5. Storage and Processing Containers

This section describes the construction of large vessels for storing or processing materials. Many vessels have no internal pressure, except that due to the weight of the contents. They are usually open to atmospheric pressure, except perhaps during loading or discharge. In this section these containers are described as storage tanks if they hold liquid or slurry. These vessels are usually cylinders with a vertical axis, because the hydrostatic stresses are then uniform round the circumference.

Containers for storing solid pieces or granules (bulk solids) are known as bins. Silos, hoppers and bunkers are considered types of bin. Silos are tall towers or pits. Hoppers are designed with a conical or wedge-shaped bottom for discharge by gravity. 'Bunker' is a term used both for a vessel for storing fuel and a rectangular storage vessel. Most design texts consider bunkers to be rectangular bins with or without a hopper bottom.

Processing tanks are vessels that are used to undertake some material processing function, such as precipitation, filtration or washing of minerals. These are often similar to storage tanks, except that they may have fixed or moving components. They therefore may be subjected to additional loads that have to be taken into account during design.

5.1. Pressure Vessels

Pressure vessels are closed containers subjected to external or internal pressure. This means that their walls are subjected to biaxial tension or compression. If the pressure is above that defined in the relevant pressure vessel standard, they must be constructed to this standard. Most pressure vessels are vertical or horizontal cylinders with rounded ends, but may be spherical.

Pressure vessels used in Australia must be designed, constructed, tested and operated in accordance with AS/NZS 1200 and the referenced standards, some of which are listed as References 6 to 9. This standard states that non-Australian standards may be used if both design and manufacture are to the same standard. It is not acceptable to design to ASME VIII and construct to AS 4458. Most pressure vessels in Australia are designed to AS 1210.

One aspect of pressure vessel design is that an independent authority must verify the design. Materials for pressure vessels must conform to the standard.

5.2. Design of Tanks and Bins

There are no Australian Standards for design and construction of tanks or bins. Tanks for holding liquid are subjected to hydrostatic pressure and may be designed to overseas standards such as AWWA Standard D-100, API 650 or BS 2654. Pressure vessel standards like AS 1210 may also be used to calculate membrane stresses in walls. AWWA D-100 is used for water tanks. BS 2654 and API 650 are intended for petrochemicals, but are often applied to other liquids, such as water.

Bins for storing bulk solids are rather more difficult to design, because these will be subjected to high flow loads during loading and unloading of these materials. These are likely to be more significant than those due to the weight (hydrostatic). These loads are because of the following factors.

- Friction between and locking of material particles causing bridging
- Friction between the material and the vessel walls
- Impact of heavy lumps
- Pressure or suction of air trapped in fine material as it is loaded or unloaded
- Changes in temperature or moisture content causing swelling of the materials (grain)

Some guidance for the design of bins is given in WTIA Technical Note 14, together with several of its references.

All large containers will need to be designed against the environmental loads of wind and earthquake. It is usual to use ring stiffeners at thin unsupported areas, such as the rim to stiffen tank shells against buckling. Stiffening is also required at the following locations.

- The transition between cylindrical and conical shell surfaces,
- The corners of rectangular bins,
- Where support columns are welded to the shell.

Design to avoid brittle failure should also be considered, and the concepts of a pressure vessel or tank code applied.

5.3. Manufacture of pressure vessels

Pressure equipment, including piping and vessels must be manufactured in accordance with AS 4458. The prime requirement is that before commencement, the manufacturer demonstrates his competence to undertake this work. Depending on the class of work, and the manufacturer's quality system, an independent inspection body may need to be appointed. AS 4458 specifies requirements for cutting, hot and cold forming, welding, tolerances, inspection and heat treatment. Qualifications of welding procedures and welding personnel are referred to AS 3992.

