

Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service

API RECOMMENDED PRACTICE 2026
FOURTH EDITION, XXXX 2022



AMERICAN PETROLEUM INSTITUTE

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Foreword

This recommended practice (RP) is intended to provide information associated with safe access/egress involving floating roofs of tanks in petroleum service. This RP includes a discussion of the common hazards associated with these operations and the appropriate precautions for preventing accidents and injuries.

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Suggested revisions are invited and should be submitted to the director of the Health and Environmental Affairs Department, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005.

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Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service

1 Scope and Objectives

1.1 Scope

1.1.1 This recommended practice (RP) addresses the hazards associated with access/egress onto external and internal floating roofs of in-service petroleum storage tanks and identifies some of the most common practices and procedures for safely accomplishing this activity.

1.1.2 This RP is intended primarily for those persons who are required to perform inspection, service, maintenance, or repair activities that involve descent onto floating roofs of in-service petroleum tanks.

1.1.3 This RP does not cover general considerations that apply to climbing onto petroleum storage tanks and other structures, including, but not limited to:

- a) slippery or ice-covered stairways and walkways,
- b) access during electrical storms, and
- c) access during emergency conditions (such as to extinguish a fire or cover exposed product with foam).

This RP may not apply to daily or routine tasks of tank gaugers and other personnel involved in non-permit-required confined spaces; however, such persons shall be trained and shall be made aware of the potential hazards described herein.

1.1.4 Preparations and precautions for entering petroleum storage tanks that have been removed from service for cleaning are covered in API 2015.

1.1.5 Some owner/operators have policies that are more stringent than those in this document. Some owner/operators do not permit access onto floating roofs while the tanks are in service. In these cases, owner/operator policies will supersede this document with respect to safe access requirements and limitations.

1.2 Objectives

This RP has the following objectives:

- a) to identify the potentially hazardous conditions associated with access/egress onto external and internal floating roofs of storage tanks while the tanks are in petroleum service; and
- b) to establish general precautionary measures appropriate to individual situations.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 650, *Welded Tanks for Oil Storage*

API Standard 2015, *Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks*

API Recommended Practice 2027, *Ignition Hazards Involved in Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service*

OSHA ¹, 29 CFR ² Part 1910, *Occupational Safety and Health Standards*

OSHA, 29 CFR 1910.134, *Respiratory Protection*

OSHA, 29 CFR 1910.146, *Permit-required Confined Spaces*

OSHA, 29 CFR 1926.1203 Subpart AA, *Confined Spaces in Construction*

OSHA, 29 CFR 1910.1000, *Air Contaminants*

3 Definitions

For the purposes of this document, the following definitions apply.

3.1 air-supplied respiratory protection

A respirator that provides a supply of safe breathing air from a tank (either a self-contained breathing apparatus portable tank or an airline supply tank) or from an uncontaminated fresh air supply source located outside of the work area.

3.2

cold work

Work activity that does not produce heat, sparks, or other forms of energy sufficient to provide an ignition source if a vapor-air mixture in the flammable range is present. Cold work is work that is not classified as hot work.

3.3

confined space

Any tank or space that

- a) is large enough and so configured that a worker can bodily enter and perform assigned work,
- b) has limited or restricted means of entry or exit, and
- c) is not designed or intended for continuous occupancy by workers.

3.3.1

attendant

A trained person stationed outside one or more permit-required confined spaces who monitors the entrants and who performs all attendant's duties in accordance with the employer's confined space program.

3.3.2

entrant

A trained person who is authorized by the entry supervisor to enter a confined space.

3.3.3

entry supervisor

The trained person designated by the employer to be responsible for determining acceptable entry conditions for permit-required confined spaces and non-permit-required confined spaces. Entry supervisors shall authorize entry, oversee entry operations, and terminate entry as

¹ U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue NW, Washington, DC 20210, www.osha.gov.

² The *Code of Federal Regulations (CFR)* is available from the U.S. Government Printing Office, Washington, DC 20402, www.gpo.gov.

required by the permit or conditions. The duties of entry supervisor may be passed from one entry supervisor to another entry supervisor, during an entry operation.

NOTE An API-certified Tank Entry Supervisor (TES) is considered qualified to perform the duties of entry supervisor.

3.3.4

confined space permit program

The employer's overall program for controlling and regulating entry into confined spaces and, where appropriate, protecting employees from confined space hazards.

3.3.4.1

confined space entry permit

The written or printed document provided by the employer issued by an entry supervisor that provides the site, potential hazard, and work specific information necessary to control and authorize entry into a confined space, including conditions canceling the permit and requirements for safeguarding or returning the space to service following termination of entry.

3.3.4.2

non-permit-required confined space

A confined space (a space that meets *all three* of the confined space requirements) that has been checked, inspected, had its atmosphere monitored, and does not have (or does not have the potential to have) any of the characteristics required to be classified as a permit-required confined space.

3.3.4.3

permit-required confined space

A tank or space that meets the confined space requirements and also has one or more of the following characteristics:

- a) contains or has the potential to contain a hazardous atmosphere,
- b) contains a material with the potential to engulf an entrant,
- c) has an internal configuration such that an entrant could become trapped or asphyxiated,
- d) contains any other recognized serious safety or health hazard(s), or
- e) has a floating roof not properly prepared and secured in accordance with API 2015.

NOTE: An improperly secured floating roof would be considered a physical hazard under the OSHA criteria for hazards in confined spaces.

3.4

entry

The action by which an entrant passes through an opening into a confined space. Entry includes ensuing work activities in both permit-required confined spaces and non-permit-confined spaces and is considered to have occurred as soon as a part of the entrant's body breaks the plane of an opening into the space.

3.5

lower explosive (flammable) limit

LEL

The minimum concentration (expressed as a volume percentage) of a vapor-in-air below which propagation of flame does not occur on contact with an ignition source; generally considered to be "too lean to burn."

3.1.5.2

upper explosive (flammable) limit

UEL

The maximum concentration (expressed as a volume percentage) of a vapor-in-air above which propagation

of flame does not occur upon contact with an ignition source; generally considered “too rich to burn.”

3.6

floating roof tank

Any aboveground vertical atmospheric storage vessel that is equipped with either an external or internal floating roof.

in-service

Contains a quantity of petroleum product that could cause a flammable, oxygen-deficient, or toxic atmosphere above the floating roof.

