Exposure to the sun, use of heat tracing, steam or chemical cleaning, or hot work may heat sludge, residue, and rust to temperatures above ambient, thereby releasing vapors. Combustible liquids may also be heated to temperatures above their flash points, creating flammable vapors.

Flammable vapors may remain in areas of the tank due to stratification or channeling.

Flammable vapors may result from chemicals used to clean the tank and from solvents used in paints, coatings, and tank lining materials.

Flammable deposits including, but not limited to, hydrocarbon sludge, waxy deposits, residue, and oil-saturated rust and scale, may form on the underside of the tank roof, on walls, supports, and rafters, or on tank appurtenances. These deposits may be ignited by flames or heat that result from cutting, grinding, abrasive blasting, or welding operations on top of the roof, on the outside of the tank walls, or inside the tank. Whenever possible, such deposits should be removed and the area cleaned where work is to be done. If not removed, these deposits should be wetted down and kept wet in order to dissipate any heat buildup while hot work is being performed.

A.1.6 Toxic Substances

A.1.6.1 General

Potential toxic substance hazards are likely to be encountered in decommissioning, vapor and gas freeing, degassing, ventilating, entering, and cleaning storage tanks. Prior to entering tanks, reviewing the history of products stored in the tanks will aid in evaluating the potential hazards and determining the proper tests (that may be highly specialized and hazard-specific) that are to be conducted. Often, there are some commercial products stored in tanks that are not easily analyzed, and in these cases, special preventive measures and precautions may be required during tank cleaning operations.

OSHA regulations require employers to provide tank cleaning supervisors and workers with information about fire, safety, and health risks from products, materials, and substances contained within the tank. Safety data sheets (SDS), or equivalent, contain the basic fire, safety, and health information for each hazardous substance stored in the tank or used to clean the tank. Government health, safety, and environmental agencies are additional sources of information concerning toxic and hazardous substances that may be encountered during tank cleaning operations.

A.1.6.2 Exposure Hazards

Exposure of workers to toxic substances can result in irritation, injury, acute or delayed illness, or death, depending on the characteristics of the substances, their concentration, and nature and duration of exposure. Toxic substances can enter the body by inhalation, ingestion, skin and eye absorption, or injection. They can affect either the tissue at the point of contact or organs remote from the point of contact.

A.1.6.2.1 Irritants

Irritants are substances that cause minor or transient (but possibly painful) injuries that heal without scars and produce no known aftereffects. Many petroleum hydrocarbons and polar solvents are irritants.

A.1.6.2.2 Corrosives

Corrosives are substances that destroy tissue and leave permanent scars. Examples of corrosives include, but are not limited to, hydrofluoric acid, sulfuric acid, and caustics.

A.1.6.2.3 Acutely Toxic Substances

Acutely toxic substances are those that, by a single dose or short-term exposure, cause symptoms ranging from headache or nausea to disablement or death. Inhalation of hydrogen sulfide (H_2S), for example, is acutely toxic.

A.1.6.2.4 Chronically Toxic Substances

Chronically toxic substances produce physiological impairment with long latency (for example, cancer), with gradual progression (for example, pulmonary obstructive disease), or that may produce harmful reproductive effects.

A.1.6.3 Exposure Limits

Permissible exposure limits (PEL) as defined by OSHA, and threshold limit values (TLV) as defined by the American Conference of Governmental Industrial Hygienists (ACGIH), are terms commonly used to describe the concentration in air of an airborne toxic substance below which, it is believed, nearly all workers may be repeatedly exposed without adverse effects. These terms are normally expressed in parts per million (ppm) per volume of air or in milligrams per cubic meter of air (mg/m^3) in any 8-hour shift of a 40-hour workweek. (See ACGIH and OSHA 29 CFR 1910.100 for additional information.)

NOTE Although there are established PEL limits, different individuals have different capacities to withstand various exposures. Some individuals cannot tolerate the standard PEL levels without adverse physical reactions or responses. In such cases, employees should use protection to minimize exposure, even if the levels are below the PELs.

A.1.7 Hydrogen Sulfide (H_2S)

A.1.7.1 H_2S is an extremely toxic, colorless, flammable gas that is present in the production, storage, processing, and refining of sour crude oil and sour crude oil fractions. Since H_2S is heavier than air, it tends to collect in low places. It will displace air and is a flammable gas that burns in air. The explosive (flammable) limit of H_2S is 4.0 % to 44.0 % by volume in air. If H_2S is present in concentrations above 10 % LEL, it may ignite.

