Annex H
(normative)

Internal Floating Roofs

H.1 Scope

- **H.1.1** This Annex provides minimum requirements that apply to a tank with an internal floating roof and a fixed roof at the top of the tank shell, and to the tank appurtenances. This Annex is intended to limit only those factors that affect the safety and durability of the installation and that are considered to be consistent with the quality and safety requirements of this standard. Types of internal floating roofs (listed under H.2) and materials (listed under H.3) are provided as a basic guide and shall not be considered to restrict the Purchaser option of employing other commonly accepted or alternative designs, as long as all design loading is documented to meet the minimum requirements herein, and all other criteria are met (except alternative materials and thicknesses as permitted by H.3.1). The requirements apply to the internal floating roof of a new tank and may be applied to an existing fixed-roof tank. Section 5.10 of this standard is applicable, except as modified in this Annex.

- **H.1.2** The Purchaser is required to provide all applicable jurisdictional requirements that apply to internal floating roofs (see 1.3).

- **H.1.3** See Annex W for bid requirements pertaining to internal floating roofs.

H.2 Types of Internal Floating Roofs

H.2.1 The internal floating roof type shall be selected by the Purchaser after consideration of both proposed and future product service, operating conditions, maintenance requirements, regulatory compliance, service life expectancy, ambient temperature, maximum design temperature, product vapor pressure, corrosion conditions and other compatibility factors. Other operating conditions requiring consideration include (but are not limited to) anticipated pumping rates, roof landing cycles, and the potential for turbulence resulting from upsets, such as vapor slugs injected into the tank. Safety and risk factors associated with the roof types shall also be evaluated.[18] The type of roof, which shall be designated by the Purchaser on the Data Sheet, Line 30, shall be one of the types described in H.2.2.

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

a) Metallic pan internal floating roofs [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] 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.

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[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 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.

[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 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.

c) Metallic pontoon internal floating roofs have peripheral closed-top bulk-headed compartments for buoyancy. Distributed closed-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.

d) Metallic double-deck internal floating roofs have continuous closed top and bottom decks, which contain bulk-headed compartments for buoyancy. These roofs are in full contact with the liquid surface and are typically constructed of steel.

e) Metallic internal floating roofs on floats have their deck above the liquid, supported by closed pontoon compartments for buoyancy. These roof decks are not in full contact with the liquid surface and are typically constructed of aluminum alloys or stainless steel.

• f) Metallic sandwich-panel/composite internal floating roofs have metallic or composite material panel modules for buoyancy compartments. Panel modules may include a honeycomb or closed cell foam core; however, cell walls within the panel module are not considered “compartments” for purposes of inspection and design buoyancy requirements (see H.4.1.7 and H.4.2.1).[22] These roofs are in full contact with the liquid surface and are typically constructed of aluminum alloys or Purchaser approved composite materials.[19]

• g) Hybrid internal floating roofs shall, upon agreement between the Purchaser and the Manufacturer, be a design combination of roof types described in H.2.2.b and H.2.2.c, having bulkhead compartments with closed-top perimeter pontoon and open-top center compartments for buoyancy. These roofs are in full contact with the liquid surface and are typically constructed of steel.

h) Other roof materials or designs if specified and described in detail by the Purchaser on the Data Sheet.

• H.3 Material

H.3.1 Selection

Internal floating roof materials shall be selected by the Purchaser after consideration of items listed under H.2.1. The Manufacturer shall submit a complete material specification in his proposal. The choice of materials should be governed by compatibility with the specified liquid. Material produced to specifications other than those listed in this Annex (alternative materials) may be used. Material shall be certified to meet all the requirements of a material specification listed in this Annex, and approved by the Purchaser or shall comply with requirements as specified by the Purchaser. When specified by the Purchaser, a corrosion allowance shall be added to the minimum nominal thickness indicated below. The “nominal thickness” is the purchased thickness with allowance for the permissible mill tolerance.

H.3.2 Steel

Steel shall conform to the requirements of Section 4 of this standard. Steel in contact with vapor or liquid shall be 4.8 mm ($^3/_{16}$ in.) minimum nominal thickness. Other steel shall be 2.5 mm (0.094 in.) minimum nominal thickness.

H.3.3 Aluminum

Aluminum shall conform to the requirements of Annex AL. Aluminum skin shall be 0.50 mm (0.020 in.) minimum nominal thickness. Aluminum floats shall be 1.2 mm (0.050 in.) minimum nominal thickness. For a sandwich panel flotation unit, core material shall be at least 25 mm (1.0 in.) thick, and metallic skin (except carbon steel) shall be 0.41 mm (0.016 in.) minimum nominal thickness.

[22] A single inspection opening per panel module is permitted, regardless of core material; however, core materials producing enclosed spaces within a module may result in undetectable combustible gas in areas isolated from the inspection opening. Design buoyancy shall be based on the loss of any two full panel modules (not cells within modules).