3.7

floating roof

A moveable cover that floats on top of the product in a floating-roof tank.

3.7.1

external floating roof

A floating roof that is designed and constructed in accordance with the provisions of API 650, Annex C. An *external floating roof* is designed to be used on a tank with no fixed roof but may be used on tanks with fixed roofs.

3.7.2 internal floating roof

A floating roof that is designed and constructed in accordance with the provisions of API 650, Annex H. An *internal floating roof* is designed to be used only on a tank with a fixed roof.

3.8

hazardous atmosphere

An atmosphere that has the potential to expose entrants to the risk of death, incapacitation, impairment of ability to self-rescue (escape unaided from a confined space), injury, or acute illness from one or more of the following causes.

- a) Flammable gas, vapor, or mist in excess of 10 % lower explosive (flammable) limit (LEL).
- b) Airborne combustible dust at a concentration that meets or exceeds 80 % of its LEL. The LEL may be approximated as a condition in which the dust obscures vision at a distance of 5 ft (1.5 m) or less.
- c) Atmospheric oxygen concentration below 19.5 % or above 23.5 %.
- d) Atmospheric concentration of any substance for which a dose or permissible exposure limit (PEL) is published in applicable government regulations, safety data sheets (SDSs), standards, or other publications or internal documents and that could result in employee exposure in excess of the substance's dose or PEL.
- e) Any other atmospheric condition immediately dangerous to life or health (IDLH).

3.9

hot work

Any work that has the potential to produce enough thermal energy to provide an ignition source in an area where a potential exists for a flammable gas or vapor-in-air atmosphere in the explosive (flammable) range to occur.

3.9.1 hot work permit

The employer's written authorization to perform hot work operations or use equipment (including, but not limited to, open flames, welding, cutting, grinding, burning, heating, abrasive blasting, and use of internal combustion engines and non-explosion-proof electric motors) capable of producing a source of ignition. The hot work permit may be part of the confined space entry permit or a separate document.

3.10

inerting

The displacement of hydrocarbon gas or vapors and oxygen (air) to eliminate the possibility of a flammable atmosphere in a permit-required confined space. This is accomplished by using an inert gas that is noncombustible, noncontaminating, and nonreactive (e.g. nitrogen) or a gas containing an insufficient amount of oxygen to support combustion (e.g. flue gas), to such an extent that the resultant atmosphere is noncombustible or nonreactive

3.11

lockout/tagout

The placement of a lockout or tagout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled are not operated until the lockout or tagout device is removed.

3.12**permissible exposure limit****PEL**

The designated limit of exposure to any airborne contaminant to which an employee may be subjected, expressed as an 8-hour time-weighted average.. The PEL is determined by the appropriate regulatory agencies (e.g. OSHA.)

3.13**permit program/permit system**

The employer's overall program of written procedures for controlling access to a specific work area, including permits for access to confined spaces and protecting entrants from hazards.

3.14**static condition**

When the floating roof is not moving as the tank is neither receiving nor discharging product and the mixers (if any) are not operating.

3.16**tank isolation**

The condition that exists when all lines and valves are closed (e.g. the valves are locked or sealed and tagged, or the lines to and from the tank are disconnected and blinded, blanked, or double-blocked, and bled as necessary) to preclude the movement of material in or out of the tank, whether the valves are at the tank or at remote manifolds. *Tank isolation* may also involve de-energizing and disconnecting switches and mechanical linkages, including lockout and/or tagout and sealing, to preclude the input of energy such as that required for heating, mixing, aerating, etc.

NOTE Fire protection systems should be assessed to ensure the safety of the entrants, and the fire protection system may be required to be isolated as per the lockout and tagout procedure.

4 General Precautions for Descent onto Floating Roofs

4.1 General Conditions

General conditions for descent onto floating roofs are the following.

4.1.1 Whenever descent onto a floating roof is determined to constitute permit-required entry into a confined

space, entry and work conditions shall follow the safe work practices recommended in API 2015 and OSHA 29 *CFR* 1910.146, *Permit-required confined spaces*, and other applicable regulatory requirements.

4.1.2 Descent onto any internal or covered external floating roof always constitutes entry into an OSHA

permit-required confined space unless the tank is out of service and cleaned and the atmosphere is determined to be safe for entry. Each tank owner and operator shall therefore establish a Confined Space Permit Program to control and authorize descent onto internal and covered external floating roofs of in-service tanks.

4.1.3 Descent onto an external floating roof may or may not be considered entry into a permit-required

confined space, depending on several factors. For external floating-roof tanks, the tank owner or operator shall determine the conditions that constitute permit-required confined space entry. When these conditions are met, the appropriate permit-required confined space entry procedures shall be established and followed for each specific descent onto external floating roofs.

4.1.4 Whether or not a Confined Space Entry Permit is required, facility procedures for descent and entry onto floating roofs

and potential hazards shall be covered in a pre-job conference including appropriate supervisory, entry, and

attendant personnel. Typical potential hazards that may occur during descent and entry onto floating roofs are outlined in Section 5 of this document.

4.1.5 When descent onto a floating roof is determined to constitute entry into a permit-required confined space, an Confined Space Entry Permit shall be issued by a designated entry supervisor. Permit conditions, entry and egress procedures, atmospheric testing requirements, respiratory protection, emergency procedures, and safe work practices shall, as a minimum, follow the recommendations provided in OSHA 29 *CFR* 1910.146 and other applicable regulatory requirements.

4.2 Confined Space Permit Program Requirements

The Confined Space Permit Program applicable to entry onto floating roofs of tanks shall establish the necessary measures to prevent unauthorized entry onto floating roofs and shall include the following as a minimum.

- a) Methods to identify, evaluate, and protect entrants from potential hazards associated with entry onto floating roofs.
- b) Criteria for acceptable entry conditions for each type of tank and tank service and each type of floating roof prior to entry and to verify safe conditions throughout the duration of entry onto a floating roof.
- c) A means for preparation, issuance, use, and cancellation of Confined Space Entry Permits, which provide for coordination between entrants, especially when more than one employer or contractor is involved in the work.

