Agenda Item: 650-1090 Steel Pan Updates

Title: **API 650 Annex H Update on Pan Roofs**

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Purpose: Update rules on usage of steel pan roofs in API 650 Annex H

Source: Phil Myers presentation for new business SGD Fall 2020.

Revision: 0

Impact: Neutral.

Rationale: Steel pan roofs are the only roof type allowed in API 650 that lacks inherent buoyancy. They are weak structurally, and a single leak anywhere on the roof is guaranteed to sink the roof. Many owner companies prohibit the use of pan roofs. In an effort to standardize industry best practices, API 650 should minimize or eliminate the use of pan roofs.

Steel internal floating roofs of type annular pontoon and double deck floating roofs meet the fundamental buoyancy requirements typically required of owners/users of internal floating roofs. These fundamental buoyancy requirements are that that the roof will survive 2 adjacent punctured pontoons and punctured center deck. The pan roof obviously cannot tolerate any puncture and will sink immediately upon being punctured. The bulkhead pan roof may or may not tolerate these conditions depending on specific size, weight and detailed design. It is unknown whether or not the bulkhead pan can meet the basic and fundamental buoyancy requirements of H.4.2.1.3 and voluminous and detailed calculations (even finite element analysis) are required to make this determination. Yet bulkhead pan roofs are commonly sold to owner/operators as meeting Annex H buoyancy requirements -when they do not.

Bulkhead pans are a type of floating roof that is of lesser quality and reliability than the typical steel floating roof and as such they need to be treated separately and as an exception to the basic buoyancy requirements expected of steel floating roofs codified in H.4.2.1.3.

During discussion in SGD Fall 2020, some members expressed a need for pan roofs for small diameter tanks, which may need a lightweight steel roof option. This agenda item proposes to limit pan roofs to tanks no more than 30' in diameter. The new rule will apply to "metallic pan internal roofs" defined in section H.2.2.a. The rule will not apply to similar roof types such as bulkhead pan roofs or aluminum roofs.
Internal steel floating roofs are used when maximum reliability is required and where fire risks must be minimized. The footnotes in API 650 Annex H numbered 18-21 are sufficiently confusing to owners, operators where the lure of lower cost bulkhead pans are offered as meeting Annex H.4.2.1.3 buoyancy requirements and they do not. There are numerous cases of disputes between owners/operators and contractors for sunken floating roofs due to the bulkhead pan floating roof being sold as meeting the basic buoyancy requirements – which they do not.

Another major consideration that is not well understood is that the bulkhead pan roof requires foam application rates that are for a full surface fire (as though there were no floating roof) meaning that the required foam delivery systems must be larger by an order or two magnitude in terms of foam and water supplies. Many owners are not aware that when they install pans roofs (or bulkhead pans) that they are invalidating their fire protection systems. Tank manufacturers and owners are typically confused about the NFPA 11 foam supply requirements and thus the critical fire protection systems that support tanks with pan roofs may be grossly undersized.

Steel pan roofs are widely recognized has having significantly worse reliability than all other roof types. Ending the floating roof pan-demic, especially failures of large pan roofs, will reduce the number of floating roof environmental and safety incidents.

Additional information related to calculations of roof tilting and deflection effects under various point loads is provided in attached file "pan roof survey results.xlsx."

Proposal: a) Metallic pan internal floating roofs [18, 19, 20,21] have a peripheral rim above the liquid for buoyancy. These roofs are in full contact with the liquid surface and are typically constructed of steel.

b) Metallic open-top bulk-headed internal floating roofs [18, ~~19,~~ 20, 21] have peripheral open-top bulk-headed compartments for buoyancy. Distributed open-top bulk-headed compartments shall be used as required. These roofs are in full contact with the liquid surface and are typically constructed of steel.

[20] These designs contain no closed buoyancy compartments ~~,~~ and are subject to flooding during sloshing or during application of fire-fighting foam/water solution. Also, without bracing of the rim being provided by the pontoon top plate, design to resist buckling of the rim must be evaluated. Accurate analysis relies on non-linear finite element analysis because conventional closed-form equations tend to underpredict out-of-plane buckling of the curved and unstiffened rim plate.

H.4.1.12 Internal floating roofs classified as Metallic pan internal floating roof type (H.2.2.a) shall not be installed on tank diameters greater than 9 m (30 ft).

H.4.2.1.3 All internal floating roofs with multiple flotation compartments shall be capable of floating without additional damage after any two compartments are punctured and flooded. Designs which employ an open center deck in contact with the liquid (types H.2.2b, c, and g) shall be capable of floating without additional damage after any two compartments and the center deck are punctured and flooded. The design of metallic open-top bulk-headed internal floating roofs (type H.2.2.b) shall demonstrate buoyant and structural stability based non-linear finite element analysis. With agreement by the Purchaser, metallic open-top bulk-headed internal floating roofs (type H.2.2.b) may be designed without the use of finite element analysis for only the center deck punctured and flooded. With agreement by the Purchaser, any floating roof 6 m (20 ft) in diameter or less with multiple flotation compartments may be designed to be capable of floating without additional damage after any one compartment is punctured and flooded.