

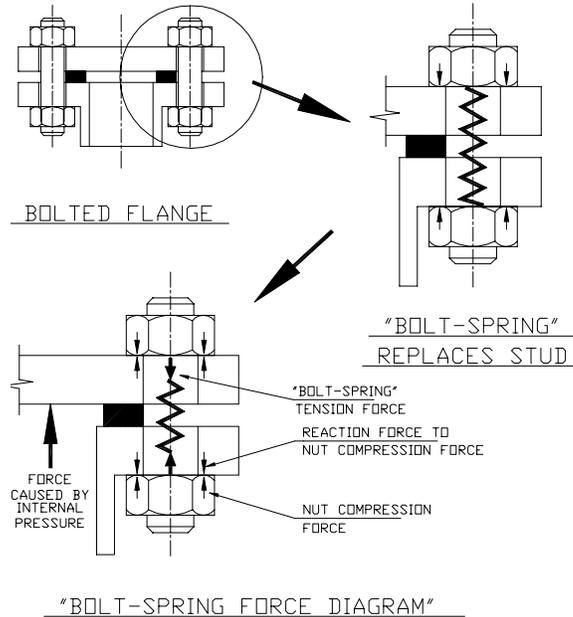
FLANGE BOLTING-UP PRACTICES

ABSTRACT

Prevent flange leaks with proper bolting practices. Bolts and gaskets behave like springs and unless flange bolts and nuts are properly tensioned the flange will leak. The correct tightening torque depends on bolt diameter, material of construction, process pressure and bolt fabrication. Key words: thread surface finish, yield strength, creep, bolting sequence, load cycling.

A BOLT IS NOT A BOLT.

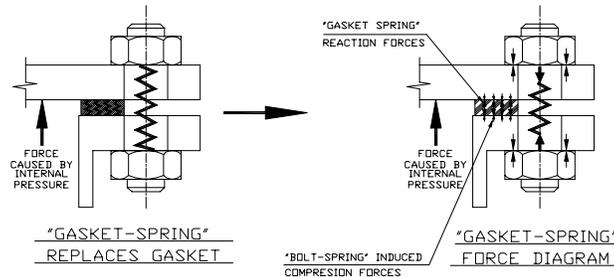
A bolt is not a bolt - it is a spring! When tightening a bolt you are tensioning or slackening a spring. The sketches below show how a spring can be considered to replace the bolt pulling the flanges together.



In this article a bolt is referred to as a 'bolt-spring'. The 'bolt-spring' must pull the flanges together more than the forces acting to push them apart. If the 'bolt-spring' is too loose, the pressure stretches the bolt and the flange leaks. To prevent the flanges separating, the bolts are preloaded (stretched). Bolt torque figures are calculated to produce a bolt stretched to at least 65% of its yield strength. Yield strength is the stress at which the bolt shank starts to deform permanently (Take it beyond this & it will snap off.).

A GASKET IS NOT A GASKET

When a gasket is sandwiched between flanges it behaves both as a seal and a spring. The sketch below is the same as the previous except the gasket is now turned into a spring like material. In this article it will be referred to as a 'gasket-spring'. A 'gasket-spring' will creep with time or temperature. Gasket creep is the gradual deformation (squeezing) of the gasket when sandwiched between flanges. The spring tension in the gasket slackens off. Gasket creep may require that flanges be re-tensioned periodically. It is often necessary to check the bolt manufacturer's **and** the gasket manufacturer's torque tables to select the highest torque to be used.



To prevent a flange leak there are a few things to check. The following table will provide some guidance.

WHAT IS REQUIRED	WHAT YOU CAN DO
The bolt-spring shaft ought to be stretched to 75% - 80% of the material yield and in excess of the maximum bolt load.	Ask the bolt manufacturer for the maximum bolt torque and the number of turns from snug to achieve this or use load-indicating washers. As a last resort use a top quality tension wrench to the bolt manufacturer's torque specification.
Bolts of sufficient tensile strength to take the process and bolting forces.	Check the bolt head forging marks against the bolt head manufacturer's standards to insure the bolts and nuts meet the load requirements for the service.
Bolt tension must allow for cycling of loads.	Swap the bolt for one of higher tensile strength and pull it up tighter. Make sure all the bolts are to

UNFIRED PRESSURE VESSEL INSPECTIONS

ABSTRACT

Unfired pressure vessel inspections. Pressure vessels must be regularly inspected and be maintained in a safe operating condition. New Australian laws stipulate that all pressure vessels must have a Hazard Level rating ('A' highest to 'E' lowest) which reflects the vessel's safety risk (see AS3920.1). The higher the risk the more stringent the requirements for operating and inspecting the vessel. Keywords: receiver, non-destructive testing, internal inspection.

