

Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks

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Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks

1 Scope

1.1 General

This standard is applicable to stationary atmospheric low-pressure (up to and including 103 kPa [15 psig]) aboveground petroleum storage tanks used in all sectors of the petroleum and petrochemical industry, including:

- crude oil and gas production;
- refining;
- petrochemicals;
- pipelines and terminals;
- bulk storage;
- ethanol facilities.

This standard provides requirements for safely planning, coordinating, and conducting tank entry and cleaning operations, from removal from service through return to service.

This standard does not and cannot cover every possible unique hazard or situation that may arise during tank-cleaning operations. Site, product, and tank-specific hazards and situations shall be addressed by employers using the appropriate principles and considerations provided for by this standard.

1.2 Non-applicability and Other Tank-cleaning Applications

This standard does not apply to the following types of tanks or vessels:

- pressure vessels and pressurized tanks exceeding 103 kPa (15 psig);
- cryogenic or refrigerated vessels or pressure tanks;
- vessels and tanks maintained under a vacuum;
- process vessels;
- underground storage tanks.

Although API Standard 2015 is not intended to cover these types of tanks and vessels, many of the safe tank-cleaning and entry principles and requirements in this standard apply and should be considered.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Recommended Practice 2009, *Safe Welding, Cutting and Hot Work Practices in the Petroleum and Petrochemical Industries*

API Recommended Practice 2026, *Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service*

API Recommended Practice 2027, *Ignition Hazards and Safe Work Practices for Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service*

API Publication 2202, *Dismantling and Disposing of Steel from Aboveground Leaded Gasoline Storage Tanks*

API Recommended Practice 2207, *Preparing Tank Bottoms for Hot Work*

API Recommended Practice 2219, *Safe Operating Guidelines for Vacuum Trucks in Petroleum Service*

API Standard 650, *Welded Tanks for Oil Storage*

API Standard 653, *Tank Inspection, Repair, Alteration and Reconstruction*

API Standard 2217A, *Guidelines for Work in Inert Confined Spaces in the Petroleum Industry*

ACGIH,¹ *TLVs and BEIs Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices*

ANSI Z49.1,² *Safety in Welding, Cutting, and Allied Processes*

ANSI Z88.1, *Respiratory Protection against Radon Dangers*

ANSI Z117.1, *Safety Requirements for Confined Spaces*

ICS, IAPH, and OCIMF; ISGOTT,³ *International Safety Guide for Oil Tankers and Terminals*

NFPA,⁴ *Fire Protection Handbook*

NFPA 30, *Flammable and Combustible Liquids*

NFPA 51B, *Cutting and Welding Processes*

NFPA 70, *National Electrical Code*

NFPA 326, *Safeguarding of Tanks and Containers for Entry, Cleaning or Repair*

3 Terms and Definitions

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

¹ American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, Ohio 45240-1634, www.acgih.com.

² American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

³ International Chamber of Shipping, 38 St Mary Axe, London, EC3A 8B, www.ics-shipping.org; International Association of Ports and Harbors, 7th Floor, South Tower New Pier Takeshiba 1-16-1 Kaigan, Minato-ku, Tokyo 105-0022 Japan, www.iaphworldports.org; Oil companies International Marine Forum, 27 Queen Anne's Gate, London, SW1H9BU, England, www.ocimf.com; Available from: Witherby Seamanship, Witherby Seamanship International Ltd, 4 Dunlop Square, Deans Estate, Livingston EH54 8SB, United Kingdom, www.witherbyseamanship.com.

⁴ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-07471



3.1

atmospheric tester

A qualified person selected by the employer who tests or monitors a permit space as necessary to determine if the acceptable limits are maintained and is able to interpret the results.

3.2

attendant

A qualified employee 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

blanking

The absolute closure of a pipe by fastening a solid, flat plate (designed to retain anticipated pressure with no leakage) between two flanges, using two gaskets and fully engaged bolts or stud bolts in all flange bolt-holes.

3.4

blinding

The absolute closure of the open end of a pipe by fastening a solid, flat plate (designed to retain anticipated pressure with no leakage) across the opening, using a gasket and fully engaged bolts or stud bolts in all flange bolt-holes.

3.5

bonding

The joining of metal parts to form an electrically conductive path that ensures electrical continuity and has the capacity to safely conduct any current likely to be generated.

3.6

bottle watch

A qualified person assigned to control and oversee supplied-air operations.

3.7

cleaning

The removal of all product, vapor, sludge, and residue from a tank and washing, rinsing, and drying a tank so that no product or residue remains on any tank surfaces (shell, bottom, sumps, columns, supports, roof, piping, appurtenances, etc.).

3.8

combustible gas indicator

An instrument used to sample the atmosphere and indicate the concentration of vapor/gas present in the atmosphere as a percentage of the lower explosive (flammable) limit.

3.9

combustible liquid

A liquid having a closed cup flash point equal to or greater than 38 °C (100 °F).

3.10

confined space

Any tank or space that meets *all three* of the following requirements:

- is large enough and so configured that an employee can bodily enter and perform assigned work;
- has limited or restricted means for entry or exit; and
- is not designed for or meant to be continuously occupied by employees.

3.11**degassing**

The process of collecting, oxidizing, or treating vapors and gases expelled from a tank or vessel so as to prevent or reduce the amount of organic volatile compounds released into the atmosphere during vapor- and gas-freeing operations.

3.12**double block and bleed**

The positive closure of a pipe by closing and locking or tagging two in-line valves and by opening and locking or tagging a drain or vent valve in the line or pipe between the two closed valves.

3.13**employer**

Owner/operator or contractor whose respective employees are performing a task or activity described in this standard.

3.14**energy-isolating device**

A mechanical device that physically prevents the transmission or release of energy.

3.15**engulfment**

The surrounding and effective entrapment of an entrant by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

3.16**entrant**

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

3.17**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-required 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.

3.18**entry supervisor**

The qualified person designated by the employer (owner/operator or contractor) to be responsible for determining acceptable entry conditions at permit-required confined spaces and non-permit-required confined spaces. Entry supervisors shall authorize entry, oversee entry operations, and terminate entry as required by the permit or conditions.

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

3.19**explosive (flammable) range**

The range of concentrations of flammable vapor-in-air between the lower explosive (flammable) limit and the upper explosive (flammable) limit that will propagate flame if ignited.

NOTE The explosive range and flammable range are not exactly the same, but for the purposes of this document, they are considered equivalent and used interchangeably.

3.20**flammable liquid**

A liquid having a closed cup flash point below 38 °C (100 °F).

3.21

flammable vapor

flammable gas

A substance that exists exclusively in the gaseous state at normal atmospheric pressure and temperature and is capable of igniting and burning when mixed with air (oxygen) in the proper proportion and subjected to a source of ignition.

NOTE In this standard, for tank-cleaning purposes, *flammable gas* is considered the same as *flammable vapor*.

3.22

flammable vapor indicator

See *combustible gas indicator*.

3.23

flash point

The minimum temperature at which sufficient vapor is given off to form an ignitable mixture with the air near the surface of the liquid, as determined in accordance with NFPA 30.

3.24

gas-freeing

See *vapor-freeing*.

3.25

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:

- flammable gas, vapor, or mist in excess of 10 % lower explosive limit (LEL);
- 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 1.5 m (5 ft) or less);
- an atmospheric oxygen concentration below 19.5 % or above 23.5 %;
- an atmospheric concentration of any substance for which a dose or permissible exposure limit (PEL) is published in applicable government regulations, material safety data sheets, standards, or other publications or internal documents that could result in employee exposure in excess of the substance's dose or PEL;
- any other atmospheric condition immediately dangerous to life or health (IDLH).

3.26

hot work

An operation that can produce enough heat from flame, spark, or other source of ignition, and with sufficient energy to ignite flammable vapors, gases, or dust.

3.27

hot work permit

The employer's written authorization to perform hot work operations or use equipment capable of producing a source of ignition.

NOTE The hot work permit may be part of the entry permit or a separate document.

3.28

immediately dangerous to life or health

IDLH

Any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an entrant's ability to escape unaided from a confined space.

NOTE Examples include oxygen-deficient atmospheres and the presence of hazardous quantities of hydrogen sulfide or other toxic substances.

3.29

inerting

Displacing hydrocarbon gas or vapors and oxygen (air) to eliminate the possibility of a flammable atmosphere in a permit-required confined space—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.

3.30

isolation

The process by which a tank is completely protected against the release of energy or material into the tank by:

- 1) lockout/tagout;
- 2) breaking, misalignment of, opening or removing sections of lines or pipes; or
- 3) disconnecting mechanical linkages.

3.31

lead-free tank

A tank that has been certified by the owner/operator as cleaned of organic lead.

3.32

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.

3.33

lower explosive (flammable) limit LEL

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

3.34

nonconfined space

A space (previously classified as a permit-required confined space or a non-permit-required confined space) that no longer meets any of the requirements for either a permit-required confined space or a non-permit-required confined space.

NOTE An example of a nonconfined space is a tank that has been cleaned, tested as gas- and vapor-free, and has a large opening (door sheet) cut into the side of the tank to provide unrestricted access and egress.

3.35

non-permit-required confined space

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

3.36

owner/operator

The legal entity having control of and/or responsibility for the operation and maintenance of an existing storage tank.

3.37

oxygen-deficient atmosphere

An atmosphere containing less than 19.5 % oxygen by volume.

3.38

oxygen-enriched atmosphere

An atmosphere containing more than 23.5 % oxygen by volume.

3.39

oxygen monitor

A device capable of detecting, monitoring, and measuring the concentration of oxygen in the atmosphere.

3.40

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, a ceiling value, a short-term exposure limit, or a skin exposure designation.

3.41

permit program

The employer's overall program of written procedures for controlling access to a tank work area, including permits for access to confined spaces and protecting entrants from hazards. Based on site-specific requirements, the procedures and permits required for entry or hot work may extend to safe (cold) work and entry into a specific work area.

3.42

permit-required confined space

A confined space that has *all three* of the confined space requirements and also has *one or more* of the following five characteristics.

- contains or has the potential to contain a hazardous atmosphere;
- contains a material with the potential to engulf an entrant;
- has an internal configuration such that an entrant could become trapped or asphyxiated by inwardly converging walls or by bottoms that slope downward, tapering to smaller cross sections;
- contains any other recognized serious safety or health hazard;
- has a floating roof not properly prepared and secured in accordance with this standard.

3.43

prohibited condition

Any condition in a permit-required confined space that is not allowed by the permit during the period when entry is authorized.

