Agenda Item: 650-1090 Steel Pan Updates

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

Date: November 15, 2022

Contact: Name : John Slupsky
Company : Exxon Mobil
Phone : (432) 701-8098
E-mail : john.slupsky@exxonmobil.com

Name : Phil Myers
Company : PEMY Consulting
Phone : 925-356-1294
E-mail : Phil@PEMYConsulting.com

Name : Andrew Yearwood
Company : PEMY Consulting
Phone : 918-698-2110
E-mail : Andrew@PEMYConsulting.com

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: 3

Impact: Neutral.

Rationale: Steel pan roofs are the only roof type allowed in API 650 that lacks reserve 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. This agenda item does not ban pan roofs, but it raises awareness of design and performance problems.

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.

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. Greater awareness of pan roof risks, especially failures of large pan roofs, will reduce the number of floating roof environmental and safety incidents.

Proposal: H.2 Types of Internal Floating Roofs

…

H.2.2 The following types of internal floating roofs are described in this Annex.

a) Metallic pan internal floating roofs [18, 19, 20,21,22] 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.

[18] Internal floating roof tanks generally have reduced fire risk, and the use of fixed fire suppression systems is often not mandatory. Various internal floating roof materials will have unique flammability characteristics, melting points and weights (perhaps with reduced buoyancy being required). If fire suppression systems are used, certain roof types need to be evaluated for full surface protection. NFPA 11 Standard for Low-Expansion Foam can provide guidance for this evaluation.

[19] The Purchaser is cautioned that this design does not have multiple flotation compartments necessary to meet the requirements of H.4.2.1.3.

[20] These designs contain no closed ~~buoyancy~~ flotation 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. Traditional structural calculations tend to over-estimate the buckling strength of the rim due to curvature and out-of-plane buckling effects. Utilizing non-linear finite element analysis in addition to traditional structural calculations is an option to further understand the buckling strength of the rim.

[21] If the floating roof is a) a metallic pan roof with or without bulkheads, or b) a non-metallic roof with or without closed ~~buoyancy~~ flotation ~~-~~compartments, then the tank is considered a fixed-roof tank (i.e., having no internal floating roof) for the requirements of NFPA
30. See NFPA 30 for spacing restrictions on floating roof tanks.

[22] Metallic pan internal floating roofs have poor structural and flotation stability. Due to lack of reserve buoyancy, a single leak can sink the roof.

Note to editor: renumber footnotes after #22

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 closed flotation compartments and an open center deck in contact with the liquid (types H.2.2~~b,~~ c, and g) shall be capable of floating without additional damage after any two compartments and the center deck are 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.

W.5.2.2 For single-deck pontoon and double-deck roofs, calculations showing that the roof design complies with the punctured compartment loading condition as specified in H.4.2.1.3~~.3~~.