TANK LIFTING

A quick and cost effective method to:

- **Remediate settlement problems in tanks**
- **Replacing floors in tanks with intrinsic safety**
- **Replace / Service basecourse foundations**
- **Inspection of underfloor**

Due to a small number of accidents resulting in the release of petro-chemical liquids, not necessarily associated with storage tanks, there has been a public outcry by the environmental lobby the results of which could have serious cost implications for operators. Those not fully understanding the subject matter has resulted in hurried
legislation which could result in requirements that would virtually be inoperable in the short term if fully enforced by regulatory bodies. Clearly, the industry must respond positively to assuage public concern and regulatory compliance, but in a manner that will clearly be seen as meaningful and positive.

Within the past five years the environmental impact on the operation of petro-chemical product storage tanks containing hydrocarbon or other dangerous goods, constructed to standards such as API 650, has taken on critical implications for refineries, distribution centres and other storers of Dangerous Goods. Pollution of the supporting foundation and possible widespread effects on ground water has resulted in moves to require the installation of secondary containment. That is not to say, necessarily, a tank with two steel bottoms, but alternative means of reducing the failure probability to an acceptable public or statutory level. Compliance with statutory codes such as Dangerous Goods Regulations and AS 1940 dictate that 'impervious' secondary containment is now required. The USA has enacted a raft of legislation with regard to secondary containment this 'mirrored' in EC and other part of the world.

Clearly, increased inspection of the tank bottom has merit and visual examination of the bottom from inside the tank can be supplemented by ultrasonic methods, acoustic leak detection and magnetic flux scanning. Tank lifting now offers a very cost-effective method for underfloor inspection, combined with the opportunity to undertake repairs to the bottom and underside painting, together with improvements and repairs to the Bit-sand surface of the tank pad. An impervious membrane can also be installed with a leak detection trough formed around the tank edge so rendering the tank compliant and extending its useful life.

Tel +61 (08) 9535 8176 **Mob 0439 913 313** Worldwide Tank Services www.worldwidetank.com.au

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In fact, tank lifting using discrete airbags offers the most cost-effective method for lifting tanks off their foundations. When compared with the more conventional system of hydraulic jacking, the airbag method results in some very distinct advantages, apart from a most significant reduction in cost. It is not necessary to weld any attachments to the shell or dig deep pits beneath the annular plate. Site preparation is an absolute minimum, and only requires excavations extending 400mm, under the tank shell by 800mm wide and30mm deep, at a number of discrete locations. In the case of smaller tanks, say up to 46M (150 feet) diameter, the annular plate can be well clear of the pad within six hours of the lifting crew arriving at site.

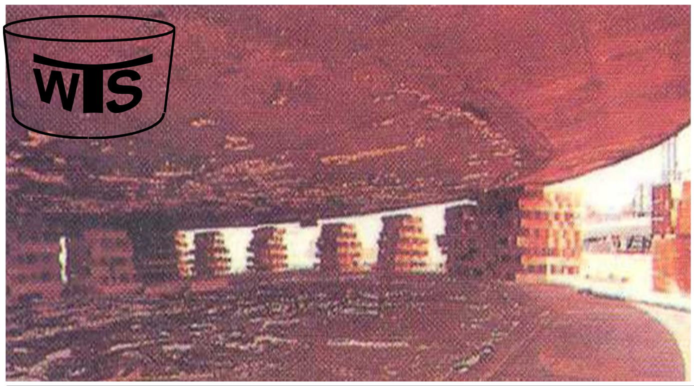
Regular programmed inspection is the obvious first task and this should be based on past historical records to ensure that all aspects of the examination are pertinent to potential sources of product leakage. Past experience has demonstrated quite conclusively that catastrophic shell failure as a consequence of long-term service is most improbable. While corrosion will reduce the shell thickness, any failure will be pre-empted by localised pin hole leaks and provide an adequate safety margin.

