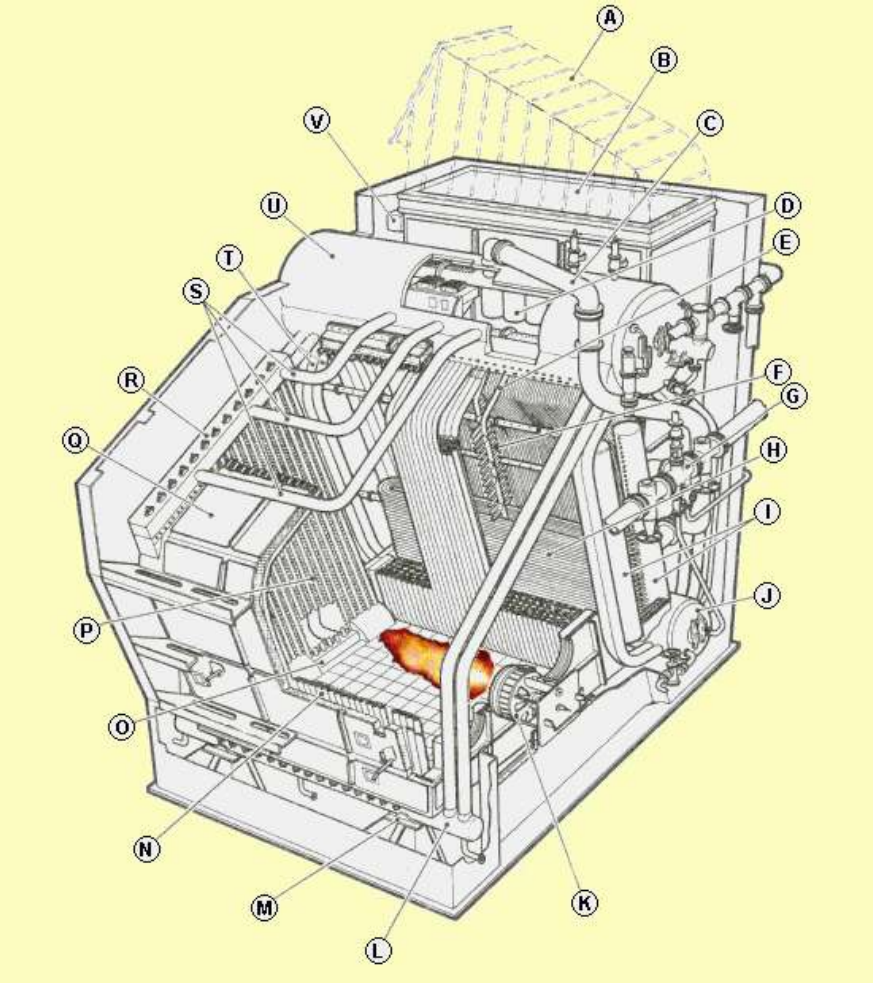
- High initial capital cost
- Cleaning is more difficult due to the design
- No commonality between tubes
- Physical size may be an issue

Sectioned View of a Modern Water Tube Boiler



Modern High Pressure Steam Package Boiler

A sectioned view of the boiler arrangement showing all the integrated parts including the economizer (B.F.W. heater) and steam superheater.



Part List Identification

A. Boiler Flue Gas Outlet
B. Economizer
C. Main Saturated Steam Outlet
D. Cyclone
E. Stay tube
F. Stays
G. Superheated steam outlet
H. Superheater
I. Superheater Headers
J. Water Drum
K. Burner

Part List Identification

L. Waterwall Header
M. Support Feet
N. Waterwall
O. Waterwall Header
P. Back side Waterwall
Q. Boiler hood
R. Waterwall Header
S. Riser
T. Downcomer
U. Steam Drum
V. Economizer Header

