TANK
INDUSTRY
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REVISION 1

Agenda Item 653-208

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Title: Elevated Temperature Tank Foundation Considerations

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Purpose: To add language to address elevated temperature considerations for existing tank foundations when the tank is placed in high temperature service.

Impact: Will help to minimize the risk of damage to foundations, tanks or unanticipated accelerated underside corrosion resulting from tanks operating at high temperatures.

Rationale: Damage to tank foundations is known to result from operating tanks at high temperatures. For example, concrete ringwall foundations may suffer scoring and/or cracking in cases where the thermal movements and associated loads have not been properly considered in the design of the foundation.
The current editions of API 653 and API 650 provide little guidance on the design and construction of foundations for elevated temperature tanks. The proposed additions to the current text would require, by reference to API 650, the user to assess the risk of damage to the tank foundation in changing the service of the tank from a lower to a higher operating temperature. Note that this agenda item also proposes additions to API 650, which in addition to the cautionary statements, would add words of guidance as to what issues should be addressed to assess the risks to the tank foundation. The additions to API 650 are necessary because the risks of damage to the foundation are similar, whether the tank is new or existing. The entire foundation-related text of API 650 is included below for information

Existing Text	Proposed Changes
API 653: *[There are currently no provisions in API 653 addressing elevated temperature tank foundation considerations.]* API 650: B.4.2.3 A ringwall should be reinforced against temperature changes and shrinkage and reinforced to resist the lateral pressure of the confined fill with its surcharge from product loads. ACI 318 is recommended for design stress values, material specifications, and rebar development and cover. The following items concerning a ringwall shall be considered: a. The ringwall shall be reinforced to resist the direct hoop tension resulting from the lateral earth pressure on the ringwall's inside face. Unless substantiated by proper geotechnical analysis, the lateral earth pressure shall be assumed to be at least 50% of the vertical pressure due	API 653: Add new section 4.5.1.3 to read as follows: 4.5.1.3 When a tank is to be used in elevated temperature (> 90°C (200°F)) service, the provisions of API 650, B.6, shall be considered in the evaluation of the suitability for service of the tank foundation. API 650: B.4.2.3 A ringwall should be reinforced against temperature changes and shrinkage and reinforced to resist the lateral pressure of the confined fill with its surcharge from product loads. ACI 318 is recommended for design stress values, material specifications, and rebar development and cover. The following items concerning a ringwall shall be considered: a. The ringwall shall be reinforced to resist the direct hoop tension resulting from the lateral earth pressure on

to fluid and soil weight. If a granular backfill is used, a lateral earth pressure coefficient of 30% may be used. b. The ringwall shall be reinforced to resist the bending moment resulting from the uniform moment load. The uniform moment load shall account for the eccentricities of the applied shell and pressure loads relative to the centroid of the resulting soil pressure. The pressure load is due to the fluid pressure on the horizontal projection of the ringwall inside the shell. c. The ringwall shall be reinforced to resist the bending and torsion moments resulting from lateral, wind, or seismic loads applied eccentrically to it. A rational analysis, which includes the effect of the foundation stiffness, shall be used to determine these moments and soil pressure distributions. d. The total hoop steel area required to resist the loads noted above shall not be less than the area required for temperature changes and shrinkage. The hoop steel area required for temperature changes and shrinkage is 0.0025 times the vertical cross-sectional area of the ringwall or the minimum reinforcement for walls called for in ACI 318, Chapter 14. e. For ringwalls, the vertical steel area required for temperature changes and shrinkage is 0.0015 times the horizontal cross-sectional area of the ringwall or the minimum reinforcement for walls called for in ACI 318, Chapter 14. Additional vertical steel may be required for uplift or torsional resistance. If the ring foundation is wider than its depth, the design shall consider its behavior as an annular slab with flexure in the radial direction. Temperature and shrinkage reinforcement shall meet the ACI 318 provisions for slabs. (See ACI 318, Chapter 7.) f. When the ringwall width exceeds 460 mm (18 in.), using a footing beneath the wall should be considered. Footings may also be useful for resistance to uplift forces. g. Structural backfill within and adjacent to concrete ringwalls and around items such as vaults, undertank piping, and sumps requires close field control to maintain settlement tolerances. Backfill should be granular material compacted to the density and compacting as specified in the foundation construction specifications. For other backfill materials, sufficient tests shall be conducted to verify that the material has adequate strength and will undergo minimal settlement.	the ringwall's inside face. Unless substantiated by proper geotechnical analysis, the lateral earth pressure shall be assumed to be at least 50% of the vertical pressure due to fluid and soil weight. If a granular backfill is used, a lateral earth pressure coefficient of 30% may be used. b. The ringwall shall be reinforced to resist the bending moment resulting from the uniform moment load. The uniform moment load shall account for the eccentricities of the applied shell and pressure loads relative to the centroid of the resulting soil pressure. The pressure load is due to the fluid pressure on the horizontal projection of the ringwall inside the shell. c. The ringwall shall be reinforced to resist the bending and torsion moments resulting from lateral, wind, or seismic loads applied eccentrically to it. A rational analysis, which includes the effect of the foundation stiffness, shall be used to determine these moments and soil pressure distributions. d. The total hoop steel area required to resist the loads noted above shall not be less than the area required for temperature changes and shrinkage. The hoop steel area required for temperature changes and shrinkage is 0.0025 times the vertical cross-sectional area of the ringwall or the minimum reinforcement for walls called for in ACI 318, Chapter 14. e. 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Backfill should be granular material compacted to the density and compacting as specified in the foundation construction specifications. For other backfill materials, sufficient tests shall be conducted to verify that the material has adequate strength and will undergo minimal settlement. h. If the tank is designed and constructed for elevated temperature service, see B.6. **B.6 Tank Foundations for Elevated Temperature**

REVISION 1 added the second sentence to item b >>>>> *REVISION 1 moved the last sentence of item b >>>>>>> to item c and re-lettered following sections.*	**Service** The design and construction of foundations for tanks operating at elevated temperatures (> 90°C (200°F)), should address the following considerations: a. When subjected to elevated operating temperatures, an unanchored tank may tend to move in one or more directions over time. This movement must be accommodated in the design of the tank fittings and attachments. b. Elevated temperature service may evaporate moisture in the soil supporting the tank and lead to increased, and possibly non-uniform, settlement. Such settlement may include differential settlement between the ringwall and soil under the tank bottom immediately adjacent to the ringwall resulting from non-uniform shrinkage of the soil with respect to the stone or concrete ringwall. c. In cases where there is a high groundwater table, elevated temperatures may vaporize groundwater and generate undesirable steam. d. Attachments to the tank must accommodate the thermal expansion and contraction of the tank without resulting in unacceptable stress levels. e. The elevated temperature must be accounted for in the design of concrete ringwall foundations. The ringwall is subject to a moment due to the higher temperature at the top of the ringwall with respect to the temperature at the bottom of the ringwall. If not adequately accounted for in the design of the ringwall, this moment can lead to cracking of the concrete foundation and loss of tank support.

Note: Proposed changes to existing wording and new wording are shown in underlined blue font.