

When to Repair Pits in Steel Water Tanks

Without protection, pitting corrosion can attack steel water tanks. However, all pits do not immediately threaten tank integrity. Here is a guide to deciding which pits require weld repair.

The first step in deciding which pits in steel water tanks need weld repair is a thorough inspection of the tank. American Water Works Association (AWWA) Standard D101 recommends that interior and exterior of storage tanks undergo inspection by an engineering firm experienced in water-tank service. Inspections should take place at least every 5 years or sooner in case of structural distress or leakage and should include evaluation of structural elements, tank coating, and safety and sanitary equipment.

Inspection for interior pitting corrosion requires that tanks be drained

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and debris removed from the tank bottom. This allows the inspector to examine corrosion in all areas of the tank more effectively than by underwater diving inspection. He should check all interior surfaces, including the riser pipe on elevated tanks, often the area of deepest and most-concentrated pitting.

The inspector should record shape, depth, size, and frequency of pit occurrence in different areas of the tank. He should verify plate thickness in unpitted areas with a nonde-

structive instrument such as an ultrasonic-thickness gage. In addition, he should verify tank dimensions—diameter, shell height, and riser diameter. Following inspection, an engineer familiar with tank design and rehabilitation then evaluates the data.

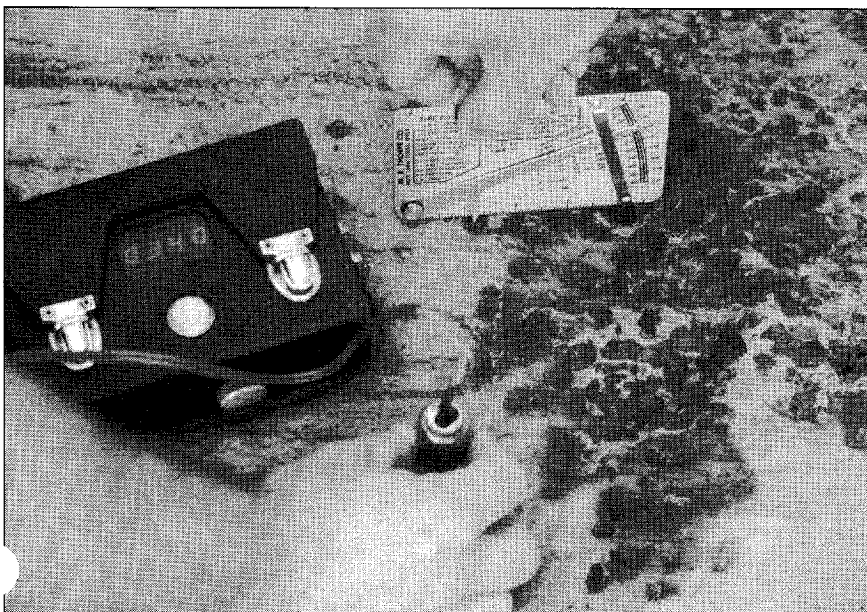
To weld or not to weld

The engineer first determines if pitting is deep and wide enough to endanger the structure. If so, welding, patching, or other structural repair is required. Pits show up in water tanks as spots or grooves. Spot pits are round and occur anywhere in the tank. Vertical grooves in the steel typically occur in the vertical portion of a tank or riser—these are called vertical-groove pits.

The effect of pitting on strength of a structure depends on the stresses in the plate and on shape, size, and concentration of the pits. If a cylindrical shell is under primarily hoop stress, as for a standpipe, one deep vertical-groove pit can severely reduce the load that the shell can withstand. If the shell is in compression, as the riser of a torus bottom tank, one pit, even a long grooved one, will not likely affect shell integrity. A small amount of general metal loss will increase stress and decrease allowable compressive stress, since thinner plates buckle more easily than do thick plates.

To determine the effect of pitting on a shell in tension, the procedure for a given steel type and thickness and pitting pattern might be as follows:

1. From the field investigation, locate the deepest groove pits or any se-



Tank inspectors typically employ a digital ultrasonic thickness gage to check parent-steel thickness and a pit-depth gage, top, to check pitting severity.