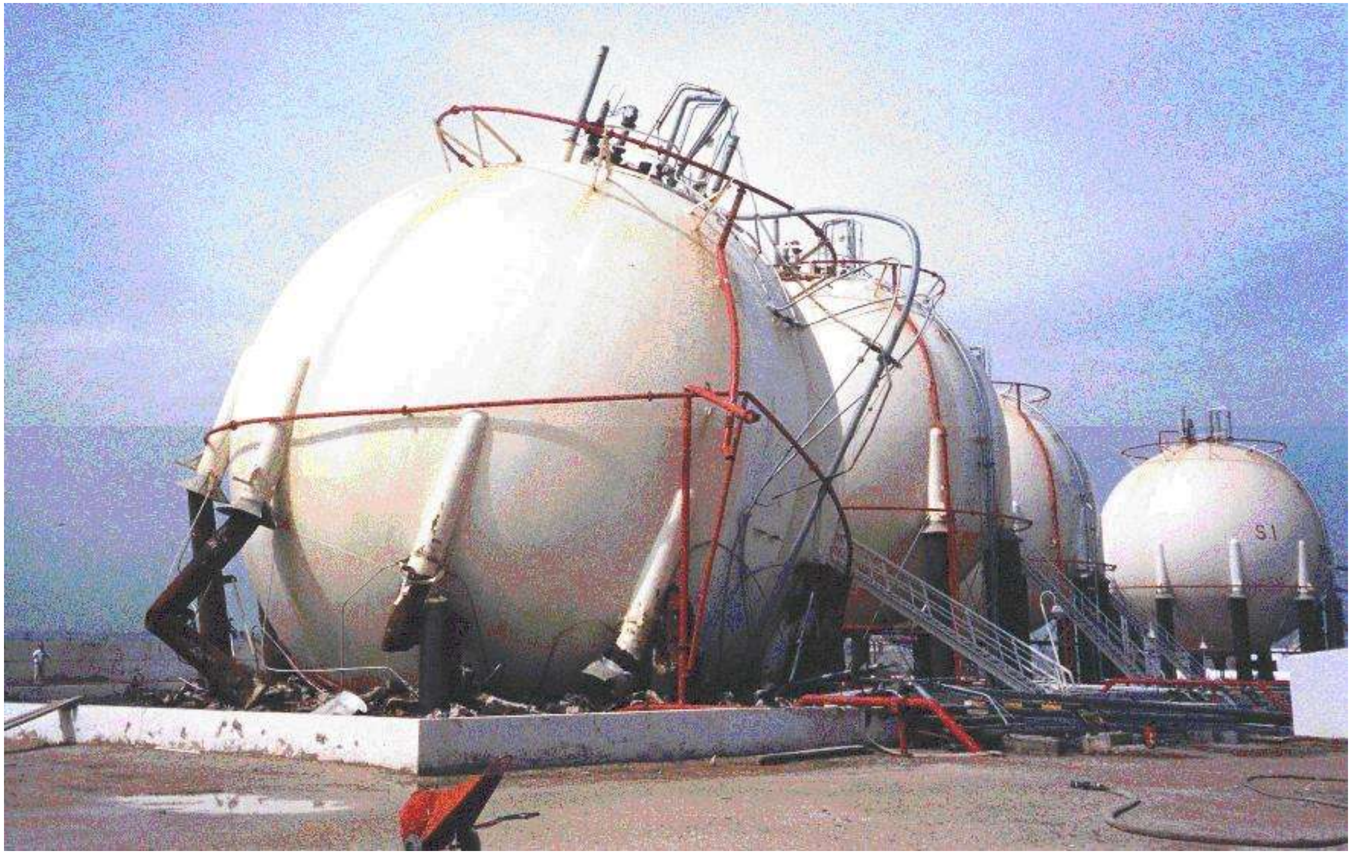
Process Plant Incorporating a Heat Recovery Steam Boiler

One of the main differences between the process gas boiler (Heat Recovery Steam Boiler) and the conventional package boiler is the thermo-siphon effect. A package boiler will naturally circulate the water by thermo-siphoning were as the process gas boiler because of it layout sometimes have to have forced circulation via a boiler circ. pump.

Testing of Pressure Vessels

- Test Pressure
- Test Fluid
- Temperature of the Test Fluid
- Are supporting structures Strong enough?

Gas storage sphere collapsed while being filled for a hydrostatic pressure test killing a worker underneath. Support legs had corroded due to water trapped between insulation and support column.



Stored Energy

Pressure testing is almost always done Hydraulic testing. If a weld or attachment does fail then there is very little of no stored energy to be release as long as the equipment has been vented and completely flooded.

Hydrostatic Test Check List

- Structure
- Joints and Spades
- Removal of air
- Pressure Gauges (QA checked)
- Hammer Test
- Multi-Chamber vessels.
- Precautions
- Drying

Hydrostatic Test Check List

Structure

Areas of interest and support should be de-lagged and cleaned and checked before flooding and that any spring support devices bellows compensators have had their gags fitted.

Hydrostatic Test Check List

Joints and Spades

All external inlet and outlet nozzles should be spaded or blanked off. Note all spading and blanking locations should be recorded on a check sheet.

Hydrostatic Test Check List

Removal of air

Ensure that you have a large and adequate method for venting the equipment in all the appropriate locations.

Hydrostatic Test Check List

Pressure Gauges (QA checked)

Most procedures require the fitting of two calibrated pressure gauges that read at least 1-1/2 to 2 times the required test pressure

Hydrostatic Test Check List

Hammer Test

Bring a vessel up to hydrostatic test pressure and hit each plate and nozzle welds with a hammer. This test was generally applied to carbon and low alloy materials but is not used much anymore.

Hydrostatic Test Check List

Multi-Chamber vessels.

Ensure that all inter vessel connection have adequate support and an adequate vent arrangement.

Hydrostatic Test Check List

Precautions

Before filling the vessel ensure that sight glasses or control instrumentation has been isolated, and if there is a danger of freezing the vessel is drained or protected by a heat source.

Hydrostatic Test Check List

Drying

If possible avoid getting the equipment wet during filling or that is in dried off as the test is in progress.

To compliment the Hydrostatic Test a series of other NDT techniques can also be used such as random radiography, dye penetration test, magnetic particle flaw detection, and ultrasonic tests if appropriate to further prove the equipment integrity.

This is an example of a fracture caused by using water for a hydrostatic pressure test when the temperature fell well below freezing after the vessel was flooded.

END OF PRESENTATION

ANY QUESTIONS