The atmosphere in any tank that contains sour crude stocks or sulfur-containing products (or has contained and has not been cleaned since) should be considered toxic, and special precautions are necessary for safe tank entry.

NOTE H_2S is typically eliminated by refining processes and is virtually absent from most finished products, with the exception of some heavy residual fuel oil and some asphalt.

At certain H_2S levels determined by the employer's hazard assessment, personnel should be evacuated from the work area.

A.1.7.2 Exposure Limits

OSHA has prescribed the permissible exposure limits (PEL) for H_2S as 10 parts per million (ppm) time-weighted average (TWA) in an 8-hour work shift and 15 parts per million (ppm) short-term exposure limit (STEL) averaged over 15 minutes.

A.1.7.3 Exposure Effects

In very low concentrations, H_2S is detectable by its characteristic foul, rotten-egg odor; however, a worker's sense of smell cannot be relied on to warn of dangerous concentrations because instantaneous exposure to slightly higher concentrations of the gas immediately paralyzes the sense of smell. Exposure to low concentrations of H_2S for a longer period also has a similar desensitizing effect. This desensitizing can result in a worker's failing to recognize the presence of dangerously high concentrations of H_2S. In low exposures, H_2S is irritating to the eyes and respiratory tract. Repeated short exposure to low concentrations of H_2S may lead to chronic irritation of the eyes, nose, and throat; however, the effects of such exposure are not cumulative and the symptoms usually disappear soon after removal from the exposure. Exposure to high concentrations of H_2S causes death by paralysis of the respiratory system.

Caution—Workers should not depend on their sense of smell to detect the presence of H_2S.

A.1.7.4 Exposure Measurement

The concentration of H_2S in an atmosphere can be measured with various H_2S indicators and measuring instruments. The accuracy and response times of such indicators vary. A test for H_2S should be made before any work is started on tanks that may have contained products with H_2S, including, but not limited to, sour crude oil and sour stocks. Even though initial test measurements may indicate that the H_2S concentration is within acceptable limits for both flammable and toxic exposures, the atmosphere in and around the tank should be monitored continuously during tank cleaning operations for the presence of H_2S.

A.1.8 Organic (Tetraethyl) Lead

A.1.8.1 Organic lead compounds (lead alkyls) including, but not limited to, tetraethyl lead (TEL), tetramethyl lead (TML), or mixtures of lead alkyls are added to gasoline in order to raise the octane rating. Lead alkyls are completely miscible with gasoline, will not separate out of a mixture, and are generally stable, as there is essentially no decomposition of the lead alkyl in gasoline while in the tank. Lead alkyls have a vapor pressure lower than that of gasoline, but are volatile enough to produce potentially lethal concentrations of organic lead vapors in the atmosphere of the tank. Although leaded gasoline production, use, and storage is very limited within the United States, production continues in other countries, and tanks storing it present an organic lead hazard.

Every storage tank that has been used to store lead additives, leaded gasoline, and other products containing lead alkyls has a potential toxic organic lead exposure hazard. This is because, in many cases, tanks used for the storage of lead additives, gasoline, and other products containing lead alkyls may not have been cleaned and documented as being lead-hazard-free prior to their use for storage of unleaded products. The operating record of a tank is the most reliable means of determining what materials or products were stored in the tank, as there is no analyzer or test method that can determine whether a tank has previously been in leaded service until it has been cleaned and tested. Any testing of the tank for lead hazard before cleaning or during the cleaning process will result in unreliable information. Every storage tank is considered a leaded storage tank, unless there is conclusive evidence that the tank was never used to store lead additives, leaded gasoline, and other products containing lead alkyls, or the tank had been previously properly cleaned, tested, and documented to be lead-hazard-free and thereafter used only for storage of unleaded products.

When cleaning leaded gasoline tanks, the primary source of the organic lead hazard is in the sludge at the bottom of the tank. The sludge is a mixture of hydrocarbons, residue, and water that contains organic lead. A secondary source of organic lead hazard is from the residue clinging to the walls and structure of the tank. As the cleaning process progresses and the sludge is agitated and the residue is removed, the more volatile hydrocarbon components containing lead alkyls will vaporize into the atmosphere.