3.44

purging

The process of inerting.

3.45**pyrophoric**

A material capable of rapid spontaneous ignition when exposed to air.

3.46**qualified person**

A person designated by an employer as having the necessary training, education, and competence to perform assigned tank work.

3.47**removal from service**

The process of removing all possible product from the tank, including inspection and setting of floating roof legs or suspension cables (to the maintenance position), if applicable.

3.48**rescuers**

The personnel designated as part of a written plan to rescue entrants from a confined space.

3.49**residue**

Undesirable (potentially flammable, toxic, and/or hazardous) material (including, but not limited to, rust, dirt, scale, paint scrapings, pyrophoric iron sulfide deposits, etc.), removed from the inside of tanks during the cleaning process.

3.50**retrieval system**

The equipment (including retrieval lines, chest or full body harnesses, wristlets, and lifting devices or anchors) used for the rescue of persons from confined spaces.

3.51**return to service**

The process of returning the tank to its intended operation after all work inside the tank has been completed.

3.52**safety data sheet****SDS**

Written or printed material prepared in accordance with applicable regulations and standards concerning hazardous chemicals that provide physical properties, safety, fire prevention and protection, personal protection, and health data.

3.53**sludge (tank bottoms)**

Undesirable materials that accumulate in the bottom of storage tanks and are removed for disposal, usually consisting of heavy petroleum products or a mixture of hydrocarbons, residue, and water that may be flammable, hazardous, and/or toxic.

NOTE The definition of "tank bottoms" in this standard is completely different than the same term used in API Standard 653.

3.54**sour**

Petroleum products where sulfur compounds, such as hydrogen sulfide (H₂S) or mercaptans, are present in products such as sour crude and heavy residual fuel oils.

3.55**supplied-air respiratory equipment**

A respirator that provides a supply of safe breathing air from a tank (either a self-contained breathing apparatus, portable tank, or an air line supply tank) or from a source of fresh air (approved breathing air compressor) not subject to potential contamination.

3.56 testing

The process by which the potential hazards that may be encountered when entering a permit-required confined space, a non-permit-required confined space, or nonconfined space are identified and evaluated. Testing includes specifying the type of testing to be performed, the instrument(s) to be used for testing, the classification of the space, and the permissible limits for safe entry into the space.

3.57 threshold limit value TLV^{TM 5}

The maximum airborne concentration of hazardous substances to which, it is believed, nearly all workers may be repeatedly exposed day after day without adverse effects, as determined by the appropriate regulatory agencies and employer policies, including but not limited to, exposure limits developed by the responsible committees of the American Conference of Governmental Industrial Hygienists.

3.58 toxic materials or substances

Any material or substance whose properties are such that they can cause injury to a biological system, depending on exposure concentration, time of exposure, and means of exposure.

3.59 upper explosive (flammable) limit UEL

The maximum concentration (expressed as a volume percentage) of a vapor-in-air above which the propagation of flame does not occur upon contact with an ignition source; generally considered “too rich to burn.”

3.60 vapor-freeing

The removal of flammable or toxic vapors and gases from a tank by displacement or the reduction of the percentage of vapors and gases in the tank to a safe level by dilution with fresh air.

3.61 ventilation

Providing fresh air inside a tank to maintain an atmosphere within acceptable permit limits.

4 Administrative Controls and Procedures

4.1 General

Tank entry and cleaning projects will require entry into confined spaces. Owner/operators and employers shall develop and implement the appropriate administrative controls, procedures, and written plans for tank-cleaning/entry projects. These requirements apply to the entirety of tank-cleaning/entry projects, from planning through return to service. Employers shall inform all workers who may enter a permit-required confined space of the existence and location of, and the danger posed by, permit-required confined spaces by posting danger signs or any other equally effective means. Employers shall take effective measures to prevent workers not authorized to enter permit-required confined spaces from entering permit-required confined space. Where owner/operator or contractor is used after “employer(s)”, a specific requirement can be met by either party or both.

4.2 Hazard Identification

Confined spaces shall be considered hazardous until determined to be otherwise. A qualified person shall identify hazards for each confined space entry prior to any entry. The process shall include but not be limited to:

- past and current service of the tank along with any potential adjacent activities that may adversely affect the atmosphere in the confined space;

⁵ This term is used as an example only, and does not constitute an endorsement of this product by API.

- physical characteristics, configuration and location of the confined space that may be obtained from drawings, maps, notes, or other documents;
- means of entry and exit, including size and location of access manways and the distances of the work activity to the entrance and to any access roads;
- existing or potential atmospheric hazards, including oxygen, flammability, and toxicity, including chemical as well as biological hazards;
- mechanical hazards, including mixers, blades, etc.;
- physical hazards unique to the construction or design of the tank;
- floating roof type and condition;
- work activities underway or scheduled during confined space entry;
- line of fire exposure.

4.3 Hazard Evaluation

Hazards shall be evaluated by a qualified person with respect to the following:

- scope of the exposure, including boundaries or limits of the potential hazards;
- magnitude of the hazard;
- likelihood of the hazard causing harm;
- consequences of the exposure;
- potential for changes in conditions during the work.

4.4 Hazard Mitigation Strategies

Hazards shall be mitigated or controlled to achieve acceptable levels of risk, and the hierarchy of controls shall be considered when developing programs and tank-specific plans. These include:

- elimination of the hazard;
- engineering controls, including ventilation, isolation, etc.;
- administrative controls, including work practices, procedures, personnel assignments, job rotation, etc.;
- personal protective equipment (PPE).

4.5 Written Tank-cleaning/Entry Programs

4.5.1 Tank-cleaning/Entry Program Elements

Written tank-cleaning/entry programs shall include an evaluation for:

- each applicable tank pre-cleaning/entry, cleaning/entry, and post-cleaning/entry element listed in [4.6](#); and
- the applicable requirements of [Section 5](#) through [Section 14](#) of this standard.

Program elements include establishing procedures for the following:

- a) qualifying and selecting tank-cleaning contractor(s) and subcontractors;
- b) training and qualifying workers for assigned tasks, including tank-cleaning supervisors, entrants, testers, attendants, bottle watches, rescuers, and other workers for tasks such as hazard evaluation, testing, permit issuance, entry, tank-cleaning, attendant, rescue, and inspection activities;
- c) evaluating potential safety, fire, and health hazards of product, sludge, and residue in the tank and the hazardous chemicals used to clean or repair the tank;
- d) establishing exposure limits and procedures for atmospheric testing and determining, achieving, and maintaining safe exposure levels for oxygen, flammable vapors, and toxic materials, such as hydrogen sulfide, benzene, and organic lead;
- e) notifying and obtaining permits from regulators;
- f) determining tank- and area-specific physical hazards;
- g) determining that the tank's structural condition and physical integrity are satisfactory to safely perform the planned work;
- h) identifying confined spaces, classification programs and procedures, and classifying tanks to be cleaned (and floating roofs to be entered) as permit-required confined spaces, non-permit-required confined spaces, or nonconfined spaces;
- i) developing the safety and health requirements for issuance of the permit; conditions for canceling or suspending the permit; and safeguarding or returning the space to service following termination of entry;
- j) developing a hot work, safe (cold) work, and entry permit program and system to establish requirements and responsibilities for permit issuance and cancellation;
- k) determining PPE and respiratory protection requirements;
- l) assigning specific work to be performed and responsibilities;
- m) conducting a tank pre-cleaning/entry meeting and site survey with all parties involved;
- n) establishing criteria for the operation of adjacent tanks within the same dike area as the tank being cleaned (or within 30 m [100 ft] of the tank being cleaned if outside the dike area) to control vapor emissions from these tanks;
- o) establishing criteria for classifying entry upon a floating roof (where applicable) as a permit-required or non-permit-required confined space entry, or as nonconfined space entry;

NOTE It is petroleum industry practice to normally consider entry upon an open-top floating roof that is within 1.5 m (5 ft) of the top of the tank to be nonconfined space entry provided that:

- 1) no physical hazards are present; and
 - 2) testing has been conducted to ensure that no hazardous flammable or toxic atmosphere is present on the top of the roof.
- p) making entry onto floating roofs, inspecting roofs for stability, and inspecting and setting legs or suspension cables;
 - q) floating roof stabilization to protect personnel under the floating roof from roof collapse;

- r) removal of recoverable product; removal, handling, storage, and disposal of sludge and residue (hazardous waste);
- s) selection of the required tank-cleaning equipment;
- t) control of potential ignition sources in the area, including hot work, sparking (e.g. inadequate grounding and bonding), electrically driven equipment, internal combustion engines, lighting, and communication devices;
- u) equipment operation, such as vacuum trucks, pumps, eductors/blowers, degassing equipment, and tank-cleaning equipment;
- v) normal and emergency communication and notification procedures;
- w) implementation of an emergency response and rescue plan, designation of rescuers, and determination of required rescue equipment;
- x) tank isolation (including valves, connections, lines, drains, water draws, impellers, agitators, heating coils, mechanical and electrical appurtenances, etc.);
- y) vapor- and gas-freeing;
- z) degassing;
- aa) inerting;
- bb) continuous or periodic flammable vapor and toxic exposure monitoring and determining need for continued ventilation during entry and work;
- cc) heat and cold exposure of employees in and around the tank, including consideration of work schedules and rest periods;
- dd) cleaning, inspection, and testing procedures to ensure the tank, double walls and bottoms, roofs, internal lines, pontoons, floating roof supports, columns, sumps, etc. are free of liquid, vapors, gases, and contaminants (including acids or chemicals used in treating or cleaning tanks) after cleaning;
- ee) assuring that any tank that is classified as either a permit-required or a non-permit-required confined space is not left open and unattended;
- ff) work and entry permit requirements for owner/operator and contractor/subcontractor employees working inside and around the tank, including requirements for PPE and respiratory protection;
- gg) reclassification of a cleaned and open tank as a non-permit-required confined space or a nonconfined space, provided all requirements for the classification are satisfied;
- hh) safe (cold) work and hot work operations inside and around a tank, depending on whether the tank is open or closed, cleaned or not cleaned, and classified as a confined space or a nonconfined space;
- ii) conducting subsequent meetings with involved parties to address changes in conditions or significant changes to the scope of work;
- jj) final acceptance criteria for tank cleanliness (there is no requirement to have a marine chemist certificate; however, the owner/operator shall determine the acceptable level of cleanliness and completion for each tank-cleaning project).