Welder shielded-metal-arc-welds a filler-metal deposit to fill pits of a steel water tank.

ries of vertically oriented spot pits 6 inches or longer. Note the locations and measure the dimensions of the deepest, largest spot pits, 3 inches or more in diameter.

2. Calculate minimum plate thickness required for the application based on applicable equations per AWWA Standard D100.

3. Repair pits that are of the minimum size determined above and that, at their deepest points, are thinner than the allowable thickness.

AWWA design criteria for welded tanks include a weld-efficiency factor. If the factor is less than 100 percent, the amount of tolerable corrosion in the steel away from the weld is greater than the amount of tolerable corrosion in the joint.

To evaluate the effect of pitting on a shell in compression:

1. From the field investigation, determine the area of the tank with the highest concentration of deep pits. Calculate the volume of steel remaining in that portion of the shell and divide by the area of the portion analyzed to obtain an average thickness of remaining steel.

2. Use the computed average thickness and the shell radius to calculate stress in the shell, then compare it to the AWWA allowable-compression stress to determine if the stresses are acceptable.

3. Repair any areas under stresses greater than allowable.

Note that this analysis is conservative in estimating allowable stress of the shell. If it indicates a need for extensive repairs, a more thorough and

precise analysis might show that fewer repairs are required.

Even if stress analysis does not reveal structural defects, pitting corrosion can lead to leaks in the tank. To forestall potential leaks, any pit leaving less than 1/8 inch of steel at its thinnest point should be repair-welded. If a large number of deep pits is present, an engineer experienced in corrosion control of water tanks may be able to suggest an economical way to save the tank.

How to repair

The engineer who calls for structural welding to repair pitting specifies the welding procedure. To fill isolated spots or grooves, deposit weld metal in the pits and grind the deposit if necessary to prepare the surface for coating. If pits are close together or surrounded by extensive metal loss, cut out and replace whole sections of the shell. If significant metal loss is in or next to a weld seam, especially for shells in tension, reweld the seam.

Pitting repair should include effective corrosion control. Pits not repair-welded but too rough or deep to coat properly should be filled with a seam sealer or pit filler. The tank needs an extra-thick coating on rough surfaces. On tanks with extremely rough surfaces or with surfaces very close to requiring structural repair, install cathodic protection in addition to a coating to arrest corrosion. If the whole tank exterior is not recoated after weld-repair, operators should clean and paint areas of damaged paint on the tank exterior.

Monitor continuously

Because corrosion of shells in tension has led to catastrophic failures in tanks, owners must check carefully for vertical-groove pitting, especially in standpipe tanks. A split at the center of a standpipe can quickly release a jet of water capable of collapsing the tank.

Because tanks designed to AWWA D100 Appendix C are constructed of thinner steel, they are more sensitive to pitting damage. These tanks are designed to high allowable stresses, up to 38,300 lb/in.² and 100-percent-efficiency factors. Corrosion 1/8-inch deep that may not cause a structural failure in a tank designed to standard AWWA stress levels—15,000 lb/in.² reduced by 85-percent joint efficiency—can be a severe structural flaw in an Appendix C tank.

Pitting of tank shells in compression will not usually cause catastrophic failure except in certain circumstances. For example, a 20-percent reduction in thickness can result in a large reduction in stiffness and can overstress the shell by more than 40 percent. The relationship between amount of metal loss and stress in shells in compression is not linear as it is in the case of shells in tension. A shell stressed at its allowable limit in tension that undergoes a reduction in thickness of one half will see a stress twice the allowable. However, a shell in compression stressed to allowable with its thickness reduced by half sees a stress 2 to 4 times the allowable.

Tank owners should recognize that no matter how well-designed a repair might be, they must maintain tanks to avoid further structural deterioration. Proper maintenance includes periodic washouts and inspections, surveillance of cathodic-protection equipment, and periodic recoating of the structure.

Mr. Knoy is chief executive officer of Tank Industry Consultants, Inc., P.O. Box 24359, Speedway, IN 46224; (317) 244-3221. The concepts included in this article are examples only, not to be used as design criteria. Tank owners should have tank corrosion evaluated on an individual basis. ■