H.3.4 Stainless Steel

Stainless steel shall conform to the requirements of ASTM A240/A240M (austenitic type only). Stainless steel skin shall be 0.46 mm (0.018 in.) minimum nominal thickness. Stainless steel floats shall be 1.2 mm (0.048 in.) minimum nominal thickness.

H.4 Requirements for All Types

H.4.1 General

H.4.1.1 An internal floating roof and its accessories shall be designed and constructed to allow the roof to operate throughout its normal travel without manual attention and without damage to any part of the fixed roof, the internal floating roof, internal floating roof seals (except for normal wear), the tank, or their appurtenances. The internal floating roof and seals shall be designed to operate in a tank constructed within the dimensional limits defined in 7.5 of this standard.

H.4.1.2 The internal floating roof shall be designed and built to float and rest in a uniform horizontal plane (no drainage slope required).

H.4.1.3 All seams in the internal floating roof that are exposed to product vapor or liquid shall be vapor-tight in accordance with H.4.3.1.

H.4.1.4 A vapor-tight rim (or skirt), extending at least 150 mm (6 in.) above the liquid at the design flotation level, shall be provided around both the internal floating roof periphery and around all internal floating roof penetrations (columns, ladders, stilling wells, manways, open deck drains and other roof openings) except for drains designed to avoid product backflow onto the roof.

H.4.1.5 The non-contact type (see H.2.2e) internal floating roof shall have a vapor-tight rim (or skirt), extending at least 100 mm (4 in.) into the liquid at the design flotation level, around both the internal floating roof periphery and around all internal floating roof penetrations (columns, ladders, stilling wells, manways, open deck drains and other roof openings), with the exception of penetrations for pressure-vacuum (bleeder) vents (per H.5.2.1).

- **H.4.1.6** All conductive parts of the internal floating roof shall be electrically interconnected and bonded to the outer tank structure. This shall be accomplished by electric bonding shunts in the seal area (a minimum of four, uniformly distributed) or flexible multi-strand cables from the external tank roof to the internal floating roof (a minimum of two, uniformly distributed). The choice of bonding devices shall be specified by the Purchaser on the Data Sheet, Line 32, considering strength, corrosion resistance, joint reliability, flexibility, and service life. All movable cover accessories (hatches, manholes, pressure relief devices, and other openings) on the internal floating roof shall be electrically bonded to the internal floating roof to prevent static electricity sparking when they are opened.

- **H.4.1.7** Each closed flotation compartment shall be capable of being field-inspected for the presence of combustible gas. Inspection openings shall be located above the liquid level and closed compartments shall be capable of being resealed in the field after periodic inspection (to prevent liquid or vapor entry). Closed-top compartments (types H.2.2c, d, and g) shall be accessible from the top of the internal floating roof and provided with a secured and gasketed manhole for visual internal inspection and the manhole cover shall be provided with a suitable vent. The top edge of the manhole shall extend a minimum of 25 mm (1 in.) above the top of the pontoon rim/skirt. With agreement by the Purchaser, type H.2.2c, d, and g floating roofs 6 m (20 ft) in diameter or less may be provided with an inspection port in place of a manhole. The inspection ports must meet the sealing, securing and extension requirements listed here for manholes in internal floating roof closed compartments.

- **H.4.1.8** All closed flotation compartments shall be seal welded to prevent liquid or vapor entry, unless otherwise specified by the Purchaser. For pontoon, double-deck and hybrid internal floating roofs (types H.2.2c, d, and g), each bulkhead in a closed flotation compartment shall also be provided with a continuous seal weld all around so that the bulkhead is liquid and vapor-tight.

- **H.4.1.9** For metallic/composite sandwich-panel roofs (type H.2.2f), if the use of adhesives is allowed by the Purchaser (per H.4.3.4) to seal the flotation panels (in lieu of welding), all exposed adhesives shall be compatible with the product service and flotation test water (Purchaser shall consider future product service, the hydrostatic test condition, and design condition changes to specify adhesive compatibility.)

- **H.4.1.10** When specified by the Purchaser for deck surfaces above the liquid level, deck drains shall be provided to return any spillage or condensate to the product. Such drains shall close automatically or extend at least 100 mm (4 in.) into the product to minimize vapor loss.

H.4.1.11 Internal floating roofs classified as full-contact types (see H.2.2) shall be designed to minimize trapped vapor space beneath the internal floating roof.

H.4.2 Internal Floating Roof Design

H.4.2.1 Buoyancy Requirements

- **H.4.2.1.1** All internal floating roof design calculations shall be based on the lower of the minimum design specific gravity or 0.7 (to allow for operation in a range of hydrocarbon service), regardless of any higher minimum specific gravity that might be specified by the Purchaser.

