

Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks

ANSI/API RECOMMENDED PRACTICE 2016
FIRST EDITION, AUGUST 2001



**Helping You
Get The Job
Done Right.SM**

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FOREWORD

This recommended practice was prepared under the auspices of the API Safety and Fire Protection Subcommittee. It is provided for the use of API member companies and others in the development and implementation of company and facility specific safe practices for planning, managing, and conducting tank cleaning operations in petroleum storage tanks.

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CONTENTS

	Page
1 GENERAL	1
1.1 Scope	1
1.2 Applicability	1
1.3 Regulatory Requirements	1
1.4 Administrative Controls and Procedures	1
2 REFERENCES	2
2.1 Codes, Standards, and Related Publications	2
2.2 United States Government Regulations	2
2.3 Other Publications and References	3
3 DEFINITIONS	3
3.1 General	3
3.2 Definitions	3
4 PETROLEUM STORAGE TANK HAZARDS	8
4.1 Hazards	8
4.2 Oxygen Deficiency and Enrichment	8
4.3 Fires and Explosions	9
4.4 Toxic Substances	11
4.5 Stress Exposures	17
4.6 Physical and Other Hazards	17
5 VAPOR AND GAS FREEING, DEGASSING, AND VENTILATING TANKS	18
5.1 General	18
5.2 Vapor and Gas Freeing (and Degassing) Hazards	19
5.3 Mechanical Vapor and Gas Freeing	20
5.4 Steam Vapor Freeing	31
5.5 Natural Ventilation	31
5.6 Inert Gas Purging	32
5.7 Displacement of Vapors Using Water (Fuel Oil)	33
5.8 Degassing	33
6 REMOVING SLUDGE AND RESIDUE FROM TANKS	39
6.1 General	39
6.2 Pumping and Vacuum Equipment	39
6.3 Safe Removal Precautions	39
6.4 Noninvasive Removal	40
6.5 Removal from Outside the Tank	40
6.6 Removal from Inside the Tank	43
6.7 Sludge Disposal	43
7 UNIQUE TANKS	44
7.1 General	44
7.2 Very Large Tanks	44
7.3 Floating Roof Tanks	44
7.4 Double Wall and Double Bottom Tanks	47
7.5 Low Pressure Storage Tanks	48
7.6 Conservation Tanks	49

	Page
8	SPECIFIC HAZARDOUS SUBSTANCES 49
8.1	General 49
8.2	Tanks with Pyrophoric Iron Sulfide Deposits 49
8.3	Cleaning Tanks With Products That Contain Hydrogen Sulfide (H ₂ S) 50
8.4	Tanks That Have Been In Leaded Service 51
8.5	Tanks Containing Hazardous Sludge and Residue 53
9	CONTROL OF IGNITION SOURCES 54
9.1	General 54
9.2	Internal Combustion Engines 54
9.3	Electrical Motors and Generators 55
9.4	Artificial Lighting 55
9.5	Electrical Bonding 55
9.6	Lightning Storms 55
9.7	Pyrophoric Iron Sulfide Deposits 56
9.8	Hot Work 56
9.9	Smoking 56
10	TANK CLEANING CHECKLIST 56
10.1	General 56
10.2	Preplanning 56
10.3	Removing Recoverable Product 61
10.4	Tank Isolation. 66
10.5	Vapor-Freeing the Tank 67
10.6	Atmospheric Testing 69
10.7	Cleaning the Tank 71
10.8	Working Inside and Around the Tank 78
10.9	Returning the Tank to Service 80
10.10	Recommissioning 81
10.11	Recommissioning Safety Check 83
11	OXYGEN, COMBUSTIBLE GAS, AND TOXIC SUBSTANCE INSTRUMENTS 85
11.1	General 85
11.2	Oxygen Monitors 85
11.3	Combustible Gas (Flammable Vapor) Indicators 85
11.4	Toxic Substance Testing Instruments 87
12	FLOATING ROOF HAZARDS ASSOCIATED WITH TANK CLEANING. 88
12.1	General 88
12.2	Applicability 88
12.3	Floating Roof Stability 88
12.4	Floating Roof Legs 89
12.5	Roof Failure and Collapse 89
12.6	Entry Onto or Below Floating Roofs (and Into Pontoons). 93
12.7	Inspections 93
12.8	Floating Roof Temporary Support Requirements. 94

Figures

4-1	Example of Ventilation for Welding Fumes During Hot Work 15
5-1	Tank Ventilation Guidelines 21

	Page	
5-2	Example of Air Mover Located on Shell Manway of Tank	22
5-3	Example of Tank Mechanical Vapor-Freeing Equipment	22
5-4	Sample Tank Ventilation Guidelines	24
5-5	Examples of Typical Ventilation Arrangement	26
5-6	Example of Vapor Freeing a Cone Roof Tank	27
5-7	Examples of Vapor Freeing an External Floating Roof Tank	28
5-8	Comparison of Tank Degassing Methods	34
5-9	Example of Thermal Oxidation Degassing	35
5-10	Example of Thermal Oxidation Unit—Internal Combustion Engine	36
5-11	Sample Tank Degassing Refrigeration Process	37
5-12	Sample of Tank Degassing Using Activated Carbon	38
6-1	Example of Eductors Used for Tank Agitation	41
6-2	Example of Water Balancing	42
10-1	Sample Hazard Assessment Checklist	58
10-2	Sample Contractor Screening Checklist	59
10-3	Sample Safe Work Checklist	60
10-4	Sample Supervisor’s Safety Inspection Checklist	62
10-5	Sample Emergency Action Plan	63
10-6	Sample Emergency Plan	64
10-7	Sample General Entry Permit (Page 1 of 2)	72
10-7	Sample General Entry Permit (Page 2 of 2)	73
10-8	Sample Confined Space Entry Permit	74
10-9	Sample Confined Entry Permit (Page 1 of 2)	75
10-9	Sample Confined Entry Permit (Page 2 of 2)	76
10-10	Sample Safe (Cold) Work, Hot Work, and Entry Permit	79
10-11	Sample Final Tank Cleaning Inspection Checklist	82
12-1	Example of Floating Roof Supports	90
12-2	Examples of Floating Roof Support Legs	91
12-3	Examples of Radial Beams with Anti-Rotation Brackets	96
12-4	Example of Floating Roof Leg Blocks	96
12-5	Example of Temp. Lateral Support Beam	97
12-6	Example of Rim Wedges	98

Tables

4-1	Explosive (Flammable) Ranges of Hydrocarbon Vapors and Gas	10
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Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks

1 General

1.1 SCOPE

ANSI/API Recommended Practice 2016, First Edition, *Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks*, supplements the requirements of ANSI/API Standard 2015, Sixth Edition, *Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks*. This recommended practice provides guidance and information on the specific aspects of tank cleaning, in order to assist employers (owners/operators and contractors) to conduct safe tank cleaning operations in accordance with the requirements of ANSI/API Standard 2015.

1.2 APPLICABILITY

This recommended practice is applicable to stationary atmospheric and low-pressure (up to and including 15 psig) aboveground petroleum storage tanks, used in all sectors of the petroleum and petrochemical industry, including crude oil and gas production, refineries, petrochemical plants, bulk plants, and terminals. Information applicable to entering and cleaning conservation tanks, low pressure storage tanks, and vessels and tanks containing specific hazardous substances is also included in this recommended practice. Employers (owners/operators and contractors) should use the information provided in this recommended practice to help develop the site, tank, and project specific guidelines and procedures required by ANSI/API Standard 2015 to ensure that the tank cleaning operations are conducted safely.

This recommended practice does not and cannot cover every possible unique situation that may arise during tank cleaning operations. Employers (owner/operators and contractors) shall use the appropriate principles and requirements provided in ANSI/API Standard 2015, supplemented by the practices, procedures, and considerations provided in ANSI/API Recommended Practice 2016, to address site specific and tank specific situations.

1.3 REGULATORY REQUIREMENTS

In addition to the requirements contained in ANSI/API Standard 2015, persons engaged in tank cleaning activities shall refer to applicable federal, state and local government regulations pertinent to specific circumstances, including regulations of governments other than those of the United States, where appropriate. ANSI/API Recommended Practice 2016 is intended to be consistent with Title 29 of the U.S. *Code of Federal Regulations*, Occupational Safety and Health Administration, and applicable NFPA Codes and Standards as they

apply to entering and cleaning aboveground petroleum storage tanks. If any provision of this recommended practice conflicts with statutory or regulatory requirements, said statutes and regulations shall govern. This recommended practice is not intended to function as a substitute for applicable regulations, codes, standards or employer (owner/operator and contractor) safe work practices and guidelines which must be reviewed in their entirety to determine their applicability to the facility, its location, the tanks involved and the proposed work.

1.4 ADMINISTRATIVE CONTROLS AND PROCEDURES

In accordance with the requirements of ANSI/API Standard 2015, employers (owners, operators or contractors) shall develop and implement appropriate administrative controls, procedures, and written plans for tank preparation, entry, and cleaning operations from decommissioning through recommissioning, including, but not limited to, the following:

- Tank pre-cleaning planning and meeting.
- Storage tank, area, atmospheric, physical and product hazard assessments.
- Entry permit requirements, limitations, issuance and cancellation.
- Identification, designation and classification by the employer of permit required confined spaces, non-permit required confined spaces and non-confined spaces.
- Entry requirements for each designated confined space.
- Safe (cold) work and hot work permit requirements.
- Vapor and gas freeing, degassing, testing, and ventilation requirements.
- Training and personal protective equipment requirements for workers and supervisors.
- Emergency response requirements, rescue operations and rescue capability.
- Contractor selection and responsibilities.
- Owner/operator responsibilities.
- Tank cleaning procedures, equipment and sludge/residue disposal.
- Regulatory and facility requirements applicable to tank cleaning operations.

2 References

2.1 CODES, STANDARDS, AND RELATED PUBLICATIONS

The following industry and consensus standards, codes, and publications referenced in ANSI/API Recommended Practice 2016 provide information related to safe entry and cleaning of petroleum storage tanks. The most recent edition or applicable code, standard, or publication should be consulted, as appropriate:

ACGIH¹

Documentation for Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices and Documentation

ANSI²

Z49.1 *Safety in Welding and Cutting*
Z88.1 *Respiratory Protection*

API³

Bul E2 *Bulletin on Management of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Production*
Std. 650 *Welded Steel Tanks for Oil Storage*
RP 2003 *Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents*
Publ 2009 *Safe Welding and Cutting Practices in Refineries, Gas Plants and Petrochemical Plants*
Std. 2015 *Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks*
Publ 2026 *Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service*
Publ 2027 *Ignition Hazards Involved in Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service*
Publ 2202 *Dismantling and Disposing of Steel from Aboveground Leaded Gasoline Storage Tanks*
Publ 2207 *Preparing Tank Bottoms for Hot Work*

¹American Conference of Governmental Industrial Hygienists, Kemper Meadow Center, 1330 Kemper Meadow Drive, Cincinnati, OH 45240.

²American National Standards Institute, 25 West 43rd Street, New York, NY 10036.

³American Petroleum Institute, 1220 L Street, NW, Washington, D.C. 20005.

Publ 2217A *Guidelines for Work in Inert Confined Spaces in the Petroleum Industry*

Publ 2219 *Safe Operating Guidelines for Vacuum Trucks in Petroleum Service*

International Chamber of Shipping, Oil Companies International Marine Forum and International Association of Ports and Harbors⁴

ISGOTT *International Safety Guide for Oil Tankers and Terminals*

NFPA⁵

NFPA *Fire Protection Handbook*
30 *Flammable and Combustible Liquids*
51B *Cutting and Welding Processes*
70 *National Electrical Code*
326 *Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*

2.2 UNITED STATES GOVERNMENT REGULATIONS

The following United States government regulations and publications provide information related to safe entry and cleaning of petroleum storage tanks in the United States. The most recent applicable regulation should be consulted, as appropriate:

NIOSH⁶

2533 *Manual of Analytical Methods*

OSHA⁷

29 CFR 1910.106 *Flammable and Combustible Liquids*
29 CFR 1910.134 *Respiratory Protection*
29 CFR 1910.251 *Subpart Q, Welding, Cutting and Brazing (general requirements)*
29 CFR 1910.1000 *Subpart Z, Toxic and Hazardous Substances (PELs)*
29 CFR 1910.1025 *Lead*
29 CFR 1926.62 *Lead Exposure*

⁴International Chamber of Shipping, International Association of Ports and Harbors, and the Oil Companies International Marine Forum, Portland House, Stag Place, London SW1E 5BH, England.

⁵National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

⁶National Institute of Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.

⁷Occupational Safety and Health Administration, U.S. Department of Labor, U.S. Government Printing Office, Washington, D.C. 20402.

2.3 OTHER PUBLICATIONS AND REFERENCES

2.3.1 “The Hazard of Lead Absorption Associated with the Cleaning and Repair of Gasoline Storage Tanks,” Ethyl Corporation, Richmond, VA, March 1971.

2.3.2 “Confined Space Safe Practices, Parts I and II”; Guy R. Colonna, Lamar Labauve, and Mike Roop; National Fire Protection Association, Quincy, MA, November, 1999.

2.3.3 “Tank Degassing Texas Style,” HMT Tank Service, Beaumont, TX.

2.3.4 “Tank Cleaning Principles,” Philip E Myers, Chevron Corp., San Ramon, CA. Paper presented at 7th Annual Aboveground Storage Tank Conference, Houston, TX, November, 1995.

2.3.5 “OSHA Confined-Space Regs. Interpreted for Storage Tank Operations,” Philip E. Myers, Chevron Corp, San Ramon, CA; *Oil and Gas Journal*, Feb., 1994.

3 Definitions

3.1 GENERAL

The following definitions are applicable to tank cleaning operations as described in this recommended practice and in ANSI/API Standard 2015:

3.2 DEFINITIONS

3.2.1 attendant: A qualified employee stationed outside one or more permit required confined spaces who monitors the entrants and who performs all attendant duties in accordance with the employer’s (owner/operator and contractor) permit required confined space program. Attendants may also perform the duties of standby personnel when entrants use respiratory protective equipment.

3.2.2 blanking: The absolute closure of a pipe or line by fastening a solid, flat plate (designed to retain the pressure of the pipeline), between two flanges, using two gaskets and fully engaged bolts or stud bolts in all flange bolt-holes. Blanks have handles extending beyond the flange with a 1/4 inch (6.3 mm) minimum hole in the handles (see ASME B 31.3 for additional information).

3.2.3 blinding: The absolute closure of the open end of a pipe, line or pressure vessel opening by fastening a solid, flat plate (designed to retain the pressure) across the opening, using a gasket and fully engaged bolts or stud bolts in all flange bolt-holes. (See ASME B 16.5 and B 16.47 for additional information.)

3.2.4 bonding: The joining of metal parts to form an electrically conductive path that will ensure electrical continuity and the capacity to safely conduct any current likely to be generated.

3.2.5 clean (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.).

3.2.6 combustible gas indicator: See *flammable vapor indicator*. An instrument used to sample the atmosphere and indicate if any flammable (combustible) vapors or gases are present and, if so, indicate the amount of vapors or gas present in the atmosphere as a percentage of the lower explosive (flammable) limit.

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

3.2.8 confined space: A 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, and
- Has limited or restricted means for entry or exit (for example, tanks and vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry or exit), and
- Is not designed for or meant to be continuously occupied by employees.

3.2.8.1 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 four 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 floors that slope downward, tapering to smaller cross-sections.
- Contains any other recognized serious safety or health hazard.

3.2.8.2 non-permit required confined space: A confined space (a space that meets all three of the confined space requirements) but 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 space.

3.2.8.3 non-confined 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 or criteria for either a permit required confined space or a non-permit required confined space.

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

3.2.9 degassing: The process of collecting or treating vapors removed 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.

3.2.10 double block and bleed: The positive closure of a line or 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.

Note: Employers may evaluate and designate a single valve that uses two sealing surfaces with a drain orifice between them as satisfying double block and bleed requirements.

3.2.11 electrical division classification of hazardous (classified) locations: The division classification system is used to designate locations where fire or explosion hazards may exist due to the potential for flammable gases, vapors or liquids.

Note: These classifications are identical to those defined by NFPA 70, *The National Electric Code*.

3.2.11.1 Class I, Division 1 location: A location wherein any one of the following conditions applies:

- Ignitable concentrations of flammable gases or vapors can exist under normal operating conditions.
- Ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage.
- Ignitable concentrations of flammable gases or vapors might be released by breakdown or faulty operation of equipment or processes that might also cause simultaneous failure of electrical equipment in such a manner as to directly cause the electrical equipment to become a source of ignition.

3.2.11.2 Group D location: A division classified location wherein any of the following conditions apply:

- A specific level of protection is required for flammable and combustible liquid vapor or flammable gas (from crude oil, gasoline and liquefied petroleum gas, for example) that may burn or explode when mixed with air and exposed to a specific ignition source.

3.2.11.3 Group A, B, and C locations: Some petrochemical products require higher levels of protection than Group D, including, but not limited to, acetylene (Group A); hydrogen (Group B) or ethylene (Group C). (See NFPA 70, Article 500, "Hazardous Classified Locations," and NFPA 30, "Flammable and Combustible Liquids," for additional information.)

3.2.12 electrical zone classification of hazardous (classified) locations: The zone classification system is an alternate to the division classification system for locations where fire or explosion hazards may exist due to flammable gases, vapors or liquids.

3.2.12.1 Class I, Zone 0 location: Is a location wherein either of the following conditions apply:

- Ignitable concentrations of flammable gases or vapors are present continuously, or
- Ignitable concentrations of flammable gases or vapors are present for long periods or time.

3.2.12.2 Class I, Zone 1 location: Is a location wherein any of the following conditions apply:

- In which ignitable concentrations of flammable gases or vapors are likely to exist under normal operation conditions.
- In which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage.
- Where equipment is operated or processes conducted in such a manner that breakdown or faulty operations could result in a release of ignitable concentrations of flammable gases or vapors and simultaneously cause failure of equipment so as to create a source of ignition.
- That is adjacent to a Class I, Zone 0 location from which ignitable concentrations of flammable gases or vapors could be communicated unless such communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

3.2.13 emergency: Any occurrence or event (including, but not limited to, failure of hazard control or monitoring equipment) internal or external to a confined space, that could endanger entrants or negatively impact on the tank cleaning operation.

3.2.14 employer: An owner, operator, contractor, or subcontractor whose respective employees are performing a task or activity described in this recommended practice.

3.2.14.1 owner/operator: The company or person responsible for the facility in which the tank to be cleaned is located.

3.2.14.2 contractor: A company or person selected and hired by the owner/operator to conduct tank cleaning operations and activities in accordance with the contract and tank cleaning agreements. There may be more than one contractor on a job at the same time.

3.2.14.3 sub-contractor: A company or person selected and hired by a contractor to conduct specific tank cleaning related operations and activities in accordance with sub-contract agreements. There may be more than one sub-contractor on a job at the same time.

3.2.15 entrant: A qualified employee who is authorized by the entry supervisor to enter a confined space.

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

3.2.17 entry permit: The written or printed document provided by the employer (owner/operator and contractor) and issued by the entry supervisor that contains the site, potential hazard and work specific information necessary to control and authorize entry into a confined space including conditions canceling the permit and requirements for safeguarding or returning the space to service following termination of entry.

3.2.18 entry supervisor: The qualified person (employee, foreman, supervisor, crew chief, etc.) designated by the employer (owner/operator and contractor) to be responsible for determining the requirements, and whether or not acceptable entry conditions exist at confined spaces, where entry is contemplated. Entry supervisors shall authorize entry, oversee entry operations and terminate entry as required by the permit or conditions. An entry supervisor, who is properly qualified, trained and equipped, may serve as an attendant or as an entrant. The duties of entry supervisor may be passed from one employee to another designated qualified employee, during the course of an entry operation.