The definition of a pressure vessel in Australian Standard AS 3873 is "a vessel subject to internal or external pressure. It includes interconnecting parts and components, valves, gauges and other fittings up to the first point of connection to connecting piping." Pressure vessels are such things as compressed air receivers (see Figure No. 1 below), barbecue gas bottles, steam boilers, aerosol cans, vertical leaf filters, beer bottles, cigarette lighters and fire extinguishers. This article discusses the general requirements for inspection of unfired pressure vessels such as compressed air and liquefied gas receivers and process reactors. The other types of vessels are inspected to different criteria.

WHY INSPECT PRESSURE VESSELS?

It is necessary to inspect the integrity of pressure vessels.

- (a) Gases and liquids stored under pressure inside a container are in an energised and compressed state. Rupture of the vessel would result in catastrophic release of pressure.
- (b) The chemicals within the pressure vessel may be toxic (e.g. chlorine and ammonia gases).
- (c) The contents may attack, erode, corrode, induce stress, change the metal characteristics or weaken the containment vessel over a period of time.
- (d) External impact or corrosion may weaken the pressure vessel. (A real problem with externally insulated vessels where the insulation gets wet from rain or from the process.)

EXTENT OF INSPECTIONS

Inspections can be in-service inspections where the inspector does an external inspection, tests the pressure relief device operation and does documentation review so he can certify the vessel for continued use for a short period of time. Or the inspection can be a full inspection requiring inspection of the vessel internal walls and attachments, the external surfaces and attachments, pressure gauges, pressure relief devices, the immediate surrounds of the vessel and documentation. It maybe necessary to remove sections of insulation to expose the outer shell wall

If full visual inspections are impossible or costly it may be possible to substitute nondestructive testing (NDT) methods to confirm the vessel integrity. Such NDT methods as ultrasonic thickness testing, eddy current thickness testing, acoustic crack detection, magnetic particle crack detection and hydrostatic pressure tests are all viable means of proving vessel integrity.

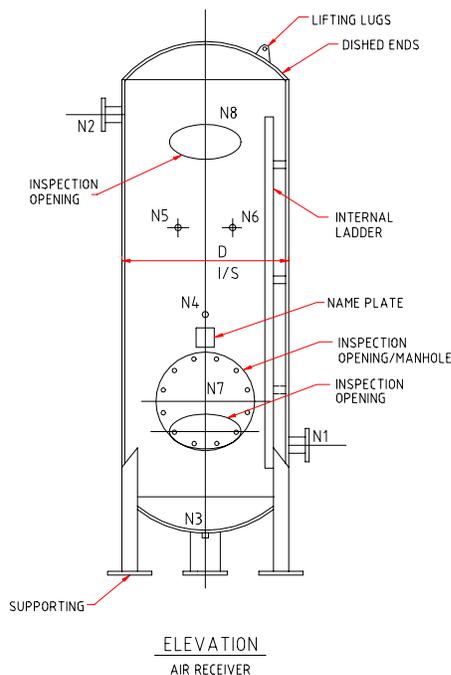


Figure No. 1 Vertical pressure receiver or accumulator.

WHAT THE INSPECTOR LOOKS FOR

Only persons experienced and trained in the techniques of pressure vessel inspections are allowed to conduct the inspection. Normally a competent, independent third party is used. The inspector may require improvements to insure

Vertical Bulk Liquid Storage Tank Construction and Maintenance

ABSTRACT

Vertical bulk liquid storage tank construction and maintenance. Bulk liquid storage tanks are constructed to contain large volumes of content. The nature of the content and the amount involved can impose major hazard and risk. For this reason bulk liquid storage tanks must be constructed and maintained to high standards. The article reviews the requirements for building and maintaining vertical, bulk liquid storage tanks. Issues, which affect the care of large storage tanks as well as common problems, are reviewed. Keywords: chemical storage, tank floor, statutory inspections.