H.4.2.1.2 All internal floating roofs shall include buoyancy required to support at least twice its dead weight (including the weight of the flotation compartments, seal and all other floating roof and attached components), plus additional buoyancy to offset the calculated friction exerted by peripheral and penetration seals during filling.

- **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. 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.

H.4.2.1.4 The internal floating roof shall be designed to meet the requirements of H.4.2.1.3 and to safely support at least two men walking anywhere on the roof while it is floating without damaging the floating roof and without allowing product on the roof. One applied load of 2.2 kN (500 lbf) over 0.1 m^2 (1 ft^2) applied anywhere on the roof addresses two men walking. With agreement by the Purchaser, the concentrated load design criteria may be modified for roofs less than 9 m (30 ft) diameter (where internal floating roofs may become unstable), to account for access needs, and expected concentrated live loads.

H.4.2.2 Internal Floating Roof Support Design Loads

H.4.2.2.1 Internal floating roof supports and deck structural attachments (such as reinforcing pads and pontoon end gussets) shall be designed to support the load combinations listed in H.4.2.2.2 without exceeding allowable stresses. Consideration shall also be made for non-uniform support settlement or other non-uniform load distribution, based on anticipated conditions specified by the Purchaser. Application of non-uniform loads is by agreement between the Purchaser and Manufacturer.

- **H.4.2.2.2** Load Combination for Floating Roof Supports.

Floating roof support loading (legs or cables) shall be as follows:

$$D_{f+} \text{ (the greater of) } P_{fe} \text{ or } L_{f1} \text{ or } L_{f2}$$

where

D_f is the dead load of internal floating roof, including the weight of the flotation compartments, seal and all other floating roof and attached components;

L_{f1} is the internal floating roof uniform live load (0.6 kPa [12.5 lbf/ft^2] if not automatic drains are provided, 0.24 kPa [5 lbf/ft^2] if automatic drains are provided);

L_{f2} is the internal floating roof point load of at least two men walking anywhere on the roof. One applied load of 2.2 kN [500 lbf] over 0.1 m^2 [1 ft^2] applied anywhere on the roof addresses two men walking;

P_{fe} is the internal floating roof design external pressure (0.24 kPa [5 lbf/ft^2] minimum).

NOTE With agreement by the Purchaser, L_{f2} may be modified for roofs less than 9 m (30 ft) diameter (where internal floating roofs may be come unstable), to account for access needs, and expected concentrated live loads.

H.4.2.2.3 The allowable load on support cables shall be determined using a factor of safety of 5 on the ultimate strength of cables and their connections. The ultimate strength calculation shall include any efficiency rating associated with proper installation. Cables and their connections shall be designed for the load combination listed in H.4.2.2.2.

H.4.2.3 Other Design Requirements

H.4.2.3.1 Aluminum load carrying members, assemblies and connections shall comply with the design requirements of the latest edition of the *Aluminum Design Manual*.

- **H.4.2.3.2** Steel structural components shall be proportioned so that the maximum stresses shall not exceed the limitations specified in the latest edition of the *Manual of Steel Construction, Allowable Stress Design*, as published by the American Institute of Steel Construction (Chicago, IL). For other steel components, the allowable stress and stability requirements shall be jointly established by the Purchaser and the Manufacturer, as part of the inquiry. Alternatively, a proof test (simulating the conditions of H.4.2) may be performed on the roof or on one of similar design.

H.4.3 Joint Design

H.4.3.1 All seams in the floating roof exposed directly to product vapor or liquid shall be welded, bolted, screwed, riveted, clamped, or sealed and checked for vapor-tightness per H.6.2.

H.4.3.2 Welded joints between stainless steel members and welded joints between carbon steel members shall conform to 5.1 of this standard. Welded joints between aluminum members shall conform to AL.5.1.

H.4.3.2.1 Single-welded butt joints without backing are acceptable for flotation units where one side is inaccessible.

H.4.3.2.2 The thickness of fillet welds on material less than 4.8 mm ($^3/_{16}$ in.) thick shall not be less than that of the thinner member of the joint.

- **H.4.3.3** Bolted, threaded, and riveted joints are acceptable when mutually agreed upon by the Purchaser and the Manufacturer.

- **H.4.3.3.1** Only austenitic type stainless steel hardware shall be used to join aluminum and/or stainless steel components to each other or to carbon steel. Where acceptable to the Purchaser and the Manufacturer, aluminum hardware may be used to join aluminum components. Aluminum shall be isolated from carbon steel by an austenitic stainless steel spacer, an elastomeric pad, or equivalent protection. The use of plated fasteners shall be permitted only when connecting steel components, if specified by the Purchaser.