A.1.8.2 Exposure Limits

OSHA has prescribed permissible exposure limits (PEL) for organic lead of 0.075 milligrams of organic lead per cubic meter (2 micrograms per cubic foot) and has indicated a skin designation for organic lead. See OSHA chemical sampling information for tetraethyl lead.

A.1.8.3 Exposure Effects

Because lead alkyls are toxic through all four routes of exposure (inhalation, skin and eye absorption, ingestion, and injection), appropriate respiratory protection, protective clothing, and eye protection are required. Symptoms and effects of organic lead exposure vary, depending on the degree of exposure and whether the toxic effect results from a single high-level exposure or from a number of relatively low-level, cumulative exposures over an extended period of time. Effects range from subtle to serious central nervous system disorders, psychological symptoms, and gastrointestinal dysfunction. The greatest potential for organic lead poisonings during tank cleaning operations occurs when entrants inside a leaded-gasoline storage tank do not wear appropriate air-supplied or self-contained breathing equipment.

A.1.8.4 Exposure Measurement

The existence and concentration of organic lead in an atmosphere can only be measured using special organic lead-in-air analyzers that work on the principal of chemical ionization. There are no direct-reading organic lead-in-air measuring instruments. A test for lead in air is recommended before any work is started on tanks that may have contained leaded products or additives. The tank should be thoroughly clean and dry for test results to be accurate. Even though initial test measurements may indicate that the lead-in-air concentration is within acceptable limits, test the atmosphere in the tank periodically whenever work is being performed that may release vapors, fumes, or liquid. This would include, but not be limited to, removal from interstitial spaces, opening columns or pontoons, or disturbing, removing, or heating deposits, sludge, or residue.

A.1.9 Airborne Dusts

The potential exists for workers to be exposed to hazardous dust from deposits, rust, paint chips, blasting grit, and tank insulation during tank cleaning and maintenance operations. Examples of toxic dust include, but are not limited to, silica from abrasive blasting, asbestos, inorganic lead, chromate, and zinc. Safety data sheets (SDS) can provide information on any chemical product that may be found in or introduced into the tank. Depending on the type of dust, engineering controls (such as filtration) can be used to control exposures as well as selection of personal protective equipment, including respiratory protection and protective clothing.

Dust can enter the body by inhalation, by ingestion via eating, drinking, or smoking on the job, or by eye contact.

A.1.9.1 Exposure Limits

ACGIH Threshold Limit Values and Biological Exposure Indices and OSHA 29 CFR 1910.1000 offer information and requirements regarding exposure limits for mineral and nuisance dusts.

A.1.9.2 Exposure Effects

Depending on its toxicity, cumulative exposure to any specific hazardous dust may result in damage to the blood, respiratory system, nervous system, kidneys, bones, heart, and reproductive system. Chronic symptoms vary and may not appear for many years. Acute exposures to some types of dust, such as asbestos, lead or silica, may result in respiratory or other illnesses, depending on the type of dust and the means of entry. Exposure to small amounts of other types of less hazardous dust may cause respiratory, headache, dizziness, and sinus problems.

A.1.9.3 Exposure Measurement

Selection of appropriate monitoring should be based on the type of airborne dust. An industrial hygienist can assist in recommending the appropriate method of testing.

Tank cleaning operations, such as grinding, scraping, paint and coating removal, and blast cleaning, can create potentially hazardous dust, and each exposure requires its own testing protocols.

A.1.10 Other Toxic Substances

The potential exists for workers to be exposed to toxic vapors, liquids, and solid materials contained in crude and petroleum products during tank decommissioning, cleaning, and maintenance operations. Examples of potentially toxic substances that may be encountered during tank cleaning include, but are not limited to, aromatic and naphthenic liquids, mists, and vapors; tank cleaning solvents; and sludge, residue, and deposits containing aromatics, naphthenics, heavy metals (other than lead), tank cleaning chemicals, acids, and caustics, tank coating and lining materials, products containing naturally occurring radioactive materials (NORM), and other substances not specifically referred to in this recommended practice that have the potential to create toxic exposures for tank cleaning workers. (See API Bulletin E3 for information on NORM.)

Toxic and harmful exposures to these substances can occur through ingestion, inhalation, and skin and eye absorption. Hazard assessments should be performed to determine potential exposures as well as appropriate air sampling protocols and methods.

A.1.10.1 Exposure Limits

OSHA requires that SDSs (or equivalent substance information) be made available by the employer from the substance supplier. Government health, safety, and environmental agencies may also provide information.