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

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

3.2.19.2 upper explosive (flammable) limit (UEL): The maximum concentration (expressed as a volume percentage) of a vapor-in-air (gas-in-air) above which propagation of flame does not occur upon contact with an ignition source; generally considered "too rich to burn."

3.2.20 fixed (cone) roof tank: A tank with a self-supporting external fixed roof, with or without internal support columns. Larger diameter fixed (cone) roof tanks may have

internal supports. Fixed (cone) roof tank roofs have vents, roof fittings and appurtenances, roof accesses and ladders that penetrate the roof. Some fixed cone roof tanks may have vapor conservation appurtenances, such as internal bladders or another, smaller, external fixed (cone) roof tank mounted on top of the roof of the tank. These tanks pose unique problems for tank cleaning.

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

3.2.22 flammable gas: See *flammable vapor*. 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.

3.2.23 flammable vapor (see flammable gas): The gaseous phase of a substance that is a liquid 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. Under ambient temperature, Class IA and IB liquids generate sufficient vapors to create flammable vapor concentrations at all times. Vapors from flammable and combustible liquids are heavier than air.

3.2.24 flammable vapor indicator: See *combustible gas indicator*.

3.2.25 floating roof tank: Any aboveground, vertical atmospheric storage vessel with an internal or external floating roof. The types of floating roof tanks are as follows:

3.2.25.1 open-top (external) floating roof tank: A tank with a roof that floats on the surface of liquid contained inside the tank (except when empty). The basic components of an open-top (external) floating roof tank are:

- A cylindrical shell and a pontoon, pan-type or combination steel or aluminum floating roof,
- Primary and/or secondary annular rim seals, attached to the perimeter of the floating roof,
- Vents, flame arrestors, foam systems, roof fittings, roof water drains, shunts, movable stairways and ladders that are attached to or penetrate the roof and serve various operational functions.

3.2.25.2 covered open-top floating roof tank: An open-top floating roof tank that has been provided with a permanently attached cover (geodesic dome or other weather protective device) over the top of the tank.

3.2.25.3 internal floating roof tank: A tank that has both a fixed roof over the top of the tank and an internal float-

ing deck or cover that rests on the surface of the liquid inside the tank. Internal floating roof tanks may have the following characteristics:

- May have a fixed roof that is supported by vertical columns within the tank (typical of fixed-roof tanks built or retrofitted with an internal floating deck).
- Have internal floating roofs that are constructed of metal, plastic or metal covered expanded plastic foam materials.
- May use honeycomb panel, pontoon or pan, solid buoyant material or a combination of these types of roof construction to provide flotation.
- Are equipped with seals to prevent vapor release and ladders to provide access from the fixed roof.

3.2.26 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 permit required confined space), injury or acute illness from one or more of the following causes:

- Flammable gas, vapor or mist in excess of 10% LEL.
- Airborne combustible dust at a concentration that meets or exceeds its LEL.
- Atmospheric oxygen concentration below 19.5% and above 23.5%.
- Atmospheric concentration of any substance for which a dose or permissible exposure limit is published in applicable government regulations, Material Safety Data Sheets, standards or other published or internal documents, and could result in employee exposure in excess of its dose or permissible exposure limit.
- Any other atmospheric condition immediately dangerous to life or health.

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

3.2.28 hot work permit: The employer's (owner/operator and contractor) written authorization to perform hot work operations or use equipment (including but not limited to, welding, cutting, grinding, burning, heating, use of internal combustion engines, and non-explosion proof electric motors) capable of producing a source of ignition.

3.2.29 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 permit required confined space. Cer-

tain irritation effects may affect the entrant's ability to escape permit required confined spaces.

Note: Some toxic substances—hydrogen fluoride gas and cadmium vapor, for example—may produce immediate transient effects that, even if severe, may pass without medical attention, but are followed by sudden, possibly fatal collapse 12–72 hours after exposure. The victim “feels normal” from recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be “immediately” dangerous to life or health. Other toxic substances, such as hydrogen sulfide (H₂S), immediately desensitize a person so that exposure is no longer noticed).

3.2.30 inert gas: A gas that is noncombustible, non-contaminating and non-reactive.

3.2.31 inerting: The displacement of oxygen (air), hydrocarbon gas and/or vapors to eliminate the possibility of a potentially flammable atmosphere in a permit required confined space. This is accomplished by using an inert gas that is non-combustible, non-contaminating and non-reactive (for example, nitrogen) or a gas containing an insufficient amount of oxygen to support combustion (for example, flue gas), to such an extent that the resultant atmosphere is non combustible or non reactive.

CAUTION: Use of an inert gas or flue gas creates an IDLH oxygen deficient atmosphere.

3.2.32 instruments: The oxygen monitors, flammable (combustible) vapor indicators and toxic substance analyzers (measuring equipment) used to test (or sample) atmospheric conditions and determine, indicate, measure and monitor the amount of oxygen in the atmosphere and presence of hazardous substances, including percentage of flammable vapor-in-air (gas-in-air) and concentrations of toxic substances.

3.2.33 isolation: The process by which a permit required confined space or non-permit confined space is removed from service (decommissioned) and completely protected against the release of energy or material into the space by such means as the following: blanking or blinding; breaking, misalignment of, opening or removing sections of lines or pipes; using a double block and bleed system; locking, sealing and/or tagging-out all sources of energy; locking, sealing and tagging all valves; and blocking and disconnecting all mechanical linkages.

3.2.34 lead free tank: A tank that has been certified by the owner/operator as never having been used to store leaded gasoline, lead additives or products that have contained lead. Alternately, a tank that has been cleaned according to this recommended practice, tested for lead-in-air and found to have an internal atmosphere below the applicable limit for exposure to organic lead. 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 recommended practice, the OSHA permissible exposure limit was 0.075 milligrams of organic lead per cubic meter (2 micrograms of organic lead per cubic foot).

3.2.35 lockout/tagout: The condition when electrical and mechanical switches are open in the de-energized position and locked out and/or mechanical linkages are set, tagged and sealed or locked out to preclude the input of product or energy into the permit required confined space or non-permit confined space. Where required by regulation or employer procedures, the system shall be tested to assure isolation.

3.2.36 material safety data sheet (MSDS): Written or printed material prepared in accordance with applicable regulations and standards (for example, OSHA 29 CFR 1910.1200), concerning hazardous chemicals. MSDSs provide physical properties, safety, personal protection, health and fire prevention and protection data.

3.2.37 may: Is used to provide information on optional procedures and practices (see “shall” and “should”).

3.2.38 non-confined space: See *confined space*.

3.2.39 oxygen deficient atmosphere: An atmosphere containing less than 19.5 percent oxygen by volume.

3.2.40 oxygen enriched atmosphere: An atmosphere containing more than 23.5 percent oxygen by volume.

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

3.2.42 periodic: The time period established by the employer (owner/operator or contractor) when atmospheric testing or monitoring is required dependent on the potential hazards and the work being performed.

3.2.43 permissible exposure limit (PEL): U.S. Department of Labor, OSHA’s designated limit of exposure to any airborne contaminant to which an employee may be subjected. PELs are expressed as 8 hour time-weighted averages, ceiling values, short-term exposure limits or skin exposure designation.

3.2.44 permit program: The employer’s (owner/operator and contractor) overall program for controlling and regulating safe (cold) work, hot work and entry into permit required confined spaces, to protect entrants from permit required confined space hazards and, where appropriate, to control employees access to and entry into permit required confined spaces.

3.2.45 permit system: The employer’s (owner/operator and contractor) written procedure for preparing and issuing permits for entry, hot work and cold (safe) work. The employer’s (owner/operator and contractor) written procedure for preparing and issuing permits for entry into permit required confined spaces shall include the safety and health related requirements for issuance of the permit, conditions for canceling or suspending the permit and requirements for safeguarding or returning the space to service following termination of entry.

3.2.46 product: Liquid petroleum hydrocarbon or other material stored in atmospheric aboveground tanks.

3.2.47 pyrophoric iron sulfide: A material capable of rapid spontaneous ignition when exposed to air.

3.2.48 purging: The process of introducing an inert gas or a flue gas into a tank in order to reduce the oxygen content or to reduce the concentration of hydrocarbon vapors by displacement.

3.2.49 qualified person: A person designated by an employer (owner/operator and contractor) as having the necessary training, education and competence to perform assigned tank cleaning and entry related tasks or activities in accordance with the employer’s (owner/operator and contractor) policy, procedures, and programs.

3.2.50 rescuers: Personnel designated to rescue entrants from the permit required confined space.

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

3.2.52 safe (cold) work: Any work that does not have the potential to create a source of ignition.

3.2.53 shall: Is used to designate mandatory requirements (see “may” and “should”).

3.2.54 should: Is used to designate recommended procedures or practices (see “shall” and “may”).

3.2.55 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 (see *residue*).

3.2.56 sour: Petroleum products where hydrogen sulfide (H₂S) is present (for example, sour crude oil and sour crude oil fractions contain appreciable amounts of hydrogen sulfide (H₂S) and/or mercaptans and heavy residual fuel may contain entrained or entrapped H₂S).

3.2.57 standby person: A qualified person assigned to control and oversee supplied air operations.

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

3.2.59 threshold limit value (TLV): The maximum airborne concentration of hazardous substances to which, it is believed, nearly all workers may be repeatedly exposed day after day without adverse effect as determined by the appropriate regulatory agencies and employer (owner/operator and contractor) policies, including, but not limited to, exposure limits developed by the responsible committees of the American Conference of Governmental Industrial Hygienists.

3.2.60 toxic substances (materials): Any material or substance whose properties are such that they can cause injury to a biological system, depending on the exposure concentration, time of exposure and means of exposure.

3.2.61 vapor and gas 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's atmosphere to a safe level by dilution with fresh air.

3.2.62 ventilation: Providing fresh air inside a tank to maintain an atmosphere within acceptable permit limits and provide a required number of air changes per hour. Ventilation occurs after flammable vapors, toxic vapors and gases, dusts, fumes or mists have been displaced or diluted by vapor and gas freeing (degassing).

3.2.63 work: Any work performed in preparation for, during tank cleaning and in recommissioning tanks.

3.2.64 worker: A qualified person working in or around a tank during tank cleaning. A worker, working inside a tank, may or may not be an entrant depending on the classification of the tank.

4 Petroleum Storage Tank Hazards

4.1 HAZARDS

All aboveground, atmospheric, low pressure storage tanks that contain crude oil, liquid hydrocarbons, petroleum products, additives, sludge, or residue have the potential to present one or more of the following hazards during some phase of tank preparation, decommissioning, entry, vapor and gas freeing, degassing ventilating, testing, inspection, cleaning, repair, and recommissioning:

- Oxygen deficiency or enrichment.
- Fires or explosions.
- Toxic substance exposures.
- Physical and other hazards.
- Psychological and physiological hazards such as claustrophobia, heat and cold stress.

Employers (owners/operators and contractors), entry supervisors, qualified persons, entrants, attendants, standby persons, rescuers and workers shall be aware of these potential hazards and establish and implement methods of recognizing and controlling them, using the procedures and precautions described in ANSI/API Standard 2015 and this recommended practice.

4.2 OXYGEN DEFICIENCY AND ENRICHMENT

4.2.1 General

Employers (owners/operators and contractors), entry supervisors, testers, attendants, entrants and rescuers shall be aware of the potential for oxygen deficiency in a storage tank that has not been properly or sufficiently ventilated and oxygen enrichment from sources including, but not limited to, leaking oxygen cylinders or hoses. It is always important to recognize the potential for and determine the reasons for oxygen deficiency or oxygen enrichment that is different from that of the normal ambient oxygen content of the air external to the tank (approximately 20.9%). (See Section 11 and ANSI Z88.1, API 2217A, ISGOTT, and OSHA 29 *CFR* 1910.134 for additional information).

4.2.2 Hazards

Vapors from liquid hydrocarbons are heavier than air and displace the air in a tank. Prior to vapor and gas freeing, degassing and ventilation, the atmosphere in the tank will normally be stratified, with the bottom portion of the atmosphere having the lowest oxygen concentration, the middle portion having additional oxygen and the upper portion having the highest concentration of oxygen. The upper portion of the tank may have enough oxygen to be within the explosive (flammable) range. As vapor and gas freeing, degassing, and ventilation progresses, the amount of oxygen in the tank's atmosphere will increase. The atmosphere will change from vapor rich, then enter into the explosive (flammable) limit and finally drop below the lower explosive (flammable) limit.

4.2.2.1 Workers entering oxygen deficient atmospheres in tanks are subject to a number of potential hazards, including, but not limited to, exposure to toxic substances or asphyxiation.

4.2.2.2 Workers entering an oxygen-enriched atmosphere in a tank are subject to increased risk of fire and explosion due to the increased flammability range of vapors and gases in the tank.

4.2.2.3 Testers shall be aware of the hazards of stratification and the potential for combustible vapor-in-air (gas-in-air) test results to be below the LEL when near the top of the stratified layers but within the explosive (flammable) limit at other levels inside the tank.

4.2.2.4 Testers shall be aware of the potential for “channeling.” Even though the vapor-in-air (gas-in-air) level at the ventilation exhaust is below the LEL, it is possible that due to poor mixing of air and vapors in the tank, the incoming air is channeled through the tank’s atmosphere, while most of the atmosphere remains in a vapor rich condition. This is a particular potential hazard in large tanks where mixing of the air and vapors is not ideal due to few or poorly arranged manholes.

4.2.3 Oxygen Limits

Before entering any tank that has contained petroleum or petroleum products, an empty tank or a clean tank that has been closed and inactive, the oxygen content in the tank’s atmosphere shall be tested by a qualified person using an approved, properly calibrated and adjusted oxygen monitor.

4.2.3.1 If the atmosphere contains less than 19.5 percent oxygen, it is oxygen-deficient, and appropriate respiratory equipment must be worn. Persons working in an oxygen deficient atmosphere without appropriate respiratory protective equipment may not sense that the atmosphere is oxygen-deficient. There is little or no warning of oxygen deficiency and the effects are compounding, beginning with the loss of reasoning ability followed by unconsciousness. Brain damage and death can occur within minutes if the body is deprived of oxygen.

4.2.3.2 Entry into atmospheres with oxygen levels below 16% is considered as IDLH. Entry under such conditions may be restricted to emergency situations and rescue operations and require specific entry conditions, requirements and approvals.

4.2.3.3 If the atmosphere contains over 23.5% oxygen, it is oxygen enriched. Oxygen enrichment increases the explosive (flammable) range of hydrocarbon vapors by reducing the lower explosive (flammable) limit and increasing the potential for a fire or explosion.

4.3 FIRES AND EXPLOSIONS

4.3.1 General

Fires will occur when sources of ignition meet flammable vapor and air (oxygen) mixtures in the proper proportions (within explosive (flammable) range). Explosions occur when fires inside tanks produce a rapid pressure increase that exceeds the design strength of the tanks and causes them to instantaneously rupture. (See *NFPA Fire Protection Handbook*, NFPA 30 and OSHA 29 CFR 1910.106 for further information).

4.3.2 Fire Triangle

Fires will not occur if any one of the three elements of the fire triangle (oxygen, fuel or source of ignition) is missing.

This fundamental principle is extremely important for the prevention of fires and explosions during tank cleaning operations.

4.3.2.1 The elimination of oxygen inside tanks by inerting or displacement, is one method of preventing fires (not normally used during tank cleaning operations). Eliminating oxygen is difficult and costly and creates another hazard, an oxygen deficient atmosphere.

4.3.2.2 Wherever flammable liquids (or combustible liquids at temperatures above their flash points) are present, flammable vapors will also exist in the atmosphere above the liquid. Flammable liquid vapors are heavier than air. They will flow from tanks, travel along the ground and settle in low places. Flammable liquid vapors can travel considerable distances, reaching remote ignition sources, and ignite. When removing covers from tanks that are rich with vapors, the vapors will pour from the manholes into the open air. If there are any running engines, vehicles, degassing units or other ignition sources within the path of the vapors, a flash fire will occur, flash back into the tank where the vapors originated and cause a fire or explosion. The removal of all hydrocarbon liquids, vapors and flammable gases from tanks is the primary method for fire prevention during tank cleaning operations.

4.3.2.3 Eliminating or controlling ignition sources, especially during the vapor and gas freeing and degassing process, is equally important for preventing fires. Elimination of ignition sources may be difficult and less certain because ignition sources are sometimes difficult to recognize or may be remote from the tank cleaning area. Unlike oxygen, vapors, and gases, measuring and testing instruments cannot detect ignition sources.

4.3.3 Explosive (Flammable) Limits

Mixtures of hydrocarbon vapor (or flammable gas) and air can be ignited only if the fuel-in-air ratio is within certain limits. These limits are called the explosive (flammable) range and are expressed as a percent by volume of vapor (or gas) in air.

4.3.3.1 Every hydrocarbon has a minimum concentration of vapor-in-air (gas-in-air) called the lower explosive (flammable) limit (LEL) below which a fire will not occur on contact with a source of ignition (too lean to burn).

4.3.3.2 There is also a maximum concentration of vapor-in-air (gas-in-air) called the upper explosive (flammable) limit (UEL), above which a fire will not occur (too rich to burn). Different hydrocarbon vapors and gases have different explosive (flammable) ranges. The explosive (flammable) range of some typical gases and vapors that may be present in and around tanks during isolating, vapor and gas freeing, degassing, testing, ventilation, entry, cleaning, and repair operations are shown in Table 4-1.

4.3.4 Flammable Vapors

The potential exists for a fire or explosion to occur when the vapor-in-air (gas-in-air) mixture in a tank is within the explosive (flammable) limits. The atmosphere in a tank that has just been emptied and opened is usually above the explosive (flammable) limit and is too rich to burn. However, as vapors (gases) are removed and the tank is ventilated, the original vapor-rich atmosphere will be diluted with air and the mixture will enter the explosive (flammable) range. Eventually, as vapors are expelled and ventilation increases, the vapor-in-air (gas-in-air) mixture in the tank's atmosphere will pass below the lower explosive (flammable) limit. Even though initial measurements indicate that the vapor-in-air (gas-in-air) concentration is within acceptable limits, the tank's atmosphere shall be monitored or checked continuously or periodically during tank cleaning operations for the presence and concentration of flammable vapor or gas, as determined by the entry supervisor or qualified person.

4.3.4.1 As the tank is vapor freed, dilution of vapors (or gas) will occur near tank openings such as hatches, manholes, vents or other openings where air mixes with vapor (gas) and these areas may be within the explosive (flammable) range.

4.3.4.2 After a tank has been emptied and freed of vapor, flammable vapors may be emitted from any remaining product, sludge or residue.

4.3.4.3 Flammable vapors may result from the inadvertent entry of liquid or vapor from outside sources, including, but not limited to, open connecting lines, leaks and spills in the vicinity of the tank or vapors emitted from nearby tanks that are being filled with flammable liquids.

4.3.4.4 Flammable vapors may develop within a supposedly empty and clean tank from sources that were overlooked. The most common sources include, but are not limited to, sludge, scale, hollow roof supports, unsealed sections of foam chambers, pontoons, heating coils, leaking bottoms, sumps, columns, drain hoses, internal wooden structures, flotation devices, and other absorbent materials.

4.3.4.5 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.