- **H.4.3.4** Use of any joint sealing compound, insulating material, polymer, elastomer, or adhesive must be pre-approved by the Purchaser. The joining procedure along with test results demonstrating the properties required by this paragraph shall be described completely. Where such joints are permitted, any joint sealing compound, insulating material, elastomeric or adhesive shall be compatible with the product stored; specified service conditions; and with materials joined. Resulting joints shall be equivalent in serviceability (with the basic floating roof components), of a size and strength that will accept the roof design loads without failure or leakage, and shall have an expected life equal to the service life of the roof. Any non-metallic component shall be selected and fabricated to preclude absorption (under design conditions specified and permitted by this standard) of hydrocarbons, hydro-test water and specified product to be stored.

- **H.4.3.5** If specified by the Purchaser, all steel plate seams exposed to the product liquid or vapor shall be seal welded (for corrosive service conditions).

H.4.4 Peripheral Seals

- In addition to the required floating roof primary peripheral seal, secondary–peripheral seals shall be provided if specified on the Data Sheet, Line 31. Floating roof primary and secondary peripheral seal types and configurations shall be provided as specified on the Data Sheet, Line 31.

H.4.4.1 A peripheral seal (also referred to as “rim seal”) that spans the annular space between the internal floating roof deck and the shell shall be provided. When an internal floating roof has two such devices, one mounted above the other, the lower is the primary peripheral seal and the upper is the secondary peripheral seal. When there is only one such device, it is a primary peripheral seal, regardless of its mounting position.

- **H.4.4.2** The peripheral seal type and material shall be selected by the Purchaser after consideration of both proposed and future product service, tank shell construction/condition, maintenance requirements, regulatory compliance, service life expectancy, ambient temperature, design metal temperature, maximum design temperature, permeability, abrasion resistance, discoloration, aging, embrittlement, flammability, and other compatibility factors. The various seal types (listed H.4.4.4) will have variable life expectancy and service limitations.

The following non-mandatory table provides guidance on frequently used materials for selected products. Each material must be evaluated for the specific product and temperature.

Fluid Stored	Seal Material
Crude oil	Fluoropolymers, urethane, nitrile
Refined products	Fluoropolymers, urethane, urethane laminate, fluoroelastomers, or Buna-N-Vinyl
Gasoline/MTBE blend	Fluoropolymers or nitrile

H.4.4.3 All peripheral seals and their attachment to the floating roof shall be designed to accommodate ±100 mm (±4 in.) of local deviation between the floating roof and the shell.

H.4.4.4 Types of Primary Seals

a) **Liquid-mounted rim seal:** Means a resilient foam-filled or liquid-filled primary rim seal mounted in a position resulting in the bottom of the seal being normally in contact with the stored liquid surface. This seal may be a flexible foam (such as polyurethane foam in accordance with ASTM D3453) or liquid contained in a coated fabric envelope. Circumferential joints on liquid-mounted peripheral seals shall be liquid-tight and shall overlap at least 75 mm (3 in.). The material and thickness of the envelope fabric shall be determined after the factors given in H.4.4.2 are considered.

b) **Vapor-mounted rim seal**: Means a peripheral seal positioned such that it does not normally contact the surface of the stored liquid. Vapor-mounted peripheral seals may include, but are not limited to, resilient-filled seals (similar in design to liquid-mounted rim seals per H.4.4.4a), and flexible-wiper seals. Flexible-wiper seal means a rim seal utilizing a blade or tip of a flexible material (such as extruded rubber or synthetic rubber) with or without a reinforcing cloth or mesh.

c) **Mechanical shoe (metallic shoe)**: Means a peripheral seal that utilizes a light-gauge metallic band as the sliding contact with the shell and a fabric seal to close the annular space between the metallic band and the rim of the floating roof deck. The band is typically formed as a series of sheets (shoes) that are overlapped or joined together to form a ring and held against the shell by a series of mechanical devices.

Galvanized shoes shall conform to ASTM A924 and shall have a minimum nominal thickness of 1.5 mm (16 gauge) and a G90 coating. Stainless steel shoes shall conform to H.3.3, and shall have a minimum nominal thickness of 1.2 mm (18 gauge). For internal floating roofs the primary shoes shall extend at least 150 mm (6 in.) above and at least 100 mm (4 in.) into the liquid at the design flotation level. If necessary, bottom shell course accessories (e.g. side mixers) and other assemblies shall be modified or relocated to eliminate interference between lower portions of metallic seal assemblies.

- Unless specified otherwise by the Purchaser, the seal shoe and compression mechanism shall be installed before hydrostatic testing. It may be necessary to remove the seal shoe after the hydro-test to accommodate cleaning, application of interior linings, or any situation where the installed shoe might interfere with the process. The fabric seal may be installed after the hydrostatic testing.

H.4.4.5 The specific requirements for all floating roof peripheral seals are listed below.

1) All fasteners and washers for installation of seal joints, including fabric seal joints, shall be austenitic stainless steel. (See restrictions on contact between galvanizing and stainless steel in S.2.1.3.)