What is a Bulk Liquid Storage Tank?

Bulk liquid tanks can be round, horizontal cylinders, vertical, cylindrical tanks and occasionally spherical vessels. We are concerned here with vertical tanks and vessels whose internal volumes are measured in tens of cubic meters through to hundreds of cubic meters. Examples are oil refinery storage tanks and process chemical storage tanks.

Tank Construction

Storage tanks are made from materials that are chemically compatible with their contents. They are designed to handle the forces resulting from a full tank. Alloy metals, steels, plastics, fibreglass and even woods, as in wine vats, are used. Where it is too costly to make the entire tank from the ideal material, the tank structure is made from less costly materials and the internals are lined with an appropriately compatible surface.

Tank roofs come in several designs. They can be self-supporting cones and domes or supported cones and domes with the structural members either on the inside or outside of the roof. They can be flat top roofs supported by internal structural members or floating roofs that move up or down with the contents and use a seal rubbing against the inside wall to prevent product escape. They can be a combination of floating and covered roofs. Figure 1 shows a vertical, bulk liquid storage tank with a range of roof configurations.

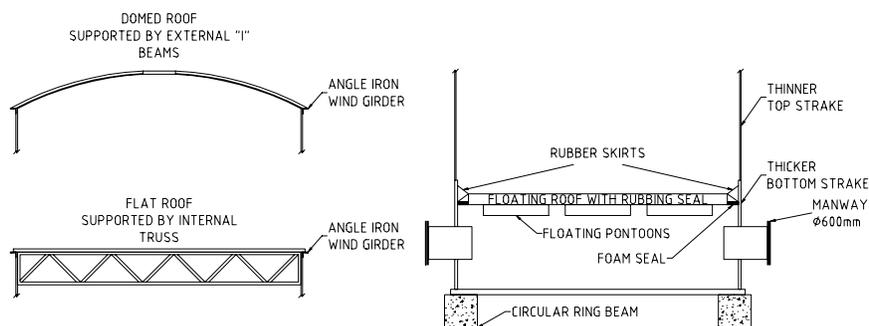


Figure 1. A Vertical Bulk Liquid Storage Tank with Various Roof Configurations.

Tanks must be constructed to a recognised engineering standard for the material of construction and the service required of it. A common standard for oil and fuel tanks is American Petroleum Institute (API) 650. The designer calculates wall, roof and floor thickness, weldment sizes and methods, nozzle reinforcements and the need for stiffening and supports to accommodate stresses induced in the tank due to its contents. Allowances are made for specific load conditions such as windage, earthquake, live loads and rain. If the tank contents are liquids with specific gravity less than one (1) the designer builds for the stresses of the water hydrotest.

Tank floors are either sloped towards the wall or sloped to a center sludge sump which is piped away to allow clean out of contaminants. The outside of the floor should have a rain cap right around it to stop rain getting under the floor. If there is a spoon drain around the outside of the tank make sure the height of the spoon drain lip is below the level of the bottom of the tank so no rain water can pool under the floor.

The most stressed part of a vertical tank is at the floor to wall connection. Great effort is taken to minimise residual welding stresses within 300-mm of this weld. For example stress points, like 'T' weld joints that form when three plates are butted together, are kept well away from this critical area. Any weld, floor or wall repairs in this area of a tank must comply with recognised tank repair standards such as API 653.

Tank Foundations

A solid, robust foundation is necessary to support a vertical tank. The foundation will take the load of the tank's self weight and its contents. In particular the foundation must support the localised load of the tank wall. The foundation can be incorporated into the tank plinth for smaller tanks or, as in the case of large vertical tanks, a reinforced, circular concrete ring beam is first constructed for the tank wall. Then the center is in-filled with appropriate clean material and compacted flat for the floor plates to be sat on. Insure in-fill material is chloride free since the presence of chlorides will accelerate the rate of corrosion. Never use beach sand to construct tank bases, as the sea salt will rapidly corrode the metal floor plates.

By following a drop of water down through the CWT we will see how the energy transfers occur during its journey to the sump. When the drop of water is first formed at the top of the tower it is at the warm temperature produced by its passage through the process. The air at the top of the tower has already passed through the tower. It has been warmed and is laden with moisture rejected from lower in the tower.

