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Purpose: To clarify the PWHT temperature controls to be consistent with ASME PWHT standards.

Rationale: A received Inquiry asked, with the current PWHT wording, when stress relieving items in the range of 1100F to 1200F, (600 °C to 650 °C), when at the hold temperature, can the 85 °C (150 °F) be added to the 650 °C or subtracted from the 600 °C (1100F) throughout the portion of the tank being heated. This is not acceptable. The requirements need to be clarified to state PWHT should be conducted at a minimum temperature of 600 °C (1100F) and the item must be held at not more than 85 °C (150 °F) throughout the portion of the item being heated. The proposal states the minimum PWHT temperature and that during the hold the entire unit must be within the 85 °C (150 °F).

Source: Inquiry – External  
Impact: Neutral

API 650 13th Edition – Proposed Changes are shown with yellow highlight with following:  
Underline = Additions/Changes; / Strikethrough = Deletions

API action 650-2052 not yet published are shown with blue highlight with following:  
Underline = Additions/Changes; / Strikethrough = Deletions

### **Para 5.7.4 – Current Words:**

#### **5.7.4 Thermal Stress Relief**

**5.7.4.1** All flush-type cleanout fittings and flush-type shell connections shall be thermally stress-relieved as an assembly prior to installation in the tank shell or, alternatively, after installation into the tank shell if the entire tank is stress-relieved. The stress relief shall be carried out within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) (see 5.7.4.5 for quenched and tempered materials) for 1 hour per 25 mm (1 in.) of shell thickness. The assembly shall include the bottom reinforcing plate (or annular plate) and the flange-to-neck weld.

**5.7.4.2** For non-flush-type nozzles and manways, when the shell material is Group I, II, III, or IIIA, all openings NPS 12 or larger in nominal diameter in a shell plate, insert plate, or thickened insert plate more than 25 mm (1 in.) thick shall be prefabricated into the shell plate, insert plate, or thickened insert plate, and the prefabricated assembly shall be thermally stress-relieved within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) for 1 hour per 25 mm (1 in.) of thickness prior to installation.

**5.7.4.3** For non-flush-type nozzles and manways, when the shell material is Group IV, IVA, V, or VI, all openings larger than NPS 2 in. nominal diameter in a shell plate, insert plate, or thickened insert plate more than 13 mm (1/2 in.) thick shall be prefabricated into the shell plate, insert plate, or thickened insert plate, and the prefabricated assembly shall be thermally stress relieved within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) for 1 hour per 25 mm (1 in.) of thickness prior to installation.

**5.7.4.4** For non-flush-type nozzles and manways, the stress-relieving requirements do not apply to the weld of the shell, insert plate, or thickened insert plate to the bottom annular plate. Further, the stress-relieving requirements need not include the flange-to-neck welds or other nozzle-neck and manhole-neck attachments, provided the following conditions are satisfied:

- a) The welds are outside the reinforcement (see 5.7.2.4).
- b) The throat dimension of a fillet weld in a slip-on flange does not exceed 16 mm (5/8 in.), or the butt joint of a welding-neck flange does not exceed 19 mm (3/4 in.). If the material is preheated to a minimum temperature of 90 °C (200 °F) during welding, the weld limits of 16 mm (5/8 in.) and 19 mm (3/4 in.) may be increase to 32 mm and 40 mm (11/4 in. and 11/2 in.), respectively.

**5.7.4.5** When openings are installed in quenched and tempered material, the maximum thermal stress-relieving temperature shall not exceed the tempering temperature for materials in the prefabricated stress-relieving assembly.