4.3.4.6 Flammable vapors (or gas) may remain in areas of the tank due to stratification or channeling.

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

Table 4-1—Explosive (Flammable) Ranges of Hydrocarbon Vapors and Gas

Fuel/Product	Approximate Explosive (flammable) Range (volume percent in air)		
Butane	1.9	to	8.5
Crude Oil	(varies depending on content)		
Gasoline	1.4	to	7.6
Hydrogen Sulfide (H ₂ S)	4.0	to	44.0
Kerosene	0.7	to	5.0
Methane	5.0	to	15.0
Propane	2.1	to	9.5
Xylene	1.1	to	7.0

4.3.5 Ignition Sources

Flammable vapor-in-air (gas-in-air) mixtures may be ignited by a number of different ignition sources, including, but not limited to, open flames, internal combustion engines, lightning, smoking, non-explosion proof electrical equipment, non-explosion proof radios, non-approved cell phones and pagers, electric short circuits caused by worn or defective extension cords, ignitable sparks from welding, cutting and other hot work operations and spontaneous combustion from oil soaked cleaning materials.

4.3.5.1 Sources of sparks include, but are not limited to, non-approved electric lamps, flashlights, power tools, electric fixtures and switches; non-explosion proof electric appliances including non-approved pagers, radios and telephones; cutting, blasting, grinding, and welding operations; and static electricity.

4.3.5.2 Another source of ignition may exist in tanks that have been used for the storage of aromatic tars, aromatic gas, asphalt or sour petroleum crude oil and products. The sulfur compounds in sour stock crude oil react with the steel of storage tanks to form pyrophoric iron sulfide deposits. When air contacts these deposits, a heat-generating chemical reaction takes place, creating temperatures that are high enough to ignite a flammable vapor-in-air mixture. Surfaces of tanks subject to pyrophoric deposits should be kept wet with water during vapor and gas freeing, degassing and ventilation operations in order to prevent contact with air and to dissipate heat generated by such contact.

4.3.5.3 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 roofs, on walls, supports and rafters or on tank appurtenances. These deposits may be ignited by flames or heat that result from cutting, grinding, 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 the 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.

4.3.5.4 Steam coils inside tanks are a potential source of ignition. Steam coils should never be operated when the liquid level is below the top of the coils. If steam coils are operated while the liquid level inside a tank is below the top of the steam coils, deposits of petroleum substances (particularly crude oils and sour products) on the coils have the potential to crack or produce pyrophoric compounds at temperatures as low as 350°F (177°C).

4.3.6 Special Situations

Vapor and gas freeing, degassing, ventilating and cleaning extremely large or specially designed aboveground, atmospheric storage tanks may present unique problems because of the tanks' very great volumes, large diameters or unusual configurations. Employers (owners/operators or contractors) shall give special consideration to vapor and gas freeing, degassing and ventilating these tanks. In addition, sludge, deposits, residue and cleaning chemicals and materials must be properly stored, handled and disposed of. The employer (owner/operator and contractor) shall identify potential hazards, precautions and procedures specific to these tanks (in addition to those included in ANSI/API Standard 2015 and this recommended practice) during the planning phase of tank cleaning. Appropriate recommendations and controls shall be established by the employer (owner/operator and contractor) and implemented by the entry supervisor during tank entry and cleaning operations.

4.4 TOXIC SUBSTANCES

4.4.1 General

Employers (owners/operators and contractors) shall determine the potential toxic substance hazards likely to be encountered in decommissioning, vapor and gas freeing, degassing, ventilating, entering and cleaning storage tanks before beginning decommissioning and tank cleaning operations. Prior to entering tanks, employers (contractors) shall establish and review the history of products stored in the tanks, evaluate the potential hazards and determine the proper tests (which may be highly specialized and hazard specific) to be conducted. There are some commercial products stored in tanks that are not easily analyzed and in these cases, employers (contractors) shall determine and establish the special preventive measures and precautions that are required during tank cleaning operations.

4.4.1.1 The entry supervisor or qualified person supervising the tank cleaning operations shall determine which toxic

substance(s) are likely to be present in or around the tank to be entered and establish the requirements and procedures for mitigating and controlling exposures.

4.4.1.2 Employers (owners/operators and contractors) shall provide tank cleaning supervisors and workers with information about fire, safety and health risks from products, materials and substances contained within tanks. Material safety data sheets or equivalent information that contain the basic fire, safety and health data for each hazardous substance stored in the tank or used to clean the tank are available from employers (owners/operators and contractors), manufacturers and suppliers. Government health, safety and environmental agencies are additional sources of information concerning toxic and hazardous substances that may be encountered during tank cleaning operations.

4.4.2 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.

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

4.4.2.2 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.

4.4.2.3 Acutely toxic substances are those that by a single dose or short-term exposure cause symptoms ranging from a simple headache or nausea to disablement or death. Inhalation of hydrogen sulfide (H₂S), for example, is acutely toxic.

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

4.4.3 Exposure Limits

Permissible exposure limits (PEL) as defined by OSHA, and threshold limit values (TLV) as defined by 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 work shift of a 40-hour work week. (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 even tolerate the standard PEL levels without adverse physical reactions or responses. In such cases, employers (contractors) shall require that these employees use protection to minimize exposures, even if the levels are below the PELs.

4.4.4 Hydrogen Sulfide (H_2S)

Hydrogen sulfide (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 hydrogen sulfide (H_2S) is heavier than air, it tends to collect in low places. 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: Hydrogen sulfide (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.

4.4.4.1 Safety Precautions

Employers (owners/operators and contractors) shall determine the potential hazards and exposure limits, and establish and implement appropriate precautionary measures to mitigate and control exposures to H_2S . Entry supervisors shall require continuous monitoring of atmospheres, both inside the tank and around the outside of tank, where the potential for exposure to H_2S exists. Entry supervisors or qualified persons shall designate and require appropriate respiratory protection (air supplied or self contained breathing apparatus) and protective clothing to be worn by entrants and workers subject to exposure.

4.4.4.2 Exposure Hazards

Hydrogen sulfide (H_2S) is extremely toxic. It will displace air and is a flammable gas that burns in air. The explosive (flammable) limits of hydrogen sulfide (H_2S) are 4.0 to 44.0 percent by volume in air, therefore precautions against sources of ignition must be taken if hydrogen sulfide (H_2S) is present in concentrations above 10% of the LEL.

4.4.4.3 Exposure Limits

Employers (owners/operators and contractors) and qualified persons shall review current government, industry and facility requirements for information about H_2S hazards, precautionary and protective measures and exposure limits.

Note: OSHA has prescribed the permissible exposure limits (PEL) for hydrogen sulfide (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.

4.4.4.4 Exposure Effects

In very low concentrations, hydrogen sulfide (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 hydrogen sulfide (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 hydrogen sulfide (H_2S). In low exposures, hydrogen sulfide (H_2S) is irritating to the eyes and respiratory tract. Repeated short, low exposures 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 hydrogen sulfide (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 hydrogen sulfide (H_2S).

4.4.4.5 Exposure Measurement

The concentration of hydrogen sulfide (H_2S) in an atmosphere can be measured with various hydrogen sulfide (H_2S) indicators and measuring instruments. The accuracy and response times of such indicators will vary. Qualified persons and testers shall understand these and other limitations of the instruments used. A test for hydrogen sulfide (H_2S) should be made before any work is started on tanks that may have contained products with hydrogen sulfide (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 shall be monitored continuously during tank cleaning operations for the presence of H_2S , as determined by the entry supervisor or qualified person. (See ANSI/API Recommended Practice 2016, Section 11 for further information.)

4.4.5 Organic Lead

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 totally 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 pres-

sure 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 presently very limited within the United States, production continues in other countries and these storage tanks will 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.

4.4.5.1 Safety Precautions

Employers (owners/operators and contractors) shall establish and entry supervisors shall follow appropriate safety and personal protection precautions and procedures when entering tanks that have neither been tested nor previously determined to be lead-hazard free. 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. Employers (owners/operators and contractors), testers and entry supervisors shall consider every storage tank as 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.

4.4.5.2 Exposure Hazards

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.

4.4.5.3 Exposure Limits

Employers (owners/operators and contractors) and qualified persons shall review current government, industry and facility requirements for information about organic lead hazards, precautionary and protective measures and exposure

limits. A lead-hazard-free storage tank is a tank that has been properly cleaned, tested, and determined to have an internal atmosphere whose lead-in-air content is below the applicable government, industry and facility requirements for exposure limits.

Note: 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) as well as indicating a skin designation for organic lead).

4.4.5.4 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.

4.4.5.5 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. Qualified persons and testers shall understand the limitations of the instruments used. A test for lead in air shall be made before any work is started on tanks that may have contained leaded products or additives. The tank must 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, the atmosphere in the tank shall be tested 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.

4.4.6 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.

4.4.6.1 Safety Precautions

When there is a potential for exposure to toxic and harmful dusts, employers (owners/operators and contractors) shall determine the potential hazard and establish control measures, testing requirements and safe work procedures. Entry supervisors shall determine and implement appropriate precautionary measures to mitigate and control exposures and requirements for respiratory protection and protective clothing to be worn by entrants and workers.

4.4.6.2 Exposure Hazards

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

4.4.6.3 Exposure Limits

Employers (owners/operators and contractors), entry supervisors, and qualified persons shall review current government, industry and facility requirements for information about hazardous dusts, exposure limits and precautionary and protective measures. (See ACGIH Threshold Limit Values and Biological Exposure Indices and OSHA 29 CFR 1910.1000 for information and requirements regarding exposure limits for mineral and nuisance dusts.)

4.4.6.4 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. Exposures to small amounts of other types of less hazardous dust may create respiratory, headache, dizziness, and sinus problems.

4.4.6.5 Exposure Measurement

A qualified person shall measure the concentration of dust in an atmosphere using appropriate instruments. The accuracy of such instruments will vary and testers shall understand these and other limitations of the instruments used. The atmosphere in and around the tank shall be periodically monitored, as determined by the entry supervisor or qualified person, during tank cleaning operations such as grinding, scraping, paint and coating removal and blast cleaning, that create potentially hazardous dust. In the event that dust measurements cannot be accurately performed, the entry supervisor or qualified person shall determine when exposure to dust may be in excess of the PEL and require appropriate protective measures.

4.4.7 Other Toxic Petroleum 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, organic lead, H₂S, NORM, and heavy metals.

4.4.7.1 Safety Precautions

When the potential exists for exposure to toxic substances, employers (owners/operators and contractors) shall determine the potential hazards and establish safe control measures and work procedures. Entry supervisors shall determine and implement appropriate precautionary measures to mitigate and control exposures and requirements for respiratory protection and protective clothing to be worn by entrants and workers.

4.4.7.2 Exposure Hazards

Toxic and harmful exposures to petroleum substances can occur through ingestion, inhalation and skin and eye absorption.

4.4.7.3 Exposure Limits

Employers (owners/operators and contractors) and qualified persons shall review current government, industry and facility requirements for basic safety and health information about petroleum substance hazards, precautionary measures and exposure limits. MSDSs (or equivalent substance information) are available from either the employer (owner/operator and contractor) or the substance supplier. Government health, safety, and environmental agencies may also provide information.

4.4.7.4 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 qualified CPR person) 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.

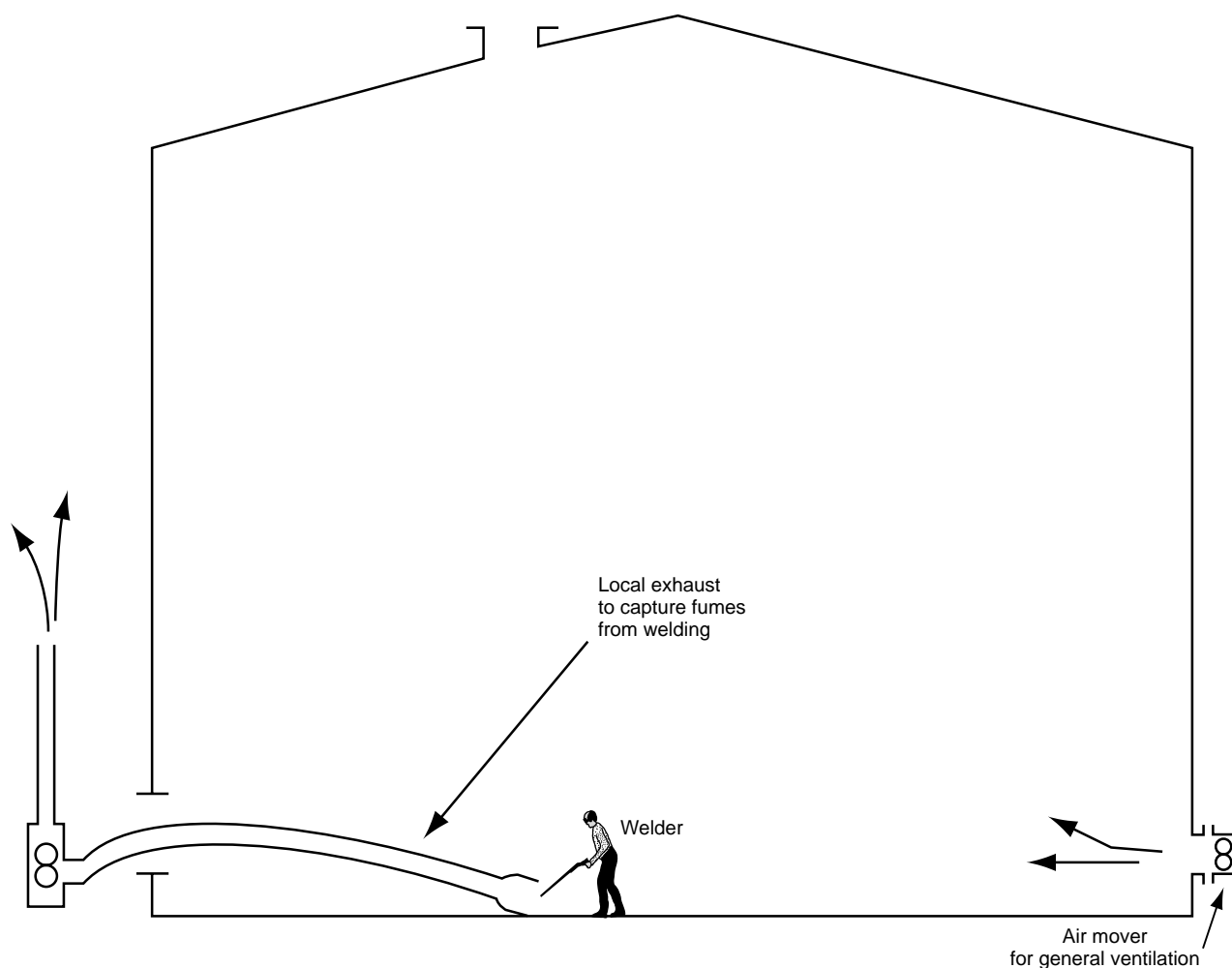


Figure 4-1—Example of Ventilation for Welding Fumes During Hot Work

4.4.7.5 Measurement

In most cases, the concentration of a toxic hydrocarbon vapor-in-air (gas-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 shall not be used to measure airborne concentrations of toxic hydrocarbon vapors. Qualified persons shall use approved toxic substance analyzers to determine the level of concentration. (See Section 11 for additional information on analyzers.)

4.4.8 Welding 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. (Figure 4-1: Example of Ventilation for Welding Fumes During Hot Work.)

4.4.8.1 Safety Precautions

When the potential exists for exposure to welding fumes, employers (owners/operators or contractors) shall determine the potential hazards and establish safe control measures and work procedures. Entry supervisors shall determine and implement appropriate precautionary measures to mitigate and control exposures and requirements for respiratory protection and protective clothing to be worn by entrants and workers.

4.4.8.2 Exposure Hazards

Exposure to welding fumes occurs primarily through inhalation.

4.4.8.3 Exposure Limits

Employers (owners/operators and contractors), entry supervisors and qualified persons should obtain safety and health information about hazards of welding fumes, precautionary measures and exposure limits from industry and government sources. (See ACGIH, ANSI Z49.1, API 2009, NFPA 51B, OSHA 29 CFR 1910.251 and 1910.1000 for additional information.)

4.4.8.4 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.

4.4.8.5 Exposure Measurement

Flammable (combustible) vapor indicators cannot be used to measure welding fumes. A qualified person shall measure the concentration of welding fumes in an atmosphere using appropriate instruments. The accuracy of such instruments will vary and testers shall understand these and other limitations of the instruments used. During the time potentially hazardous welding is being conducted, the atmosphere in the area shall be periodically monitored, as often as determined by the entry supervisor or qualified person, for the presence of hazardous welding fumes and to verify the effectiveness of the exhaust ventilation system.

4.4.9 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, non-industrial 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.

4.4.9.1 Safety Precautions

When the potential exists for exposure to lead, employers (owners/operators and contractors) shall determine the potential hazards and establish safe control measures and work procedures. Prior to commencing work (including demoli-

tion) on a tank where the potential for lead exposure exists, employers (owners/operators and contractors) shall establish a written lead abatement program for the safe removal and handling of lead-based paint and other lead containing materials. This program shall include procedures for the use of appropriate engineering controls, work practices, respiratory protection and personal protective equipment to keep exposures to inorganic lead below its permissible exposure limits (the OSHA PEL is 50 micrograms per cubic meter of air over an 8 hour period). In addition, the program shall include procedures for exposure assessment, medical surveillance and training supervisors, qualified persons, entrants, attendants, rescuers and workers.

4.4.9.2 Exposure Hazards

Inorganic lead is a systemic, cumulative poison that can enter the body by inhalation of its dusts or fumes or by ingestion via eating, drinking or smoking on the job or by contact with paint, coatings and additives containing inorganic lead. 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 other heat producing operations during the renovation, dismantling and demolition of storage tanks.

4.4.9.3 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.

4.4.9.4 Exposure Limits

Employers (owners/operators and contractors), entry supervisors and qualified persons should obtain safety and health information about hazards of lead, precautionary measures and exposure limits from industry and government sources. (See ACGIH and OSHA 29 CFR 1910.1025 and 1926.62 for additional information.)

4.4.9.5 Exposure Measurement

A qualified person shall measure the concentration of lead dust in an atmosphere using appropriate instruments. The accuracy of such instruments will vary and testers shall understand these and other limitations of the instruments used. The atmosphere in and around the tank shall be periodically monitored, as determined by the entry supervisor or qualified person, during tank cleaning operations that create potentially hazardous inorganic lead or lead dust exposures.

In addition, employers shall test blasting grit and paint residue for lead contamination and if necessary, implement appropriate hazardous waste handling and disposal measures.

4.4.10 Other Chemical Hazards

There are many other hazardous petroleum and non-petroleum products, chemicals and substances, including, but not limited to, 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 E 3 for information on NORM.)

4.4.10.1 Safety Precautions

When the potential exists for exposure to toxic chemicals and substances, employers (owners/operators and contractors) shall determine the potential hazards and establish safe control measures and work procedures. Entry supervisors shall determine and implement appropriate precautionary measures to mitigate and control exposures and requirements for respiratory protection and protective clothing to be worn by entrants and workers.

4.4.10.2 Exposure Hazards

Entry supervisors or qualified persons shall review specific substance information to determine the potential exposure hazards when tanks are to be entered and cleaned that contain toxic petroleum products, chemicals and substances.

4.4.10.3 Exposure Limits

Employers (owners/operators and contractors), entry supervisors and qualified persons shall obtain safety and health information about hazards of toxic chemicals and other substances, precautionary measures and exposure limits from facility, industry and government sources.

4.4.10.4 Exposure Effects

The potential health effects of exposure to other substances and chemicals vary in type and severity from mild to extremely serious, depending on the material and the type, degree and extent of exposure. Entry supervisors or qualified persons shall determine potential exposure effects prior to the start of operations where exposure may occur.

4.4.10.5 Exposure Measurement

In all cases, the concentration of toxic hydrocarbon vapors-in-air (gases-in-air) exceeds their permissible exposure limits or threshold limit values at levels well below those measurable by flammable (combustible) vapor indicators. Therefore, flammable (combustible) vapor indicators shall not be used to

determine airborne concentrations of toxic hydrocarbon vapors. Qualified persons shall use approved toxic substance analyzers and indicators to determine the level of concentration of each potential or suspected toxic substance or chemical. (See Section 11 for additional information on analyzers.)