4.5.2 Tank Return-to-service Program Elements

These elements include establishing procedures for the following:

- a) returning tanks to service, including inspections and safety checks to ensure that the tank is free from any tools, waste, and debris;
- b) checking the tank and lines for leaks during refilling;
- c) preventing overfilling the tank;
- d) entry onto tank roofs following refilling (where permitted by owner/operator);
- e) ensuring that all required reports, documentation, and records are completed, maintained on file, and filed with the proper authorities, as required;
- f) conducting a post-tank-cleaning/entry review and adjusting procedures as necessary.

4.6 Written Tank-specific Cleaning/Entry Plans

4.6.1 General

Before a tank is opened and before workers enter a tank for any reason, employers shall develop written tank-specific work plans that shall be discussed and understood by all affected parties in a tank pre-cleaning/entry meeting. The written tank-specific plan may be done in several separate plan documents for each phase of the work scope when different personnel or contractors are involved. These plans shall include the following.

4.6.2 Scope of Work

The written work plan shall include identification of and requirements for:

- a) specific tank(s) to be cleaned and/or entered;
- b) tank construction and condition of the tank(s);
- c) products contained;
- d) specific work to be done;
- e) roles and responsibilities of employers and workers;
- f) schedule of each phase of the work; and
- g) programs identified under 4.5 that are applicable to the specific tank project.

The scope of work may change throughout the course of a tank project, and written work plans shall be modified to reflect significant changes to the scope of work.

4.6.3 Tank Pre-cleaning/Entry Meetings

A meeting and site survey shall be conducted for all tanks to be entered or cleaned. This meeting shall include all parties that could potentially enter the tank or whose activities could affect tank entry operations. Topics shall include;

- tank removal from service;
- job-specific vapor- and gas-freeing, degassing, and ventilation requirements;
- the scope of work and specific roles and responsibilities of all parties that could affect the project;
- job-specific requirements for tank entry;

- job-specific lockout/tagout requirements, isolation devices, and energy sources; and
- anticipated site and tank entry hazards.

4.6.4 Subsequent Meetings

Subsequent meetings may be required to address changes in conditions or significant changes in work scope, including:

- safety issues;
- different phases of a tank project (cleaning, repairs, coatings, etc.);
- different contractors associated with different project phases;
- scope of work changes;
- changes in identified hazards;
- changes in entry requirements;
- changes in personnel assigned to the project.

4.7 Regulatory Requirements

In addition to the requirements contained in this standard, employers shall refer to applicable federal, state, and local government regulations pertinent to specific tank-cleaning activities, including regulations of governments other than those of the United States, when appropriate.

This standard is intended to be consistent with Title 29 of the *U.S. Code of Federal Regulations (CFR)*, *Occupational Safety and Health Administration Standards*, Part 1910, "Occupational Safety and Health Standards," and Part 1926, "Safety and Health Regulations for Construction."

This standard is intended to be consistent with appropriate National Fire Protection Association codes and standards applicable to the entry and cleaning of aboveground petroleum storage tanks.

If any provision of this standard conflicts with statutory or regulatory requirements, said statutes and regulations shall govern. This standard is not intended to be a substitute for regulations, codes, standards, or employer safe (cold) and hot work practices and procedures, all of which shall be reviewed in their entirety to determine applicability to the facility, and the location, the tanks involved, and the proposed work.

4.8 Tank-cleaning/Entry Overview

4.8.1 General

The following outline summarizes the steps involved in the process of emptying and cleaning a tank, making it safe for entry to perform any inspection and repairs, and, finally, returning the tank to service.

Performing a task safely is of the utmost importance. Tasks should not be attempted unless the hazards have been properly assessed and the tasks can be completed in a safe manner. Inspection may be required to determine that the hazards have been properly addressed.

There are several basic activities applicable to every tank that is to be cleaned or entered. These cleaning activities include, but are not limited, to:

- a) isolation and removal from service;

- b) vapor- and gas-freeing and ventilation (including degassing);
- c) product sludge and residue removal and disposal;
- d) non-entry inspection (for safety);
- e) hazard evaluation and atmospheric testing;
- f) confined space classification;
- g) tank entry;
- h) hot work and safe (cold) work.

After the tank has been cleaned, other activities may include:

- 1) entry inspection (for safety);
- 2) hot and safe (cold) work;
- 3) return to service; however, in some instances tank may not be returned to service.

Other common activities not necessarily applicable to every tank include, but are not limited, to:

- setting floating roof legs or cables; and
- stabilizing floating roofs.

Many of these activities are covered by existing employer programs and procedures such as confined space; energy isolation (lockout/tagout); hot work and safe work; hazard communications; operations, maintenance, and inspection; respiratory protection; and process safety hazard analysis.

5 Preparing the Tank for Cleaning and Entry

5.1 Initial Preparation (Prior to Tank-cleaning/Entry Operations)

5.1.1 Employers shall review available up-to-date drawings and sketches of the external and internal tank configuration, piping and valves, supports, floating roof design, appurtenances, and the site layout. Plans shall be developed to mitigate or control the potential physical hazards expected before and during the tank-cleaning/entry operation.

5.1.2 Employers shall obtain and review applicable safety data sheets (SDSs) or equivalent information concerning the products presently and historically contained in the tank to be cleaned, the products presently contained in adjacent tanks in the same dike area, and any hazardous materials to be used to clean the tank. Employers shall determine the potential hazards associated with these products, their sludge and residue, and their cleaning materials. They shall develop methods for:

- vapor- and gas-freeing;
- ventilation;
- degassing, mitigation, and control, where required; and
- personal protection requirements.

SDSs and other information regarding potential hazardous exposures from products and materials shall be available at the work site for worker review.

5.1.3 Employers shall write procedures that include the safety and health requirements for issuance of the permit, conditions for canceling or suspending the permit, and safeguarding or returning the space to service following termination of entry.

5.1.4 Employers shall identify and classify such tanks as permit-required confined spaces, non-permit-required confined spaces, or nonconfined spaces, depending upon the condition of the tank at any time during the tank-cleaning/entry process.

5.1.5 Employers shall establish criteria for classifying entry upon a floating roof (where applicable) as a permit-required or non-permit-required confined space entry, or as nonconfined space entry.

NOTE It is petroleum industry practice to normally consider entry upon an open-top floating roof that is within 1.5 m (5 ft) of the top of the tank to be nonconfined space entry provided that: 1) no physical hazards are present; and 2) testing has been conducted to ensure that no hazardous flammable or toxic atmosphere is present on the top of the roof.

5.1.6 Employers shall ensure that confined-space entry plans are made available to all workers and that workers are properly trained prior to assignment to any confined space work.

5.1.7 Employers shall ensure that procedures and work plans provide sufficient information for workers to anticipate, recognize, test, analyze, and determine appropriate measures to control potential hazards that may be encountered during tank-cleaning/entry operations.

5.1.8 Owners/operators shall determine if tanks operating within the same dike area (or within 30 m [100 ft]) as the tank being cleaned will interfere with safe cleaning procedures.

5.2 Removal from Service

5.2.1 Setting Floating Roof Legs or Suspension Cables

The following shall be performed while the floating roof is floating, provided it can be done safely.

- The floating roof legs or suspension cables shall be properly adjusted at the same height (preferably in the high position) to allow room for entrants to work underneath the roof after the tank is emptied.
- The floating roof legs or suspension cables (including attachment to the cone roof) shall be visually inspected where possible or otherwise evaluated for damage or deterioration and any unsafe condition reported to the entry supervisor prior to landing the floating roof.
- If applicable, floating roof compartments shall be inspected to ensure that they are empty. Pontoons that are not empty or cannot be inspected shall be reported to the entry supervisor prior to landing the floating roof.
- The floating roof shall be visually inspected for damage. Potentially unsafe damage shall be reported to the entry supervisor prior to landing the floating roof.

Any deficiencies reported to the entry supervisor shall be corrected prior to removal from service. If the entry supervisor determines that it may not be safe to continue with removal from service, the entry supervisor shall stop work and contact a storage tank engineer for additional evaluation.

If the floating roof is not properly stabilized or the floating roof is not determined to be safe for tank entry without additional hazard mitigation steps, even if the tank is otherwise determined to be a nonconfined space due the presence of a large opening, the tank is a permit-required confined space.

5.2.2 Product Removal

The tank shall first be emptied of all product through the tank discharge nozzle, sample line, water draw-off, or other suitable fixed connections without opening the tank openings (e.g. manways).

Product, sludge, and residue that remains below the tank discharge nozzle or other fixed connections shall be removed from the tank using procedures established by the employer for the specific tank-cleaning operation.

5.3 Isolating the Tank

5.3.1 General

All energy sources that are potentially hazardous shall be identified, de-energized, secured, relieved, disconnected, or restrained before personnel are permitted to enter the confined space. Energy sources may include electrical, mechanical, hydraulic, pneumatic, thermal, etc. A qualified person shall evaluate the hazards and determine the appropriate methods and means to prevent hazardous energy, including flammables, toxics, oxygen-displacing gases, vapors, or liquids from entering the space. The entry supervisor shall verify that the safeguards are in place on the entry permit and shall identify isolation items in accordance with the owner/operator's lockout/tagout procedures.

5.3.2 Isolating Lines

The tank shall be isolated from all connected lines, including, but not limited to, product, vapor, relief, gauging and sampling, and water draw-off lines (see exception for foam lines, below). Lines shall be isolated as close to the tank as practicable by performing the following:

- installing blanks between two flanges sized for the proper pressure in piping nearest to the confined space, using two gaskets and fully engaged bolts or stud bolts in all flange bolt-holes;
- using double-block-and-bleed valve systems with lockout/tagout devices; if the bleed valve is not the same diameter as the line, then the bleed point shall be monitored periodically during the work shift;
- depressurizing and disconnecting lines from the tank and installing line blinds across the opening sized for the proper pressure, using a gasket and fully engaged bolts or stud bolts in all flange bolt-holes;
- misaligning or removing pipes at connections closest to the tank and capping, blinding and/or plugging ends.

Blinds and blanks shall completely cover the bore. They shall be capable of withstanding the anticipated chemical exposures and maximum pressure of the line with no leakage beyond the gasket, blind, or blank.

A qualified person shall inspect the blinds and blanks prior to use to ensure that they are installed properly and in good condition with no cracks, pits, holes, or other deterioration.

The entry supervisor shall confirm that the lines have been properly isolated.

5.3.3 Isolating Energy Sources

Entry supervisors shall confirm that the following have been performed.

