Case N-865-1
Alternative Requirements for Pad Reinforcement of Class 2 and 3 Atmospheric, and 0 psi to 15 psi (0 kPa to 100 kPa), Storage Tanks
Section XI, Division 1

Inquiry: As an alternative to the defect removal requirements of Article IWA-4000, what requirements may be applied for wall reinforcement of Class 2 and 3 atmospheric, and 0 psi to 15 psi (0 kPa to 100 kPa), storage tanks that have experienced wall thinning from localized erosion, corrosion, or pitting?

Reply: It is the opinion of the Committee that, in lieu of the defect removal requirements of Article IWA-4000, areas of Class 2 and 3 atmospheric, and 0 psi to 15 psi (0 kPa to 100 kPa), storage tanks experiencing wall thinning from localized erosion, corrosion, or pitting (collectively referred to herein as “corrosion”) may have the wall reinforced by applying reinforcing pads to any surface of the tank in accordance with the following requirements. Excluded from these provisions are conditions involving flow-accelerated corrosion (FAC), cavitation, corrosion-assisted cracking, or any other form of cracking.

1 GENERAL REQUIREMENTS

(a) The provisions of this Case apply to vertical cylindrical flat bottom above ground welded tanks at atmospheric pressure, which contain nonflammable fluids such as refueling water, condensate, borated reactor water, or liquid radioactive waste.

(b) The provisions of this Case also apply to 0 psi to 15 psi (0 kPa to 100 kPa) aboveground welded storage tanks. These tanks may contain nonflammable liquids or gases such as refueling water, condensate, borated reactor coolant, or radioactive waste. Such tanks may be located within building structures, and may be located below grade, provided the tanks are not subject to external pressure resulting from earth or fill.

(c) Application of the reinforcing pad shall be performed in accordance with a Repair/Replacement Plan satisfying the requirements of IWA-4150.1

(d) The design, materials, and installation shall meet the requirements of the Construction Code and Article IWA-4000, except as stated in this Case.

(e) If the minimum required thickness of reinforcing pad necessary to satisfy the requirements of 3 is greater than the nominal thickness of the tank, use of this Case is not permitted.

(f) Additional reinforcement or repair is not permitted on top of an existing reinforcing pad.

2 INITIAL EVALUATION

(a) The material beneath the surface to which the reinforcing pad is to be applied and the adjacent area shall be measured ultrasonically or by direct thickness measurement to establish the existing wall thickness and the extent and configuration of degradation to be corrected by the reinforcing pad.

(b) Prior to returning to service, the cause and rate of degradation shall be determined. The extent and rate of degradation at the inside and outside surfaces of the tank shall be evaluated to ensure that there are no other unacceptable locations within the surrounding area that could affect the integrity of the repaired tank. The dimensions of the surrounding area to be evaluated shall be determined by the Owner, considering the type of degradation present.

(c) The effects of the repair on the tank and any remaining degradation shall be evaluated in accordance with IWA-4311.

3 DESIGN

3.1 TYPES OF REINFORCING PADS

(a) Reinforcing pads may be used for leak prevention only (pressure pad) or for leak prevention plus structural reinforcement of thinned areas including areas that do, or are expected to, penetrate the tank wall (structural pad).

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1 The references to Section XI in this Case refer to the 2017 Edition. For use of this Case with other Editions and Addenda, refer to the Guide-line for Cross-Referencing Section XI Cases, Table 1.
(1) Pressure pads are designed to retain pressure, and may be used only where the tank is predicted to retain full structural integrity until the next refueling outage, assuming a corrosion rate of either 2 times the actual measured corrosion rate in that location, or 4 times the estimated maximum corrosion rate for the same degradation mechanism in that system or similar system at the same plant site. Pressure pads, including those installed during a refueling outage, shall not remain in service beyond the end of the next refueling outage.

(2) Structural pads are designed for pressure plus full structural reinforcement for the design life of the pad.

(b) Reinforcing pads may be applied as follows:

(1) On the outside of tanks for mitigation of internal or external corrosion, except that pressure pads may not be applied to the outside of the tank for mitigation of externally corroded areas that are subject to bulging due to wall thinning.

(2) On the inside of tanks for mitigation of internal or external corrosion.