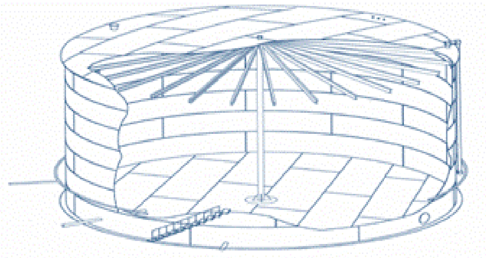
It is not unknown for a leaking tank bottom to wash away the foundation to the extent that the static head of liquid can no longer be supported. The bottom plate lap welds will rupture leading to the complete discharge of the contents, almost invariable when the tank is at or close to its maximum capacity. Fears of bottom failure have led to a number of proposals such as building in a double bottom to the tank or installing some form of leak detection membrane beneath the tank.

Such actions are not without their own problems such as setting up a galvanic cell or trapping rain water beneath the tank should settlement in the shape of dishing take place.

Whilst internal inspection of the bottom plates can give a clear picture of what is happening to the upper surface, it requires the use of ultrasonic or magnetic flux methods of examination to assess what may be happening to the bottom surface. Magnetic flux scanning can provide a great deal of useful information in a relatively short period of time, but does nevertheless fall short in a number of critical areas. The greatest by far of these is the inability to address the 'root cause' of the corrosion but only to detect that it is there.

The 'root cause' is invariably the basecourse foundation and in particular debris left on the foundation cap such as welding rod stubs, wood blocks or stones projecting through the cushion layer atop the foundations all of which result in corrosion cells being set up. Lifting the tank clear or its foundation offers what must be the most definitive method of underside inspection. Moreover, once the tank has been raised it is then possible to grit blast and paint the bottom and install an impervious membrane if necessary included in the remake of the foundation of the tank.





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Practical Considerations

Lifting tanks using hydraulic jacks has been looked upon as the conventional method, but requires a great deal of preparatory work, digging either numerous deep pits beneath the tank annular or welding on brackets at about 5-6 m (15-18 ft) intervals around the tank shell to install the hydraulic jacks.

In contrast, using airbags it is only necessary to excavate a minimum number of slots extending 400mm (20 inches) under the tank shell by 1m (40 ins) wide and 75-100mm (3-4 ins) deep, at a number of discrete locations. The number of airbags to be used for initial lifting and final lowering requires consideration because of the local increase in compressive stress in the shell. Once the tank is clear of the ground, many more bags can be used to speed up the lifting process.