2) The seals shall be designed for a temperature range extending from design metal temperature less 8 °C (15 °F) to the maximum operating temperature.

3) Lengths of seal sections shall be as long as practical. No holes or openings shall be permitted in the completed seal. The seal material may be fabricated in sections resulting in seams, but any such seam shall be joined or otherwise held tightly together along the entire seam. For peripheral seals that use a fabric material to affect the seal, the requirement in the preceding sentence applies only to the fabric and not to any support devices. An adequate but minimum number of expansion joints shall be provided.

4) Provisions shall be made to prevent damage to the seal due to any overflow openings in the shell.

5) Rough spots on the shell that could damage the seal assembly shall be ground smooth. See H.6.1.

6) All metallic components shall be electrically bonded. See H.4.1.6 or C.3.1.6 for electrical bonding requirements.

H.4.4.6 If wax scrapers are specified on the Data Sheet, Line 31, they shall be located such that the scraping action occurs below the liquid surface. Design of wax scrapers shall not interfere with bottom shell course accessories.

H.4.5 Roof Penetrations

Columns, ladders, and other rigid vertical appurtenances that penetrate the deck shall be provided with a seal that will permit a local deviation of ±125 mm (±5 in.). Appurtenances shall be plumb within a tolerance of ±75 mm (±3 in.).

H.4.6 Roof Supports

- **H.4.6.1** The floating roof shall be provided with adjustable supports, unless the Purchaser specifies fixed supports.

H.4.6.2 Unless specified otherwise, the height of the floating roof shall be adjustable to two positions with the tank in service. The design of the supports shall prevent damage to the fixed roof and floating roof when the tank is in an overflow condition.

H.4.6.3 The Purchaser shall specify clearance requirements to establish the low (operating) and high (maintenance) levels of the roof supports. The low roof position shall be the lowest permitted by the internal components of the tank including shell nozzles with internal projections. If specified, a single position support height shall be based on the Purchaser-specified clearance dimension. The Purchaser shall provide data to enable the Manufacturer to ensure that all tank appurtenances (such as mixers, interior piping, and fill nozzles) are cleared by the roof in its lowest position. In addition to fitting elevations, such data shall include minimum mixer operation level and low level alarm settings (if applicable). If not specified otherwise by the Purchaser, the following apply:

H.4.6.3.1 The high roof position shall provide a 2-m (78-in.) minimum clearance throughout the bottom between the roof and the tank bottom unless specified otherwise on the data sheet, line 32.

H.4.6.3.2 Where propeller-type mixers are used, the support legs shall provide a minimum clearance of 75 mm (3 in.) from the underside of the internal floating roof (or roof notch) to the tip of the mixer propeller. Deviations from that spacing for any component (mixer, nozzles, shell manholes, seals, etc.) shall be noted on the data sheet and discussed with the Manufacturer.

H.4.6.4 Support attachments in the deck area shall be designed to prevent failure at the point of attachment. On the bottom of the steel welded deck plates (used on types H.2.2a, b, c, d, and g), where flexure is anticipated adjacent to supports or other relatively rigid members, full-fillet welds not less than 50 mm (2 in.) long on 250 mm (10 in.) centers shall be used on any plate laps that occur within 300 mm (12 in.) of any such support or member.

H.4.6.5 Supports shall be fabricated from pipe, unless cable or another type is specified on the Data Sheet, Line 34 and approved by the Purchaser. Supports fabricated from pipe shall be notched or otherwise constructed at the bottom to provide complete liquid drainage. Cable supports shall be adjustable externally and shall not have an open penetration at the floating roof surface. Fixed roofs shall be designed or verified suitable for cable support loads, when used, per agreement between the Purchaser and tank/roof Manufacturers.

H.4.6.6 Steel pads or other means shall be used to distribute the loads on the bottom of the tank and provide a wear surface. With the Purchaser's approval, pads may be omitted if the tank bottom will support the live load plus the dead load of the floating roof. If pads are used, they shall be continuously welded to the tank bottom.

H.4.6.7 Aluminum supports shall be isolated from carbon steel by an austenitic stainless steel spacer, an elastomeric bearing pad, or equivalent protection, unless specified otherwise by the Purchaser.

H.4.6.8 Special protective measures (corrosion allowance, material selection, linings) are to be evaluated for supports that interface with stratified product bottoms, which may include corrosive contaminant combinations not found in the normal product. The Purchaser shall specify if any protective measures are required.

H.4.6.9 For tanks with internal linings, the Purchaser shall specify on Line 23 of the Data Sheet any special requirements for minimizing corrosion where the leg contacts the tank bottom, such as a flat plate or bull nose on the leg base, a thicker base plate, or other means.