- All energy sources shall be isolated (including, but not limited to, electrical, steam, hydraulic, and mechanical) in accordance with the owner/operator's lockout/tagout procedures.
- All tank equipment and appurtenances (including, but not limited to, tank mixers, heaters, sensors, and other instrumentation) shall be isolated.

- A qualified person shall inspect and test gauging and instrumentation equipment to ensure that no liquid product, hydrocarbon vapor, toxic material, or toxic atmosphere is present within the system that may affect the confined space.
- Isolation devices shall be locked/tagged out and tested before beginning tank-cleaning operations.
- Locks and tags shall remain in place in accordance with the owner/operator's lockout/tagout policy. Any removal of locks, tags, or other protective measures shall only be done in accordance with the owner/operator's energy control program and procedures.

5.3.4 Connected Foam Lines

If the tank has a fixed or semi-fixed fire protection foam system, a qualified person shall inspect and test the foam lines to ensure that no liquid product, hydrocarbon vapor, toxic material, or toxic atmosphere is present within the system that may affect the confined space entry. Foam lines may remain connected throughout the tank-cleaning operation for use against a fire within the tank.

5.3.5 Cathodic Protection

If a tank or lines have cathodic protection, the employer shall ensure that whenever a tank valve or line is to be disconnected, safe isolation practices are followed in the order shown.

- 1) Turn off the cathodic protection system. If atmosphere within tank tests is in acceptable concentrations for LEL, CP can be re-energized.
- 2) Install a bond wire from the tank to the lines.
- 3) Disconnect and remove the valve or line.
- 4) Remove the bond wire only after the valve or line is disconnected.

The entry supervisor shall confirm that the cathodic protection system has been properly secured.

5.4 Control of Ignition Sources

5.4.1 General

Entry supervisors shall ensure that all ignition sources in the area are eliminated or controlled before permitting any work to be performed that might involve the potential release of flammable vapors into the atmosphere around or inside the tank.

5.4.2 Motorized (Internal Combustion) Equipment

Before issuing entry or work permits, entry supervisors shall require that internal combustion-powered equipment (including automobiles, trucks, vacuum trucks, forklifts, pumps, welding machines, and compressors) are restricted to designated safe areas (such as outside the tank dike area) away from sources of flammable vapors, by notation on the permits and, if necessary, by posting signs and/or barricading access to the area. Entry supervisors shall be aware that the use of diesel-powered internal combustion equipment is preferred to using gasoline- or gas-powered equipment.

5.4.3 Electrical Tank Equipment

Entry supervisors shall ensure that all electrical equipment and appurtenances that may be a source of ignition and that are in, attached to, and around the tank are disconnected and locked or tagged out before issuing an entry permit. Such equipment and appurtenances include metering devices, alarms, sensors, overflow protection systems, cathodic protection systems, and electric heating coils.

5.4.4 Electrical Tank-cleaning and Maintenance Equipment

Depending on the potential exposures, entry supervisors shall ensure that all electrically powered tank-cleaning and related equipment, electrically powered tools, communication devices, lights, and motors used throughout tank-cleaning operations meet the minimum requirements of NFPA 70 for Class I, Division 1, Group D (or higher) locations; Class I, Zone 0 locations; or Class I, Zone 1 locations. The use of any type of non-explosion-proof electrical equipment shall be prohibited, unless specifically permitted under an authorized job site procedure or entry, hot work, or safe (cold) work permit.

5.4.5 Electrical Bonding and Grounding (Earthing)

5.4.5.1 Bonding and grounding cables and clamps shall be inspected by a qualified person to ensure good condition, adequacy, and integrity prior to the start of work and periodically, as necessary, during the work. Entry supervisors shall ensure that equipment capable of creating an ignitable spark upon disconnection is properly bonded and grounded (earthed) before issuing permits. Entry supervisors shall ensure that bonding and grounding procedures include the following requirements.

5.4.5.2 All metallic parts of vacuum hoses, suction hoses, vacuum trucks, and pumping equipment shall be bonded to the tank.

5.4.5.3 All metallic parts of vapor- and gas-freeing, degassing and ventilating equipment, including blowers, educators, and ducting (wire helix) shall be bonded to the tank.

5.4.5.4 Nozzles for steam, water, solvent, and chemical hoses shall be bonded to the tank.

5.4.5.5 Static-generating equipment, including, but not limited to, vacuum trucks, compressors, and pumps shall be bonded to the tank and properly grounded (earthed).

5.4.5.6 Conductive connectors and conductive hoses used for product and sludge transfer and solvent and chemical washing shall be bonded to the tank and to the receiving (or dispensing) container or truck (see API 2219 for additional information).

5.4.5.7 All portable electrical equipment shall be grounded (earthed) by using an approved ground fault circuit interrupter (GFCI) or other approved means of grounding (earthing). A qualified person shall ensure that the capacity and continuity of the GFCI adequately protects workers.

5.4.5.8 Welding machines shall be grounded (earthed) and bonded to the tank or other equipment or structure being welded. A qualified person shall ensure that the capacity and continuity of the grounding and bonding are adequate to protect workers.

5.4.6 Ignition Sources from Compressed Air

Employers shall require and entry supervisors shall ensure that air compressors are equipped with appropriate filters to remove moisture, scale, rust, oil, and other contaminants from the compressed air, as moisture and particles in the air stream can generate static electricity and become a source of ignition. Entry supervisors shall ensure that any compressors used to provide fresh air (non-breathing air) into a tank for vapor- and gas-freeing, degassing, and ventilation are grounded (earthed) and bonded to the tank.

5.4.7 Lightning and Thunderstorms

Whenever an electrical storm is threatening or in progress in the area of a facility where tank-cleaning and/or entry activities are being conducted, entry supervisors shall require the following actions to be taken.

— The entry and work permits shall be canceled.

— All work inside and outside the tank shall cease and entrants shall leave the tank.

- All activity with the potential to release vapors into the air, including, but not limited to, vapor- and gas-freeing, degassing, ventilation, vapor recovery, product transfer, sludge and residue removal, and vacuum truck operations shall stop.
- All openings into the tank shall be closed, sealed, or otherwise protected, if necessary, to prevent release of flammable vapors into the air.
- Entrants, attendants, bottle watches, and tank-cleaning workers shall leave the immediate area around the tank and move to a designated safe location.

5.4.8 Pyrophoric Iron Sulfide Deposits

Entry supervisors shall ensure that procedures are in place and adequate precautions are required and taken to prevent pyrophoric iron sulfide deposits (often found in tanks containing sour crude petroleum or petroleum products containing hydrogen sulfide) from becoming an ignition source.

5.5 Vapor- and Gas-freeing, Degassing, and Ventilating

5.5.1 General

Employers shall establish requirements, and entry supervisors shall implement safe procedures for vapor and gas-freeing, degassing, and ventilating tanks applicable to working around the outside of the tank, opening the tank, testing the tank's atmosphere, inspecting the tank, entering the tank, and cleaning the tank.

5.5.2 Vapor- and Gas-freeing Methods

Entry supervisors shall ensure that the tank's atmosphere is freed of flammable and hazardous gas and vapors by using approved and appropriate methods that will safely displace or dilute the vapors and gas in the tank, including, but not limited to, the following:

- 1) vapor- and gas-freeing by the use of mechanical or natural ventilation;
- 2) displacing vapors and gas by purging the tank with inert gas, flue gas, or steam;
- 3) displacing the vapors or gas with water or fuel oil; and
- 4) degassing (where required) by the use of thermal oxidation, vapor recovery, carbon absorption, or other approved methods.

5.5.3 Vapor- and Gas-freeing Selection

Employers shall be aware of the requirements and shall select specific methods for vapor- and gas-freeing and degassing the tank, dependent upon the following factors:

- 1) the nature of the vapors or gases involved;
- 2) degassing and emission control requirements;
- 3) the potential hazards of the vapor or gas; and
- 4) the area and the type, size, construction, and location of the tank.

5.5.4 Tank Location

Entry supervisors shall be aware that when tanks are located below the surrounding ground level, there is a potential for contaminated air from nearby internal combustion engine exhausts, vacuum truck exhausts, or flammable or toxic vapors that have collected in low-lying areas to be drawn into tanks during vapor- and gas-freeing.

freeing, degassing, and ventilation operations. Entry supervisors shall identify such situations, establish safe work procedures, and develop and implement preventative measures to ensure fresh air is introduced into the tank.

5.5.5 Environmental Factors

During the tank pre-cleaning phase of the operation, and prior to the start of vapor- and gas-freeing and degassing, employers shall review applicable environmental regulations to determine if there are requirements to reduce atmospheric vapor emissions through degassing. If degassing is required, entry supervisors shall establish and implement appropriate control measures.

5.6 Initial Tank Cleaning

Employers shall determine the potential hazards and exposures and the required flammable and toxic vapor and gas concentration levels at which workers may safely begin cleaning the tank from outside the tank opening (manway). Entry supervisors shall designate the appropriate personal protective clothing and equipment to be used by workers (without entering the tank) and issue the appropriate safe (cold) work permits. Entry supervisors shall issue an entry permit if the initial cleaning process requires that tank-cleaning workers' hands and arms break the plane of the tank opening (manhole), because this is considered entry into a tank.

6 Testing the Tank Atmosphere

6.1 Atmospheric Testing Procedures

Prior to the initiation of tank work, the employer shall establish written procedures and requirements for testing the atmosphere around the outside of the tank and inside the tank. Atmospheric testing procedures and requirements shall be addressed in work and entry permits.

6.2 Atmospheric Testing Instruments

6.2.1 General

All testing equipment shall be intrinsically safe or approved for use in either Class I, Zone 0 locations; Class I, Zone 1 locations; or Class I, Division 1, Group D (or greater) locations (see [Section 7](#) for additional requirements).

6.2.2 Testing Equipment

6.2.2.1 Qualified persons shall only use instruments approved for use by their employer.

6.2.2.2 The manufacturer recommendations and procedures shall be followed, including instrument use and limitations, calibration, bump-testing, maintenance, and repair.

6.2.2.3 The type and amount of exposure to contaminants and the history of need for recalibration shall be considered when determining the calibration criteria for specific instruments under specific working conditions.

6.2.2.4 The employer shall maintain verification of instrument calibration on record for at least one year (or the period of time required by applicable regulations or designated in the employer's confined space program, if longer).

6.3 Atmospheric Testing

6.3.1 Testing Sequence

Initial and subsequent tests around and inside the tank shall be conducted in the following order:

- 1) oxygen content;

- 2) flammable vapors; and
- 3) toxic exposures.