4.5 STRESS EXPOSURES

4.5.1 General

Entry supervisors shall recognize that the potential exists for stress-related exposures to entrants and workers during tank cleaning operations, including, but not limited to, heat stress inside tanks during warm or hot weather, exposure to cold weather and physiological hazards (such as claustrophobia).

4.5.1.1 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.

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

4.5.1.3 Entrants and workers will be subject to potential heat stress inside storage tanks when ambient temperatures are high, especially when wearing protective clothing or equipment.

4.5.1.4 When wearing semi-impermeable or impermeable clothing, entrants and workers can encounter heat stress working in temperatures as low as 70°F (21°C).

4.5.1.5 Entrants and workers may be subject to stress while working in and around tanks during cold weather.

4.5.2 Safety Precautions

Employers (owners/operators and contractors) shall establish and entry supervisors shall implement heat and cold stress prevention techniques and protocols depending on the operations, situations and environment. Attendants shall monitor entrants and workers for signs of heat and cold stress (and other physiological stresses) and supervisors shall implement appropriate preventative measures to reduce or control stress related to temperature, environmental and humidity exposures. Entry supervisors, attendants, entrants and tank cleaning workers shall be trained or educated to recognize symptoms of environmental stress.

4.6 PHYSICAL AND OTHER HAZARDS

4.6.1 General

Employers (owners/operators and contractors) and entry supervisors shall recognize that the potential exists for physical and other hazards to be present or created both inside and outside the tank during tank cleaning and entry opera-

tions. 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 impact on 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:

1. Internal tank configuration with inwardly converging walls or floors that slope downward, tapering to smaller cross-sections, that could trap or asphyxiate workers.
2. Tripping, falling and bumping hazards from the internal structural components of a tank.
3. Sharp metal edges, welds, etc. within the tank that can snag clothing or skin and tangle or cut hoses and retrieval lines.
4. Corroded roofs, decks, scaffolds and stairways that are unsafe to walk or work on or under.
5. Continuing to work in and around a tank during conditions that cause the permit to be cancelled, including, but not limited to, increased exposures over the permit limits, lightning storms, emergencies, environmental extremes and receipt of product into nearby tanks.
6. Use of lighting, such as ordinary household-type lights and non-explosion proof flashlights, that fail to meet Zone 1 or Class I, Division 1, Group D, or higher (depending upon the type of product in the tank) electrical classification requirements.
7. Structural failure of the tank shell, internal or external roof, roof support members, swing line cables, braces, pontoons or other tank members.
8. Falls from elevations such as roofs, scaffolds, decks, wind girders, stairs, and ladders.
9. Accidental discharge of steam, high pressure air, water or oil, either into the tank or against workers inside or outside the tank.
10. Tools or other objects dropped from overhead.
11. Tripping over hoses, pipes, tools, or tank cleaning equipment inside and outside the tank.
12. Slipping on wet or oily surfaces.
13. Tripping over or colliding with objects in poorly lit or inadequately lighted work areas
14. Working and walking on an internal floating roof.
15. Failure to wear required respiratory protection and personal protective equipment.
16. Improper, insufficient, faulty, or contaminated personal protective equipment and clothing.

17. Use of improper or poorly maintained tools, especially electrical tools or equipment.

18. Failure to disconnect, de-energize, or make electrical, hydraulic, pneumatic, or mechanical equipment inoperative.

19. Exposure to noise above acceptable levels (use of power tools inside the tank).

20. The tank contains a material with the potential to engulf an entrant.

21. Inadequate or restricted working space.

22. Openings, holes, sumps, cracks in floors, etc. and uneven floor plates.

23. Restricted access and egress into, around and on top of the tank.

4.6.2 Safety Precautions

The entry supervisor or qualified person shall determine and evaluate the potential physical and other hazards and indicate the necessary precautions and control measures required by entrants and workers on the entry permit. Tank cleaning supervisors, testers, entrants, attendants and tank cleaning workers shall be adequately trained, educated, experienced or skilled to recognize the potential physical hazards associated with tank cleaning operations. Owners/operators shall be responsible for the issuance of work and entry permits for their employees and employees of contractors (other than the tank cleaning contractor and its sub-contractors) working in and around the tank cleaning area. The tank cleaning contractor shall designate permit issuers to be responsible for issuance of work and entry permits for their own contractor and subcontractor employees.

5 Vapor and Gas Freeing, Degassing, and Ventilating Tanks

5.1 GENERAL

Vapor and gas freeing usually involves the removal of flammable and/or toxic vapors and gases from a tank's atmosphere by mechanical or natural displacement and dilution with fresh air. Vapor and gas freeing may also be accomplished by purging the tank with inert gas, flue gas or steam or displacing the vapor or gas with water or fuel oil. Vapors and gas may be discharged direct to the atmosphere, or degassed by discharge through a vapor treating or recovery system. Degassing removes toxic gases and volatile organic vapors prior to emission to the atmosphere by the use of vapor recovery and treatment methods such as refrigeration, thermal oxidation or carbon absorption.

Note: See Section 7.3.8 for vapor freeing spaces in tanks such as pontoons, columns, double bottoms, etc.

After flammable and toxic vapors and gases have been removed from the tank, ventilation is required to provide an appropriate amount of fresh air inside a tank to maintain the atmosphere within acceptable permit limits for entry and work. The amount of fresh air required is normally 5 air changes per hour (replace the volume of air in the tank every 12 minutes) except where regulatory agencies or facilities have established different requirements. Employers (owners/operators and contractors) shall evaluate the specific ventilation and air change requirements needed for very large (200 foot diameter and over) storage tanks as 5 air changes per hour may be difficult to achieve. In such cases, supplemental local ventilation in the work areas may be required. (See Section 5.3 for additional information on air changes.)

5.1.1 Regulatory Requirements

Employers (owners/operators and contractors), entry supervisors and qualified persons shall be familiar with applicable government regulations, facility requirements and local conditions affecting the discharge of vapors and gases direct to the atmosphere. Employers (owners/operators and contractors) shall establish and institute appropriate degassing control measures, including, but not limited to, vapor recovery or burning, vapor treatment and water treatment where required. In many cases, the employer (owner/operator and contractor) shall be required to obtain an air or wastewater discharge permit from the local or state authority having jurisdiction.

Note: These regulatory requirements are beyond the scope of this recommended practice and are not covered either by ANSI/API Standard 2015 or ANSI/API Recommended Practice 2016.

5.1.2 Vapor and Gas Freeing (Degassing) Requirements

Prior to the start of tank decommissioning and vapor and gas freeing operations, the employer (owner/operator or contractor) shall determine the applicable requirements and the method to be used to remove vapors from the tank. The selection of an appropriate and effective vapor and gas freeing and degassing (where required) method depends on many factors, including, but not limited to, the following:

5.1.2.1 The product or material (crude oil, hydrocarbon, additive or petroleum) stored in the tank, the amount remaining in the tank after removal of recoverable product, the potential for hazardous toxic and exposures during vapor and gas freeing and regulatory requirements for degassing vapors.

5.1.2.2 The size, design, type, configuration, location and condition of the tank, including tank openings, relief devices, flame arrestors, vents, seals, pontoons, flotation devices and other applicable appurtenances and tank characteristics such as inlet and outlet locations.

5.1.2.3 Regulatory and environmental considerations and requirements for the release, recovery or treatment of liquids, gases and vapors.

5.1.2.4 The availability of inert gas, flue gas, fuel oil, water or steam for displacement or purging.

5.1.2.5 Requirements for and availability of vapor recovery, burning and treatment facilities.

5.1.2.6 The surrounding area and activities taking place therein that could impact on, or be impacted upon, by vapor and gas freeing (degassing) operations.

5.1.2.7 The amount and nature of the vapors in the tank and the degree of stratification.

5.2 VAPOR AND GAS FREEING (AND DEGASSING) HAZARDS

Vapor and gas freeing (and degassing) is one of the most hazardous tank cleaning operations. Employers (owners/operators and contractors) shall assure that entry supervisors, qualified persons, testers, entrants, attendants, standby persons, rescuers and workers are aware of the potential flammable and toxic hazards and establish and institute appropriate prevention and control measures during vapor and gas freeing (and degassing) operations.

5.2.1 Fire Hazards

Tanks that have contained flammable gas and low flash point flammable liquid products will have high concentrations of flammable gas and vapors, and their atmospheres will initially be above the upper explosive (flammable) limit (for the product stored). During the mechanical vapor freeing process, as fresh air is introduced into the tank, the vapors and gases will be diluted. The atmosphere in the tank will change from being "too rich," into the explosive (flammable) range and ultimately fall below the lower explosive (flammable) limit or become "too lean to burn," as the vapor-in-air (gas-in-air) mixture becomes increasingly diluted.

5.2.1.1 The entry supervisor or qualified person shall assure that the vapors or gases discharged from the tank do not create hazardous conditions outside the tank. Since some hydrocarbon vapors are heavier than air, discharging the vapors at the top of the tank or at a high elevation provides for quick dispersion (where degassing is not required or used). This precaution prevents flammable vapor or gas from settling at ground level and flowing to an ignition source, being ignited and flashing back into the tank.

5.2.1.2 During the initial stages of vapor and gas freeing (degassing), while the tank still contains high concentrations of flammable vapor and gas, the entry supervisor or qualified person shall restrict all maintenance work in the immediate area surrounding the tank and on top of the tank roof.

5.2.1.3 All sources of ignition in the area should be prohibited during vapor and gas freeing and degassing. A hot work permit shall be issued by the entry supervisor or qualified person and continuous monitoring for flammable vapors or gases shall be conducted in order for any hot work to be performed during vapor and gas freeing (degassing) operations.

5.2.2 Toxic Hazards

Employers (owners/operators and contractors), entry supervisors and qualified persons shall be aware of the potential for exposure to toxic and hazard vapors, dust or gases emitted from the tank during the vapor and gas freeing (degassing) process and develop and establish measures to control or prevent exposure of workers to these substances.

5.2.3 Physical Hazards

Prior to the start of operations, the employer (owner/operator or contractor) shall review the method selected for vapor and gas freeing and degassing and the condition and construction of the tank in order to determine the potential hazards, including, but not limited to, the following:

5.2.3.1 A qualified person shall assure that the induced air, steam, water, oil or inert gas does not pressurize the tank in excess of its maximum design pressure during vapor and gas freeing (degassing) operations.

5.2.3.2 When displacing vapors or gas with water or fuel oil, a qualified person shall determine that the tank is structurally able to hold the weight of water or fuel oil.

5.2.3.3 If tanks are connected by a common venting or vapor recovery system, a qualified person shall assure that the tank being vapor or gas freed is isolated from the other tanks.

5.2.4 Atmospheric Hazards

The potential exists for drawing flammable vapors, toxic fumes or exhaust gases into the tank during vapor and gas freeing and ventilation operations when tanks are located near areas where internal combustion engines may be operating or if tanks are located in low lying areas below the surrounding ground level (where vapors may accumulate). Entry supervisors and qualified persons shall be aware of such situations and implement appropriate measures to assure that only fresh, uncontaminated air enters the tanks.

5.3 MECHANICAL VAPOR AND GAS FREEING

5.3.1 General

Mechanically introducing fresh air into a tank is the preferred method of removing vapors or gas from a storage tank, provided that the tank design, size, type, configuration, condition and location and the product stored in the tank permit this method of vapor and gas freeing. There are two basic methods of mechanical vapor and gas freeing. In the first method, eductors pull vapor and gas out of the tank, creating

a slight negative pressure inside the tank that draws in fresh air. The second method used air blowers to push fresh air into the tank, creating a slight positive pressure inside the tank that forces vapor or gas out of the tank. Eductors and air blowers may be operated by compressed air, approved explosion-proof electrical motors or steam.

CAUTION: Open vents and pressure/vent devices on tanks shall be considered when planning mechanical ventilation. (Figure 5-1: Tank Ventilation Guidelines.)

5.3.1.1 Compressed air is the preferred and safest method of operating blowers or eductors.

5.3.1.2 Steam driven eductors or blowers are also acceptable, provided the steam discharge does not create an electrostatic charge or impact upon equipment or a person.

CAUTION: If the blower or eductor is powered by steam, the steam exhaust must not enter the tank.

5.3.1.3 Electric powered equipment shall not be used unless specifically approved by the employer (owner/operator and contractor), inspected by a qualified person prior to use to assure good condition and electrical integrity and identified on the permit by the entry supervisor. Only explosion-proof electrically powered air blowers and eductors, that meet Zone 1 or Class I, Group D and Class II Groups E, F and G electrical classification requirements, and are suitable for use in classified locations, shall be approved for use in tank cleaning.

5.3.2 Eductor and Blower Selection

Approved venturi-type eductors, with no moving parts, should be used to remove vapors or gas from a tank. Blowers or eductors with moving parts that have the potential to produce a spark or source of ignition, should not be used to educt tank vapors or gas, as the resultant vapor-in-air (or gas-in-air) mixtures may be in the explosive (flammable) range at any time. The possibility exists that the metal blades or bearings of an exhaust blower that is defective, not properly maintained or worn, could heat up and become sources of ignition for the flammable vapor-in-air (or gas-in-air) mixtures being exhausted from the tank. (Figure 5-2: Example of Air Mover Located on Shell Manway of Tank.) (Figure 5-3: Examples of Tank Mechanical Vapor-Freeing Equipment.)

5.3.2.1 Eductors and air blowers shall be electrically bonded to the tank shell to prevent a static spark.

5.3.2.2 Regardless of whether an eductor is used to suck out vapors and gases or an air blower is used to push in fresh air, the vapors and gases that are released to the atmosphere shall be discharged at a high elevation, preferably from or near the top of the tank roof and at least 12 feet (3.7 meters) above the ground level or discharged to a degassing system (where required).

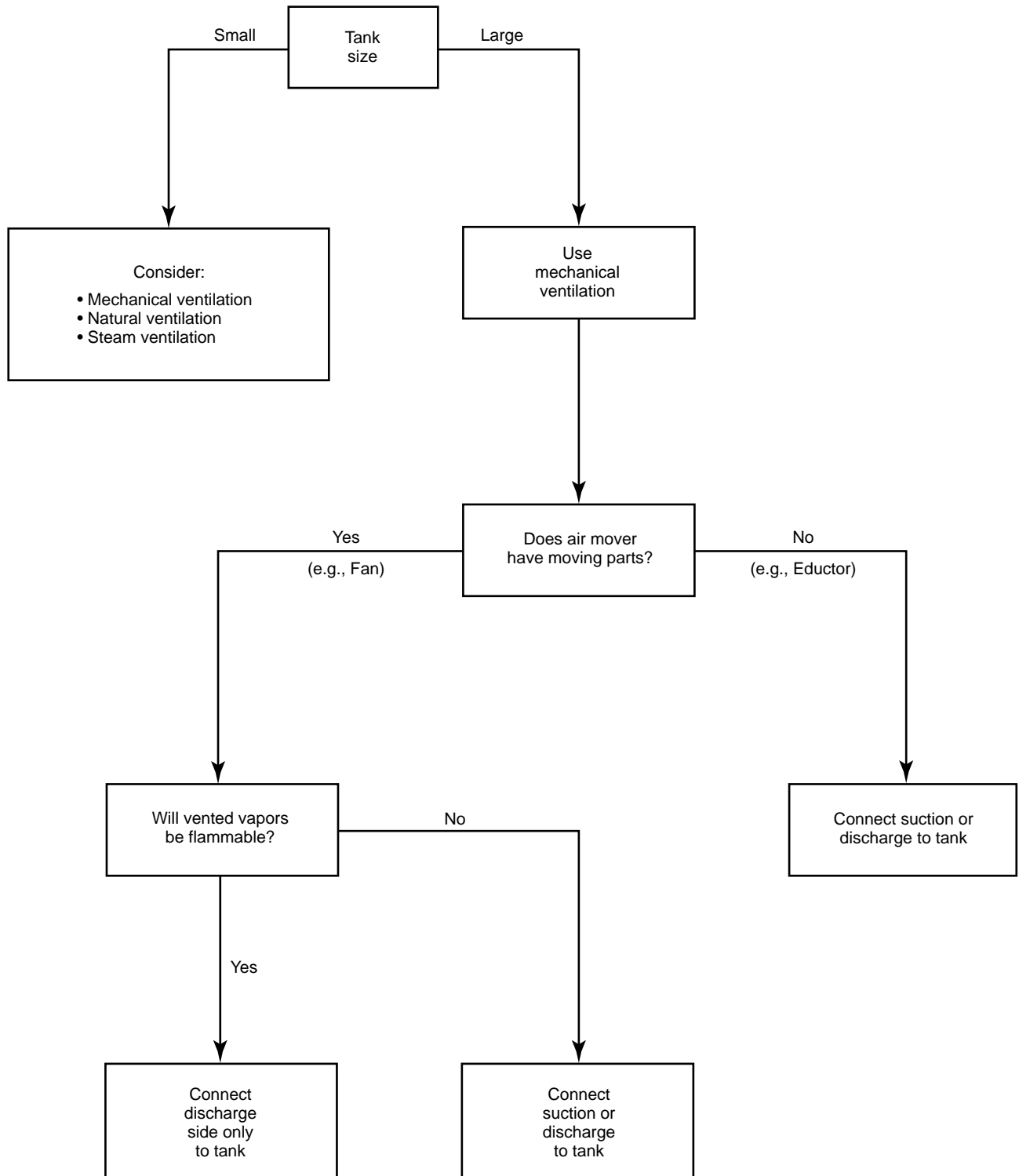


Figure 5-1—Tank Ventilation Guidelines

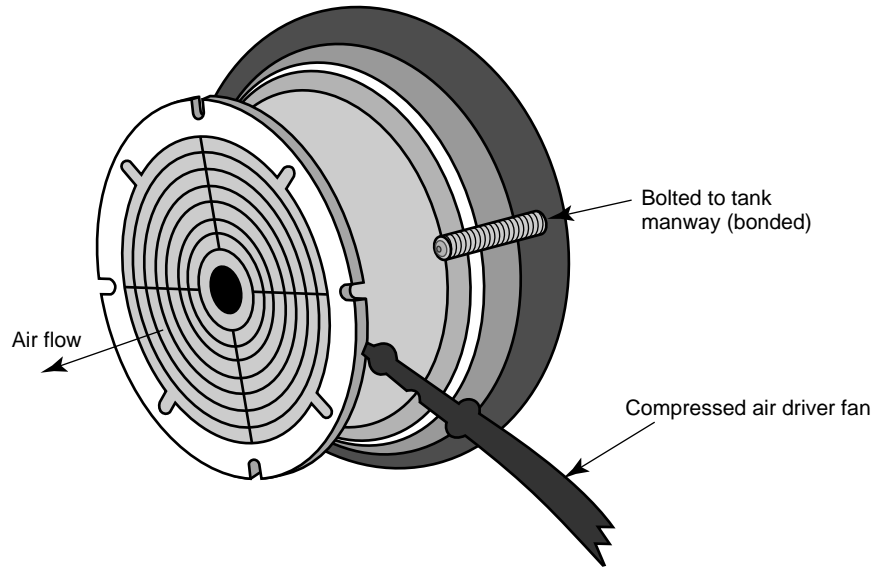


Figure 5-2—Example of Air Mover Located on Shell Manway of Tank



Figure 5-3—Example of Tank Mechanical Vapor-Freeing Equipment

5.3.2.3 Where the potential exists for stratification of vapors inside a tank or where very heavy vapors are present, two or more eductors and air blowers may be used in concert in order to improve ventilation. This is accomplished by forcing air into the tank with air blowers at the same time that vapors are drawn out of the tank using eductors.