3.2 GENERAL DESIGN REQUIREMENTS — PRESSURE AND STRUCTURAL PADS

(a) The design of reinforcing pads shall be in accordance with the applicable requirements of the Construction Code or Section III (N-3100, and NC-3800 or NC-3900; or ND-3100, and ND-3800 or ND-3900).

(b) The reinforcing pad shall be sized to encompass the unacceptable area with the attachment welds located on adjacent base material of sufficient thickness to accommodate the design stresses.

(c) The plate for the reinforcing pad shall be rolled or otherwise formed to fit the contour of the tank to achieve proper weld fit-up.

(d) The thickness of the reinforcing pad shall be sufficient to maintain required thickness for the design life of the reinforcing pad.

(e) The tensile strengths of the plate and weld filler metal for the reinforcing pad shall be at least that specified for the base metal to which it is applied.

(f) The predicted maximum degradation of the reinforced tank for the design life of the reinforcing pad shall be included in the design. The predicted degradation of the tank shall be based on in-situ inspection of, and established data for, similar base metals in similar environments. If the reinforcing pad will be, or is predicted to become, exposed to the contained fluid, the predicted degradation of the reinforcing pad shall be based upon established data for base metals or weld metals with similar chemical composition to that used for the reinforcing pad.

(g) Material for reinforcing pads shall be in accordance with the Construction Code or Section III, and the Owner’s Requirements for the tank, with welds of compatible weld filler metal. Material for the pad and welds shall be selected to minimize the probability of galvanic corrosion.

(h) The following factors shall be included, as applicable, in the design and application of the pad:

(1) the effects of shrinkage and distortion, if any, on the tank

(2) stress concentrations caused by installation of the reinforcing pad or resulting from existing and predicted tank surface configuration

(3) effects of welding on any coating

(4) added weight of the pad with respect to any design analyses that could be affected

(5) potential for buckling during pressure testing

(i) Corners of reinforcing pad plates shall be rounded with radii not less than the reinforcing pad nominal thickness, and the toes of attachment welds at the corners shall have 1 in. (25 mm) minimum radius.

(j) Unless otherwise established by analysis in accordance with the requirements of (a), the distance between toes of attachment welds on the tank shell and other attachments, branch reinforcement, or other structural discontinuities (Figure 1) shall not be less than the following equation:

\[ d = 2.0 \sqrt{R t_{nom}} \]

where

\[ d = \text{minimum distance between toes of fillet welds of adjacent fillet welded attachments} \]

\[ R = \text{the outer radius of the tank} \]

\[ t_{nom} = \text{nominal thickness of the tank} \]

(k) If the degraded area on the tank shell is within the distance of \( d \) from a nozzle without external reinforcement, the reinforcing pad shall be designed to extend 360 deg around the nozzle, and shall be welded thereto using a full penetration weld with a reinforcing fillet (Figure 2, Section B-B).

(l) If the degraded area on the tank shell is within the distance of \( d \) from a nozzle with external reinforcement, the reinforcing pad shall be designed to extend to the external reinforcement, and shall be welded thereto using a full penetration weld (Figure 2, Section B-B).

(m) If permitted by the design, suitable gasket material or sealant may be applied between the pad and the tank surface to prevent moisture during welding. Any residual moisture shall then be removed by heating prior to welding.

(n) For reinforcement pads applied on tank bottoms, the following restrictions shall also apply:

(1) Pad attachment welds shall be no closer than 2 in. (50 mm) from adjacent pads or 6 in. (150 mm) from the tank shell.

(2) On lap welded bottoms, the pad shall be aligned so that the attachment welds are essentially perpendicular and parallel to existing lap joints, and may cover existing lap joints.
(-a) The pad attachment welds parallel to existing two-plate lap joints shall not be less than 2 in. (50 mm) from the existing welds.

(-b) The portion of pad attachment welds installed over two-plate lap joints shall be not less than 12 in. (300 mm) from any other three-plate lap joints or the tank shell.

(-c) Reinforcing pads may be installed over three-plate laps provided the pad extends no less than 12 in. (300 mm) in all directions from the three-plate lap.

(a) For reinforcement pads applied between the tank shell and tank bottom (Figure 3), the following restrictions shall also apply:

(1) The reinforcing pad shall be welded to the tank shell using a full penetration weld with a reinforcing fillet (Figure 2, Section B-B).