- d) Provision for review of the Confined Space Permit Space Program as tankage, storage, and conditions change.
- e) Provision for testing, communications, respiratory and personal protective, lighting, barriers, ventilation, rescue, and emergency response equipment required for safe entry onto floating roofs.
- f) Requirements to ensure that knowledgeable, trained, and qualified entry supervisors, attendants, testers, and entrants are designated for each permit-required confined space entry onto a floating roof.
- g) Requirements that entry supervisors, entrants, and attendants, , shall be familiar with the potential hazards and emergency services applicable to each specific permit-required confined space entry.
- h) The requirement for the presence of at least one attendant to be stationed at the top of the tank for the duration of permit-required confined space floating-roof entry operations.
- i) Rescue and emergency response procedures applicable to floating-roof entry, including summoning rescuers, retrieving entrants, providing emergency services for entrants, and preventing unauthorized persons from attempting a rescue.
- j) Provision for hazard communications awareness or training for all entrants, testers, entry supervisors, attendants, and rescue persons, covering the material contained in the tank whose floating roof is to be entered.

4.3 Requirements for Descent onto Floating Roofs

The entry supervisor shall ensure that all necessary tests have been conducted and that all personnel, procedures, and equipment required by the Confined Space Entry Permit are in place before authorizing descent onto the floating roof.

5 Potential Hazards Associated with Entry onto Floating Roofs

5.1 Potential Atmospheric Hazards

5.1.1 General

The oxygen content of the atmosphere above the floating roof may be above or below the minimum levels for safe entry, hydrocarbon vapors (e.g. gasoline) may be present in the flammable range, and the atmosphere may contain toxic vapors (e.g. benzene or hydrogen sulfide) that exceed established exposure limits for safe entry without respiratory equipment.

5.1.2 Identification of Potential Atmospheric Hazards

Before initial descent onto a floating roof is authorized, the entry supervisor shall identify the potential atmospheric hazards, determine the permit entry requirements, and evaluate the test results.

5.2 Potential Oxygen Content Hazards

Atmospheric testing for oxygen levels shall be conducted before entry onto a floating roof in order to determine:

- a) whether sufficient oxygen is present in the atmosphere to conduct flammable vapor testing;
- b) whether oxygen levels are within, above, or below the limits required to allow entry without air-supplied respiratory protection (provided that no toxic atmosphere is present); and
- c) if oxygen levels are too high to either enter the confined space or to determine correct upper flammable limits and lower flammable limits of any flammable vapor that may be present.

5.3 Potential Flammable Vapor Hazards

5.3.1 Atmospheric vapor testing shall be conducted to determine whether or not a flammable vapor/air mixture is present in the atmosphere above a floating roof prior to entry. Flammable or combustible liquids may be present on the floating roof or in the pontoons, floats, or seal areas.

5.3.2 The flammable vapor or gas content of the atmosphere above the floating roof may be above 10 % LEL, the current OSHA-established maximum level for safe entry into a confined space. In such cases, the space above the floating roof may need to be ventilated to reduce the concentration of vapor in air or inerted to eliminate oxygen, and the atmosphere retested prior to permitting entry.

5.3.3 A flammable atmosphere may also be present inside pontoons, floats, and primary and secondary seal areas or underneath a floating roof out of flotation. These areas must be considered as separate confined spaces and must be tested appropriately, with entry restricted if the flammable vapors inside the area exceed 10 % LEL. These spaces may also need to be ventilated or inerted, and the atmosphere retested prior to permitting entry.

5.4 Potential Toxic Vapor and Gas Hazards

5.4.1 The atmosphere above the floating roof may contain hazardous hydrocarbon vapors (such as gasoline), toxic vapors (such as hydrogen sulfide, benzene, or organic lead), or inert gases (such as nitrogen) that exceed established exposure levels for safe entry without approved respiratory and personal protective equipment.

NOTE See OSHA 29 *CFR* 1910.134 and API 2015.

5.4.2 A determination shall be made of the toxic substances known or suspected to be present in the atmosphere of the confined space. Information concerning potential exposures and proper precautions with respect to specific hazardous materials and conditions shall be obtained from the following sources:

- a) the employer, tank owner, or operator or from the manufacturer or supplier of the material.
- b) established standards, such as those from OSHA, and publications such as those published by the American Conference of Government Industrial Hygienists (ACGIH); or
- c) the SDS for the product involved.

NOTE See OSHA 29 *CFR* 1910.1000.

5.4.3 Atmospheric testing for contaminants shall be conducted by a tester before entry onto a floating roof in order to determine whether toxic exposures are present in excess of established PELs. The need for continuous or intermittent monitoring and the selection and use of respiratory protective equipment shall depend on the results of the testing and the potential for increased or continued exposure during entry. If the potential exists for acute toxic exposures, such as H₂S, continuous monitoring equipment shall be used, even if initial monitoring indicates safe levels.

5.4.4 The employer shall document the basis for determining that all potential hazards in a permit-required confined space have been eliminated using a certification (Confined Space Entry Permit) available to all entrants containing the date, location, and signature of the person making the determination.

5.4.5 Because many petroleum products have PELs in parts per million that are considerably less than their

LELs, the PEL, rather than a percentage of the LEL, shall be the criteria for entry without respiratory protection.

5.4.6 The tank owner or operator shall provide SDSs covering products that have been stored in the tank, which address toxic substances and their potential effects, permissible exposure levels, and personal protection information.

5.5 Potential Vapor Exposures

5.5.1 Even when the floating roof structure is in good mechanical condition, vapors may escape past the roof

seals and gauge pipe well seals and, in some cases, may migrate through the automatic bleeder (pressure vacuum) vent or other openings in the floating roof. The quantity of vapors escaping during normal tank operation is usually negligible, provided that the seals are in good condition and neither the shell nor the roof is distorted.

5.5.2 Escaping vapors may also accumulate in pontoons of the floating roof because of leakage. Pontoons

should be considered as confined spaces and atmospheric testing and appropriate permit system and entry procedures should be followed whenever workers are required to enter a pontoon.

5.5.3 Some of the factors that affect the quantity of vapors that may escape include, but are not limited to, the following.