A.1.10.2 Exposure Effects

Effects of absorption of toxic petroleum substances can range from mild dermatitis (from low-level, short exposures) to more serious health effects, including cancer (from long-term, repeated exposures). Inhalation of high concentrations of hydrocarbon vapors can initially cause signs and symptoms of intoxication. Symptoms can also vary from dizziness to excitement to unconsciousness, and are similar to those produced by alcohol or anesthetic gases. If such effects occur, the worker should be immediately removed to fresh air. If breathing has stopped, artificial respiration (by a person qualified in CPR) should be started promptly and medical assistance immediately summoned. If the exposure is minor, breathing fresh air or inhaling pure oxygen may result in rapid recovery.

A.1.10.3 Exposure Measurement

In most cases, the concentration of a toxic hydrocarbon vapor-in-air exceeds its permissible exposure limit (PEL) or threshold limit value (TLV) at levels well below 10 % LEL. (For example, benzene is considered hazardous at very low concentrations in the range of 1 ppm (part per million) for a time-weighted 8-hour exposure and 5 ppm for a short-term, 15-minute exposure). Therefore, flammable (combustible) vapor indicators are not acceptable for measuring airborne concentrations of toxic hydrocarbon vapors. Use substance analyzers to determine the level of concentration.

Consult an industrial hygienist for assistance with the different hazardous substances.

A.1.11 Fumes

Toxic fumes are generated when welding or cutting metals coated with or containing alloys of lead, zinc, cadmium, chromium, beryllium, and certain other metals. Some paints may produce toxic fumes when heated with a cutting or welding torch. The toxicity, composition, concentration and quantity of fumes depends on the materials being welded or cut, the coatings or paints, the composition of the welding rods, the welding process in use and the circumstances of use including, but not limited to, local exhaust provisions, ventilation, tank size, and configuration and environmental conditions.

Local exhaust equipment can be an effective engineering control to reduce employee exposures.

A.1.11.1 Exposure Hazards

Exposure to welding fumes occurs primarily through inhalation.

A.1.11.2 Exposure Limits

Safety and health information about the hazards of welding fumes, precautionary measures, and exposure limits is available from industry and government sources. (See ACGIH, ANSI Z49.1, API 2009, NFPA 51B, and OSHA 29 CFR 1910.251 and 1910.1000 for additional information.)

A.1.11.3 Exposure Effects

The potential health effects of exposure to welding fumes vary in type and severity, from mild to extremely serious, depending on the materials being welded, any residue, deposits, coatings or paints, the composition of the welding rods, the welding process, and the degree and extent of exposure.

A.1.11.4 Exposure Measurement

Flammable (combustible) vapor indicators cannot be used to measure welding fumes. Consult an industrial hygienist for assistance in appropriate exposure measurement protocols.

A.1.12 Lead-based Paints

Inorganic lead has been a common component of paints and coatings used to protect both the outside and inside of storage tanks for many years. As lead hazards became known, nonindustrial uses of lead were discontinued. However, due to the excellent resistance of lead-based paint to rust and chemical corrosion, it is still used for many industrial applications. Inorganic lead has also been used as a lubricity additive in some petroleum products, including, but not limited to, metal working oils and gear oils, and traces may remain in tanks used to store such products.

Prior to commencing work (including demolition) on a tank where the potential for lead exposure exists, OSHA requires employers to determine if lead-based paint is present and if it poses a hazard. If the work activities will disturb lead, OSHA requires a written program for the safe removal and handling of lead-based paint and other lead-containing materials. This program includes procedures for the use of appropriate engineering controls, work practices, respiratory protection, and personal protective equipment to keep exposure to inorganic lead below its permissible exposure limits. In addition, depending on the activities and potential exposure, the program may also include procedures for exposure assessment, medical surveillance, and training supervisors, qualified persons, entrants, attendants, rescuers, and workers. (See OSHA standard 29 CFR 1926.62, Lead in Construction, for further information.)

A.1.12.1 Exposure Hazards

Inorganic lead is a systemic, cumulative poison that can enter the body by inhalation of its dusts or fumes, by ingestion via eating, drinking, or smoking on the job, or by contact with paint, coatings, and additives. Significant lead exposure can occur during removal of paint from surfaces previously coated with lead-based paint by various methods, including, but not limited to, abrasive blasting of lead-based painted structures, using torches or heat guns, and sanding or grinding lead-based painted surfaces. Exposure to lead may also occur when flame-torch cutting, welding, or conducting other heat-producing operations during the renovation, dismantling, and demolition of storage tanks.