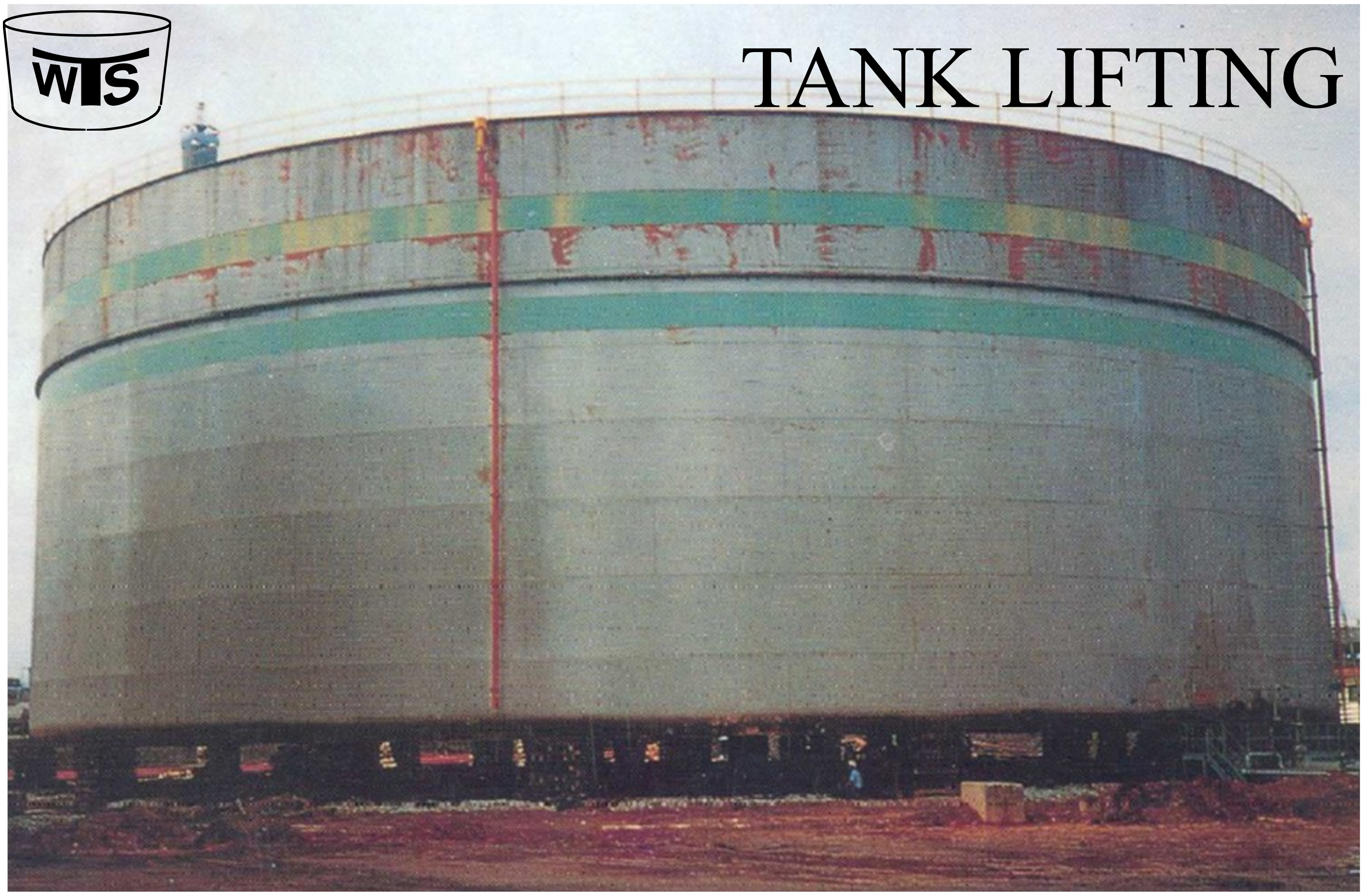
The lifting procedure must follow a set sequence to minimise sideways or rotational movement of the tank as it is raised. This follows from the fact that the airbag is quite flexible. If the tank were simply raised on all the airbags at the same time it would lack rigidity and not maintain position. However, by the same token should the tank move or need to be moved relative to its original position, it is a simple task to pull it to the desired position whilst sitting on the airbags or use the airbags 'differentially' to reposition the tank both laterally and rotationally.

The normal method of lifting is to jack the tank sector by sector, always keeping part of the annular in contact with the wooden stiles that are erected under the tank at it rises. This provides resistance against movement. The lowering sequence is the reverse of the lifting sequence so ensuring that should any movement have occurred, the process is reversed as the tank is lowered.

Experimental Evidence

As a matter of course, when any tank is lifted, the deflection of the bottom is recorded together with its initial position. The same records are taken for the floating roof when this is appropriate together with details of the rolling ladder tracks and any stiffening that the roof may have. Strain gauge testing is also carried out on tank sizes for which no previous results are available. The results are used to confirm the accuracy of the modified theoretical predictions and so enhance the safety associated with lifting using the airbag method.

All of the aforementioned considerations and calculations together with the strain gauging results conducted by Nanyang University of Singapore have cumulated in our ability to develop a computer program to ensure that any size tank whether floating or fixed roof can be lifted without exceeding acceptable stress limitations.



Summary

The application of the airbag method for lifting bulk liquid storage tanks has been described, together with some of the background theory and experimental measurements that have been made to develop a safe and very economical means of raising tanks so that their bottom underside can be examined or foundation pad repaired or complete secondary containment inserted under the tank.

NDT methods are always a ‘compromise’ and address the evaluation of a defect but not the ‘root cause’ or seek to remediate the cause, this can lead to defects caused by foundation debris continuing to manifest themselves in the corrosion of repaired plates on a floor.

Other considerations are those causing settlement problems in storage tanks where the ground bearing capacities have not resisted the forces applied by the tank. Planar tilt and differential settlement render the tank unusable if this exceeds the limitations in Appendix B of API 653. The lifting of the tank either partially or wholly to insert a ring beam is required to remediate the settlement.

The merits of this method compared with hydraulic jacking are considerable not least of which are the speed of operation and the reduction in cost. Because the airbags can be used under the floor as well as around the shell there would appear to be no technical limit the size of tank that could be lifted.