The drop cannot remain hotter than its surroundings without a supply of energy. When the drop and air first make contact the two temperatures start to equalise. The water starts to cool and release vapour and the air warm and become more humid. But the rate, or speed, at which cooling first occurs is slow as the difference in temperatures and humidity is not great because the air is already warm and wet.

Lower down in the tower the falling drop hits the fill arrangement and breaks into smaller droplets. The droplets collect into broken, turbulent streamlets running down throughout the fill. The water now contacts cooler air lower down in the tower. This air is dryer, not having passed over much water. The cooler, dryer air removes the heat in the water at a faster rate than at the top of the tower because the difference in temperatures and humidity are much greater.

Finally the fine, thin streamlets fall out the bottom of the fill into the sump where the only cooling that occurs is from the surface of the water pool as air is drawn across it.

Materials of Construction

The majority of packaged CWT's are presently made of fiberglass, plastic and stainless steel. The frame and housing is fibreglass, the fill and piping is plastic and the bracketing stainless steel. These materials are compatible with water and deliver a long, trouble free life.

Large CWT's are often made of concrete, wood, cement sheeting and stainless steel. The sump is concrete, the frame and fill is of wood, the cement sheeting is used for covers and stainless steel is used for bracketing. Fiberglass is an alternate material to replace the wood and cement sheeting.

Locating Cooling Towers

Choosing the position to locate a cooling tower requires knowledge of its local environment. The direction of the prevailing winds will determine where the vapour plume is blown. Whether the ground immediately around the tower is sealed or uncovered will affect dust loading in the tower.

The nearness of buildings influences the passage of air to the CWT and the movement of the plume. It is critical that recirculation of the plume back through the tower is minimised. If the moist vapour plume continually contacts metal in buildings they will rust at an accelerated rate. The chemicals stored or used in the vicinity must be known. Chemical vapours drawn into the tower, such as hydrochloric acid or car exhaust fumes, attack it. The nearness to places of work and the amount of exposure people may have to the plume requires consideration.

Cleanliness and Water Treatment

Bacteria and algae grow in the CWT's warm waters and wet crevices. Legionnaire Disease is the most famous illness that is associated with CWT's but there numerous different bacteria that have been found in CWT's. Cleanliness standards and procedures have been developed by health organisations for the care of cooling towers and tower owners and users are obliged to meet these requirements.

Typically a standard requires bacteria counts per volume of water to be less than a maximum number. The control of bacteria levels is usually done by the use of chemical biocides dosed into the tower. The biocides can be slug dosed or metered in by pump. The standard also specifies water cleanliness and requires towers to be emptied and cleaned when dirt loads become excessive. A water bleed-off point is used to control the amount of dissolved solids build-up in the tower. In-line filters can also be installed in the piping circuit to keep the water clean for longer.

Entry into a cooling tower constitutes a confined space entry and appropriate training and procedures need to be in place.

Issues with operating Cooling Towers

Check the following CWT operating issues regularly:

- Water distribution is even – sprays and holes do block.
- The fill is properly in place right across the tower – gaps in the fill let air channel through them.
- Mist eliminators are properly in place right across the tower – an incomplete arrangement lets vapour laden air escape and water consumption rises.
- Fan blade corrosion can be excessive. Inspect regularly.

Mike Sondalini – Maintenance Engineer

Other operational issues with rotary screw compressors have been rotor shaft end seal leaks from poor manufacturing tolerances; on vee-belt driven machines the belts can slip either from stretch or from dust settling onto the pulleys and reducing the coefficient of friction. In a dusty location the entire machine cabinet internals must be sealed from the dust and additional filtration added to the air intake grill. When things go wrong with these machines they are costly to fix. Regularly service them, provide quality air and oil filtration and condition monitor to get the longest, trouble free life.

RECIPROCATING COMPRESSOR ISSUES

A reciprocating compressor uses a piston and cylinder to squeeze a small volume of air into a tight space in the cylinder head before releasing it. Multiple pistons can be used. These machines produce low volumes of air, measured in 10's of CFM, and up to very high pressure in the 100's of bar. The pressures are adjustable by a pressure switch that signals when the outlet valve opens.