- a) *Condition of seals*—An increased quantity of vapors will escape past seals that are in poor condition.
- b) *Products entering the tank*—A volatile stock or high-temperature product entering the tank may lead to the creation of an increased quantity of vapors, especially at high pumping rates.
- c) *Mixing or agitation*—When the tank contents are mixed or agitated, vapors under the roof may escape past the seal or through the automatic bleeder vent. A substantial vapor release can cause entrained liquid to blow past the seal and accumulate on top of the floating roof.
- d) *Tank operations*—When pumping out of the tank, especially at high pumping rates, the wetted walls of the tank may lead to the creation of an increased quantity of vapors in the space above the floating roof.
- e) *Roof out of flotation*—A roof is inherently more vapor-tight when it is in flotation. Support-leg wells and tank gauge float wells do not function as vapor barriers when the liquid level has dropped below the bottom of the wells. When a floating roof is on its legs, the area between the floating roof and the liquid level will be occupied by vapors or a mixture of vapors and air.
- f) *Returning a tank to service*—The greatest vapor concentration above the floating roof may be expected when the roof has been out of flotation and is then being refloated (the tank is being refilled). These vapors may persist for extended periods depending on conditions.
- g) *Abnormal roof condition*—Vapors will be present if the floating roof sinks beneath the surface of the product or if it is hung up inside the tank in a tilted position.

5.6 Potential Fire Hazards

5.6.1 Some of the potential fire hazards associated with descent onto floating roofs include, but are not limited to, the following.

- a) A flammable vapor air mixture may exist in the atmosphere above the floating roof (e.g. a roof seal can leak).
- b) A flammable or combustible liquid may be present on the floating roof (e.g. due to overflow or pontoon leakage).
- c) A flammable or combustible liquid or vapor may be present in the pontoon or in the seal area (e.g. due to a pontoon leak or a rupture in the seal).
- d) When the floating roof is out of flotation and the liquid level is below the roof support, a flammable vapor/air mixture may exist in the atmosphere below the roof (e.g. roof seal does not seal properly and air entered the interstitial space).

- e) When filling a tank whose roof has been out of flotation and the liquid level has been below the roof level, vapors may be forced through the roof seal and into the atmosphere above the floating roof.

- f) Absorbent buoyant materials used in the construction of some floating roofs may retain flammable or combustible liquids.

NOTE Some plastics may be susceptible to fire damage or sustain combustion even without absorption.

5.7 Potential Physical Hazards

5.7.1 Entry onto floating roofs presents potential physical hazards including, but not limited to, restricted

entry and exit, limited visibility in internal and covered external floating-roof tanks, tripping, and falling. Employers shall ensure that safe work practices address potential physical hazards associated with entry onto floating roofs in their facilities.

5.7.2 Examples of falling and tripping hazards include, but are not limited to, the following.

- a) Falling from a ladder or stairway.
- b) Falling from a tank roof or walkway onto the floating roof.
- c) Slipping, tripping, or falling on the floating roof.
- d) Corrosion may occur on the underside of floating roofs in contact with products, such as high sulfur crude oil; therefore, falling through a corroded internal or external floating roof into product and sinking is a potential hazard. Corrosion may also occur in vapor spaces within the floating roof, such as roof manway covers, vacuum breakers, and gauge pole sleeves.

5.7.3 External floating roofs are usually constructed of steel with pontoons for flotation and, when in good

condition, will support the weight of workers and equipment. Floating roofs shall be visually inspected from above for structural stability prior to descent. Because some mechanical deficiencies and corrosion may not be noticeable from the top platform, if there is any doubt about the integrity of a floating roof, metal-thickness readings or other appropriate structural testing or measurements should be obtained using proper safety precautions.

5.7.4 Internal floating roofs may be constructed of lighter materials (such as foam, plastic, fiberglass, or

aluminum) and mechanical damage or defects may not be easy to recognize. Some internal floating roofs have pontoons for greater buoyancy and others do not. Entry onto internal floating roofs that do not have pontoons for increased buoyancy should be considered extremely hazardous and conducted under specific safe work procedures and practices to protect entrants from engulfment by product, should the roof sink or tilt.

5.7.5 Some internal floating roofs have walkways that are constructed of a more substantial material that will

distribute weight. If such walkways are not included, the temporary placement of metal planks or plywood should be considered to improve weight distribution. When entering onto internal floating roofs, the tank owner or operator should obtain and follow the maximum allowable load concentrations provided by the roof manufacturer.

5.7.6 If weak areas are found during inspection or are known to exist in the floating roof, access to these areas shall be prohibited until suitable reinforcement has been provided.

5.7.7 Medium- and large-diameter external floating-roof tanks are normally provided with movable internal

stairways and ladders, which are usually easy to negotiate, but at very high and very low roof positions the steps are often at awkward angles and special precautions may be needed when descending and climbing.

5.7.8 Some small-diameter external floating-roof tanks and most internal floating-roof tanks have stationary

vertical ladders that extend from the top platform down through a well in the floating roof to the tank floor.

- a) It is advisable to schedule entry at a time when the floating roof is in its highest practical position, but preferably not less than 8 ft (2.4 m) below the lowest point of the fixed roof, thus minimizing the entrant's travel distance while providing adequate height to stand on an internal floating roof without interference from the fixed roof above.

- b) When the floating roof is in its lowest position, climbing down the ladder to the floating roof constitutes a considerable travel distance and a ladder-climbing safety device should be considered.

5.7.9 Adequate lighting, suitable for the area's hazard classification, shall be provided for work to be

performed on the floating roof. Lighting equipment shall be in good condition, adequately protected from mechanical damage, and kept clear of liquids. Where needed, lighting equipment shall be intrinsically safe. Types of lighting that may be considered include, but are not limited to:

- a) general illumination of the entire work area, which enables the attendant to maintain surveillance of operations on the floating roof, and
- b) task lighting required at the work location on the floating roof.

5.7.10 The outside roofs and covers, wind girders, ladders, stairways, walkways and rails, and other roof

supports and appurtenances shall be inspected to ensure they can hold and support the weight of any equipment or material that is to be placed on top of them, or attached to them, for lowering onto the floating roof prior to such use.

6 Preparation for Entry onto Floating Roofs: Ventilation, Testing, and Rescue

6.1 Ventilation Requirements

6.1.1 Natural Ventilation

Factors that influence the natural dissipation of vapors above floating roofs include, but are not limited to, the following.

- a) *Tank size*—Floating-roof tanks with a large diameter-to-height ratio allow more rapid dilution and dissipation of vapors.

NOTE See API 650 for methods of determining the minimum venting requirements.