H.4.6.10 Consideration shall be given to the use of fixed supports for the operating position (low level) of internal floating roofs, which utilize cable supports suspended from a fixed roof. These supports are typically not adjustable, are sealed to prevent emissions, and are for the operating position (low level) set at a level as specified by the Purchaser. The use of fixed supports for the low level positions are intended to reduce the frequency of fixed roof loading. The operating position (low level) and length of the cables shall be such that sinking and/or collapse of the internal floating roof will not apply loads to the support cables.

H.4.6.11 If cable supports are used, the supports shall be adjustable from the fixed roof while the floating roof is floating and with the cables unloaded.

H.4.6.12 Cables, cable segments, or cable connections which support the floating roof are prohibited from using a fusible link or other devices which are designed to fail at a specified load limit.

H.4.6.13 Cables used to support internal floating roofs shall be 300 series stainless steel and shall be flexible to facilitate repeatable lay down patterns on the floating roof as it travels up and down within the tank. Lay down patterns shall be positioned to avoid rim seals and floating roof appurtenances that could prevent the cable from freely extending as the floating roof lowers.

H.5 Openings and Appurtenances

H.5.1 Ladder

- **H.5.1.1** The tank interior is considered a confined space environment with restricted access (see API Recommended Practice 2026). If specified by the Purchaser, the tank shall be supplied with a ladder for internal floating roof deck access. If a ladder is not supplied and the floating roof is not steel, a ladder landing pad shall be provided on the floating roof.

H.5.1.2 The ladder shall be designed to allow for the full travel of the internal floating roof, regardless of any settling of the roof supports.

H.5.1.3 The ladder shall be installed within a fixed-roof manhole, per H.5.5.1.

- **H.5.1.4** If a level-gauge stilling well is provided, the well may form one or both legs of the ladder, as specified by the Purchaser.

H.5.1.5 The ladder shall not be attached to the tank bottom unless provision is made for vertical movement at the upper connection.

H.5.2 Vents

- **H.5.2.1 Internal Floating Roof Pressure-Relieving Vents**

H.5.2.1.1 Vents suitable to prevent overstressing of the roof deck or seal membrane shall be provided on the floating roof. These vents shall be adequate to evacuate air and gases from underneath the roof such that the internal floating roof is not lifted from resting on its supports during filling operations, until floating on the stored liquid. The vents shall also be adequate to release any vacuum generated underneath the roof after it settles on its supports during emptying operations to limit the floating roof external pressure to P_{fe}. The Purchaser shall specify filling and emptying rates. The manufacturer shall size the vents.

H.5.2.1.2 Internal floating roofs which utilize support legs shall be equipped with leg- or pressure-vacuum-activated vents. The Purchaser may specify the type of vent and the associated design conditions (see Line 33 of the Data Sheet). Leg activated vents shall be adjustable as required per H.4.6.

H.5.2.1.3 Internal floating roofs, which utilize cable supports and mechanical activated vents shall have a leg or cable activated vent(s) for the operating position (low level) and a cable activated vent(s) for the maintenance position (high level). Alternatively, internal floating roofs which utilize cable supports shall use a pressure vacuum vent(s) to provide the required venting for all floating roof support levels.

H.5.2.1.4 Unless agreed otherwise by the Purchaser and roof Manufacturer, leg or cable activated vents shall be designed to open automatically when the roof lowers to 150 mm (6 in.) above its support levels and to close

automatically when the roof raises more than 150 mm (6 in.) above these support levels. The following factors should be considered if the design vent setting is less than 150 mm (6 in.):

a) potential construction imperfections;

b) anticipated differential settlement of the tank (leg supported);

c) floating depth of the floating roof (cable supported);

d) deformation of the tank roof (cable supported).

Float-activated vents shall be designed to remain closed while the roof is floating. Pressure-vacuum activated vents shall be designed to open and achieve required flow rates within the design capacities of the floating roof and floating roof support system as described in H.5.2.1.1.

H.5.2.2 Tank Circulation Vents

- **H.5.2.2.1** Peripheral circulation vents shall be located on the tank roof (unless otherwise specified by the Purchaser) and meet the requirements of H.5.3.3, so that they are above the seal of the internal floating roof when the tank is full. The maximum spacing between vents shall be 10 m (32 ft), based on an arc measured at the tank shell, but there shall not be fewer than four equally-spaced vents. The venting shall be distributed such that the sum of the open areas of the vents located within any 10 m (32 ft) interval is at least 0.2 m^2 (2.0 ft^2). The total net open area of these vents shall be greater than or equal to 0.06 m^2/m (0.2 ft^2/ft) of tank diameter. These vents shall be covered with a corrosion-resistant coarse-mesh screen (13 mm [$^1/_2$ in.] openings, unless specified otherwise by the Purchaser) and shall be provided with weather shields (the closed area of the screen must be deducted to determine the net open vent area).