**5.7.4.6** The thermal stress relief procedure shall be as outlined in the following:

- a) The temperature of the furnace shall not exceed 425 °C (800 °F) at the time the part or section of the tank is placed in it.
- b) The rate of heating above 425 °C (800 °F) shall be not more than 220 °C (400 °F) per hour divided by the maximum metal thickness, in inches, of the wall plate being heated, but in no case shall it be more than 220 °C (400 °F) per hour.
- c) During the heating period, the temperature throughout the portion of the tank being heated shall not vary more than 140 °C (250 °F) within any 4.6 m (15 ft) interval of length and, when at the hold temperature, not more than 85 °C (150 °F) throughout the portion of the tank being heated. A minimum temperature of 595 °C (1100 °F) (except as permitted in 5.7.4.8) shall be maintained for a period of one hour per inch of metal thickness (maximum metal thickness of the tank wall plates affected). During the heating and holding periods, the furnace atmosphere shall be controlled to avoid excessive oxidation of the surface of the material being treated. The furnace shall be designed to prevent direct impingement of the flame on the material.
- d) At temperatures over 425 °C (800 °F), cooling shall be done in a closed furnace or cooling chamber at a rate not greater than 280 °C (500 °F) per hour divided by the maximum metal thickness, in inches, of the plates affected, but in no case shall the rate be more than 280 °C (500 °F) per hour. **During the cooling period above 425 °C (800 °F), the temperature variations within the heated portion of the tank during the cooling phase shall not be greater than 140 °C (250 °F) within any 4.6 m (15 ft) interval.** At temperatures below 425 °C (800 °F), the material may be cooled in still air.

**5.7.4.7** Examination after stress relief shall be in accordance with 7.2.3.7 or 7.2.3.8.

**5.7.4.8** When it is impractical to stress relieve at a minimum temperature of 600 °C (1100 °F), it is permissible, subject to the Purchaser's agreement, to carry out the stress-relieving operation at lower temperatures for longer periods of time in accordance with the tabulation below. The lower temperature/longer time PWHT may not provide material toughness and residual stresses equivalent to that using the higher temperature/shorter time PWHT; therefore, a review by a knowledgeable metallurgist and possible verification by mill testing of heat-treated coupons and/or testing of welded plates shall be considered. See Line 23 of the Data Sheet for any Purchaser-specified requirements applicable to this heat-treatment option.

### **Proposed Changes:**

**5.7.4.1** All flush-type cleanout fittings and flush-type shell connections shall be thermally stress-relieved as an assembly prior to installation in the tank shell or, alternatively, after installation into the tank shell if the entire tank is stress-relieved. The stress relief shall be carried out with a **minimum** temperature of **595 °C (1100 °F)** **range of 600 °C to 650 °C (1100 °F to 1200 °F)** (see 5.7.4.5 for quenched and tempered materials) for 1 hour per 25 mm (1 in.) of shell thickness. The assembly shall include the bottom reinforcing plate (or annular plate) and the flange-to-neck weld.

**5.7.4.2** For non-flush-type nozzles and manways, when the shell material is Group I, II, III, or IIIA, all openings NPS 12 or larger in nominal diameter in a shell plate, insert plate, or thickened insert plate more than 25 mm (1 in.) thick shall be prefabricated into the shell plate, insert plate, or thickened insert plate, and the prefabricated assembly shall be thermally stress-relieved **within a temperature range of 600 °C to 650 °C**

(1100 °F to 1200 °F) with a minimum temperature of 595 °C (1100 °F) for 1 hour per 25 mm (1 in.) of thickness prior to installation.

**5.7.4.3** For non-flush-type nozzles and manways, when the shell material is Group IV, IVA, V, or VI, all openings larger than NPS 2 in. nominal diameter in a shell plate, insert plate, or thickened insert plate more than 13 mm (1/2 in.) thick shall be prefabricated into the shell plate, insert plate, or thickened insert plate, and the prefabricated assembly shall be thermally stress relieved within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) with a minimum temperature of 595 °C (1100 °F) for 1 hour per 25 mm (1 in.) of thickness prior to installation.

**5.7.4.4** For non-flush-type nozzles and manways, the stress-relieving requirements do not apply to the weld of the shell, insert plate, or thickened insert plate to the bottom annular plate. Further, the stress-relieving requirements need not include the flange-to-neck welds or other nozzle-neck and manhole-neck attachments, provided the following conditions are satisfied:

- a) The welds are outside the reinforcement (see 5.7.2.4).
- b) The throat dimension of a fillet weld in a slip-on flange does not exceed 16 mm (5/8 in.), or the butt joint of a welding-neck flange does not exceed 19 mm (3/4 in.). If the material is preheated to a minimum temperature of 90 °C (200 °F) during welding, the weld limits of 16 mm (5/8 in.) and 19 mm (3/4 in.) may be increased to 32 mm and 40 mm (1 1/4 in. and 1 1/2 in.), respectively.