6.3.2 General

6.3.2.1 Entry supervisors shall require that oxygen, flammable vapors, and toxic hazard exposures be tested by a qualified person prior to permitting work inside or around the outside of tanks (including tanks that have been previously vapor- and gas-freed, degassed, ventilated, and cleaned but have remained inactive and closed since the time of cleaning). A qualified person shall measure the atmospheric concentrations of oxygen, flammable vapors, and toxic materials inside and around the outside of the tank.

6.3.2.2 Testing shall be performed using properly calibrated instruments.

6.3.2.3 A qualified person shall perform testing as frequently as necessary to maintain safe working conditions.

6.3.2.4 Entry permits shall reference SDSs or equivalent information pertinent to determination of atmospheric testing requirements.

6.3.2.5 A qualified person shall determine the safe exposure limits applicable to the proposed entry or work.

6.3.2.6 A qualified person shall determine the need to use specialized toxic substance or other hazardous substance testing or monitoring instruments, in addition to oxygen and flammable vapor instruments.

6.3.2.7 Qualified persons who use testing instruments shall be trained in, knowledgeable of, and follow the requirements given in [6.2](#).

6.3.2.8 At a minimum, a function check, e.g., bump test, shall be done prior to each day's use.

6.3.3 Testing Requirements

6.3.3.1 A qualified person shall determine the extent of atmospheric tests required and when to conduct initial testing and subsequent testing. Such determinations shall be based on several factors, including the following.

6.3.3.2 The liquids (including additives) that have been contained in the tank since it was last cleaned (and in the case of leaded products, the entire service history, unless certified lead-free) and the materials used to vapor-free and clean the tank.

6.3.3.3 The environmental, operational, and other external factors that may potentially affect the atmosphere inside and around the outside of the tank.

6.3.3.4 The tank's configuration and condition; the ability to vapor-free, degas, and ventilate the tank; and the work to be performed.

6.3.4 Testing the Atmosphere outside the Tank

6.3.4.1 Entry supervisors shall require that a qualified person test and monitor the atmosphere around the outside of the tank, continuously or periodically as required, to ensure that atmospheric conditions are within acceptable or permissible levels.

6.3.4.2 Entry supervisors shall ensure that vapor- and gas-freeing, degassing, and ventilation equipment is in place and operating during these tests.

6.3.4.3 Tests shall be performed by a qualified person in the areas around the tank where vapors could collect.

6.3.4.4 Based on the results of testing, the entry supervisor shall determine the potential hazards and permit requirements to enable work around the outside of the tank can be conducted safely.

6.3.5 Testing the Atmosphere inside the Tank

6.3.5.1 Entry supervisors shall require that a qualified person test and monitor the atmosphere inside the tank after vapor- and gas-freeing and degassing and during ventilation to ensure that oxygen levels are satisfactory and flammable and toxic vapors are not present above acceptable or permissible levels.

6.3.5.2 Where entry is to be made into an Occupational Safety and Health Administration (OSHA) permit-required confined space, workers (or their authorized representatives) shall have the opportunity to observe the pre-entry and subsequent testing.

6.3.5.3 Based on the results of the testing, entry supervisors shall determine the potential hazards and permit requirements so that tank-cleaning work and other activities can be conducted safely inside the tank.

6.3.5.4 Entry supervisors shall require that vapor- and gas-freeing, degassing, and ventilating equipment is shut down for at least 15 minutes prior to testing inside the tank (based on industry experience for 46 m [150 ft] diameter tanks) to allow the atmosphere inside the tank to reach equilibrium conditions. Entry supervisors shall determine the time required for the atmosphere in larger-size tanks to stabilize.

6.3.5.5 Remote probes should be used to test areas whenever feasible prior to performing testing by entry into the confined space.

6.3.5.6 The qualified person performing the tests shall wear the appropriate protective clothing and supplied-air or self-contained breathing apparatus (SCBA), positive-pressure, full face-piece, respiratory protective equipment, and a harness/lifeline when entering the tank to conduct testing to establish entry conditions.

6.3.5.7 Prior to permitting vertical entry into a tank (entry from the top of the tank), a qualified person shall test the internal atmosphere at 1.2 m (4 ft) vertical intervals (from top to bottom) to ensure that flammable and toxic vapors have not stratified within the tank. This testing shall be done without entry, if possible.

6.3.5.8 The qualified person who performs the tests shall ensure that the results represent the true condition of the inside of the tank in order to allow a proper decision to be made by the entry supervisor regarding safe entry or work inside the tank. A qualified person shall determine if there is a need to test the atmosphere at various elevations or levels inside the tank to establish that permissible entry conditions exist throughout the tank.

6.3.6 Monitoring the Tank's Atmosphere during Entry

Entry supervisors shall require that atmospheric testing or monitoring for oxygen levels, flammable vapors, and toxic exposures be conducted periodically or continuously, as necessary, while workers are inside and/or around the outside of the tank in order ensure that desired atmospheric conditions are maintained in accordance with the entry permit, safe (cold) work, and hot work requirements.

6.3.7 Documentation

The results of all atmospheric testing, the time of the testing, and the signature of the qualified person who performed the tests shall be recorded on (or attached to) the entry permit and shall be available for review by workers (or their authorized representatives). Documentation shall include maintenance and calibration record and may include date of purchase, sensor change schedule, repair history, data logging calibration history, and battery life. Documentation may be maintained using electronic logs.

6.4 Acceptable Limits

The atmosphere of the confined space shall be considered within acceptable limits whenever the following conditions are maintained:

- 1) Oxygen—19.5 % to 23.5 % by volume.

- 2) Flammability less than or equal to ten percent of the lower explosive limit (LEL). Any level above zero shall be investigated.
- 3) Toxicity less than recognized published exposure limits. When testing for volatile organic compound (VOC), it is important to distinguish the VOC being tested. Many VOCs are indistinguishable and have different levels of toxicity.

Whenever testing of the atmosphere indicates that levels of oxygen, flammability, or toxicity are not within acceptable limits, entry shall be prohibited until appropriate controls are implemented, appropriate work procedures are established, engineering and administrative controls are applied and, if necessary, appropriate PPE is used.

If the source of the contaminant cannot be determined, continuous monitoring is required throughout the duration of the entry with limitations set by the entry supervisor. If the contaminant is present below the acceptable levels, entry can still proceed.

If there is a possibility that the atmosphere can become unacceptable during the course of the work, procedures and equipment shall be provided to all for safe exit from the confined space.

7 Storage Tank Hazards

7.1 General

[Section 7](#) sets forth minimum requirements regarding mitigation or elimination of storage tank hazards when performing tank cleaning or entry. Additional information on these specific storage tank hazards is located in [Annex A](#).

Entry supervisors shall be aware of and consider the following hazards, including the specific information contained in this section:

- a) oxygen deficiency or enrichment;
- b) fires and explosions;
- c) toxic substance exposures; and
- d) physical and other hazards.

Before workers enter a tank at the beginning of each workday or shift, the entry supervisor shall ensure that tank's atmosphere is tested and evaluated by a qualified person for oxygen, flammable vapors, and toxic exposures and inspected for physical and other hazards. The entry supervisor shall issue entry permits only if all entry requirements are met. When reentering a tank following an evacuation or a break in entry causing cancellation of the permit, the tank's atmosphere shall be retested and reevaluated by a qualified person to determine that conditions have not changed and entry requirements are still being met. The entry supervisor shall then issue a new permit or reissue the existing entry permit before entrants are permitted to reenter.

7.2 Oxygen Deficiency and Enrichment

7.2.1 General

Before entrants (qualified persons) initially enter any tank, including a clean tank that has been closed and inactive or an empty tank, the entry supervisor shall ensure that a qualified person tests the atmosphere for oxygen content.

Following testing and evaluation of test results, the entry supervisor shall issue an entry permit only if conditions are met. While entrants are in the tank, continuous oxygen monitoring shall be conducted as necessary to ensure

that the oxygen content in the atmosphere does not change (increase or decrease) from that required by the permit. If a pertinent change in oxygen content occurs, work shall stop and all entrants shall immediately vacate the tank until a qualified person has determined the cause of the change, conditions are evaluated and corrected, and the entry permit is reissued.

7.2.2 Oxygen Deficiency

7.2.2.1 Entry supervisors shall be aware of causes of oxygen deficiency, including the following.

7.2.2.2 Flammable or toxic vapors, steam, water mist, or inert gases are still present in the tank, which could occur if the tank has not been properly vapor- and gas-freed/degassed and ventilated.

WARNING A tank that has been purged with inert gas or flue gas will be almost devoid of oxygen. If a tank has been maintained under an inert atmosphere, extreme caution shall be exercised because the tank may be in an immediately dangerous to life and health (IDLH) condition.

7.2.2.3 Product or vapors may have entered the tank from a variety of sources, including:

- vapors from sludge;
- vapors from deposits and residue on tank walls, bottoms, and roofs; and
- liquids under the tank bottom and in supports, lines, and pontoons.

The vapors of most hydrocarbons stored are heavier than air and will displace or dilute air (oxygen).

7.2.2.4 Oxidation (rusting) may have depleted the tank's oxygen content, especially if the tank has been closed for an extended period of time, even if previously cleaned.

7.2.2.5 Oxygen may be displaced through combustion by welding, cutting, or other hot work.

7.2.2.6 Oxygen may be displaced by evaporation of solvents used in paint, linings, or coatings.

7.2.3 Oxygen Enrichment

7.2.3.1 Entry supervisors shall be aware of the hazards and causes of oxygen enrichment. Oxygen enrichment increases the explosive (flammable) range of hydrocarbon vapors, effectively reducing the lower explosive (flammable) limit and creating a dangerous potential for a fire to occur should a source of ignition be present. An oxygen-enriched atmosphere in a tank (oxygen content over 23.5 %) should not normally occur during the cleaning of stationary storage tanks that have contained petroleum or petroleum products, unless there are unusual or extraordinary circumstances.

7.2.3.2 Upon any instance of oxygen enrichment that occurs within a tank above that of the ambient air external to the tank, the following actions shall be taken.

7.2.3.2.1 The entry supervisor shall immediately stop operations, entrants shall leave the tank, and the entry permit shall be canceled. The entry supervisor shall identify and control all sources of ignition in the tank area.

7.2.3.2.2 A qualified person shall investigate the cause of the oxygen enrichment (for example, oxygen bottles or cylinders used during welding or cutting may leak and provide a source of oxygen enrichment).