5.3.2.4 The use of blowers to push air into a tank may provide a slight advantage over the use of blowers to exhaust vapors from a tank, as there is less opportunity for vapors in the explosive range to pass through the blowers.

5.3.3 Eductor and Blower Requirements

Employers (owners/operators and contractors) shall assure that, prior to the start of tank cleaning operations, a qualified person is assigned to analyze the situation and requirements, determine the number and capacity of the blower/eductors and the selection and placement of vapor and gas freeing, degassing and ventilation equipment. The required number, capacity and location of air blowers and eductors depends on the following factors:

1. Type of tank and its size and design
2. Dilution factor of the vapor or gas produced by the product or material in the tank.
3. The number of manholes and their sizes, locations and configuration.

In addition, when determining the requirements for blowers/eductors, consideration shall be given to back pressure and restricted air flow caused by flexible ducts used for intake and exhaust and whether the vapors are being degassed or expelled direct to the atmosphere. (Figure 5-4: Sample Tank Ventilation Guidelines.)

5.3.3.1 Employers (owners/operators and contractors) shall evaluate each tank and determine the appropriate ventilation requirements. The amount of air required is normally 5 air changes per hour, except if regulatory agencies or facilities have established other requirements.

Example 5.1—Provide 5 Air Changes/Hour in a Fixed (Cone) Roof Tank

A 40 feet high, 125 foot diameter, fixed (cone) roof tank has a space approximately 500,000 cubic feet in size. Using 3 large blower/eductors, each with a capacity of 17,000 cubic feet per minute, would exhaust 51,000 cubic feet per minute from the tank. (This assumes 100% blower/eductor efficiency and no obstructions to airflow, such as backpressure from duct constraints or degassing systems). At this exhaust rate, it would take 10 minutes to displace the volume of the tank (1 air change) and thereby pro-

vide about 6 air changes per hour in the tank (under perfect conditions).

5.3.3.2 Large tanks usually have floating roofs and therefore only the spaces where entrants are working (either underneath a floating roof or on top of an internal or covered floating roof) need to have the required amount of air changes. By considering the areas above and below the floating roof as separate spaces for ventilation purposes, the blower/eductor requirements can be considerably reduced. When ventilating floating roof tanks, the area below the floating roof (sitting on its high legs) to be ventilated may be only 1/6 of the tank's total capacity, thereby reducing the amount of required ventilation accordingly.

Example 5.2—Provide 5 Air Changes/Hour in the Space under a Floating Roof

A very large 250 foot diameter covered floating roof tank that is 40 feet high, has a space that is approximately 2,000,000 cubic feet in size. If the floating roof is sitting on its high legs (7 feet above the tank bottom), the space beneath the floating roof would be approximately 1/6 of the tank's volume or 330,000 cubic feet. To achieve 5 air changes an hour in this space, 1,650,000 cubic feet of air per hour (or approximately 27,500 cubic feet per minute) would have to be exhausted. Two blower/eductors, each with a capacity of 14,000 cubic feet of air per minute (assuming 100% efficiency and perfect conditions) would be needed to achieve 5 air changes an hour.

5.3.3.3 Often volatile hydrocarbons (typically solvents) are only a portion of a blended product or a mixture of co-mingled materials stored in a tank. Materials containing volatile hydrocarbons are also used to dilute sludge or clean residue from a tank or used to paint, coat or treat the inside of a tank after cleaning. When this occurs, it is important that a qualified person calculate the amount of vapor that will be produced in order to determine the requirements for vapor and gas freeing, degassing or ventilating the tank.

Example 5.3.3.3—Dilution Volume Calculations for a Product Containing Toluene

The following formula is used to determine the dilution volume (*DV*):

$$DV \text{ (cubic feet of air)} = 4 (100 - LEL) V_s \div LEL$$

[*V_s* = cubic feet of vapor per gallon of volatile hydrocarbon (solvent)]

Tank Volume*	Manways	Fan	Qty.	psig	Airflow Consumed		Air Exchanges/ Hr.	
					cfm	scfm		
78,540 cu ft (50 ft diameter)	One 20 in. shell, one 20 in. roof	6 in. Eductor/Air Horn	1	60	3,940	98	3.00	
			1	80	4,500	126	3.44	
		8 in. Eductor/Air Horn	1	60	5,600	178	4.27	
			1	80	6,250	233	4.77	
		20 in. Reaction Fan	1	60	9,500	160	7.25	
			1	80	11,000	210	8.40	
314,160 cu ft (100 ft diameter)	One 20 in. shell, one 20 in. roof	20 in. Reaction Fan	1	60	9,500	160	1.81	
			1	80	11,000	210	2.10	
	Two 20 in. shell, two 20 in. roof	20 in. Reaction Fan	2	60	19,000	320	3.63	
			2	80	22,000	420	4.20	
	One 24 in. shell, one 24 in. roof	24 in. Reaction Fan	1	60	14,600	324	2.79	
			1	80	16,900	400	3.23	
	Two 24 in. shell, two 24 in. roof	24 in. Reaction Fan	2	60	29,200	648	5.58	
			2	80	33,800	800	6.46	
	1,256,640 cu ft (200 ft diameter)	Two 20 in. shell, two 20 in. roof	20 in. Reaction Fan	1	60	9,500	160	0.45
				1	80	11,000	210	0.52
				2	60	19,000	320	0.90
				2	80	22,000	420	1.04
Two 24 in. shell, two 24 in. roof		24 in. Reaction Fan	1	60	14,600	324	0.70	
			1	80	16,900	400	0.81	
			2	60	29,200	648	1.40	
			2	80	33,800	800	1.62	
Three 24 in. shell, two 24 in. roof		24 in. Reaction Fan	3	60	43,800	972	2.10	
			3	80	50,700	1,200	2.43	
2,827,440 cu ft (300 ft diameter)		Two 24 in. shell, two 24 in. roof	24 in. Reaction Fan	2	60	29,200	648	0.62
				2	80	33,800	800	0.72
	Three 24 in. shell, two 24 in. roof	24 in. Reaction Fan	3	60	43,800	972	0.93	
			3	80	50,700	1,200	1.07	

Notes:

*All tank volumes calculated at 40 ft tank height.

Calculations are based on positioning the fan(s) to blow into the tank (air supply configuration).

Figure 5-4—Sample Tank Ventilation Guidelines

The dilution volume for toluene ($V_s = 30.4$ and $LEL = 1.4$) would be:

$$DV = 4(100 - 1.4) 30.4 \div 1.4 = 8,564 \text{ cubic feet of air per gallon of toluene.}$$

The following formula is used to calculate ventilation (vapor and gas freeing) requirements:

$$VV \text{ (cfm)} = DV \text{ (ft}^3 \text{ air)} \times \text{Gallons of Volatile Liquid (Solvent)}$$

[$VV =$ Ventilation Volume (cubic feet per minute)]

If a tank is being coated with a product containing 40% toluene applied at the rate of one gallon per minute, what are the ventilation requirements?

$$VV = 8,564 \text{ ft}^3 \times 1 \text{ gpm coating} \times 0.4 \text{ (gal toluene per gal coating)} = 3,426 \text{ cfm}$$

Ventilation Volume (VV) = 3,426 cubic feet of fresh air per minute.

5.3.4 Mechanically Vapor and Gas Freeing Fixed (Cone) Roof Tanks

There are several methods for mechanically removing vapors and gas from fixed (cone) roof tanks, including, but not limited to, the following: (Figure 5-5: Examples of Typical Ventilation Arrangements) (Figure 5-6: Example of Vapor Freeing a Cone Roof Tank).

5.3.4.1 Install and bond a venturi type eductor (no moving parts) onto a manhole on the roof of the tank with an airtight connection. With the bottom shell manholes still closed, start the eductor at a low rate of flow to create a slight negative pressure (up to but not exceeding 1 inch water gauge) inside the tank. (Before a bottom shell manhole is opened, the negative pressure inside the tank should be kept at a minimum to prevent shell and roof plates from collapsing or buckling and causing major tank damage.) This procedure establishes a slight negative pressure differential so that there will be no release of vapor or gas at ground level when the bottom shell manhole cover is removed. The shell manhole to be opened should be selected to provide adequate cross ventilation for vapor or gas removal.

CAUTION: All tanks constructed to API 650 can nominally withstand one-inch water gauge pressure without special design considerations. Beyond that, there is a potential for damage to the tank. Prior to starting vapor and gas freeing operations, a qualified person shall make specific calculations for each tank to be cleaned.

5.3.4.2 After the shell manhole cover has been removed, the air eductor may be operated at full capacity. Vapors and gas are discharged at the roof level as fresh air enters the tank through the bottom shell manhole. Other bottom shell manholes may be subsequently removed, provided that the eductor has sufficient capacity so that fresh air enters through all of the manholes and vapors and gases are not be allowed to escape out of bottom shell manholes.

5.3.4.3 Install and bond a venturi type eductor (no moving parts) onto a manhole on the roof of the tank, with an airtight connection. Attach a flexible duct to the suction side of the eductor that extends into the tank and ends near the floor of the tank. Open a second roof opening to provide fresh air, keeping the shell manholes closed. The heavy vapor is drawn from near the bottom of the tank, flows up the tube through the eductor and is discharged the roof level. When only one roof manhole is available for use, a smaller eductor provided with an annular-open support will allow fresh air to enter through the roof manhole.

5.3.4.4 Install and bond an air blower (a fan type blower with moving parts may be used) onto an open bottom shell manhole with an airtight connection. Keep the roof manhole and all other shell manholes closed until the blower is installed, so as to minimize the escape of vapor or gas through the open bottom shell manhole. Then remove the roof manhole cover and start the blower immediately. The shell and roof manholes to be opened should be selected to provide adequate cross ventilation for vapor and gas removal. Air is blown into the tank, creating a slight pressure inside the tank that forces the vapor-in-air (gas-in-air) mixture out of the tank through the roof manhole.

5.3.4.5 Install and bond an air blower (a fan type blower with moving parts may be used) onto an open bottom shell manhole with an airtight connection. Keep the roof manhole and all other shell manholes closed until the blower is installed, so as to minimize the escape of vapor through the open bottom shell manhole. Then remove a second shell manhole cover, connect an elbow and a vertical duct to expel the vapor or gas to a degassing system (where required) or as high as possible (minimum 12 feet) above ground level and start the blower immediately. The shell manholes to be opened should be selected to provide adequate cross ventilation for vapor or gas removal. Air is blown into the tank, creating a slight pressure inside the tank that forces the vapor-in-air (gas-in-air) mixture out of the tank through the top of the exhaust duct.

5.3.4.6 Install and bond a venturi type eductor on an open bottom shell manhole with an airtight connection. Keep the roof manhole and all other shell manholes closed until the eductor is installed, to minimize the escape of vapor or gas. Connect an elbow and a vertical duct to the eductor in order

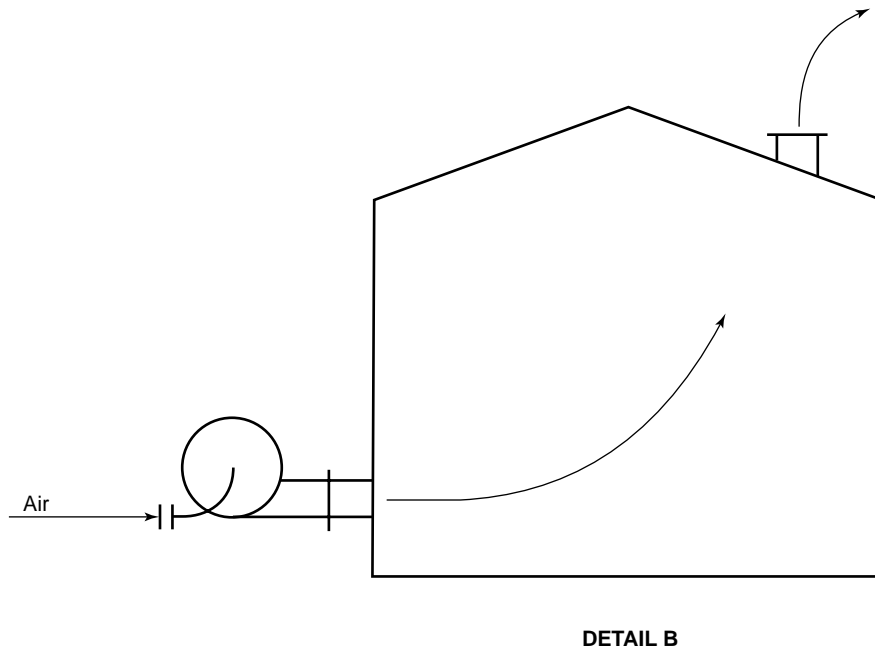
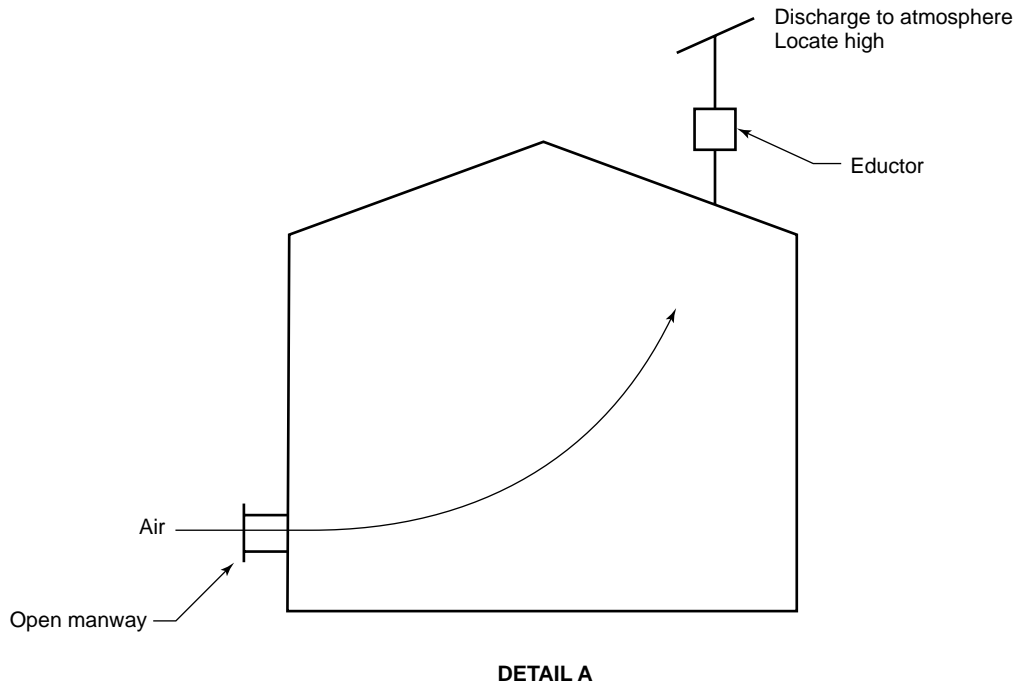


Figure 5-5—Examples of Typical Ventilation Arrangement

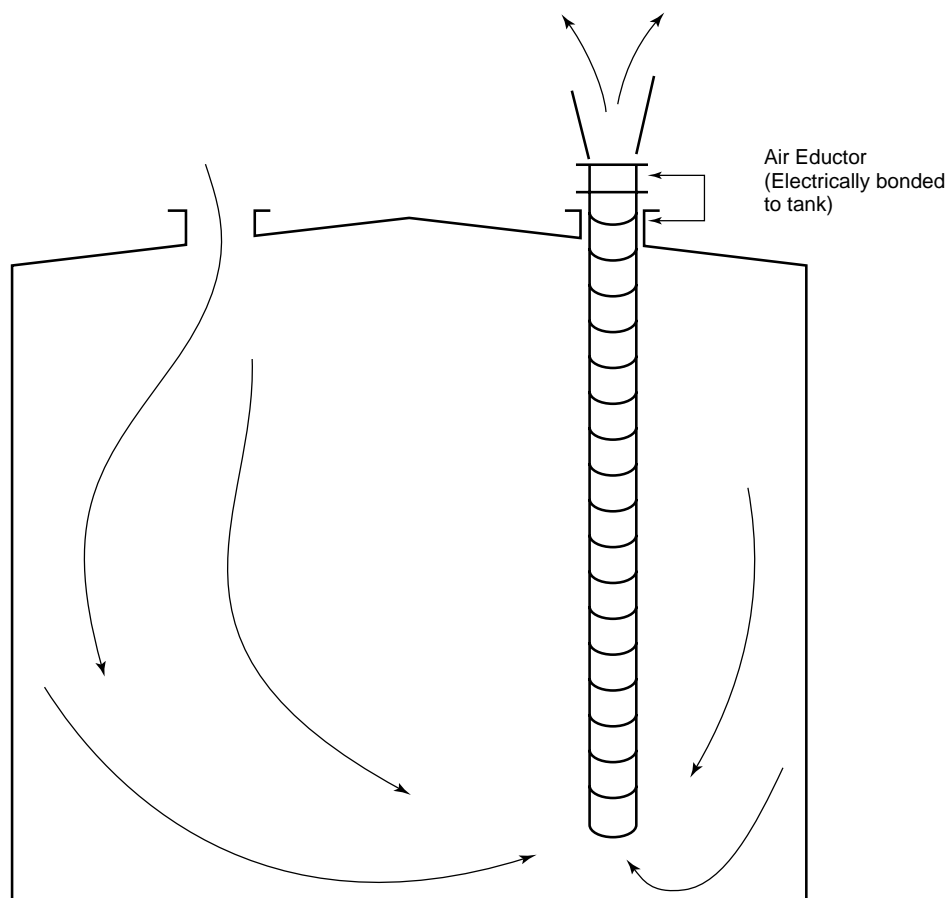


Figure 5-6—Example of Vapor Freeing a Cone Roof Tank

to expel the vapor and gas as high as possible (minimum 12 feet) above ground level or direct the vapors or gas to a degassing system (where required). Then remove a roof manhole or shell manhole cover, and start the eductor immediately. The roof or shell manhole to be opened should be selected to provide adequate cross ventilation for vapor or gas removal. Air is drawn into the tank through the open manhole, creating a slight pressure inside the tank as the eductor forces the vapor-in-air (gas-in-air) mixture out through the exhaust duct.

5.3.5 Mechanically Vapor Freeing Open-Top (External) Floating Roof Tanks

There are several methods for mechanically removing vapors from open-top (external) floating roof tanks, similar to those used to vapor free fixed (cone) roof tanks, including, but not limited to, the following: (Figure 5-7: Examples of Vapor Freeing an External Floating Roof Tank).

5.3.5.1 There may be vapors above an external floating roof that have not dissipated. Mechanically vapor free the space above the floating roof by installing and bonding a ven-

turi type air eductor at the top of the tank. Connect a duct to the suction side of the eductor and lower its open end to the top of the floating roof. The eductor is started and vapors are drawn from the floating roof level and discharged at the top of the shell perimeter.

5.3.5.2 After the atmosphere on the top of external floating roof is within acceptable levels for entry, the eductor is connected and bonded onto an open manhole or hatch (if available) on the external floating roof with an airtight connection. A duct is extended from the discharge side of the eductor to the top and outside of the tank shell. With the bottom shell manholes still closed, the eductor is started at a low rate of flow to create a slight negative pressure inside the tank.

CAUTION: Before the bottom shell manhole is opened, the negative pressure inside the tank should be kept at a minimum to prevent shell and roof plates from buckling and causing major tank damage.