- b) *Vapor characteristics*—Lighter vapors diffuse in air and escape more rapidly, whereas heavier vapors persist for a longer period of time.
- c) *Roof elevation*—Vapors dissipate and escape more rapidly when the floating roof is at a higher position.
- d) *Atmospheric conditions*—Ambient temperature affects the dissipation of vapors over a liquid pool of product on the roof. The time of day, weather conditions, and the amount of area exposed affect the rate of vaporization. Air movement dilutes vapors, disperses them, and speeds up the vaporization process. The greater the air movement, the faster the dissipation.

NOTE Extremely high winds blowing across the roof of an external floating-roof tank in the high roof position can create negative pressure in the vapor space, causing the release of more vapors and, in extreme cases, even liquid product.

- e) *Refloatation*—When noncovered external floating roofs are refloated, vapor concentrations usually reach levels that allow safe entry in approximately 1 to 4 hours depending on product, roof conditions, roof height, and wind velocity. With internal floating roofs, the period is much longer and can vary from 12 to more than 48 hours after refloatation.

6.1.2 Mechanical ventilation is seldom necessary on an external floating roof, especially if the floating roof is

at a high position. Mechanical ventilation may be necessary in order to reduce flammable and toxic vapor levels or increase oxygen levels inside internal and covered external floating-roof tanks, particularly if leakage past seals or any other appurtenances could produce a change in the atmosphere while work is in progress.

6.1.3 Mechanical forced-air ventilation arrangements will vary according to the type, size, and configuration

of the tank. Air- or steam-driven eductors or blowers are recommended in order to reduce ignition hazards. If electric motor-driven blowers are used, they shall be suitable for the area's electrical hazard classification. All air movers shall be properly bonded to the tank shell or roof to eliminate the possibility of any electrostatic accumulation.

NOTE See API 2015 for specific details on tank ventilation.

6.1.4 Continuous mechanical forced-air ventilation, if needed, shall comply with the following OSHA confined space entry requirements.

- a) Entry shall not be permitted until forced-air ventilation has eliminated the hazardous atmosphere.
- b) The forced-air ventilation shall be directed so as to ventilate the immediate work area on the floating roof and shall continue until workers have left the space.
- c) The air supply shall be from a clean source and may not increase the hazards in the space.
- d) The atmosphere within the work area shall be periodically tested as necessary to ensure that the continuous mechanical forced-air ventilation is preventing the accumulation of any hazardous atmosphere.

6.2 Atmospheric Testing Requirements

6.2.1 General

6.2.1.1 A tester (who could also be the entry supervisor and/or an entrant) shall be designated to conduct appropriate testing for atmospheric hazards in the following sequence:

- a) oxygen,
- b) flammability (combustible gases or vapors), and
- c) toxic air contaminants.

Initial testing of the atmosphere above the surface of internal and covered external floating roofs shall be conducted through the sampling and gauging hatches or other appropriate place outside the tank.

6.2.1.2 As a minimum, atmospheric testing shall be conducted prior to descent at the beginning of each shift, prior to reentry after any prolonged periods of inactivity or work interruption, prior to starting hot work, and anytime conditions are suspected to have changed. Testing of the atmosphere in the work area above the surface of the floating roof shall be either continuous or conducted as necessary to ensure the continuation or maintenance of permitted safe working conditions. The need for continuous or intermittent monitoring and the use of approved respiratory protective equipment shall depend on the results of the testing and the potential for increased atmospheric contamination or oxygen availability during entry and work operations.

6.2.1.3 Should subsequent testing indicate that exposure limits or permit conditions are not being met or are exceeded, the entry supervisor shall determine whether work is to be continued and, if so, under what conditions and requirements. Otherwise, continued entry shall be denied, the entry supervisor or attendant shall cancel the permit, and work shall cease until such time as the established entry requirements are met.

6.2.1.4 Ventilation equipment should be shut down for 15 minutes (based on industry experience) to allow the tank atmosphere to reach equilibrium conditions before testing the interior.

6.2.1.5 The tester should visually inspect the internal ladder (or stairway) and the floating roof to identify obvious problems, such as mechanical damage or liquid, on the roof. The floating roof should also be visually inspected for levelness, as a roof that is not level may indicate pontoon leakage or other damage leading to instability.

6.2.1.6 Results of testing the atmosphere above the floating roof must meet the following criteria.

- a) The oxygen content of the air is at least 19.5 % and no greater than 23.5 % for entry onto the floating roof without air-supplied respiratory protection (provided that there are no hydrocarbon vapors or toxic materials present in the atmosphere above acceptable limits).
- b) The oxygen content of the atmosphere is at least 10 % in order to accurately determine flammable hydrocarbon vapor levels.
- c) Flammable vapor levels in the atmosphere are below 10 % of the LEL in order to allow entry onto the floating roof with approved air-supplied or air-purifying respiratory protection, depending on the task or situation.

CAUTION: Should vapors rise above 10 % LEL, work must stop immediately, entrants shall leave the floating roof, and the hazards reassessed and mitigated. Work may not resume until further testing indicates that the vapor level has dropped below 10 % LEL.

- d) Toxic materials and other hazardous substances are below their exposure limit values if entry is to be made without respiratory protection, or if respiratory protection is to be used, do not exceed the level of protection provided by the respirator.
- e) Hydrocarbon vapors do not exceed the exposure limits for the products or any of their components, or if respiratory protection is to be used, do not exceed the limits for the level of protection provided by the respirator.

NOTE Most petroleum products have an exposure limit in parts per million far lower than the LEL entry criteria. This exposure limit, rather than a percentage of the LEL, will therefore be the criterion for entry without respiratory protection.

6.2.1.7 If test results show that toxic exposure or hydrocarbon vapor limits are exceeded, the entry supervisor shall decide whether to continue mechanical ventilation or to permit entry and work using appropriate respiratory protection. Otherwise, entry should be denied until safe limits are met. When a decision is made to permit entry with appropriate respiratory equipment, compliance with applicable regulations is required (see OSHA 29 *CFR* 1910.146).