7.2.3.2.3 A qualified person shall determine and implement the corrective action required to eliminate or control the oxygen enrichment.

7.2.3.2.4 A qualified person shall conduct atmospheric testing in the tank to ensure the conditions are within acceptable limits before the entry supervisor reissues the permit or issues a new permit to allow entrants to reenter the tank and resume work.

7.3 Fire and Explosion Hazards

7.3.1 General

7.3.1.1 Entry supervisors shall be aware of the combination of elements that cause fire and explosions. Fires and explosions occur when a source of ignition is introduced into an atmosphere where mixtures of flammable vapor and air are within the explosive (flammable) range. The potential for a fire inside or outside a tank exists during all phases of tank work but the potential is particularly high during vapor- and gas-freeing and degassing.

7.3.1.2 During tank work, qualified persons shall control vapor exhaust and ignition sources in the vicinity of the tank to prevent possible ignition of flammable vapors.

7.3.1.3 Entry supervisors shall determine that the flammable vapor-in-air levels required for entry into the tank to perform specific operations are within acceptable limits before any entry permits are issued.

7.3.2 Testing

The entry supervisor shall ensure that a qualified person periodically or continuously (as required by the permit) tests and monitors the atmosphere in and around the tank for flammable vapors, especially when vapor- and gas-freeing, degassing, and ventilating is being conducted.

7.3.3 Factors Leading to Fires and Explosions

A source of ignition inside or near a tank may result in either a fire or an explosion, depending upon several factors, including, but not limited to, the following:

- 1) tank design, construction, condition, and integrity;
- 2) product(s) that have been stored in the tank;
- 3) inadequate cleaning or ventilation;
- 4) chemicals used to clean the tank;
- 5) application of paint, linings, or coatings; or
- 6) the location of open vents, relief devices, and other tank openings.

7.4 Toxic Substances

7.4.1 General

7.4.1.1 Entry supervisors shall be aware of potential toxic substances and steps to mitigate or eliminate the hazards. Toxic substances can cause irritation, injury, and immediate or delayed illness or death, depending upon the characteristics of the substances, the concentration of the substances, and the duration of exposure. Entry supervisors shall ensure that workers are aware of the potential routes of toxic exposure (inhalation, skin or eye absorption, injection, or ingestion), depending upon the characteristics of the substance and the nature of the exposure.

7.4.1.2 Information about the materials contained in the tank, including applicable SDSs, shall be obtained and reviewed by a qualified person during the planning phase of the work to determine the potential toxic hazards and safe exposure requirements. This information shall be available to all workers at the tank work site.

7.4.1.3 A qualified person shall review regulatory requirements applicable to the potential toxic exposures to ensure protection and entry requirements are compliant with the OSHA Hazard Communication (HAZCOM) Standard and/or local regulations.

7.4.1.4 Entry supervisors shall determine that exposure levels are within acceptable limits for entry and the appropriate protective clothing, equipment, and respiratory protection required for entrants are provided before an entry permit is issued.

7.4.2 Hydrogen Sulfide

7.4.2.1 Hydrogen sulfide (H_2S) is a highly toxic, colorless, flammable gas that is dangerous even in low concentrations. It has a rotten egg smell.

WARNING Sense of smell shall never be used as a means to detect the presence of hydrogen sulfide. At higher concentrations it can be fatal. Since higher concentrations deaden the sense of smell, relying on the human nose can often have catastrophic results.

7.4.2.2 Employers shall require precautions, procedures, and controls for prevention of exposure to hydrogen sulfide gas.

7.4.2.3 Entry supervisors shall require the use of appropriate engineering controls and/or respiratory protection when the hazard assessment determines that significant exposure is likely.

7.4.3 Organic Lead

7.4.3.1 Highly toxic organic lead compounds, such as tetraethyl lead (TEL) and tetramethyl lead (TML), are typically present in tanks that contained leaded gasoline and other leaded products and additives. Exposure to organic lead is highly toxic and can occur at any time until the tank is thoroughly cleaned, dried, tested, and declared to be lead-in-air free.

7.4.3.2 Entry supervisors shall be aware of applicable regulatory requirements for exposure to lead (such as U.S. DOL OSHA 29 *CFR* 1910.1000). At the time of publication of this standard, the OSHA-permissible exposure limit was 2 μg of organic lead per cubic foot (0.075 mg of organic lead per cubic meter).

7.4.3.3 Entry supervisors shall classify tanks that contain or may have previously contained leaded gasoline, leaded compounds, and additives or other petroleum products containing lead, as permit-required confined space entry until the tanks have been vapor- and gas-freed (degassed); ventilated; properly cleaned, dried, and tested; evaluated; and declared lead-in-air free by a qualified person.

7.4.3.4 Entry supervisors and testers shall be aware that there are no instruments that will detect or determine if the tank is or has been in organic leaded service prior to cleaning and drying. If tests are performed before or during vapor- and gas-freeing, degassing or cleaning, or while there is liquid or moisture in the tank, the results will be erroneous and misleading.

7.4.3.5 Entry supervisors shall ensure that entry permits require the use of appropriate lead hazard personal protection, including supplied-air or self-contained breathing apparatus, impervious clothing, and protective equipment for entry into these tanks.

7.4.3.6 Entry supervisors shall ensure that applicable regulatory requirements and facility procedures for control of exposures to organic lead and any product, sludge, or residue containing organic lead during handling, removal, and disposal are followed during tank-cleaning operations.

7.4.3.7 Employers shall establish and implement procedures for decontamination and disposal of contaminated clothing and materials and provide workers with appropriate facilities for washing and changing clothes.

7.4.3.8 Employers shall establish and implement procedures for testing and disposal of product, sludge, deposits, and residue that contain organic lead.

7.4.4 Inorganic Lead

7.4.4.1 Inorganic lead may be present in paints and coatings used on tanks and piping and may also be present in sludge, residue, and products such as gear lubricants and metalworking fluids containing inorganic lead additives. Exposure to inorganic lead can occur when performing the following:

- sludge, deposit, and residue removal;
- grinding, abrasive blast cleaning, and scraping where coatings are present.

7.4.4.2 Lead-in-paint tests shall be performed by qualified persons inside and/or on the outside the tank prior to abrasive blasting of internal or external linings that have not been documented to be free from lead (subject to testing detection limits).

7.4.4.3 Entry supervisors shall ensure that workers are aware of employer procedures and applicable regulatory requirements for control of exposures to inorganic lead and lead dust during handling, removal, and disposal and that safety requirements are followed.

7.4.4.4 Entry supervisors shall ensure that permits require appropriate engineering and administrative controls and workers use appropriate lead hazard respiratory protection and personal protective clothing and equipment during operations involving potential contact with products, sludge, residue, and dust containing inorganic lead.

7.4.4.5 Employers shall establish and implement procedures for decontamination and disposal of contaminated clothing and materials and provide workers with appropriate facilities for washing and changing clothes.

7.4.4.6 Employers shall establish and implement procedures for testing and disposal of blasting grit, paint deposits, and residue that contain inorganic lead.

7.4.5 Aromatics

7.4.5.1 Some aromatic compounds found in petroleum hydrocarbons, such as benzene, have been determined to have the potential to cause cancer.

7.4.5.2 The employer shall establish and the entry supervisor shall implement requirements for safe entry and other work that addresses exposure to aromatic hydrocarbons in which there is a potential for such exposure.

7.4.5.3 A qualified person shall determine the requirements, and the entry supervisor shall ensure that workers use the appropriate protective equipment, depending on the potential concentration, method, and amount of exposure to aromatic hydrocarbons.

7.4.5.4 Testing for VOCs may be used to determine if hazardous aromatic compounds might be present. If VOCs are detected and they cannot be accounted for, additional testing may be required to determine if benzene or other hazardous aromatic compounds may be present. Specific testing should be required for benzene or any other aromatic compound that may be introduced in the cleaning or internal coating process, as many aromatics are indistinguishable with generic VOC testing equipment. Portable benzene detectors are currently available that are benzene- and/or total aromatic compound (TAC)-specific.

7.4.5.5 Employers shall establish and entry supervisors shall implement procedures for decontamination and disposal of contaminated clothing and materials and provide workers with appropriate facilities for changing clothes and washing hands.

7.4.5.6 Employers shall establish and implement procedures for testing and disposal of product, sludge, deposits, and residue that contain aromatic hydrocarbons.

7.4.6 Naturally Occurring Radioactive Materials

7.4.6.1 Crude oil (and sludge or residue from crude oil tanks) may contain naturally occurring radioactive materials (NORM).

7.4.6.2 The employer shall establish and the entry supervisor shall implement requirements for safe entry and work that addresses NORM in which there is a potential for such exposure.

7.4.6.3 A qualified person shall determine the requirements and the entry supervisor shall ensure that engineering controls or administrative controls are implemented and/or workers use the appropriate protective equipment, depending on the potential concentration, method, and amount of exposure to NORM.

7.4.6.4 Employers shall establish and entry supervisors shall implement procedures for decontamination and disposal of contaminated clothing and materials and provide workers with appropriate facilities for changing clothes and washing hands.

7.4.7 Other Toxic Materials

7.4.7.1 Entry supervisors shall ensure that a qualified person reviews applicable SDSs and other available information covering the products, sludge, residue, or materials contained in the tank to determine if there is potential for exposure to other toxic substances.

7.4.7.2 A qualified person shall also review SDSs and available information on the materials used to clean the tank and determine if there is a potential for incompatibility or exposure to toxic substances.

7.4.7.3 The employer shall establish and the entry supervisor shall follow the hierarchy of controls to implement requirements for safe entry and work in which there is a potential for exposure to other toxic substances.

7.4.7.4 A qualified person shall determine the requirements and the entry supervisor shall ensure that workers use the appropriate engineering and administrative controls, and/or PPE, depending on the potential concentration, method, and amount of toxic exposure.

7.4.7.5 Entry supervisors shall ensure that applicable regulatory requirements and facility procedures for control of exposures to toxic materials are followed during tank-cleaning operations, material handling, and waste disposal.

7.4.7.6 Employers shall establish and entry supervisors shall implement procedures for decontamination and disposal of contaminated clothing and materials and provide workers with appropriate facilities for changing clothes and washing hands.

7.5 Physical and Other Hazards

7.5.1 General

Physical and other hazards may be present or created, both inside and outside the tank during tank-cleaning and entry operations. Workers shall be aware of potential physical hazards and the symptoms of physiological and psychological hazards.