H.5.2.2.2 A center circulation vent with a minimum net open area of 30,000 mm^2 (50 $in.^2$) shall be provided at the center of the fixed roof or at the highest elevation possible on the fixed roof. It shall have a weather cover and shall be provided with a corrosion-resistant coarse-mesh screen (the closed area of the screen must be deducted to determine the net open vent area).

- **H.5.2.2.3** If circulation vents (per H.5.2.2.1 and H.5.2.2.2) are not installed, gas blanketing or another acceptable method to prevent the development of a combustible gas mixture within the tank is required. Additionally, the tank shall be protected by pressure-vacuum vents in accordance with 5.8.5, based on information provided by the Purchaser.

H.5.3 Liquid-Level Indication, Overfill Protection, and Overflow Slots

- **H.5.3.1** The Purchaser shall provide appropriate alarm devices to indicate a rise of the liquid in the tank to a level above the normal and overfill protection levels (see NFPA 30 and API 2350). Overflow slots shall not be used as a primary means of detecting an overfill incident.

- **H.5.3.2** The internal floating roof Manufacturer shall provide information defining the internal floating roof and seal dimensional profile for the Purchasers' determination of the maximum normal operating and overfill protection liquid levels (considering tank fixed-roof support, overflow slots or any other top of shell obstructions). The floating roof Manufacturer shall provide the design flotation level (liquid surface elevation) of the internal floating roof at which the pressure/vacuum relief vents will begin to open (to facilitate the Purchasers' determination of minimum operating levels).

- **H.5.3.3** The use of emergency overflow slots shall only be permitted if specified by the Purchaser. When emergency overflow slots are used, they shall be sized to discharge at the pump-in rates for the tank. The greater of the design specific gravity or 1.0 shall be used to determine the overflow slot position so that accidental overfilling will not damage the tank or roof or interrupt the continuous operation of the floating roof. Overflow discharge rates shall be determined by using the net open area (less screen) and using a product level (for determining head pressure) not exceeding the

top of the overflow opening. The overflow slots shall be covered with a corrosion-resistant coarse-mesh screen (13 mm [1/2 in.] openings) and shall be provided with weather shields (the closed area of the screen must be deducted to determine the net open area). The open area of emergency overflow slots may contribute to the peripheral venting requirement of H.5.2.2.1 provided that at least 50 % of the circulation-vent area remains unobstructed during emergency overflow conditions. The floating-roof seal shall not interfere with the operation of the emergency overflow openings. Overflow slots shall not be placed over the stairway or nozzles unless restricted by tank diameter/height or unless overflow piping, collection headers, or troughs are specified by the Purchaser to divert flow.

H.5.4 Anti-rotation and Centering Devices

The internal floating roof shall be centered and restrained from rotating. A guide pole with rollers, two or more seal centering cables or other suitable device(s) shall be provided as required for this purpose. The internal floating roof shall not depend solely on the peripheral seals or vertical penetration wells to maintain the centered position or to resist rotation. Any device used for either purpose shall not interfere with the ability of the internal floating roof to travel within the full operating elevations in accordance with H.4.1.1.

H.5.5 Manholes and Inspection Hatches

H.5.5.1 Fixed-Roof Manholes

At least one fixed-roof manhole complying with this standard, with a nominal opening of 600 mm (24 in.) or larger, shall be provided in the fixed roof for maintenance ventilation purposes. If used for access to the tank interior, the minimum clear opening shall be 750 mm (30 in.).

H.5.5.2 Floating-Roof Manholes

At least one internal floating roof deck manhole shall be provided for access to and ventilation of the tank when the floating roof is on its supports and the tank is empty. The manhole shall have a nominal opening of 600 mm (24 in.) or larger and shall be provided with a bolted or secured and gasketed manhole cover. The manhole neck dimensions shall meet the requirements of H.4.1.4 and H.4.1.5.

• H.5.5.3 Inspection Hatches

When specified by the Purchaser, inspection hatches shall be located on the fixed roof to permit visual inspection of the seal region. The maximum spacing between inspection hatches shall be 23 m (75 ft), but there shall not be fewer than two equally-spaced hatches. There shall be not fewer than three equally spaced hatches for tank diameters larger than 9 m (30 ft), and there shall be not fewer than four equally spaced hatches for tank diameters larger than 12 m (40 ft). Designs that combine inspection hatches with tank-shell circulation vents (located on the tank roof) are acceptable.

• H.5.6 Inlet Diffuser

Supply inlet diffusers if required on the Data Sheet (also see 5.8.11.2).

• H.5.7 Gauging and Sampling Devices

When specified by the Purchaser, the fixed roof and the internal floating roof shall be provided with and/or accommodate gauging and sampling devices. Sampling devices on the deck of the floating roof shall be installed beneath the fixed-roof hatch (as specified for this purpose) and, unless designed as a gauge pole (extending up to the fixed roof), shall have a funneled (tapered) cover to facilitate use from the roof of the tank. All such devices on the floating roof shall be installed within the plumbness tolerance of H.4.5. See C.3.14 for additional requirements applicable to gauge wells and poles.