5.4. Manufacture of flat bottomed tanks

The manufacture of large flat-bottomed tanks can be considered a case study that can be applied to the manufacture of similar structures. These tanks are used for storing large quantities of liquids, such as potable water and petroleum products. They have a floor of lapped plates and a cylindrical shell, which is usually butt-welded. The roof may be a conventional structure of clad steel sheeting on rafters and purlins supported on columns inside the tank. Alternatively a floating roof, or a simple cone shaped roof may be used. Some tanks are open-topped. Mineral processing tanks are of a similar configuration, except that instead of a lapped floor, they sometimes have a butt welded floor, which may be flat or conical.

The choice of standard used for erection and welding of tanks is a source of confusion without a relevant Australian standard being available. AWWA D-100 and API 650 specify that welding procedures and welders should be qualified to ASME IX, and refer to ASME VIII for acceptance standards. In order for the tank to conform to a particular code, all work must be in accordance with the code and its references. However, it is common practice for fabrication to be undertaken to AS/NZS 1554, in which case it is strictly wrong to state the tanks conform to one of the American codes.

The normal sequence of erection is as follows. First, the foundations are laid. This is often coarse sand, which may be dry or wetted with heavy oil to help protect the underside of the tank from corrosion. The foundations are invariably contained in a concrete ring wall, which supports the annular ring and shell. It is important the top of the ring wall is flat to within 2mm to ensure the shell is vertical within tolerance. Next the annular ring is laid and joined. This is the outer portion of the floor on which the shell sits. After placing the floor plates, the first ring or strake of the shell is erected. The vertical seams in this ring are fully welded and then the second strake is erected. After welding all the verticals in Strake 2, the circular seam between strakes 1 and 2 is welded. The process is repeated, adding ring stiffeners where required. The floor is laid and lap-fillet welded from the centre outwards while the shell is being erected, not welding it to the annular ring at this stage. The annular ring is fillet welded to the shell when erection of the shell has been completed. The floor is not welded to the annular ring until all other floor and shell welding is complete.

The final operation is assembly and welding of the roof. Floating roofs are assembled and welded on suitable spacing jigs, to allow access to the underside. Sometimes cone roofs are assembled and welded at floor level, and then are lifted to the top of the shell by air pressure inside the tank. They are then welded to the top of the shell before releasing the air pressure. This allows most of the work to be completed at a safe height.

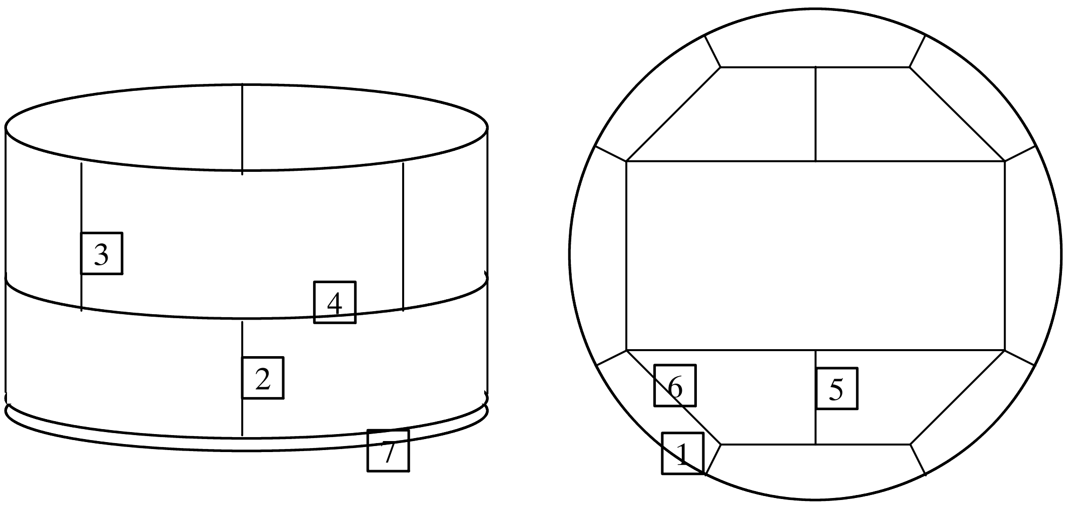

Figure 59 Sequence of Welding a Tank

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