7.5.2 Requirements

A qualified person shall determine and evaluate the potential physical and other similar hazards. The entry supervisor shall conduct a safety review of the tank and surrounding area and ensure that hazards are mitigated and/or eliminated and shall institute necessary precautions and control measures.

7.5.3 Hazard Identification

Workers shall be aware of physical and other hazards that could be potentially encountered during tank-cleaning operations, including, but not limited to, the following.

- Physical hazards related to a tank's function or design, including, but not limited to, restricted entry and egress, tripping or bumping into internal tank components, piping, or roof supports, and falling into sumps or holes in the bottom.
- Physical hazards related to a tank's condition, including, but not limited to, corroded roofs, cracks, and openings in bottoms; poorly supported or corroded stairways and ladders; sunken roofs; or the collapse of landed floating roofs by either spiraling or dropping down upon workers (see [7.6](#)).
- Physical hazards related to a tank's location, including, but not limited to, being next to a tank that is taking in product and releasing flammable vapors, being near a process unit that is venting or relieving hazardous vapors or gases to the atmosphere, or being close to an outside potential ignition source, such as a public highway or close neighbor.
- Physiological hazards, including, but not limited to, heat stress (see [7.7](#)) and cold stress inside tanks and exposure to extreme cold or inclement weather outside of tanks.
- Psychological hazards, including, but not limited to, claustrophobia.

Workers shall inform the entry supervisor of any hazards found and the entry supervisor shall eliminate or mitigate the hazard where feasible.

7.6 Heat Stress

The entry supervisor shall be aware of potential heat stress conditions, including consideration of the temperature, humidity, heat index, solar load, exposure times, and PPE, as applicable. The entry supervisor shall be aware that air conditioning to cool and dehumidify the space may be desirable to allow increased exposure times for workers.

The entry supervisor shall be aware of and implement appropriate engineering and administrative controls, including:

- air conditioning;
- additional ventilation;
- adiabatic cooling with air horns;
- evaporative cooling by spraying the tank exterior with water;
- shaded areas with drinking water; and
- job rotation (control of exposure time).

7.7 Pyrophoric Iron Sulfide

Sulfur compounds in sour stock can react with steel to form pyrophoric iron sulfide deposits. When air contacts these deposits, a heat-generating chemical reaction can occur, creating temperatures high enough to ignite a flammable vapor-in-air mixture. Typically, affected products include aromatic tars, aromatic gas, asphalt, liquid sulfur, or sour crude oil and products.

Entry supervisors shall determine the potential for pyrophoric iron sulfide ignition. If the potential exists, keeping surfaces and deposits moist shall be implemented where feasible.

7.8 Floating Roof Hazards

7.8.1 General

Floating roof hazards include the following:

- 1) catastrophic failure due to loss of vertical support from support leg failure, unsupported legs, suspension cable failure, floating roof deterioration, and overload (due to water, ice, snow, or product on the deck or in pontoons);
- 2) catastrophic failure due to translation, such as what may occur when perimeter seals are inadequate or removed;
- 3) catastrophic failure due to rotation, such as what may occur when anti-rotation devices (poles, bars, perimeter seals, or cable suspension systems) are inadequate, deteriorated, or do not exist (floating roofs without seals are of particular concern);
- 4) fire caused by product in pontoons, product-saturated seals, or product in roof drains and an ignition source;
- 5) fire caused by trapped vapors between primary and secondary perimeter seals;
- 6) ignition or fire caused by leaking product falling through the air;
- 7) ergonomic hazards, especially if the floating roof is landed on low legs (set the legs at the high position for maintenance work and any other activity requiring workers to enter under the roof).

Entry supervisors shall determine if any of these potential hazards exist and shall eliminate or mitigate these hazards prior to allowing entry on to the top of the floating roof or into any confined space where the floating roof is present. Various inspections may be needed to meet these requirements.

If confined space entry is needed to inspect or perform work to eliminate the floating roof hazard, entry will be permitted with special precautions and procedures recognizing the hazard until it is eliminated or mitigated.

7.8.2 Entry onto or below Floating Roofs (and into Pontoons)

Employers should ensure that all workers are familiar with the principles of roof collapse, as well as the methods and the devices used to stabilize the roof, including the use of jacking devices. Before permitting entry to personnel onto or under floating roofs and into pontoons, the entry supervisor should implement procedures to inspect and, when necessary, support the roof as required by this standard and in accordance with industry practices.

7.8.3 Floating Roof Inspections

7.8.3.1 General

The entry supervisor should ensure that a qualified person conducts visual inspections to effectively identify potential floating roof failure hazards and to ensure that appropriate backup systems, including but not limited to, rim blocking, vertical load supports, and lateral and anti-rotation devices have been installed or are in preparation.

7.8.3.2 Inspections above the Roof

7.8.3.2.1 General

A qualified person should conduct the following visual inspections from above the roof, at the top of the tank, at the gauge platform, or through a roof manhole, without entry into the confined space.

7.8.3.2.2 Water or Product

The inspection should ensure that there is virtually no standing water or liquid product on the roof prior to entry and that the pontoons or compartments do not contain product or water.

7.8.3.2.3 Floating Roof Legs

The inspection should verify that all legs are properly set and that they are all set at the high-leg position or the low-leg position. The following should be considered.

- The inspection should include a check for nonvertical alignment of the legs.
- The entry supervisor should ensure that any legs that have been identified as excessively misaligned or improperly set are designated as requiring a temporary support under the roof.

7.8.3.2.4 Anti-rotation System

Resistance to rotation of the roof is provided by both the anti-rotation device (usually a guide pole) as well as by the seal (however, seals vary in their ability to prevent rotation). Anti-rotation devices typically use an anti-turn pole or cable that should be checked to ensure proper alignment and attachment to the tank shell. The following items should be considered.

- The inspection should verify that the tank has a working anti-rotation device. An anti-rotation system shall be present before any entry under the roof may occur.
- The floating roof fitting that the anti-turn pole or cable passes through should be inspected to determine if any damage has occurred.
- If the condition of the anti-rotation system cannot be verified by inspection, the entry supervisor should ensure that the system is either in good working order or replaced with a backup system prior to issuing an entry permit.

7.8.3.2.5 Rim Seals

Rim seals provide resistance to lateral movement of the roof. A damaged seal may not provide this lateral support or it may place lateral loads on the roof that could initiate or contribute to roof movement. The resistance to lateral movement of the roof is provided in varying degrees by the rim seal. The following items should be considered.

- The inspection should verify that the rim seal has not failed in any locations around the floating roof. If failure has occurred, the entry supervisor should consider blocking the rim space from the top of the roof before entering under the roof.
- A shoe seal provides the maximum resistance to rotation and will not allow the roof to begin rotation without an applied external force.
- A wiper seal provides little to no resistance to roof rotation.
- A resilient toroid (bag seal) may provide an unknown amount of resistance to movement, as the condition of the seal cannot be determined by any inspection that could be conducted at this point in the procedure.

7.8.3.3 Inspections below the Roof

7.8.3.3.1 General

A qualified person should conduct the visual inspections from outside the tank through a shell or roof manhole without entry into the confined space (see Annex A).

7.8.3.3.2 Floating Roof Legs

An inspection should be conducted through the shell manhole to determine if buckling, misalignment, or excessive corrosion of the floating roof legs has occurred. Legs near the shell manhole should be more closely inspected to verify their condition. The entry supervisor should ensure that any specific leg whose condition is questionable should be identified as requiring temporary support.

7.8.3.3.3 Anti-rotation System

An inspection should be conducted through the shell manhole to verify that the anti-turn pole is connected to the tank shell or bottom. If the condition of the anti-rotation system cannot be verified by inspection, the entry supervisor should ensure that the system is either in good working order or have it replaced with a backup anti-rotation system prior to issuing an entry permit.

7.8.3.3.4 Rim Seals

An inspection should be conducted through the roof manhole to check and verify areas of potential rim seal failure identified from above the floating roof.

If a secondary seal shielded the primary seal from being inspected from the top of the tank, the primary seal should be inspected through the shell manhole.

If the rim seal has failed in any locations around the floating roof, the entry supervisor should ensure that the floating roof rim open space is blocked on the top of the floating roof before permitting entry under the roof.

Floating roofs with pan-wiper seals or pan-log seal combinations should have backup support systems installed if work is to be performed under the roof.

7.8.4 Requirements for Entry

Entry into the tank, either below or above the roof or into pontoons, should be minimized. The entry supervisor should permit entry on or under the floating roof only by those individuals who are trained and qualified to comply with the requirements of this standard. Workers should stop work if they believe that a temporary support or jack stand is not working properly or if any other safety concern arises. The entry supervisor should not issue a permit for entry to begin tank cleaning or other work under the floating roof until an anti-rotation system and a properly positioned rim seal or rim seal blocks are provided and the legs are properly supported or are in a stable condition to prevent collapse. The entry supervisor should issue the required confined-space entry permit to allow for the establishment of the required supporting system. The entry supervisor should ensure that the amount of time spent in the tank to provide this stability is minimized because the atmosphere is often hazardous.

7.8.5 Backup Support Systems

7.8.5.1 General

Entry supervisors should be aware that, depending on the mechanical condition of the anti-rotation devices, seals, and legs, there may be a need to have backup support systems to prevent floating roof collapse. Backup support systems include, but are not limited to, vertical load backup, lateral movement backup, and anti-rotational backup.

Entry supervisors should be aware that cribbing can provide effective protection for personnel working under floating roofs.

Entry supervisors should ensure that lateral movement backup is provided for all floating roofs that do not have shoe seals.

Entry supervisors should require that a backup anti-rotation system is installed, unless the guide pole system (pipe) is present, the seal is a shoe, and the condition of all of the components and their attachments to the tank are satisfactory.

When temporary floating roof leg wood supports are required by the entry supervisor, a qualified person should ensure that all temporary floating roof leg wood supports are 100 mm (4 in.) by 100 mm (4 in.) kiln-dried timber (green timber should not be used), strapped to the legs at both the top and bottom of the leg. The qualified person should ensure that the strapping does not allow the wood supports to freely move from side to side.

The entry supervisor should ensure that the three legs nearest to the shell manhole have a temporary wood support strapped to them. When rim blocking is required by the entry supervisor, the entry supervisor should ensure that at each rim blocking point, the nearest floating roof leg most likely to receive lateral pressure from the rim blocking has a temporary wood support.