This procedure establishes a pressure differential so that there will be no release of vapor at ground level when the

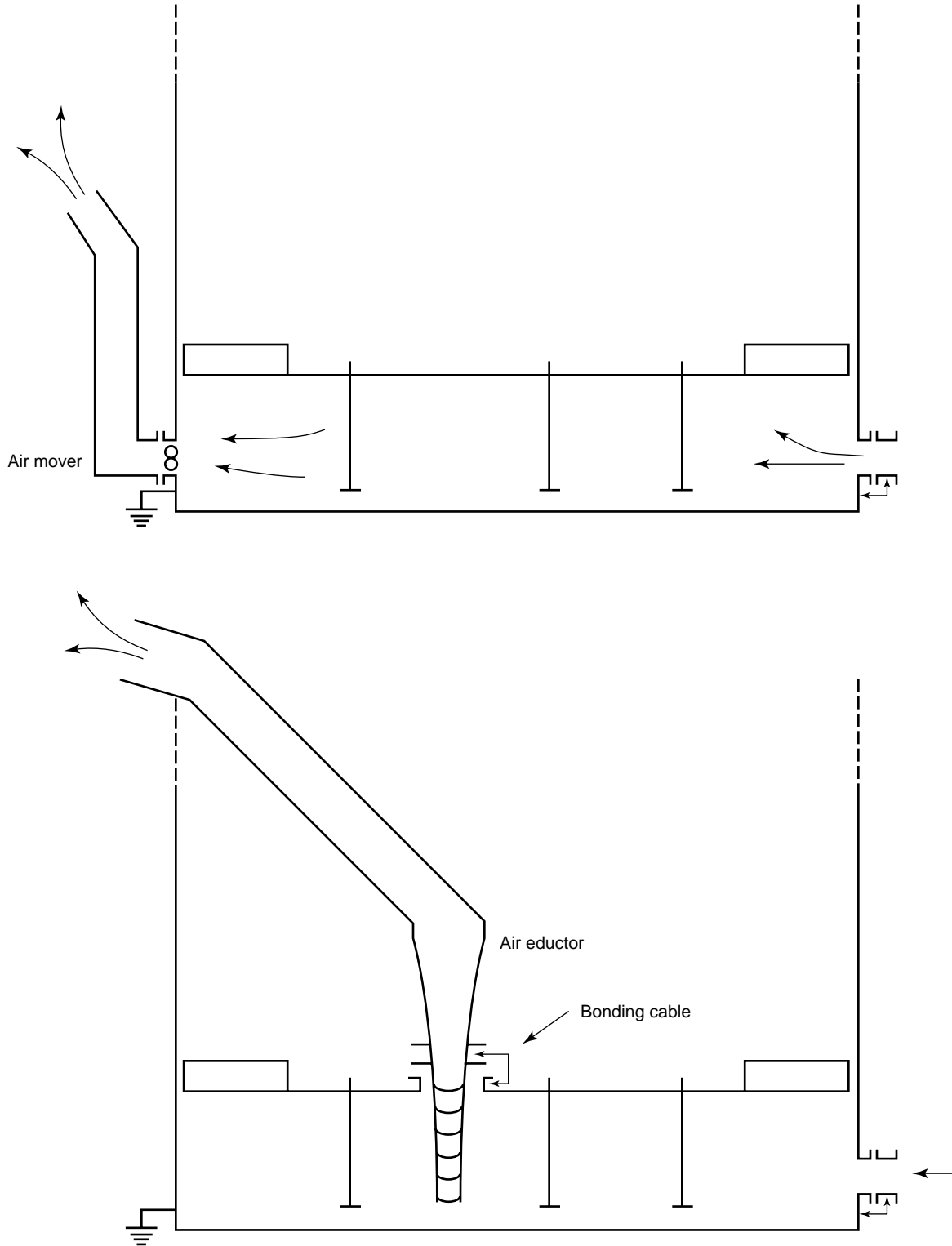


Figure 5-7—Examples of Vapor Freeing an External Floating Roof Tank

bottom shell manhole cover is removed. The shell manhole to be opened should be selected to provide adequate cross ventilation for vapor removal. After the shell manhole cover has been removed, the air eductor may be operated at full capacity. As fresh air enters the tank through the bottom shell manhole, vapors are discharged at the top, outside of the shell. Other bottom shell manholes may be subsequently removed, provided that the eductor has sufficient capacity so that fresh air enters through all of the open manholes and vapors are not be allowed to escape out of bottom shell manholes.

5.3.5.3 When shell manholes are not available, a venturi type eductor (no moving parts) may be installed and bonded, with an airtight connection, onto an open manhole on the external floating roof of the tank, after vapor freeing the roof level. Attach a flexible duct to the suction side of the eductor, extending into the tank near to the tank bottom. Another duct is extended from the eductor to the top and outside of the tank shell. A second external floating roof manhole, hatch or vents are opened to provide for fresh air (and the shell manholes remain closed). The opening or vents should be selected to provide adequate cross ventilation for vapor removal. The heavy vapor is drawn from near the bottom of the tank, flows up the duct through the eductor and is discharged at the top and outside of the tank shell. When using this method when only one roof manhole is available, a smaller eductor provided with an annular-open support, will allow fresh air to enter the tank from the manhole.

5.3.5.4 To vapor free the space below an external floating roof, install and bond an air blower on a bottom shell manhole with an airtight connection. Keep the roof manhole and all other shell manholes closed until the blower is installed, so as to minimize the escape of vapor through the open bottom shell manhole. Connect a vertical duct to a manhole, hatch or opening on the external floating roof, selected to provide adequate cross ventilation for vapor removal, and extend it to the top and outside of the tank shell. Position the air blower on the manhole so that it pushes air into the tank, creating a slight pressure inside the tank that discharges the vapor-air mixture through the duct. As an alternate, a duct may be attached to an opposite shell manhole, selected to provide adequate cross ventilation for vapor removal, and extended so that the vapors are discharged as high as possible (minimum 12 feet [3.7 meters]) above ground level or to a degassing system (where required).

5.3.5.5 As an alternate method of removing vapors from the space below a floating roof, install and bond a venturi type eductor on a bottom shell manhole with an airtight connection. Keep the roof manhole and all other shell manholes closed until the eductor is installed, so as to minimize the

escape of vapor through the open bottom shell manhole. Position the eductor on the manhole so that it draws vapor from the tank, creating a slight negative pressure inside the tank. Connect an elbow and a vertical duct to the eductor and extend it so that the vapors are discharged as high as possible (minimum 12 feet [3.7 meters]) above ground level or to a degassing system (where required). Open an opposite shell manhole, selected to provide adequate cross ventilation for vapor removal, to allow air to enter the tank.

5.3.5.6 For small diameter external floating roof tanks with only one shell manhole, install and bond an eductor on this manhole with an airtight connection, to draw vapors from the tank. To vapor free under the roof, air is drawn in through the open piping attachment nozzles and through the floating roof's annular seal area. Floating roofs are usually equipped with a vent that opens when the roof is positioned on its legs. Air can be drawn in through this opening to provide additional circulation. Connect an elbow and a vertical duct to the eductor and extend it so that the vapors are discharged as high as possible (minimum 12 feet [3.7 meters]) above ground level or to a degassing system (where required).

5.3.6 Mechanically Vapor and Gas Freeing Internal Floating Roof and Covered, Open Top Floating Roof Tanks

Vapors may be present in internal floating roof and covered, open top floating roof tanks, both above and below the floating roof. Therefore, all of the methods for mechanically removing vapors from these tanks require that the space between the fixed outer roof of the tank and the floating roof and the space between the floating roof and the tank bottom be treated as two separate entities. There are a number of methods for removing vapors from internal and covered floating roof tanks including, but not limited to, the following:

5.3.6.1 The space between the fixed roof and the floating roof may be mechanically vapor freed as follows:

1. Install and bond a venturi type air eductor onto a manhole on the fixed roof of the tank with an airtight connection in order to remove any vapor present between the fixed roof and the floating roof. Connect a flexible duct to the suction side of the eductor that extends into the tank and ends near the deck of the floating roof. Fresh air is drawn in through the shell eave vents or another roof manhole or opening. The heavy vapor is drawn from near top of the floating roof, flows up the duct through the eductor and is discharged the roof level. The suction end of the duct should be moved to different areas of the floating roof to assure that vapors do not remain in any pockets or low spots. The shell manholes should be closed during this operation in order to prevent drawing vapors from

beneath the floating roof through the annular seal area and the column seals.

2. Install and bond an air blower onto a manhole on the fixed roof of the tank with an airtight connection. Connect a flexible duct to the blower and lower it to the top of the floating roof. The blower is started and fresh air is inducted into the tank at the floating roof level, creating a slight pressure inside the tank as compared to the ambient atmosphere. The vapors are dissipated and discharged through shell eave vents and openings at the top of the tank.

Note: The shell manholes may be open and the lower portion of the tank may be vapor freed during this operation.

5.3.6.2 There are several methods for mechanically vapor-freeing the space beneath the internal floating roof that are similar to those used to vapor free fixed (cone) roof tanks, including, but not limited to, the following:

1. After the atmosphere on the top of external floating roof is within acceptable levels for entry, connect and bond a venturi type eductor (no moving parts) onto a manhole (or opening) on the external fixed roof of the tank using an airtight connection. Extend a flexible duct from the suction end of the eductor and connect it to a manhole, hatch or opening on the floating roof. (Alternately, the eductor may be attached and bonded onto an opening on the internal floating roof of the tank with an airtight connection. A flexible duct is then extended from the discharge side of the eductor to the external roof and outside of the tank shell.) With the bottom shell manholes still closed, the eductor is started at a low rate of flow to create a slight negative pressure inside the tank.

CAUTION: Before the bottom shell manhole is opened, the negative pressure inside the tank should be kept at a minimum to prevent shell and roof plates from buckling and causing major tank damage.

This procedure establishes a pressure differential so that there will be no release of vapor at ground level when the bottom shell manhole cover is removed. The shell manhole to be opened should be selected to provide adequate cross ventilation for vapor removal. After the shell manhole cover has been removed, the air eductor may be operated at full capacity. As fresh air enters the tank through the bottom shell manhole, vapors are discharged at the top, outside of the shell. Other bottom shell manholes may be subsequently removed, provided that the eductor has sufficient capacity so that fresh air enters through all of the open manholes and vapors are not be allowed to escape out of bottom shell manholes.

2. When shell manholes are not available, after removing vapors from the level above the floating roof, install and bond a venturi type eductor (no moving parts) on an open

manhole on the external, fixed roof of the tank with an airtight connection. Attach a flexible duct to the suction side of the eductor, extending into the tank and connected to an opening on the floating roof. (Alternately, the eductor may be attached and bonded to an opening on the floating roof of the tank using an airtight connection. A flexible duct is then extended from the discharge side of the eductor to the external roof and outside of the tank shell.) A second flexible duct may be connected between another opening at the top of the tank to a vent or opening on the floating roof. This flexible duct provides for fresh air to enter the lower portion of the tank (as the shell manholes remain closed). When using this method when only one roof manhole is available, a smaller eductor provided with an annular-open support from the manhole will allow fresh air to enter the tank. (Alternately, air can be drawn into the lower portion of the tank direct from the area above the internal floating roof.) The fresh air enters the tank due to the negative pressure created as the heavy vapor is drawn from near the bottom of the tank. The vapor flows up the tube through the eductor and is discharged at the top and outside of the tank shell.

3. To vapor free the space below an internal floating roof, install and bond a venturi type eductor on an open bottom shell manhole, with an airtight connection. Keep all other shell manholes and openings closed until the eductor is installed, to minimize the escape of vapor. Connect an elbow and a vertical duct to the eductor in order to expel the vapor as high as possible (minimum 12 feet [3.7 meters]) above ground level or to a degassing system (as required). Then remove another shell manhole cover and start the eductor immediately. The shell manhole to be opened should be selected to provide adequate cross ventilation for vapor removal. Air is sucked into the tank through the open shell manhole, creating a slight pressure inside the tank that forces the vapor-air mixture out through the duct.

4. Install and bond an air blower (a fan type blower with moving parts may be used) on an open bottom shell manhole with an airtight connection. Keep the external and internal roof manholes closed throughout this operation. Keep all other shell manholes and openings closed until the blower is installed, so as to minimize the escape of vapor through an open bottom shell manhole. Then remove the cover from a second shell manhole that has been selected to provide adequate cross ventilation for vapor removal. Connect an elbow and a vertical duct to expel the vapor as high as possible (minimum 12 feet [3.7 meters]) above ground level or to a degassing system (as required) and start the blower immediately. Air is blown into the tank, creating a slight pressure inside the tank that forces the vapor-air mixture out through the top of the duct.

5.4 STEAM VAPOR FREEING

5.4.1 Steam Vapor Freeing Hazards

Although displacing and purging vapors with steam may be advantageous in specific cases, the use of steam introduces additional hazards when the potential exists for a flammable atmosphere in the tank. Steam jets are prolific generators of static charges on the input nozzle and on objects inside the tank that the steam impinges upon. In addition, steam also produces an electrostatic charge in the mist in a short period of time. This charge can cause sparks that result in the ignition of flammable vapors. Care must also be taken to prevent steam spray from directly impinging on the tank and thereby causing heat stress on the metal.

5.4.2 Steam Vapor Precautions

The following precautions are required to minimize the electrostatic build-up when using steam:

5.4.2.1 The pipe or nozzle through which the steam discharges shall be electrically bonded to the tank; however, this bonding will not prevent a static charge from being generated inside the tank.

5.4.2.2 The flow of steam into a tank may also generate static electricity after the steam leaves the nozzle or end of the pipe, therefore the tank itself shall be grounded.

5.4.2.3 A charge may accumulate on an electrically insulated object inside the tank and result in a spark when the object comes close enough to any part of the tank to create a spark gap. Therefore, conductive insulated objects subject to steam impingement or condensation shall also be electrically bonded to the tank shell.

5.4.3 Steam Vapor Freeing Procedures

To be effective, steam must be introduced at a rate high enough to raise the temperature throughout the interior of the tank to at least 170°F (77°C). The rate of the steam supply must exceed the rate of condensation, so that the entire tank is heated. Often, the available steam may be insufficient to do this, particularly during cold weather or when used on large tanks.

CAUTION: The steam temperature must not exceed the flash point of the product contained in the tank.

5.4.3.1 If the temperature in the tank reaches equilibrium below 170°F (77°C), the steam will condense as fast as it is introduced, and vapors will no longer be expelled.

5.4.3.2 Steam should be introduced through a connection near the bottom of the tank, and either the roof manhole or the gauge hatch must be left open during the entire operation. This prevents the buildup of excessive pressure while steaming and prevents the creation of a vacuum during cooling.

5.4.3.3 When using steam to vapor free a tank, sufficient vacuum venting must be provided to prevent vacuum formation within the tank as a result of rapid steam condensation.

5.4.4 Steam Vapor Freeing Small Tanks

Steam vapor freeing may be appropriate for small tanks having an initial vapor-in-air atmosphere that has been tested and found to be above the upper explosive (flammable) limit (vapor rich).

5.4.4.1 Injecting purge steam through an enclosed piping connection ensures that the tank atmosphere is displaced by steam and never goes through the explosive (flammable) range.

5.4.4.2 For this method to be effective in removing all vapor, the steam rate must be high enough to produce a good steam plume from a manhole or other opening on top of the tank. This outlet should be located opposite the steam inlet to ensure a complete purge of the tank's interior.

5.5 NATURAL VENTILATION

5.5.1 General

Natural ventilation requires the removal of all roof and shell manhole covers and allowing the tank to stand open and idle until it becomes vapor or gas free. The atmosphere inside the tank expands as the tank warms up during the day, emitting vapors and gas and cools at night, creating a negative pressure in the tank that draws in fresh air. Wind sails or scoops may be used to direct air into the manholes.

5.5.2 Natural Ventilation Hazards

Natural ventilation is the least desirable method of removing vapors or gas from a tank for the following reasons:

5.5.2.1 Natural ventilation is a very slow process. The tank is required to remain in a hazardous (open) condition for a prolonged period of time.

5.5.2.2 Natural ventilation is dangerous as flammable vapors or gas may drift to a source of ignition. At the start of vapor and gas freeing, dense, heavier than air vapors and gas will flow from the shell manholes and under certain atmospheric conditions, can drift a considerable distance from the tank. As vapor and gas freeing progresses, the flow may reverse due to changes in the density of the vapor or gas, wind velocity and atmospheric changes in temperature and humidity, expelling gases and vapors from the roof manhole. This normally occurs toward the end of the vapor and gas freeing operation.

5.5.2.3 Natural ventilation may not provide a sufficient number of air changes (normally 5 changes per hour) to satisfy regulatory or facility requirements to enter or work inside the tank.

5.5.2.4 Regulations may not allow natural ventilation to release vapors or gas into the atmosphere.

5.5.3 Natural Ventilation Precautions

5.5.3.1 Because the tank is considered a permit required confined space during natural ventilation, employers (owners/operators and contractors) must safeguard the open tank from unauthorized entry during the entire vapor and gas freeing period.

5.5.3.2 Sources of ignition must be controlled and work must be restricted in a wide area surrounding the tank, because vapor and gas drift and concentration are unpredictable during natural ventilation.

5.5.3.3 As vapors and gas can leave the tank freely at low levels, work must be restricted in and around the tank area during natural ventilation, until permit conditions are satisfied. Workers must wear proper respiratory protection and protective clothing and should be allowed in the immediate area during natural ventilation only to conduct necessary vapor testing.

5.6 INERT GAS PURGING

5.6.1 General

Another method of vapor and gas freeing a tank is to purge the vapors or gas from the tank with an inert gas or flue gas. This method requires a readily available supply of inert or flue gas.

5.6.2 Purging Precautions

Purging removes all of the air (oxygen) from the tank along with the vapor and gas. As a result, the atmosphere inside the tank is IDLH (immediately dangerous to life and health). Purged tanks shall be classified as permit required confined spaces and entry shall be permitted only under IDLH conditions (see ANSI/API Standard 2015 for additional information on entering IDLH spaces).

5.6.2.1 Entry supervisors shall assure that the tank is thoroughly ventilated with fresh air and all purge gas is removed before entry and tank cleaning work is allowed under either non-permit required confined space or non-confined space conditions (depending on the tank's classification). Prior to entry, a qualified person shall test the tank's atmosphere to assure that it meets appropriate permit requirements.

5.6.2.2 Alternatively, the entry supervisor may permit work to be conducted inside the tank after establishing and instituting specific precautionary measures appropriate for entry into a permit required confined space under conditions immediately dangerous to life and health (IDLH).

5.6.2.3 During and following purging, manholes shall be fitted with warning signs and/or restriction devices to prevent

entry into the tank until the tank's atmosphere is tested and determined to be safe.

5.6.2.4 Precautions shall be taken during ventilation because the mixture of air, purge gas and flammable vapors or gas can be in the explosive (flammable) range.

CAUTION: Per ISGOTT, a final oxygen level of 8% or less in a tank can be achieved only if the inert or flue gas oxygen content is considerably below 8%. Employers (owners/operators and contractors) shall assure that the oxygen content of inert gas is controlled within a range of 1.5% to 2.5% and does not exceed 5%. If flue gas is used, the oxygen content shall be controlled to be less than 5%.

1. The temperature of the inert gas (flue gas) shall not exceed the ambient temperature or the flash point of the product or liquid in the tank.
2. Where necessary, inert (flue) gas shall be scrubbed with water to remove entrained solid contaminants (soot and sulfur) in order to prevent accumulating a static electric charge in the tank.

5.6.3 Purging Methods

The removal of flammable vapors and gas (or toxic gas) from the tank by purging with inert gas or flue gas is accomplished by either dilution or displacement.

5.6.3.1 Dilution

Dilution occurs when the air and flammable vapor and gases in the tank mix with the incoming purge gas to form a homogeneous mixture throughout the tank. As dilution progresses, the concentration of the air, flammable vapor (gas) and toxic gas in the tank's atmosphere decreases. As the air, vapor and gas mixture is pushed out of the tank, the atmosphere in the tank becomes increasingly inert.