(2) Pad attachment welds shall be no closer than 2 in. (50 mm) from adjacent pads and lap joints on the tank floor.

(3) The reinforcing pad maximum dimension along the shell shall be 24 in. (600 mm).

(4) The minimum dimension along the shell between two adjacent reinforcing pads shall be as shown in Figure 3.

(5) The reinforcing pad may cover existing joints on the floor. In this case, the portion of pad attachment welds installed over two-plate lap joints shall be not less than 12 in. (300 mm) from any other three-plate lap joints or the tank shell.

3.3 SPECIFIC DESIGN REQUIREMENTS — PRESSURE PADS

Pressure pads shall meet the requirements of 3.2, Figures 1 and 2 and the following:

(a) Fillet-welded pressure pads shall be designed to withstand the membrane strain of the tank in accordance with the requirements of the Code specified in 3.2(a) such that the following criteria are satisfied:

(1) The allowable membrane stress is not exceeded in the tank or the pad.

(2) The strain in the pad does not result in fillet weld load exceeding the following equation:

\[ F = 0.55wS_a \]

where

- \( F \) = the allowable force on the fillet weld per in. (lb/in.)
- \( S_a \) = the allowable stress of the tank material (psi)
- \( w \) = the minimum fillet weld leg size (in.)

(b) Design as a reinforced opening in accordance with the Construction Code shall satisfy (a).

(c) As an alternative to (a), pressure pads may be designed as structural pads in accordance with 3.4.

3.4 SPECIFIC DESIGN REQUIREMENTS — STRUCTURAL PADS

Structural pads shall meet the requirements of 3.2, Figures 1 and 2, and the following:

(a) Structural pads shall be attached by partial-penetration welds (see Figure 2, Section A-A) that, unless otherwise established by analysis in accordance with the requirements of 3.2(a), extend for a distance of at least \( s \) in each direction beyond the area predicted, for the design life of the structural pad, to infringe upon the required thickness, where \( s \geq 2t_{n.o.m} \) and \( s \geq 1 \) in. (25 mm) in all cases (\( t_{n.o.m} \) = nominal wall thickness of the tank).

(b) The thickness of the partial penetration attachment welds shall equal the thickness of the pad. The edges of the welds shall be tapered to the tank surface at a maximum angle of 45 deg (Figure 2, Section A-A).

(c) Final configuration of the structural pad including attachment welds shall permit the examinations and evaluations required herein.

(d) Except for the tapered edges, the structural pad plate and attachment welds shall have a uniform thickness.

(e) Where structural pads are applied on the outside of tanks to mitigate externally-corroded areas with potential for bulging, the corrosion cavity shall be filled to near the original contour of the tank with hardenable fill material to minimize the gap beneath the reinforcing pad.

4 WATER-BACKED APPLICATIONS

(a) Attachment welds on water-backed ferritic tanks shall be applied using the SMAW process using low hydrogen electrodes.

(b) When welding a reinforcing pad to a leaking area, precautions, such as installation of a gasket or sealant or seal welding beneath the pad, shall be taken to prevent welding on wet surfaces. Any residual moisture shall be removed by heating. Attachment welds shall not be applied on wet surfaces.

(c) For ferritic tank materials other than P-No. 1, Group 1, the surface examination required in 6 shall be performed no sooner than 48 hr after completion of welding.

5 INSTALLATION

(a) The base material in the area to be welded shall be cleaned to bare metal.

(b) Weld metal shall be deposited using a groove welding procedure qualified in accordance with Section IX and the Construction Code.

(c) Provisions for venting during the final closure weld, or for pressurizing for leak testing, shall be included, if necessary.

2 Design thickness as prescribed by the Construction Code.
(d) The surface of the attachment weld shall be prepared, if necessary, by machining or grinding to permit performance of surface and volumetric examinations required by 6. For ultrasonic examination, a surface finish of 250 RMS or better is required.

6 EXAMINATION

(a) The completed attachment weld shall be examined using the liquid penetrant or magnetic particle method and shall satisfy the surface examination acceptance criteria for welds of the Construction Code or Section III (NC-5300, ND-5300) and the Owner’s Requirements.

(b) Except for the tapered edges, partial penetration attachment welds, including the tank base metal beneath the weld, shall be ultrasonically measured to verify acceptable wall thickness.