6.2.2 Descent onto Floating-roof Tanks

6.2.2.1 Before initial descent onto the floating roof (floating-roof tanks that are covered with semi-fixed geodesic or similar domes) is authorized, the assigned tester shall conduct atmospheric tests from outside the tank, i.e. initial testing of the atmosphere on top of the floating roof shall be conducted from the top of the tank, prior to descent. Test samples should be taken at several elevations or by lowering test instruments or sample-collecting devices from the top of the tank. Test samples should be taken at several elevations within the space between the floating roof and the top of the tank. In order to preclude the possibility of a static electricity discharge, the tester, when approaching the top and before opening any gauge hatch or other openings, shall touch the steel handrail or tank shell with a bare hand.

6.2.2.2 After atmospheric tests have been conducted from outside the tank, the tester shall descend cautiously, testing during the descent. If tests indicate any values outside acceptable limits (see 6.2.2.1, above), the tester shall retreat from the tank immediately and the situation shall be reevaluated to determine the appropriate course of action. Regardless, if the tank contains materials, such as leaded gasoline or products with high sulfur contents that may create potentially harmful exposures, the tester shall wear an approved air-supplied respirator with an escape pack or self-contained breathing apparatus. Descents without respiratory equipment are permissible, provided that atmospheric and operating conditions meet the requirements established by the employer or a designated entry supervisor.

6.3 Emergency Rescue Planning

6.3.1 Difficult rescue situations can develop if entrants become ill, are injured, or are otherwise incapacitated

while on the floating roofs of tanks. The appropriate rescue provisions to be used will depend on the tank type, service, operation, diameter, roof elevation, and work being performed on the floating roof.

6.3.2 Emergency rescue plans are required for OSHA permit-required confined spaces. Facilities should also consider emergency rescue plans covering entry onto non-permit-required floating roofs.

6.3.3 Emergency rescue plans shall be in writing and should address, but not be limited to, the following:

- a) attendant and rescue personnel duties,
- b) procedures for summoning rescue and emergency services,
- c) methods for rescuing entrants,
- d) provisions for necessary emergency medical services for rescued personnel, and
- e) preventing unauthorized personnel from attempting a rescue.

6.3.4 Emergency rescue plans should be covered in the pre-job conference, which includes the entry supervisor, entrants, attendants, and on-site rescuers (if used). Local fire department(s) and/or rescue squad(s) (if used) shall be notified to ensure availability, if needed (see 6.3.8). The plans should include provisions needed to effect a rescue, including emergency phone numbers, if required.

6.3.5 An attendant shall be stationed at the top of the ladder or near the roof opening to maintain visual or aural contact with the entrants on the floating roof. The attendant shall be trained to recognize hazards and changing conditions and shall be equipped with a horn, a two-way radio approved for the area's electrical hazard classification, or another means of summoning assistance.

6.3.6 If the work being performed has the potential for exposure to liquid or vapors, or if the entrants on the floating roof are using respiratory protective equipment, attendants and rescuers shall be provided with equivalent respiratory protective equipment or self-contained breathing apparatus.

6.3.7 The attendant shall immediately advise the entrants if an emergency occurs elsewhere in or near the facility that requires them to exit from the floating-roof tank.

6.3.8 If a facility rescue team is to be used, the emergency rescue plan should identify the personnel who are trained and qualified to perform the rescue, the rescue equipment that is readily available, and the appropriate procedure to be used to evacuate the entrant(s) from the floating roof. If an outside entity, such as a local fire department or mutual aid group, is to provide emergency rescue service, the method of determining the areas of responsibility should be detailed in the plan.

7 Additional Procedures for Descent onto External Floating Roofs

7.1 Additional Procedures

7.1.1 A pre-job meeting shall be conducted with facility and contractor personnel that includes the designated entry supervisor, tester, entrant(s), attendant(s), and designated rescuers (if needed) to review the

proposed work, potential hazards, entry conditions, and emergency plans.

7.1.2 The external floating roof should be in flotation (not sitting on its legs) and the bleeder valve closed

prior to descent. Prior to allowing entry onto the external floating roof, a minimum of 1 to 4 hours should be allowed for dissipation of vapors after an external floating-roof tank has been refloated and product delivery has stopped (see 4.1).

7.1.3 Entrants shall not be allowed to descend onto an external floating roof that is out of flotation (sitting on its legs) until atmospheric testing has been conducted both above and below the external floating roof and conditions allow the issuance of an Confined Space Entry Permit.

7.1.4 Conditions to be considered when preparing for descent onto an external floating roof include, but are not limited to, the following.

- a) *Atmospheric conditions*—The oxygen content of the atmosphere shall be between 19.5 % and 23.5 % for entry without air-supplied respiratory protection (provided that there are no hydrocarbon vapors or toxic materials present in the atmosphere above acceptable limits); hydrocarbon vapors are below 10 % of the LEL; and hydrocarbons and hazardous or toxic substances, such as hydrogen sulfide, do not exceed their PELs (or if respiratory protection is to be used, do not exceed the level of protection provided by the respirator) (see 6.2.2).
- b) *Working conditions on or around seals*—If work is to be performed on or near seals or other openings, additional tests must be performed to ensure that the atmosphere in the immediate work area is not toxic and that hydrocarbon vapor levels remain below their PELs or 10 % LEL, whichever is applicable.
- c) *Tank service conditions*—In addition to hydrocarbon flammability factors, tanks must be evaluated with respect to potentially toxic exposures. For example, tanks containing petroleum products with high sulfur content present the added hazard of acute hydrogen sulfide toxicity and tanks that have been in leaded gasoline service may expose entrants to toxic lead hazards.
- d) *Operating conditions*—Whenever possible, the external floating roof should be in the highest position prior to entry. For descent onto a permit-required external floating roof:
 - 1) the tank valves should be closed, locked, and tagged;
 - 2) the lines should be disconnected and blinded or blanked; or
 - 3) the valves should be closed and double blocked and bled.

NOTE For tasks of short duration, such as gauging and sampling, or when performing minor maintenance activities on external floating roofs when product is not being discharged or received, it may not be necessary to close tank valves or blind tank lines.

- e) *Product loading conditions*—Product shall never be put into a tank while entrants are on a permit-required external floating roof.
- f) *Physical conditions*—Prior to descent, the external floating roof shall be checked for potential physical hazards and stability (see 5.7).
- g) *Power-driven equipment conditions*—When required by the permit, all electrical, steam, and other power-operated equipment, such as tank mixers, heaters, steam coils, and remote control tank valves, shall be shut off at their motor controllers and locked and/or tagged in accordance with the facility's lockout/tagout and tank isolation procedures. Following lockout/tagout, pushbutton stations should be operated to ensure that power has actually been disconnected.
- h) *Weather conditions*—Electrical storms in the vicinity can present special hazards that must be considered at the time of occurrence. Descent onto external floating roofs of tanks should not be conducted during electrical storms, tornadoes, or high wind conditions.