A.1.12.2 Exposure Effects

Cumulative exposure to lead may result in damage to the blood, nervous system, kidneys, bones, heart, and reproductive system. Symptoms vary, and include loss of appetite, constipation, and colicky abdominal pain. Nervous system complaints include headache and irritability.

A.1.12.3 Exposure Limits

OSHA has prescribed the permissible exposure limits (PEL) for inorganic lead as 50 micrograms per cubic meter on a time-weighted average (TWA) in an 8-hour work shift.

A.1.12.4 Exposure Measurement

There are currently no direct-read devices to measure airborne lead. OSHA requires personal monitoring of a representative sample of workers for each task. Air monitoring results should be performed by a certified laboratory, and results are not available in real time. OSHA requires that the results are communicated to exposed workers within a specified time frame. Handling of spent blasting grit and paint residue may result in exposures, in addition to those generated during removal activities.

A.1.13 Heat, Humidity, and Cold Exposure

The potential exists for stress-related exposures to workers during tank cleaning operations, including, but not limited to, heat stress inside tanks during warm or hot weather, heat exhaustion, exposure to cold weather, and physiological hazards (such as claustrophobia). There is a significant difference between heat exhaustion and heatstroke. Knowing the difference is critical to proper first aid, and untreated heatstroke can be fatal.

A.1.13.1 Heat and Humidity

An aboveground storage tank can absorb enough heat from direct sunlight to cause a significant temperature increase inside the tank, as compared to the ambient temperature.

If water is used for cleaning, the humidity in the tank may be high, increasing the heat index.

Protective clothing or equipment contributes to potential heat stress inside storage tanks when ambient temperatures are high. When wearing semi-impermeable or impermeable clothing, entrants and workers can encounter heat stress working in temperatures as low as 21 °C (70 °F).

While there are no specific OSHA standards on this topic, OSHA offers assistance and interpretations outlining work-break requirements when working under hot and humid conditions. Various OSHA sanitation standards cover requirements to providing sufficient quantities of drinking water to workers in these conditions.

Engineering controls, such as refrigerant dehumidification, whose primary function may be for environmental quality control, also offer a benefit to reduce heat stress for workers inside tanks under hot and humid ambient conditions.

A.1.13.2 Cold

Exposure to cold may occur even if temperatures are above freezing. If employees are not properly clothed, hypothermia may occur. In extremely low temperatures, unprotected skin, such as ears, nose, and extremities, may be subject to frostbite. Proper clothing and regular opportunities to access heated areas are helpful in reducing cold-related stress.

A.1.13.3 Claustrophobia

While it may be easily overlooked, fear of enclosed or confined spaces is very real to workers who experience claustrophobia. Workers who have a fear of entering or working in confined spaces should not be forced to work under these conditions.

A.1.14 Physical Hazards

Physical hazards may be a function of a tank's design or its condition, or result from operational activities or emergency conditions that occur elsewhere in the facility and affect the tank cleaning operation. Typical physical hazards and situations that may be expected to be encountered during tank cleaning operations include, but are not limited to, the following:

- internal tank configuration with inwardly converging walls or bottoms that slope downward, tapering to smaller cross-sections that could trap or asphyxiate workers;
- tripping, falling, and bumping hazards from the internal structural components of a tank;
- sharp metal edges, welds, etc., within the tank that can snag clothing or skin and tangle or cut hoses and retrieval lines;
- corroded roofs, decks, scaffolds, and stairways that are unsafe to walk or work on or under;
- lightning storms, emergencies, environmental extremes, and receipt of product into nearby tanks;
- structural failure of the tank shell, internal or external roof, roof support members, swing-line cables, braces, pontoons, or other tank members;
- falls from elevations such as roofs, scaffolds, decks, wind girders, stairs, and ladders;
- accidental discharge of steam, high-pressure air, water, or oil, either into the tank or against workers inside or outside the tank;
- rust scale or other objects falling from overhead;
- tripping hazards from hoses, pipes, tools, or tank cleaning equipment inside and outside the tank;
- slipping on wet or oily surfaces;
- poorly or inadequately lighted work areas;
- failures to disconnect, de-energize, or make electrical, hydraulic, pneumatic, or mechanical equipment inoperative;
- exposure to noise above acceptable levels (use of power tools inside the tank);
- tank contains a material with the potential to engulf an entrant;
- inadequate or restricted working space;
- openings, holes, sumps, cracks in tank bottoms, and uneven tank bottom plates;
- restricted access and egress into, around, and on top of the tank.