Operating issues with these machines include the need to control the vibration induced by the reciprocating piston. Insuring the unit is solidly bolted down onto a thick concrete surface is usually sufficient but on light floors it may be necessary to put it on vibration dampening mounts. Most units are vee-belt driven and these require periodic replacement or tightening as they stretch. Usually a 3-month preventative maintenance (PM) routine covers this problem. The smaller models come as a 'packaged unit' with their own air receiver. In that case the air receiver requires an automatic drain installed on the bottom drain point to prevent water building up in the receiver. Receivers can filled up with water following the failure of the auto-drain. Again a 3-monthly PM to test the auto drain operation will pick up this problem.

Mike Sondalini – Maintenance Engineer

Fired Packaged Boiler Basics

ABSTRACT

Fired packaged boiler basics. Steam boilers not used for power generation and of smaller size and energy output are termed packaged boilers. The heat source is usually either electric coils or a burning fuel. When a flame is used to heat the water it is known as a fired packaged boiler. Fired boilers are considered efficient steam generators with about 85% of the available energy converted to steam. They can be of water-tube or fire-tube design. Boilers incorporate many key aspects of heat transfer to create steam from water. This article describes how fired boilers work and their key components.

Keywords: steam generation, hardness, feed water

A fired boiler consists of a burning flame enclosed in a chamber around which water is circulated until the water boils off as steam. Figure No. 1 shows a simple schematic drawing of a two-pass boiler and its primary components.

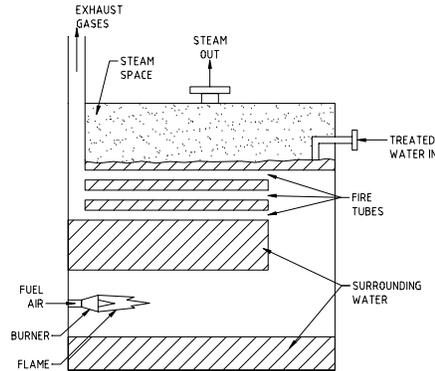


Figure No. 1 Fired boiler schematic drawing.

The Burner

Burners use gas, atomised oil mist or finely ground coal burnt in a stream of air to create a heat source. The water absorbs heat by circulating the water through pipes passing through the hot space (water-tube boiler) or by passing the hot gases through pipes passing through the water volume (fire-tube boiler). A boiler is a heat exchanger with hot gas on one side and cold water on the other.

The Heat Exchanger

The metal tubes are held at each end by expanding them into holes drilled in thick sheets of steel. The method of expanding the tubes produce firm, leak-tight seals in the end tube sheets. Tube leaks can occur if the required thermal expansion of the tubes and the tube sheet is prevented because of scale build-up behind the tube sheets.

The hot gases are made to give up as much heat as possible by passing them by the water several times. Eventually the temperature difference between the cooling gas and the heated water become so small to make heat transfer worthwhile and the gas is sent up the stack.

The water inside a packaged boiler is bubbling as if it were a boiling saucepan on a stove. The water space is pressurised to the working pressure of the boiler. The higher the pressure, the hotter the steam. The pressure a boiler reaches and the volume of steam created depends on the temperature of the flame, the amount of surface area through which the heat enters into the water and the rate at which the steam is drawn from the boiler. If the steam pressure gets too high it is vented-off into the atmosphere by pressure relief valves.

When bringing boilers up to working duty it is critical that they are warmed gradually to allow the metal to expand gently without thermal shock. Follow the manufacturer's instructions exactly in this regard. Boilers that are brought up to temperature too quickly, too often, will give years of expensive metal fatigue, refractory and thermal stress problems.

The Feed Water

The water to a boiler must be treated to remove 'hardness'. 'Hardness' is the scale that builds up on hot surfaces when water is boiled. If the 'hardness' is not removed it scales over the pipes and stops heat transfer from the hot flame to the water. This means expensive energy is wasted. 'Hardness' deposits are often seen in kitchen kettles used for boiling water as white or brown solid sediment.

'Hardness' causing chemicals do not go out with the steam. As the water that carries them boils away, they stay behind in the boiler. If they are not mostly removed before entering the boiler they would soon build-up within the boiler as solid material covering pipes and stopping heat exchange.