CAUTION: Work on external floating roofs shall be suspended, the floating roof shall be returned to a normal (safe) condition, and entrants and attendants shall vacate the roof during lightning storms.

- i) *Lighting conditions*—Safe, appropriate low-voltage lighting, approved for the area's classification, shall be provided, if required (see 5.7.9).

7.1.5 During maintenance or repair work on an external floating roof, or when entrants will be on the roof for more than a brief visit, entrant(s) should have available at least two 30-lb BC-type portable fire extinguishers, ready for use unless modified by owner operator policy. Entrants should exit the space immediately in the event of a fire.

7.1.6 Any entry into the pontoons or underneath the secondary seals of an external floating roof shall be considered as permit-required confined space entry. Each individual space shall be checked by the tester to determine the atmospheric conditions prior to the issuance of an Confined Space Entry Permit by the entry supervisor.

7.1.7 At the end of each work period or upon vacating the external floating roof for any extended period of time, the floating roof shall be returned to a safe condition, as near to normal as possible, with all seals and bonding shunts or straps in place and all materials, tools, and equipment removed.

7.1.8 Although tanks should normally be in a static condition, operating conditions or emergencies may require that product be moved into or out of the tank while cold work, such as inspection, maintenance, or secondary seal repair, is in progress (see 7.2.3). Product withdrawal/receipt shall require the approval of the tank owner or operator and the entry supervisor. Use of a cold work permit or other written procedures is recommended to address safety requirements. *The rate of product withdrawal should be controlled so that the atmospheric hazards do not exceed the levels established by the permit.* Atmospheric monitoring shall be conducted during product withdrawal to ensure that flammable vapor and toxic exposures do not exceed the levels established by the permit.

7.2 Permissible Work on External Floating Roofs

7.2.1 By following appropriate established safe work and entry procedures and obtaining written approval, certain types of work can be performed on external floating roofs of tanks in service. Whenever possible, work should be scheduled for a period when the floating roof is in a high position.

7.2.2 Only owner operator approved methods shall be used to affix materials to the external floating roof. If used, cutting and drilling operations shall be continuously flushed using water or approved coolant to prevent heat buildup and sparking.

7.2.3 Examples of cold work that may be performed on external floating roofs of tanks that are in petroleum service include, but are not limited to, the following.

- a) Adjustment of external floating roof support legs from high to low position after the tank is placed into service and from low to high position before the tank is taken out of service.
- b) Adjustment of the vent or bleeder valve relief in the external floating roof.

NOTE This vent will normally be closed when the roof is in flotation.
- c) Gauging, sampling, and temperature measurement of the product in the tank.
- d) Adjustment and repair of the level gauge.
- e) Inspection of the external floating roof, pontoons, seals, and fire protection system.
- f) Opening, closing, and mechanical repairs and maintenance of external floating-roof water drains.
- g) Adjustment and repair of the anti-rotation devices.

- h) Painting, cleaning, and cold work (non-spark-producing) surface preparation prior to painting, using hand-held or air-powered tools only. Pressure washing (low pressure water cleaning) may be used provided the pressure washer is located outside of the tank.

NOTE The external floating roof should be floating in a high position. Painting and cleaning may require ventilation because of solvent vapors produced by paint or cleaners.

- i) Installation or repair of secondary seals and repair or replacement of bonding straps and shunts on external floating roofs under carefully controlled conditions to preclude ignition sources.

NOTE A means of positive bonding between the external floating roof and the tank shell must be maintained at all times.

- j) Removal of blasting grit, dirt, dust, liquid, ice, or snow from the external floating roof using hand-held tools or air-powered equipment without creating sparks or heat.
- k) Inspection and measurement of seal gap and installation, repair, or replacement of secondary seals, with the external floating roof in a high position.
- l) Minor repairs and replacement of one section of the primary seal at a time, under carefully controlled and permitted conditions, in order to preclude vapor releases, ignition sources (including lightning), etc. Tanks shall be in a static condition and product movement to or from the tank shall be prohibited during repair of primary seals.

NOTE A layer of firefighting foam may be placed on top of the exposed liquid in the annular area between the external floating roof and the tank shell in order to control the release of flammable vapors while seals are removed.

7.2.4 Examples of hot work that may be performed on open top external floating roofs of tanks that are in petroleum

service include, but are not limited to, the following:

- a) abrasive blasting,

NOTE Locate air compressors upwind, outside of, or on top of, the dike and at a minimum distance of 50 ft (15.25 m) away from the tank or other sources of flammable vapors.

- b) grinding using air-powered equipment, and

- c) use of electrical tools.

Refer to API 2027 *Ignition Hazards and Safe Work Practices for Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service* for additional guidance.

Appropriate work permits shall be issued for motorized equipment and hot work as applicable to work practices being performed.

7.2.5 Entrant(s) engaged in cleaning liquid product, sludge, rust, and scales from external floating roofs,

including pontoons, seals areas, vents, and appurtenances on tanks that have previously contained leaded gasoline or products containing toxic materials, such as hydrogen sulfide, shall wear appropriate approved personal protective clothing and air-supplied respiratory apparatus with escape packs or self-contained breathing apparatus (see API 2015).

8 Additional Procedures for Descent onto Internal and Covered External Floating Roofs

8.1 General

8.1.1 Descent onto internal floating roofs or covered external floating roofs constitutes permit-required

confined space entry, and all associated safety requirements must be met. Each internal or covered external floating roof tank owner or operator shall develop and implement a permit system for entry and working within permit-required confined spaces.

NOTE Access onto external floating roofs of tanks that utilize metallic geodesic domes or other types of caps or covers

installed to minimize the accumulation of rain water or snow on the floating roof shall be considered as access into permit-required confined spaces and treated the same as access onto internal floating roofs.

8.1.2 If a tank with an internal or covered external floating roof is in flammable, combustible, or toxic liquid service, descent onto the floating roof should be considered only when the work to be performed is essential to operations. This work should be limited to cold work.