**5.7.4.5** When openings are installed in quenched and tempered material, the maximum thermal stress-relieving temperature shall not exceed the tempering temperature for materials in the prefabricated stress-relieving assembly.

**5.7.4.6** The thermal stress relief procedure shall be as outlined in the following:

- a) The temperature of the furnace shall not exceed 425 °C (800 °F) at the time the part or section of the tank is placed in it.
- b) The rate of heating above 425 °C (800 °F) shall be not more than 220 °C (400 °F) per hour divided by the maximum metal thickness, in inches, of the wall plate being heated, but in no case shall it be more than 220 °C (400 °F) per hour.
- c) During the heating period, the temperature throughout the portion of the tank being heated shall not vary more than 140 °C (250 °F) within any 4.6 m (15 ft) interval of length, and, when at the hold temperature, not more than 85 °C (150 °F) throughout the portion of the tank being heated. During the holding period, there shall not be a greater difference than 83 °C (150 °C) between the highest and lowest temperature throughout the portion of the item being heated. A minimum temperature of 595 °C (1100 °F) (except as permitted in 5.7.4.8) shall be maintained at all locations in the assembly for a period of one hour per inch of metal thickness (maximum metal thickness of the tank wall plates affected). During the heating and holding periods, the furnace atmosphere shall be controlled to avoid excessive oxidation of the surface of the material being treated. The furnace shall be designed to prevent direct impingement of the flame on the material.
- d) At temperatures over 425 °C (800 °F), cooling shall be done in a closed furnace or cooling chamber at a rate not greater than 280 °C (500 °F) per hour divided by the maximum metal thickness, in inches, of the plates affected, but in no case shall the rate be more than 280 °C (500 °F) per hour. During the cooling period above 425 °C (800 °F), the temperature variations within the heated portion of the tank during the cooling phase shall not be greater than 140 °C (250 °F) within any 4.6 m (15 ft) interval. At temperatures below 425 °C (800 °F), the material may be cooled in still air.

**5.7.4.7** Examination after stress relief shall be in accordance with 7.2.3.7 or 7.2.3.8.

**5.7.4.8** When it is impractical to stress relieve at a minimum temperature of 595 °C (1100 °F), it is permissible, subject to the Purchaser's agreement, to carry out the stress-relieving operation at lower temperatures for longer periods of time in accordance with the tabulation below. The lower temperature/longer time PWHT may not provide material toughness and residual stresses equivalent to that using the higher temperature/shorter time PWHT; therefore, a review by a knowledgeable metallurgist and possible verification

by mill testing of heat-treated coupons and/or testing of welded plates shall be considered. See Line 23 of the Data Sheet for any Purchaser-specified requirements applicable to this heat-treatment option.

For Committee Review Only

**FOR REFERENCE INFORMATION – NOT PART OF THE ACTION**

ASME PWHT

(d) The operation of postweld heat treatment shall be carried out by one of the procedures given in UW-40 in accordance with the following requirements:

(1) The temperature of the furnace shall not exceed 800°F (425°C) at the time the vessel or part is placed in it.

(2) Above 800°F (425°C), the rate of heating shall be not more than 400°F/hr (222°C/h) divided by the maximum metal thickness of the shell or head plate in inches, but in no case more than 400°F/hr (222°C/h). During the heating period there shall not be a greater variation in temperature throughout the portion of the vessel being heated than 250°F (140°C) within any 15 ft (4.6 m) interval.

(3) The vessel or vessel part shall be held at or above the temperature specified in Tables UCS-56-1 through UCS-56-11 or Table UCS-56.1 for the period of time specified in the Tables. During the holding period, there shall not be a greater difference than 150°F (83°C) between the highest and lowest temperature throughout the portion of the vessel being heated, except where the range is further limited in Tables UCS-56-1 through UCS-56-11.

(4) During the heating and holding periods, the furnace atmosphere shall be so controlled as to avoid excessive oxidation of the surface of the vessel. The furnace shall be of such design as to prevent direct impingement of the flame on the vessel.

**Table UCS-56-1**

**Postweld Heat Treatment Requirements for Carbon and Low Alloy Steels — P-No. 1**

Normal Holding  
Temperature, °F (°C), - - For P1 materials 1100 (595) degrees F / C  
**Minimum**