1. When using the dilution method, the purge gas must be injected into the bottom of the tank at a sufficient velocity to mix with heavier vapors accumulating in the lower portion of the tank.
2. The purge gas, air, flammable vapor (gas) and toxic gas mixture must be expelled from the tank as high as possible (minimum 12 feet [3.7 meters]) above ground level (using flexible ducting if necessary) or to a degassing system (if required).

5.6.3.2 Displacement

Because purge gas used for displacement is usually lighter than hydrocarbon vapors, it must be injected into the top of the tank in order to push the heavier hydrocarbon vapors out of a bottom connection.

1. The displacement method requires that the purge gas be injected at a very low entry velocity so as to develop a stable interface between the purge gas and the flammable vapor in the tank (a small amount of dilution will occur at the interface).
2. Using flexible ducting, the air, toxic gas and flammable vapor mixture is expelled from the tank as high as possible (minimum 12 feet [3.7 meters]) above ground level or to a degassing system (if required).

5.6.4 Purging Procedures

The procedures used to purge fixed (cone) roof and floating roof tanks are similar to those used for mechanical vapor and gas freeing. Additional requirements include, but are not limited to, the following:

- 5.6.4.1 Close all manholes, except for the purge gas inlet and the vapor/gas mixture outlet.
- 5.6.4.2 Bond all purge gas components to the tank.
- 5.6.4.3 Inject purge gas at low pressure to minimize electrostatic buildup.
- 5.6.4.4 Ventilate the tank and replace the purge gas with fresh air prior to entry.

5.7 DISPLACEMENT OF VAPORS USING WATER (FUEL OIL)

Displacement of flammable vapors and gas and toxic gases by filling a tank with water (or fuel oil) is an appropriate method of vapor and gas freeing small fixed (cone) roof tanks, horizontal tanks and spheres.

5.7.1 Displacement Methods

- 5.7.1.1 The tank must be completely filled with water (fuel oil) and drained.
- 5.7.1.2 The filling and draining procedure may need to be repeated to assure that all vapors and gases are eliminated.

5.7.2 Precautions

- 5.7.2.1 During filling, the flammable vapor must be expelled from the tank as high as possible (12 feet [3.7 meters]) above ground level or to a degassing system (if required).
- 5.7.2.2 All waste water (fuel oil) shall be properly handled, treated or disposed of in accordance with regulatory and facility requirements.

5.8 DEGASSING

Degassing prevents or reduces the amount of organic volatile compounds released into the atmosphere during vapor and gas freeing, ventilation, entry and tank cleaning opera-

tions by collecting or treating vapors and gases removed from a tank. When degassing of volatile organic compounds is required, the displaced vapors and gasses shall be vented to the degassing control (incinerator, refrigeration condenser, scrubber, absorption or liquid balancing) system for the amount of time necessary until regulatory requirements for emission of vapors direct to the atmosphere can be met. All of the safety precautions applicable to vapor and gas freeing also apply to degassing operations. (Figure 5-8: Comparison of Tank Degassing Methods.)

5.8.1 Degassing Methods

Degassing is accomplished by a number of methods, including, but not limited to, the following:

5.8.1.1 Thermal Oxidation

Thermal oxidation methods include direct burner, internal combustion engine and catalytic incineration. A flame detonation arrestor, to prevent flash back into the tank, should be installed on the flexible tubing or piping used to pass vapors from the tank to the thermal oxidizer. As with vapor and gas freeing, other manholes or vents on the tank must remain open in order not to create a vacuum in the tank.

Note: Pressure valves should remain operational during degassing.

Continuous monitoring of the exhaust gas temperature immediately downstream of direct flame incinerators and inlet and outlet gas temperatures of catalytic incinerators may be required to assure proper oxidation has occurred. (Figure 5-9: Example of Thermal Oxidation Degassing.) (Figure 5-10: Example of Thermal Oxidation Unit—Internal Combustion Engine.)

1. Portable burner (flame oxidation) units, consisting of a furnace, blowers, piping, controls and a propane fuel supply, use a flame to oxidize (burn) the hydrocarbons. Sufficient residence time and temperature is needed to provide proper combustion.
2. Internal combustion engines pass vapors through knockout pots to remove liquids and through filters to remove solid particles. The vapors are then mixed with air and burned in the internal combustion engine.
3. Catalytic combustion passes vapors over an active catalyst.

5.8.1.2 Refrigeration

Refrigeration systems recover displaced vapor by condensation. Regulations may require that the operator monitor the flow rate into the condenser and the condenser temperature (Note: Some jurisdictions require the vapor temperature to be reduced to -100°F or lower.) and document any interruption of service that releases vapor or gas to the atmosphere. A flame arrestor shall be placed in the line to prevent flashback. (Figure 5-11: Sample Tank Degassing Refrigeration Process.)

Degassing Method		Applicability and Characteristics	Performance	Safety Considerations
Thermal	Flame Units	<p>Large or small tanks primarily hydrocarbon.</p> <p>Relatively simple operation.</p> <p>Burner controls interlocked for safety, but can be over-ridden by operators.</p>	Quick and efficient, meets all of the most stringent air district requirements.	<p>Can be ignition source.</p> <p>Safety of oxidizer design is critical.</p>
	Engine Units	<p>Lower flow rate causes longer tank downtime.</p>	Not as efficient as flame unit.	<p>Same hazards except that an engine backfire is likely.</p> <p>Unit depends on flame arrestor to prevent a flashback to tank and the design of the flame arrestor and piping must be exacting to prevent incident.</p>
Refrigeration		<p>Large or small tanks.</p> <p>Complex unit, subject to meticulous maintenance and operation requirement.</p>	Slower than thermal, may not meet the most stringent requirements.	
Activated Carbon		<p>Small tanks or as air cleaning units on tank breathing and displacement air.</p>	<p>Excellent.</p> <p>Spent carbon must be disposed of or regenerated making this impractical for larger tanks.</p>	<p>Can be ignition source, especially when flow through unit is variable or stops.</p> <p>Probability of hot spots greatest when chemically activated carbons used.</p>
Water Balancing		<p>Useful primarily for stock changes in tanks or when liquid level brought below landed roof position and to meet air jurisdiction requirements.</p> <p>Not applicable for general tank entry or cleaning operations.</p>	Variable results, depends on contents of tank, sludge contents, and the displacement liquid used.	Relatively safe.

Figure 5-8—Comparison of Tank Degassing Methods

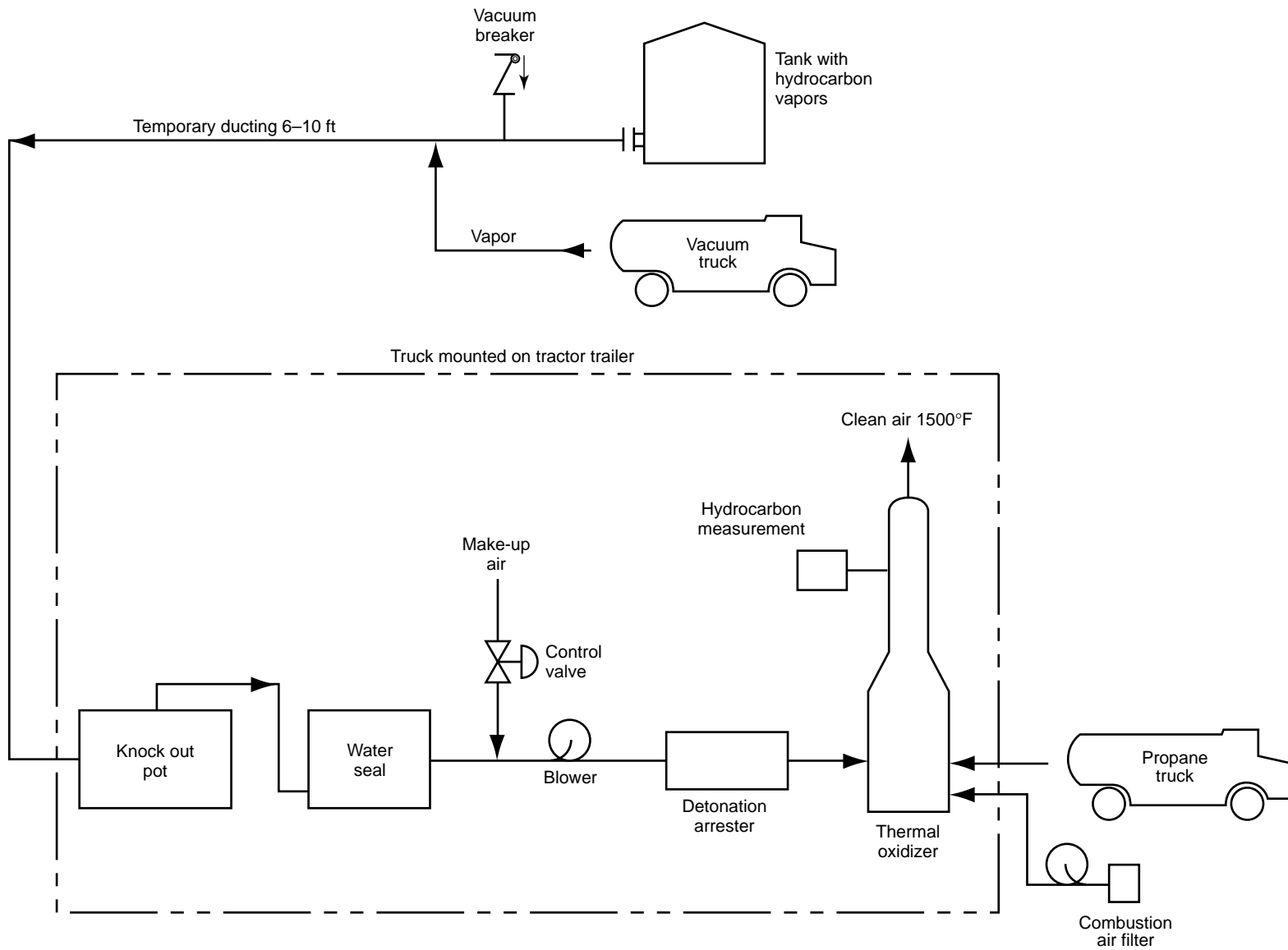
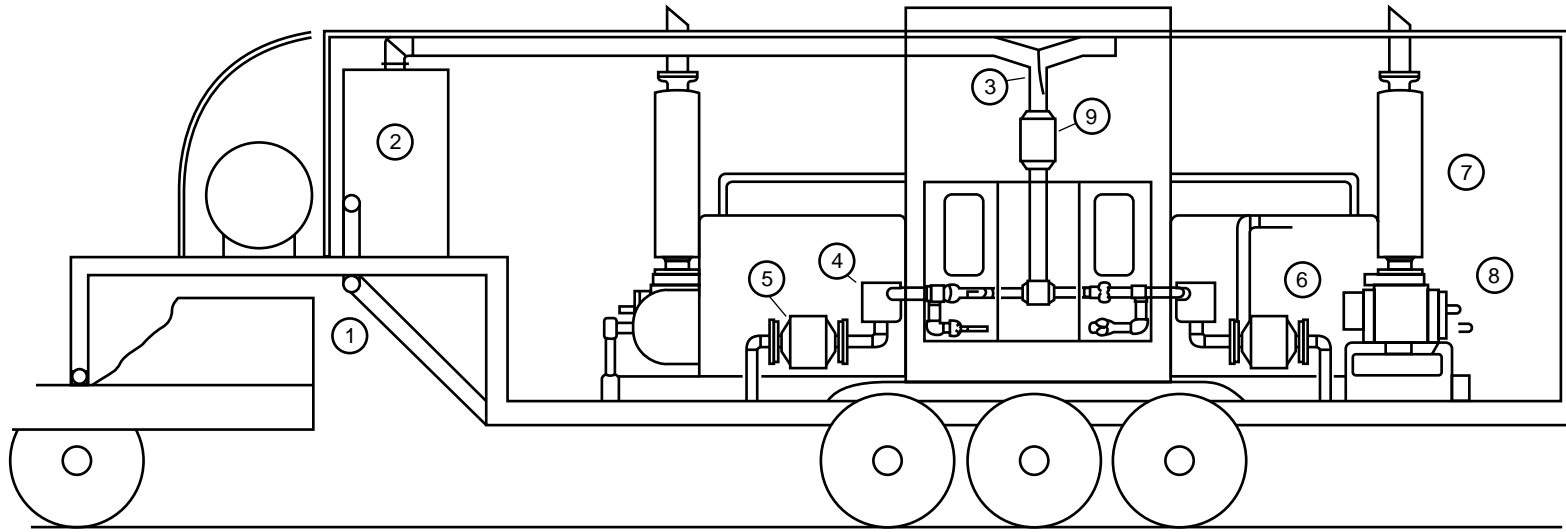


Figure 5-9—Example of Thermal Oxidation Degassing



- | | | |
|-------------------|-------------------|-----------------|
| 1. Vapor inlet | 4. Filter | 7. Silencer |
| 2. Separator drum | 5. Flame arrestor | 8. Load blower |
| 3. Mixing valve | 6. Engine | 9. Vapor blower |

Courtesy: GEM Degassing, Inc.

Figure 5-10—Example of Thermal Oxidation Unit—Internal Combustion Engine

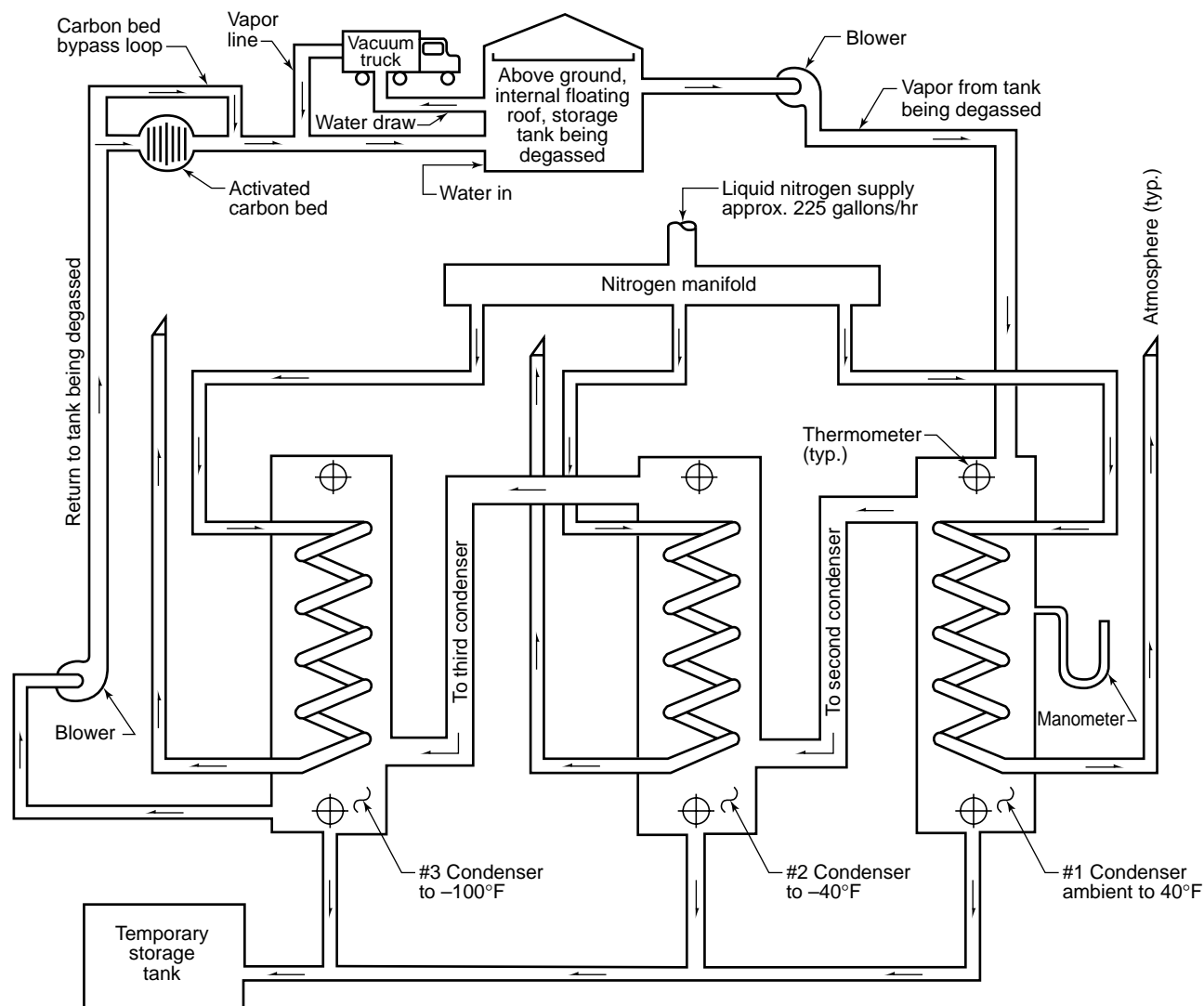


Figure 5-11—Sample Tank Degassing Refrigeration Process

5.8.1.3 Carbon Adsorption

Carbon adsorption systems use activated carbon to remove volatile organic vapors. Two or more portable carbon canisters are used in parallel so they can be switched and replaced as they become saturated. A flame arrestor shall be placed in the line from the tank to the canister to prevent flashback in event of spontaneous combustion in the canister. The jurisdiction may require that an organic vapor monitor be installed at the exit of the carbon adsorption unit to determine the concentration of hydrocarbons released to the atmosphere. (Figure 5-12: Sample of Tank Degassing Using Activated Carbon.)

Note: Regeneration or disposal of spent carbon may require a permit.

5.8.1.4 Liquid Balancing

Liquid balancing is a method where an organic liquid (in a tank) subject to degassing regulations is displaced with water or another liquid (diesel fuel) that is not subject to air quality requirements. The resultant vapor may be released to the atmosphere provided jurisdictional requirements are met.

5.8.1.5 Scrubbing

Scrubbing is a vapor phase absorption method whereby the volatile organic vapors are absorbed into another, less hazardous or volatile hydrocarbon and recycled.