8.2 Preparations Prior to Descent onto Internal and Covered External Floating Roofs

8.2.1 The internal or covered external floating roof should be in flotation (not sitting on its legs) and the bleeder valve closed prior to descent. A minimum of 12 to 48 hours (depending on tank size, roof elevation, operations, and service) should be allowed before permitting entry onto the roof for dissipation of vapors after an internal or covered external floating roof tank has been refloated and product delivery has stopped. Mechanical ventilation may be necessary to accelerate ventilation of the space above the internal or covered external floating roof in order to meet permit requirements (see 6.1).

8.2.2 Entrants shall not be allowed to descend onto an internal or covered external floating roof that is out of flotation (sitting on its legs) until atmospheric testing has been conducted both above and below the floating roof and conditions allow the issuance of an Confined Space Entry Permit.

8.2.3 Entry supervisors shall evaluate the potential hazard of falling through or upsetting (tilting) an internal or covered external floating roof constructed of aluminum, light metal, foam, or plastic prior to issuing an Confined Space Entry Permit. Each tank owner or operator shall establish safe work procedures that are a condition of entry to ensure that the roof will adequately support personnel and equipment (see 5.7).

8.3 Working on Internal and Covered External Floating Roofs of Tanks in Service

8.3.1 Continuous forced-air mechanical ventilation may be necessary to maintain a safe atmosphere in the space above the internal or covered external floating roof. Entry shall not be permitted until the forced-air ventilation has reduced the hazards, as required by the entry or hot work permit. When required, forced-air ventilation shall be directed so as to ventilate the area where entrants are working and ventilation shall continue until the tank is vacated (see 6.1).

8.3.2 During work on an internal or covered external floating roof, entrant(s) should have available at least two 30-lb BC-type portable fire extinguishers, ready for use, unless modified by owner operator policy. Owner operators may direct entrants to immediately exit the tank roof in lieu of fighting incipient fires.

8.3.3 Any entry into the pontoons or underneath the seals of an internal or covered external floating roof shall be considered as separate permit-required confined space entries. Each individual space shall be checked by the tester to determine the atmospheric conditions prior to entry supervisor issuance of an Confined Space Entry Permit.

8.3.4 At the end of each work period or upon vacating the external floating roof for any extended period of time, the floating roof shall be returned to a safe condition, as near to normal as possible, with all seals and bonding shunts or straps in place and all materials, tools, and equipment removed.

8.3.5 Product shall never be put into a tank while entrants are on an internal or covered external floating roof.

Whenever possible, work should be scheduled for a time when the roof will be in a high position. Tanks shall be in a static condition, and neither product delivery nor withdrawal shall normally be allowed while entrants are on the internal or covered external floating roof (see 7.1.8 and 8.4.5 for exceptions). Air-supplied respiratory protection and mechanical ventilation shall be provided, if needed, to minimize exposure to atmospheric combustible vapors and toxic substances (see 6.1 and 6.2).

8.4 Permissible Work on Internal and Covered External Floating Roofs

8.4.1 Descent onto an internal or covered external floating roof while the tank is in petroleum service should

be considered only when the work to be performed is essential to operations. By establishing safe work practices and following appropriate entry procedures, certain types of cold work can be performed on internal and covered external floating roofs of tanks in service.

8.4.2 Only self-tapping screws and bolts shall be used to affix materials to the external floating roof. Cutting and drilling operations shall be continuously flushed using water or approved coolant to prevent heat buildup and sparking.

8.4.3 Examples of cold work that may be performed on internal or covered external floating roofs of tanks that are in petroleum service include, but are not limited to, the following.

- a) Adjustment of support legs from high to low position after the tank has been placed into service and from low to high position before the tank is to be taken out of service.
- b) Adjustment of the vent or bleeder valve relief in the floating roof. This vent will normally be closed when the roof is in flotation.
- c) Gauging, sampling, and temperature measurement of the product in the tank.
- d) Adjustment and repair of the level gauge.
- e) Inspection of the external floating roof, pontoons, seals, and fire protection system.
- f) Opening, closing, and mechanical repairs and maintenance of external floating roof water drains.
- g) Adjustment and repair of the anti-rotation devices.
- h) Painting, cleaning, and cold work (non-spark-producing) surface preparation prior to painting, using non-sparking hand-held or air-powered tools or pressure washing only.

NOTE The internal or covered external floating roof should be in a high position.

- i) Installation, replacement, or repair of seals with the floating roof in a high position. Items to consider include respiratory protection, ventilation, and monitoring of combustible vapors and toxic hazards.
- j) Repair or replacement of bonding straps and shunts on external floating roofs under carefully controlled conditions to preclude ignition sources.

NOTE A means of positive bonding between the external floating roof and the tank shell must be maintained at all times.

- k) Removal of blasting grit, dirt, dust, liquid, ice, or snow from the external floating roof using hand-held tools or air-powered equipment without creating sparks.
- l) Inspection, measurement of seal gap, installation, repair, or replacement of secondary seals, with the external floating roof in a high position.

8.4.4 Hot work shall not be performed on floating internal or covered external roofs of tanks in service.

8.4.5 Operating conditions or emergencies may require that product be withdrawn from the tank while tasks of short duration involving entry onto the internal or covered external floating roof are in progress. These tasks include, but are not limited to, gauging, sampling, inspecting, or minor maintenance work (see 7.2.3).

- a) Product withdrawal shall require the approval of the tank owner or operator and the entry supervisor and shall be controlled by a cold work permit containing the appropriate safety requirements.
- b) Written procedures shall be prepared covering the preventative measures to be taken by the use of blocking, locking, or sealing and tagging to ensure that product is only withdrawn from the tank and not put into the tank.

- c) The rate of product withdrawal should be controlled so that atmospheric hazards in the confined space do not exceed allowable limits per the permit..

- d) Atmospheric monitoring shall be continuously conducted during product withdrawal to ensure that flammable vapor and toxic exposures do not exceed the levels established by the Confined Space Entry Permit.

8.4.6 Entrant(s) engaged in cleaning liquid product, sludge, rust, and scales from internal and covered external floating roofs, including pontoons, seals areas, vents, and appurtenances, shall wear appropriate approved personal protective clothing and air-supplied respiratory apparatus with escape packs (see API 2015).



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