The entry supervisor should ensure that any leg identified as needing support has a temporary wooden support to provide backup in case the steel leg becomes unstable.

7.8.5.2 Hazards and Disadvantages of Backup Support Systems

Entry supervisors should be aware that there are disadvantages to using cribbing, including, but not limited to, the following.

- Installing cribbing in tanks with hazardous atmospheres may create excessive exposure and inhibit work due to the requirement for PPE.
- The use of cribbing in tanks that are being retrofit with double bottoms requires either pouring a slab under the crib stacks or using multiple pours, both of which breach the integrity of the concrete double-bottom spacer.

7.9 Hazard Assessment to Determine Permit-required Confined Space

The employer shall perform a hazard analysis and establish the conditions and precautionary requirements for entry into tanks that are classified as a:

- permit-required confined space;
- non-permit-required confined space; or
- nonconfined space.

8 Personal Protective Equipment (PPE)

8.1 Protective Clothing and Equipment

8.1.1 General

Employers shall provide and workers shall wear protective clothing and equipment required by applicable regulations. Personal protection shall be appropriate for the potential hazards; atmospheric exposure; tank conditions; and the task, operation, or activity to be performed.

8.1.2 Selection

Entry supervisors shall evaluate the potential exposures and hazards, and a qualified person shall determine the personal protection needed by the workers entering the confined space. The following shall be considered in the selection process:

- 1) impervious clothing, gloves, and footwear to protect the skin (entry supervisors shall review and understand the potential consequences of using impervious clothing in areas subject to heat stress);
- 2) light-colored clothing to enhance visibility and to assist in identifying contamination on clothing;
- 3) fire-retardant impervious coveralls, flame-resistant clothing, coveralls to protect from a potential fire (fire-retardant clothing shall be worn where required by the owner/operators policies);
- 4) hardhats, head coverings, work gloves, safety shoes and boots, face shields, and goggles to minimize skin and eye exposure to hazardous substances and physical hazards;
- 5) the capability of certain clothing materials to generate static electricity (producing a static discharge).

8.1.3 Toxic Contamination

Entry supervisors shall ensure that if worker's skin, eyes, clothing, or equipment becomes contaminated with hazardous substances or toxic materials, appropriate response actions are immediately taken. Entry supervisors shall ensure that such response includes one or more of the following, as required:

- a) decontaminating the person by providing the necessary personal hygiene and showering;
- b) decontaminating and/or disposing of contaminated clothing and equipment;
- c) determining required first aid or medical care; or
- d) determining the extent of exposure and required medical surveillance or testing.

8.1.4 Inspection, Use, and Disposal

PPE shall be inspected prior to each use. Employees shall wear the appropriate PPE in accordance with the work task being performed. PPE shall meet applicable standards and regulations, and PPE shall not exacerbate present hazards or create any additional hazards for workers.

PPE use shall follow the manufacturer's recommendations, including recommendations for:

- safety considerations and limitations of use;;
- recommend storage practices;
- inspection frequency;
- donning/doffing procedures;
- maintenance, cleaning, and decontamination;
- removal from service criteria;
- change schedule, e.g. filters.

8.1.5 Regulatory Requirements

Employers and entry supervisors shall be aware of and implement the requirements of OSHA 29 *CFR* 1910.132–6, 1926.28, and/or other regulatory requirements applicable to the use of PPE.

8.2 Respiratory Protection

8.2.1 General

Employers shall establish and implement the proper respiratory protection programs to protect workers from occupational injuries, illnesses, and diseases caused by breathing air that is contaminated with harmful substances.

8.2.2 Respirator Selection

8.2.2.1 Entry supervisors shall ensure that available information covering the materials contained in the tank or used to clean the tank is reviewed by a qualified person to determine and select appropriate respiratory protection. This includes review of SDSs; product, sludge, and residue information; and specific health standards.

8.2.2.2 Employers shall provide workers with respirators that are appropriate and suitable for the potential exposures and the purpose intended. Employers shall ensure that equipment provided is not subject to deterioration or corrosion caused by product or residue in the tank, by chemicals used to clean the tank, or by solvents contained in tank coatings, paint, and liners.

8.2.2.3 Employers shall ensure that the respirators furnished to employees provide adequate respiratory protection against the particular hazard for which they are designed in accordance with standards established by competent authorities. In the United States, competent authorities include the Mine Safety and Health Administration (U.S. Department of Labor) and the National Institute for Occupational Safety and Health (U.S. Department of Health and Human Services).

8.2.2.4 Entry supervisors shall ensure that the appropriate respiratory protective equipment is selected, designated, and worn by workers, as established by the entry and work permits.

8.2.3 Regulatory Requirements

Employers, qualified persons and entry supervisors shall be aware of and review the appropriate requirements in government regulations and industry standards that are applicable to the use of respiratory protective equipment. In the United States, this includes, but is not limited to, ANSI Z88.1 and OSHA 29 *CFR* 1910.134, 1910.1000, 1910.1025, and 1910.1028.

8.2.4 Training

Employers shall ensure that entry supervisors and workers using respiratory protection receive instruction and training in the fit testing, inspection, cleaning, and use of respiratory protective equipment required by the permit and provided by the employer.

8.2.5 Respiratory Protection Program

Employers shall establish, implement, and maintain respiratory protection programs as required by government regulations (in the United States, OSHA 29 *CFR* 1910.134 covers respiratory protection requirements), industry standards and facility policy. The respiratory protection programs shall include the following requirements.

- 1) A written respirator program, including procedures governing the selection, inspection, maintenance, and use of respirators.
- 2) Respirator selection based on the potential hazards to which users may be exposed.
- 3) Instruction and training for users in the proper fit testing, inspection, wearing, and use of respirators and their limitations.
- 4) Procedures for cleaning and disinfecting respirators after each use.

- 5) Provision of convenient, clean, and sanitary storage locations for respirators.
- 6) Respirator inspection after each use and during cleaning.
- 7) Inspection of emergency use respirators after each use and at least once every month, if not used.
- 8) Appropriate surveillance of work area conditions and monitoring the degree of employee exposure or stress while using respirators.
- 9) Respirator clearance examination by a health care professional to ensure that workers assigned to tasks requiring the use of respirators are physically able to use the required respiratory protective equipment.
- 10) Periodic reviews and evaluations to determine the continued effectiveness of the written respiratory protection program, including and updating the respiratory protection program, when necessary.

8.2.6 Fitting, Testing, and Checking Respirators

8.2.6.1 Employers shall provide every respirator user with a properly fitting respirator. Training shall include demonstration and practice in the correct way to wear the respirator, its proper adjustment and fit, and checking instructions to determine that it fits properly.

8.2.6.2 To ensure proper protection, the users shall check the facepiece fit each time they don their respirators.

8.2.6.3 Fit checks performed by employees shall not be confused with the qualitative or quantitative fit testing that is conducted initially and periodically thereafter, by a qualified person, and in accordance with regulatory or employer requirements.

8.2.6.4 Respirators shall not be worn when conditions prevent a good face seal.

8.2.7 Breathing Air Cylinders

8.2.7.1 Employers shall require and a qualified person shall verify that breathing air supplied to respirators meets the appropriate regulatory requirements for breathing air, such as the specification for Grade D breathing air, as described in CGA G-7.1.

8.2.7.2 Entry supervisors shall ensure that approved (Grade D, or equivalent) breathing air is supplied to respirators from approved air supply cylinders.

8.2.7.3 Breathing air cylinders shall be equipped with low-level indicators or an alarm system.

8.2.8 Breathing Air Compressors

8.2.8.1 The use of breathing air compressors shall be allowed only when permitted by the employer.

8.2.8.2 A qualified person shall inspect and verify that breathing air compressors (or air compressors provided with an approved purification system) used to supply breathing air are approved for use and are in good operating condition. Breathing air shall be Grade D minimum, or equivalent.

8.2.8.3 The entry supervisor shall ensure that the breathing air compressor is located upwind of the tank and the fresh air intake is located above ground level and away from potential sources of exhaust gases, fumes, or flammable or toxic atmospheres from both internal (from the tank) and external (outside the tank) sources. These sources include internal combustion engine exhausts, vapors discharged from the tank, vapors emitted from vacuum truck operations, and vapors from nearby tanks during product receipts.

8.2.8.4 Entry supervisors shall assign a qualified person to act as a bottle watch to continuously monitor air compressor intake air quality, provide a constant breathing air supply, and ensure that the compressor is protected

from physical damage. Bottle watches shall immediately notify entrants to switch to emergency bottled air and leave the tank in case of compressed air supply contamination or failure.

8.2.9 Location of Breathing Air Cylinders

8.2.9.1 Entry supervisors shall ensure that breathing air cylinders are properly located to protect the air supply and the bottle watch from potential exposure to flammable or toxic vapors from both internal (from the tank) and external (outside the tank) sources.

8.2.9.2 The bottle watch shall maintain air supply cylinders in a secured, upright position and properly switch cylinders as required to provide a constant air supply and ensure that the cylinders are protected from physical damage and contamination.

8.2.9.3 The entry supervisor shall ensure that a qualified person inspects breathing air supply systems prior to each use and periodically during use to ensure the integrity and good condition of the air supply.

8.2.9.4 Bottle watches shall immediately notify entrants to switch to emergency bottled air and leave the tank in case of cylinder air supply failure.

8.2.10 Air Supply Lines, Hoses, and Couplings

8.2.10.1 The entry supervisor shall ensure that a qualified person inspects breathing air supply systems prior to each use and periodically during use to ensure the integrity and good condition of the air supply lines, hoses, and airline couplings.

8.2.10.2 Employers shall provide breathing air line couplings that are not compatible with outlet connections for other air or gas systems in the facility, including, but not limited to, nitrogen, industrial air, hydrogen, and oxygen.

8.2.10.3 Entry supervisors shall ensure that breathing air supply lines are isolated from plant utilities by use of non-matching connectors to prevent inadvertent servicing of air line respirators with non-respirable gases or oxygen.

8.2.10.4 The entry supervisor and bottle watch shall ensure that breathing air supply lines, hoses, and couplings are not used for supplying anything other than breathing air.

9 Tank-cleaning/Entry Personnel

9.1 General

9.1.1 Workers

Tank-cleaning/entry personnel (workers) shall be qualified persons. These workers include:

- a) testers;
- b) bottle watches;
- c) vacuum truck operators;
- d) operations personnel;
- e) safe (cold) work and hot work permit issuers;
- f) entry supervisors;
- g) tank-cleaning workers;