A.2 Unique Tanks and Special Situations

A.2.1 General

Vapor freeing, degassing, ventilating, and cleaning extremely large or specially designed aboveground, atmospheric storage tanks may present unique problems because of the tanks' great volumes, large diameters, or unusual configurations.

In addition, particularly for older tanks, available information on the initial design and construction requirements and the various services in which the tank has been used can offer guidance when performing a hazard assessment.

Unusual or potentially hazardous conditions may be found in these special tanks due to their size, shape, design, and/or configuration, including, but not limited to, the following:

- very large tanks;
- floating roof tanks (see A.3 for floating roof hazards);
- double-wall and double-bottom tanks;
- low-pressure storage tanks; and
- conservation tanks.

A.2.2 Very Large Tanks [> 61 m (> 200 ft) in Diameter]

The requirements for decommissioning, vapor, and gas freeing, degassing (where required), ventilating, entering, cleaning, and recommissioning, as described in this standard, apply to all fixed (cone) roof, open top, and covered open top tanks. Very large, multimillion-barrel tanks, generally about 61 m (200 ft) in diameter or larger, require special consideration and additional tank cleaning precautions and safety procedures, such as those described below.

- Multiple and simultaneous use of eductors and air blowers are required to increase air flow when vapor and gas freeing (degassing) and ventilating large tanks.
- Very large tanks may not have been completely freed of vapor and ventilated to the required limits due to channeling.
- Maintaining adequate communications between attendants and testers or entrants in large tanks can be challenging.
- Large tanks present unique rescue situations due to the potential distances to the victims.

A.2.3 Double-wall and Double-bottom Tanks

A.2.3.1 General

Double-wall and double-bottom tanks present unique challenges to tank cleaning entrants and workers. The area between the double walls may be either empty or filled with an insulation material, and the area between the double bottoms may be filled with sand or other material. Even though the primary tank has been vapor-freed, the potential exists for the interstitial space between the double walls or double bottoms of tanks to contain liquid and/or vapor.

A.2.3.2 Vapor Freeing

Ensure that these areas are inspected, drained, vapor-freed, and tested, and that liquid and vapors do not reenter the tank during the tank cleaning process.

Remove liquids from interstitial spaces prior to vapor freeing. This may be accomplished by draining through available fittings (or hot-tapping new fittings) and by water or fuel oil displacement.

Vapor freeing insulated or sand-filled interstitial spaces may be accomplished by using inert gas. Low-pressure compressed air may also be used to dilute vapors and ventilate interstitial spaces.

Empty spaces may be vapor-freed by inert gas purging, water displacement, or ventilation with fresh air.

A.2.3.3 Return to Service

Before returning double-wall and double-bottom tanks to service, ensure that the interstitial space is air dried and tested to verify that there is no leakage. Ensure that any insulation or sand that was removed during the tank cleaning process has been replaced with new material, and that old material is disposed of properly.

A.2.4 Low-pressure Storage Tanks

A.2.4.1 General

Many of the methods, procedures, and precautions for vapor freeing, degassing (where required), ventilating, and cleaning liquid petroleum atmospheric cone (fixed) roof storage tanks also apply to low-pressure liquefied hydrocarbon gas storage tanks. Low-pressure storage tanks are used to store liquefied hydrocarbon gases and refrigerated products at relatively low pressures. Low-temperature liquefied gas, such as ethane, ethylene, and methane, is stored at or near atmospheric pressure and at temperatures corresponding with the initial boiling point of the liquid at the storage pressure. Refrigerated products, such as liquefied natural gas, butane, butadiene, and propane, are stored under a combination of near-atmospheric pressure and low temperatures.

A.2.4.2 Low-pressure Tank Design

Low-pressure storage tanks may be single-wall, insulated tanks or double-wall tanks, consisting of an inner tank storing the refrigerated liquid and an outer tank that encloses an insulation space (that usually has a lower gas pressure) around the inner tank. Double-wall tanks are composite tanks, wherein the outer tanks are not required to structurally contain the product of the inner tanks.

A.2.4.3 Vapor Freeing

Safe operating procedures will vary with the type of tank, its location, requirements for vapor and gas disposal, and availability of water and inert gas.