H.5.8 Corrosion Gauge

When specified by the Purchaser, a corrosion gauge for the internal floating roof shall be provided adjacent to the ladder to indicate the general corrosion rate.

H.5.9 Foam Dams

A foam dam, if specified on the Data Sheet, Line 32, shall be fabricated and installed in compliance with NFPA 11.

H.6 Fabrication, Erection, Welding, Inspection, and Testing

H.6.1 The applicable fabrication, erection, welding, inspection, and testing requirements of this standard shall be met. Upon the start of internal floating roof installation, or concurrent with assembly within a tank under construction, the tank (interior shell and vertical components) shall be inspected by the floating roof erector, unless otherwise specified. The purpose of this inspection shall be to confirm plumbness of all interior components, along with roundness and the condition of the shell (for the presence of damage, projections, or obstructions) to verify that the floating roof and seals will operate properly. Any defects, projections, obstructions or tank tolerance limits (exceeding those defined in 7.5 of this standard), which would inhibit proper internal floating roof and seal operation, that are identified by the internal floating roof erector shall be reported to the Purchaser.

H.6.2 Deck seams and other joints that are required to be vapor-tight per H.4.1.3 shall be tested for leaks by the shop or field joint assembler. Joint testing shall be performed by means of penetrating oil or another method consistent with those described in this standard for testing cone-roof and/or tank-bottom seams, or by any other method mutually agreed upon by the Purchaser and the roof Manufacturer.

H.6.3 The floating roof Manufacturer shall supply all floating roof closures required for testing per H.4.1.3, H.4.1.7, H.4.3.1, and H.6.2. Rivets, self-tapping screws, and removable sections are not acceptable for test plugs.

H.6.4 Any flotation compartment that is completely shop-fabricated or assembled in such a manner as to permit leak testing at the fabricating shop shall be leak tested at the shop as well as retested in the field by the floating roof erector for all accessible seams. In the field assembly yard or in the erected position, the erector shall spot leak test 10 % of the flotation compartments, whether shop- or field-fabricated. The Purchaser may select the specific compartments to test and the test location, based on his visual inspections for indications of damage or potential leaks (see the Data Sheet, Line 34). Any leaking compartments shall be repaired and re-tested by the roof Manufacturer. If the testing finds any leaks in compartments tested, except for those damaged by shipping, then 100 % of the roof compartments shall be leak tested. Unless prohibited by safety concerns, leak testing of cylindrical sections shall be at an internal pressure of 20 kPa to 55 kPa (3 lbf/in.^{2} to 8 lbf/in.^{2}) gauge using a soap solution or commercial leak detection solution. For other compartment shapes, each compartment weld shall be tested for leak tightness using internal pressure (pressure to be agreed between the Purchaser, roof manufacturer, and roof erector) or a vacuum box and a soap solution, or penetrating oil.

NOTE Special contract terms may be required to cover the costs of the field testing.

H.6.5 Upon assembly and prior to a flotation test, the erector shall inspect to verify that the peripheral seal produces an acceptable fit against the tank shell.

H.6.6 Initial Flotation

A flotation test and initial fill inspection shall be conducted by the Purchaser. This test may be performed or witnessed by the erector, as subject to agreement with the Purchaser. The party performing the flotation test shall make water connections and supply all tank closures required for testing and remove all water connections and temporary closures (including gaskets, fasteners, test blanks, etc.) after completion of the test, unless otherwise specified by the Purchaser.

H.6.6.1 Internal floating roofs in accordance with types H.2.2a, b, c, d, and g shall be given a flotation test on water. Internal floating roofs in accordance with types H.2.2e and H.2.2f shall be given a flotation test on water or product at the option of the Purchaser. During this test, the roof and all accessible compartments shall be checked to confirm that they are free from leaks. The appearance of a damp spot on the upper side of the part in contact with the liquid shall be considered evidence of leakage.

H.6.6.2 During initial fill the internal floating roof should be checked to confirm that it travels freely to its full height. The peripheral seal shall be checked for proper operation throughout the entire travel of the internal floating roof. During the first event of lowering the level from full height, particular attention shall be given for tanks that contain a floating suction to ensure proper operation.

H.6.6.3 Because of possible corrosive effects, consideration shall be given to the quality of water used and the duration of the test. Potable water is recommended. For aluminum floating roofs, AL.7.5 shall be followed. For stainless steel floating roofs, S.4.10 shall be followed.

H.6.6.4 The high flotation level shall be evaluated for clearance and the floating suction (if existing) shall be compensated for the excess buoyancy that will be encountered during hydrostatic testing of the floating roof system.