(c) For reinforcing pads, partial penetration attachment welds shall be volumetrically examined when full penetration welds in the tank are required by the Construction Code and the Owner’s Requirements to be volumetrically examined. Where configuration does not permit meaningful volumetric examination, the first layer, each 1/2 in. (13 mm) thickness of weld metal deposit, and the final surface, shall be examined in accordance with (a) in lieu of volumetric examination.

(d) If volumetric examination is required, the full volume of the attachment weld, excluding the tapered edges, and including the volume of base metal required for the intended life of the reinforcing pad as determined by the Construction Code or Section III, and the Owner’s Requirements using either the ultrasonic or radiographic method, and shall, to the depth at the surface of the tank, satisfy the acceptance criteria for welds of the Construction Code or Section III (NC-5320, ND-5320 or NC-5330, ND-5330) and the Owner’s Requirements. Any volume of the tank beneath the reinforcing pad that is credited in the design shall satisfy the volumetric acceptance criteria of Section III (NC-5320, ND-5320 or NC-5330, ND-5330), as applicable.

7 PRESSURE TESTING

In lieu of IWA-4540, a system leakage test of the repair/replacement activity shall be performed in accordance with Article IWA-5000 prior to, or as part of, returning to service. Reinforcing pads attached to tanks that have not been breached shall be equipped with pressure taps for performance of pressure testing.

8 INSERVICE MONITORING

(a) Upon completion of the repair, thickness inspections shall be performed for structural pads, using ultrasonic or direct thickness measurement, to record the thickness of the plate, the thickness at the attachment welds, including the underlying base metal, and to the extent examinable in a 3-in. (75-mm) wide band, surrounding the repair, as a baseline for subsequent monitoring of the repair.

(b) The Owner shall prepare a plan to repeat the thickness monitoring inspections as follows:

(1) The first inservice thickness monitoring inspection shall be performed to validate the corrosion rate during the first refueling outage following installation, or at one-half the design life based on the corrosion rates used in the initial design, whichever occurs first.

(2) Subsequent thickness monitoring inspections for structural pads shall be performed at least every refueling outage, to verify that minimum design thicknesses as required by the Construction Code or Section III are not violated in the pad or attachment welds, including the underlying base metal. More-frequent thickness monitoring inspections shall be scheduled when warranted by the degradation rates calculated using reductions in thicknesses observed during these thickness inspections, such that the required design thicknesses will be maintained at least until the subsequently-scheduled thickness monitoring inspection.

(c) Areas containing pressure pads shall be visually observed at least once per month to monitor for evidence of leakage. If the areas containing such pads are not accessible for direct observation from the exterior of the tank (e.g., internal pressure pads on tank bottom), monitoring shall be accomplished by visual assessment of surrounding areas, or by monitoring of local leakage collection systems.

(d) If the results of the monitoring program identify leakage or indicate that the minimum design thicknesses required by the Construction Code or Section III will not be maintained for the design life of the reinforcing pad, additional repair/replacement activities not prohibited by 1(f) shall be performed prior to encroaching upon the design limits.

(e) For all pressure pads, regardless of when during a cycle or inspection interval they are installed, the repair shall be considered to have a maximum service life of the time until the end of the next refueling outage.
Figure 1
Shell Reinforcing Pads

Degraded areas

\[ d = 2.0 \sqrt{R_{\text{nom}}} \]
Figure 2
Weld Configuration

| Structural Pad Partial Penetration Weld Configuration |
| Typical for Shell and Bottom Reinforcement Pads |
| Section A-A |

Tie-in at unreinforced nozzle

Tie-in at reinforced nozzle

\[ x = \text{lesser of } f_{\text{nozzle}} \text{ or } \frac{1}{8} \text{ in. (10 mm)} \]

Weld Configuration at Shell Nozzles

Section B-B

Pressure Pad Weld Configuration

Typical for Shell and Bottom Reinforcement Pads

Section C-C
Figure 3
Shell-to-Floor Repairs

Lap joint

2 in. (50 mm)
min. radius

2 in. (50 mm)
min.

Tank shell

2 in. (50 mm)
min.

12 in. (300 mm)
min.

X

24 in. (600 mm)
maximum width

Lesser of X/2
or Y/2 min.

Y

24 in. (600 mm)
maximum width

CASE (continued)
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