After recovering as much product as possible from a low-pressure storage tank, the tank is to be isolated from other equipment, except for the pump-out line. Ensure that tank cleaning workers are aware of the potential physical hazards of frost burns resulting from contact with discharged product or uninsulated low-temperature piping and valves.

Where the pump-out connection is above the bottom of the tank, water should be pumped into the tank (at a rate no greater than the pump-out rate) through a bottom connection in order to float liquid hydrocarbons to the pump-out connection. A check valve should be provided to prevent back flow. The tank should be structurally able to hold the weight of the water to be used.

After all liquid hydrocarbons are flushed, the water should be removed through the water draw-off system. The water draw-off valve is closed as soon as vapor appears. The tank will now contain gas under pressure. The remaining gas should be vented to a degassing system, if available or required. If gas is vented to the atmosphere, it is released at an elevation high enough above ground level [minimum 3.7 m (12 ft)] to safely disperse the vapors. The tank may then be gas-freed by displacement with water or purging with an inert gas, followed by ventilating with low-pressure fresh air.

A.2.4.4 Other Vapor-freeing Methods

Another method of gas freeing is the use of low-pressure compressed air to dilute and displace the flammable gas. However, at some stage in this process, the tank's atmosphere will be in the explosive (flammable) range.

Low-pressure, nonrefrigerated tanks may be gas freed by being completely filled with water after all of the liquid is pumped out and the tank is depressurized. The gas is dispersed out of a closed system through a water knockout drum, through a degassing system, or to the atmosphere at a safe level [minimum 3.7 m (12 ft)] above ground level. Upon completing gas freeing, the water level should be lowered and a check made for any remaining gas that may have been trapped in the interior of the tank. The tank should then be ventilated with fresh air after removal of the water.

If double-wall, low-pressure tanks contain gas within the interstitial space, this area should also be gas-freed by using inert gas or low-pressure compressed air.

A.2.4.5 Return to Service

When returning low-pressure and refrigerated tanks to service after cleaning, dry inert gas should be used to purge the tanks of all air prior to receiving low-temperature liquefied gas. If dry inert gas is not available, LPG vapor or natural gas may be used.

A.2.5 Conservation Tanks

A.2.5.1 Tank Designs

Conservation tanks are designed to provide for and contain expanding vapors from liquid petroleum products, such as high-octane aviation gasoline, that readily vaporize at ambient temperatures. When temperatures decrease, the vapor condenses back into the liquid product with little or no vapor loss. Conservation tanks include, but are not limited to, the types in the following sections.

A.2.5.1.1 Wet Seal Lifter Tank

A wet seal lifter tank is a fixed (cone) roof tank that contains a telescopic vertical lift or gas-holder roof that rises to increase the volume of the vapor space. The lifter roof has a skirt around its perimeter that dips into a liquid seal (normally fuel oil) contained in a trough around the top of the tank shell.

A.2.5.1.2 Flexible Diaphragm Tank

A flexible diaphragm tank is a fixed (cone) roof, variable-vapor-space tank with an internal flexible membrane that provides an expandable volume. As vapors expand due to temperature increases or when the product tank is being filled, the flexible diaphragm contains the vapors without allowing venting to the atmosphere. Conversely, the diaphragm prevents atmospheric air from entering the vapor space. The vapor tank may be a separate auxiliary tank or a smaller, integral vapor tank mounted on top of the primary fixed roof tank that confines and shelters the diaphragm. Newer vapor tanks are separated by the fixed roof of the primary tank and are connected to the primary tank by piping, whereas older vapor tanks were separated from the primary tank by the diaphragm only. Another type of flexible diaphragm tank is a sphere with an internal membrane.

A.2.5.1.3 Breather Balloon Tank

A breather balloon tank is a fixed (cone) roof tank with a separate, top-mounted breather balloon bag that operates on the same principle as the flexible diaphragm tank. The breather balloon requires a separate weather-protective housing. There are probably none of these tanks remaining in service today.

A.2.5.2 Vapor-freeing Conservation Tanks

Vapors will be present inside the primary tank and inside the conservation space. In addition, vapors may be present in the space between the conservation diaphragm and the tank shell. The space inside the primary tank, the vapor expansion space inside the expansion tank, and, where applicable, the space between the diaphragm and the tank shell should be treated as separate entities when establishing the methods to be used to vapor-free conservation tanks. These methods should be similar to those used to vapor-free internal floating roof tanks, but should be adjusted according to each specific situation.