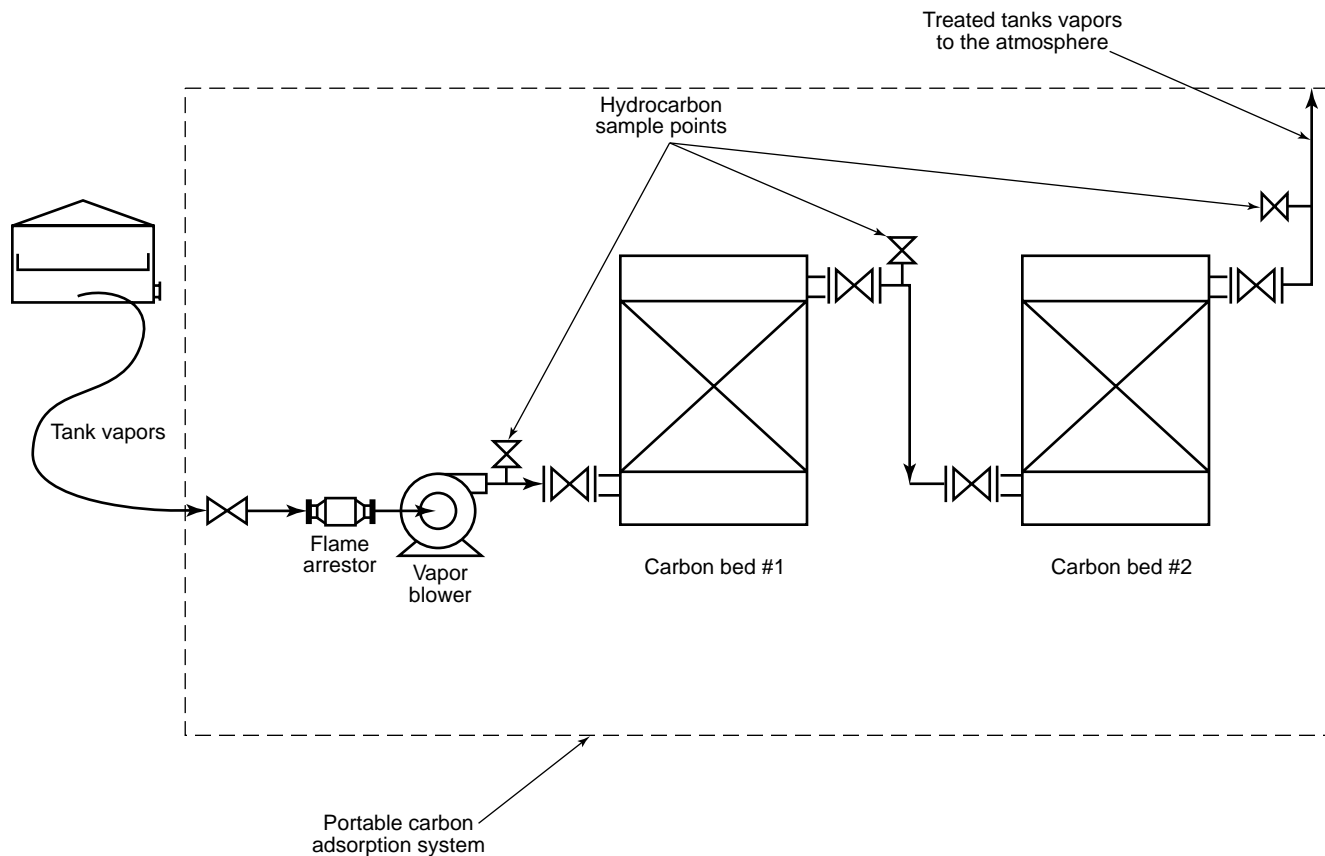


Figure 5-12—Sample of Tank Degassing Using Activated Carbon

5.8.2 Degassing Criteria

The employer (owner/operator or contractor) shall determine the method and approximate amount of time required to degas a tank depending on the following criteria:

1. Tank size and configuration.
2. Rate of withdrawal of vapors.
3. Type, amount and vaporization rates of unrecoverable product, sludge and residue.
4. Time of day and weather conditions (temperature, pressure, etc.).
5. Facility operations impacting on tank cleaning operations.
6. Method of degassing.
7. Regulatory requirements for emission of volatile organic compounds to the atmosphere.

5.8.3 Degassing Records

When degassing vapors, regulatory agencies typically require that degassing records be maintained for at least two

years following completion of operations for all tanks, vessels and marine vessels degassed at the facility. Owners/operators shall be aware of applicable record keeping requirements and establish appropriate administrative controls. Records to be maintained typically include, but are not limited to, the following information:

1. Tank's owner and address.
2. Tank capacity and chemical name of materials stored.
3. Degassing operator's name, permit number, contact and telephone.
4. Control efficiency of the system, flow rate and volatile organic compound (VOC) concentration vented to the degassing equipment and exhaust gas VOC concentration for carbon adsorption systems.
5. Direct flame incinerator exhaust gas temperatures and inlet and outlet gas temperatures of catalytic incinerators.
6. Chemical name and total amount of VOC processed in the degassing equipment.
7. Dates and reasons for interruption of service, maintenance and repair and quantity and duration of any releases to the atmosphere during interruptions.

6 Removing Sludge and Residue From Tanks

6.1 GENERAL

Employers (owners/operators and contractors) shall establish and implement noninvasive procedures to remove as much heavy product, sludge and residue as possible from the tank before the tank cleaning workers arrive. This minimizes atmospheric emissions and reduces the potential for flammable and toxic exposure hazards associated with removal when opening and entering the tank.

6.1.1 Removal Using Fixed Connections

Removal of heavier materials through fixed connections, without opening the tank, can be facilitated by the use of solvents, special diluents and chemicals, hot washes, circulation, agitation, and other methods of loosening and breaking up the sludge so that it can be easily pumped from the tank.

6.1.2 Removal Using Manholes

After all available non-recoverable product, sludge and residue have been removed from the tank through fixed connections, a manhole on the tank may then be opened and vapor and gas freeing and degassing operations started. Employers (owners/operators and contractors) shall establish and implement procedures to remove as much non-recoverable product, sludge and residue as possible through manholes, such as open manholes, doorways or door sheet openings. This may be accomplished using suction pumps, hose streams, solvent flooding and skimming, vacuum and robotic mechanical cleaning devices, without requiring workers to enter the tank.

6.1.3 Removal from Inside the Tank

After as much sludge and residue as possible is removed without entering the tank, employers (owners/operators and contractors) shall establish and implement procedures and the entry supervisor shall issue permits for workers to enter the tank to safely remove the last remaining sludge and residue.

6.1.4 Reclamation

Employers (owners/operators and contractors) should reclaim and recycle as much recoverable product and usable components of the sludge and residue as possible, in order to minimize the amount of hazardous waste.

6.2 PUMPING AND VACUUM EQUIPMENT

Pumps used to inject water, steam, solvent and chemicals into tanks and pumps or vacuum equipment used to suction product, sludge and residue from tanks, shall preferably be powered by air or steam. Employers (owners/operators and contractors) shall approve and qualified persons shall issue hot work permits for the use of pumps and vacuum equip-

ment driven by approved explosion proof electric motors or powered by internal combustion engines.

6.2.1 Sources of Ignition

All equipment constituting sources of ignition, including vacuum trucks and approved electrically driven and internal combustion powered pumps, shall be located up wind and at least 50 feet from the tank and preferably on top of or outside the tank dike area.

6.2.2 Bonding and Grounding

All pumping or vacuum equipment, regardless of its power source, shall be both grounded (earthed) and electrically bonded to the tank through conductive connections and/or separate bonding cables.

6.2.3 Electric Pumps

The employer (owner/operator or contractor) shall approve electrically driven pumps for use. The qualified person issuing the permit shall assure that the pumps are driven by explosion proof electric motors that meet the area electrical classification requirements. A qualified person shall inspect the pumps and motors prior to use, to verify good operating condition and electrical integrity.

6.3 SAFE REMOVAL PRECAUTIONS

Employers (owners/operators and contractors) shall establish and qualified persons shall implement safe work procedures for removal of product, sludge and residue that include, but are not limited to, the following precautions:

6.3.1 Controlling Vapors

Vapor and gas freeing, degassing (where required) and ventilation shall be conducted at a location and rate to assure flammable vapors will not flow out of openings at ground level. Vapors and gases shall be degassed (where required) or expelled at a high level (minimum 12 feet [3.7 meters]) above ground level, away from the open manhole. Vacuum equipment exhausts shall also be degassed or expel vapors at a high level, down wind from the tank and vacuum truck and away from sources of ignition (see API 2219).

6.3.2 Vapor Monitoring

Vapor monitoring shall be conducted by a qualified person prior to start-up and continuously or periodically thereafter as directed by the permit. Testing should be conducted in the vicinity of the tank, open manhole, connections, points of potential and actual vapor emission and the degassing, pumping and vacuum equipment. The qualified person shall advise the entry supervisor to stop work and control ignition sources should the percentage of vapors in the atmosphere exceed the permit limits.

6.3.3 Standby Person

A qualified person shall be assigned to standby and monitor the pumping and vacuum equipment during operation and to immediately stop their operation if actions detrimental to tank cleaning operations, including, but not limited to the following, occur:

1. Vapors in the atmosphere exceed the permitted levels
2. Tank vapor and gas freeing, ventilation or degassing is stopped for any reason
3. The permit is cancelled for any reason.

6.4 NONINVASIVE REMOVAL

Noninvasive removal of non-recoverable product, sludge and residue by pumping or vacuuming through fixed tank connections may be accomplished by a number of methods including, but not limited to, heating, circulation and agitation, water and oil flooding and use of petroleum solvents and chemicals. All the tank equipment, piping and fixed connections shall be isolated following noninvasive removal through fixed connections.

6.4.1 Heating, Circulation, and Agitation

Heating, circulation or agitation may be used to fluidize heavy non-recoverable products, sludge and residue, allowing them to be pumped or vacuumed out through closed connections. The use of internal heaters and agitators shall be restricted when the product level is below the level of this equipment, as residue on unsubmerged piping, agitators or heaters could be overheated and become a source of ignition. (Figure 6-1: Example of Educators used for Tank Agitation.)

6.4.2 Water or Fuel Oil Flooding

Water or fuel oil may be used to float lighter hydrocarbons to a fixed tank connection where they can be removed from the tank. Contaminated water must be treated before disposal, whereas fuel oil may be recovered and returned to storage (depending on its contamination). (Figure 6-2: Example of Water Balancing.)

6.4.3 Chemicals, Solvents, and Dispersants

Special chemicals, dispersant surface active additives and petroleum solvents, including, but not limited to gas oil, light crude oil and diesel fuel, may be used to breakup, disperse, or dissolve heavy non-recoverable product, sludge and residue so that it can be removed through fixed tank connections. Injection of these materials may be conducted from roof or shell nozzles, or by hot tapping injectors onto the tank shell. Before cleaning chemicals are used, the entry supervisor or

qualified person shall determine the potential for flammable and toxic hazards from the chemical used and institute proper precautions for storage, handling and disposal.

6.4.4 Hot Water/Chemical Treatments

Hot water/chemical techniques depend on the characteristics of the heavy non-recoverable product, sludge and residue and the ability of the facility to treat and dispose of the contaminated water, chemicals and hydrocarbons. The water is mixed with chemicals, including, but not limited to, wetting agents, emulsion breakers and dispersants and mixed with cutter oil in proportions equal to the volume of sludge. The mixture in the tank is then heated to the required temperature (approximately 150°F [66°C]) by use of internal heaters or steam injection or by recirculating the fluid through external heat exchangers, until the separation of liquid hydrocarbons from the sludge occurs.

6.5 REMOVAL FROM OUTSIDE THE TANK

6.5.1 General

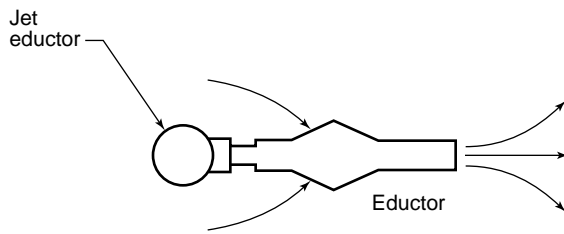
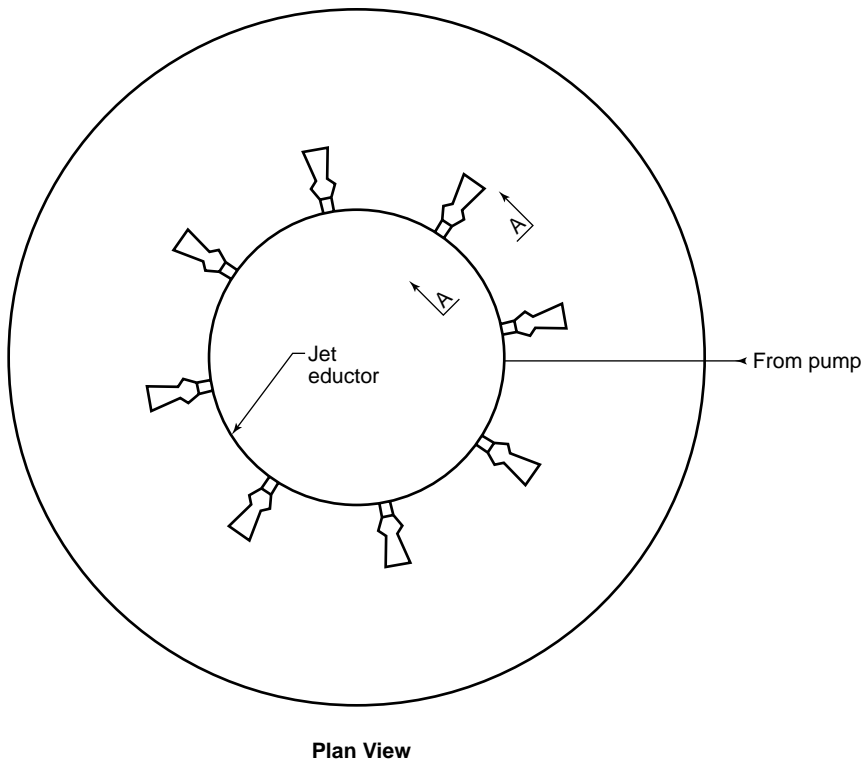
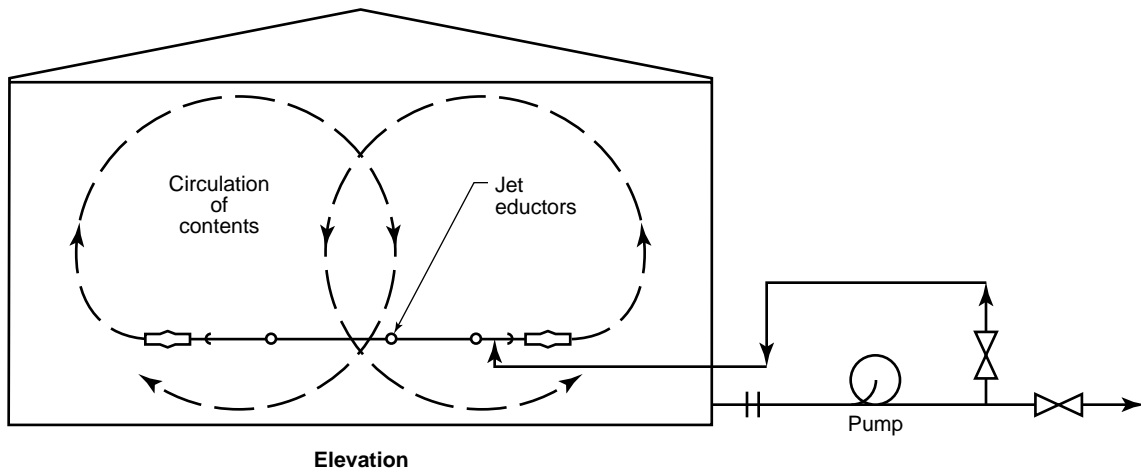
After all available non-recoverable product, sludge and residue has been removed from the tank through closed connections, the remaining material may be removed from the outside of the tank through an open manhole, doorway or door sheet opening. The door sheet may be opened using a water cutting technique that minimizes heat, thus reducing the potential for ignition. The tank shall be vapor freed (degassed) and ventilated during these operations.

6.5.1.1 Entry supervisors shall review the potential hazards, determine the safe procedures and requirements, have qualified persons conduct atmospheric testing and issue entry permits to begin tank cleaning from the outside of the tank.

6.5.1.2 Tank cleaning workers shall wear approved respiratory and appropriate personal protective equipment, as required, throughout the cleaning operation.

6.5.2 Vapor and Gas Freeing

Before beginning sludge breakup and removal from outside the tank, the tank atmosphere shall be vapor and gas freed (and the vapors degassed, if required) until the vapor-in-air (gas-in-air) mixture leaving the tank is at or below 10% LEL. Because agitation of sludge and residue will release vapors and increase the vapor-in-air concentration inside the tank, cleaning from the outside of the tank shall stop if the vapor-in-air (gas-in-air) mixture leaving the tank rises above 10% LEL. Vapor and gas freeing (degassing) and ventilation shall be continued until the tank's atmosphere is again below 10% LEL, when sludge breakup and removal from outside the tank can resume.



Eductor Detail A-A

Figure 6-1—Example of Eductors Used for Tank Agitation

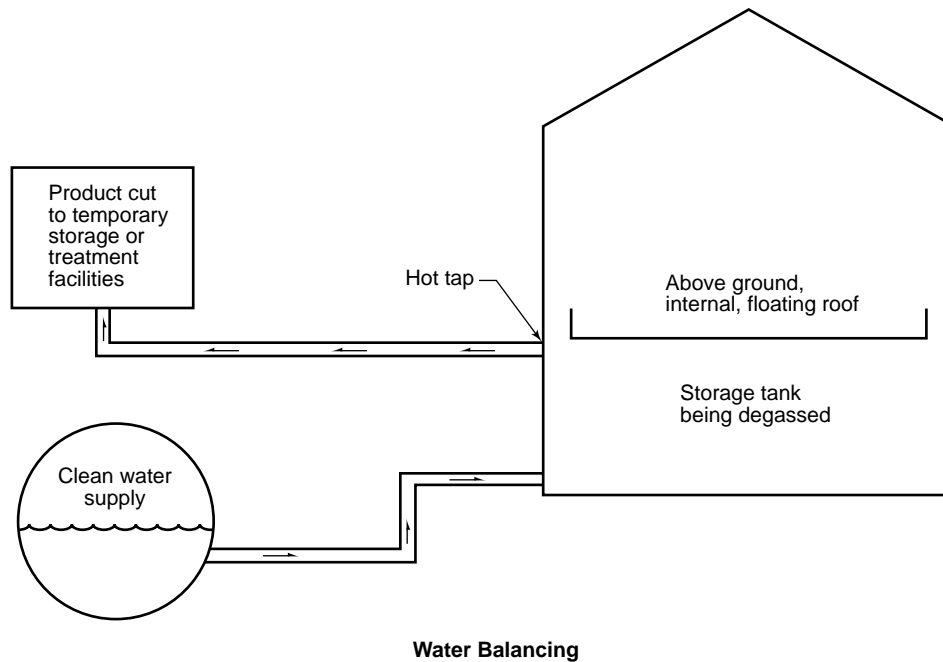


Figure 6-2—Example of Water Balancing

6.5.2.1 Vapor and gas freeing, degassing (where required) and ventilation shall continue throughout the removal activity (except in inert tanks).

6.5.2.2 A qualified person shall conduct atmospheric monitoring for flammable vapor and gas and toxic exposures, continuously or periodically as required by the entry supervisor, in the ventilation exhaust areas, around degassing systems and at open manhole, doorway or door sheet areas during the cleaning operation.

6.5.2.3 Cleaning shall stop if the flammable vapor or gas levels or toxic exposure levels in the work area exceed the permit limits.

6.5.3 Removal of Product, Sludge, and Residue After Opening the Tank

Dispersant surface additives and petroleum solvents may be added to heavy non-recoverable product, sludge and residue to increase fluidity.

6.5.3.1 Dilute concentrations of hyperchlorites or permanganate solutions may be used to assist in oxidizing pyrophoric compounds or to assist in tank cleaning. The entry supervisor shall be aware that this usage has a potential to create a runaway exothermic reaction that can result in sufficient heat to create an ignition source and institute appropriate preventive measures.

6.5.3.2 Water streams, steam jets and petroleum solvent or chemicals may be injected through the open manhole to break up and dislodge heavy non-recoverable product, sludge and residue and float it to a pump out connection. Hose nozzles and suction hoses shall be bonded to the tank to reduce the potential for electrostatic buildup.

6.5.3.3 Approved mechanical powered equipment may be permitted to enter the tank through the doorway or door sheet opening to remove large amounts of dry, caked sludge, deposits and residue from inside the tank. The entry supervisor shall be aware that the use of such equipment has the potential for a source of ignition and institute appropriate protective measures. Mechanical powered equipment shall have explosion proof motors, ground fault interrupters and shall be bonded to the tank.

6.5.3.4 Mechanical robotic cleaning devices may be used inside tanks to carry cutter oil hoses and nozzles to specific locations where the solvent is applied directly into the heavy non-recoverable product, sludge or residue. This direct application of a pressure jet is more effective and uses less solvent than a hose stream operated from an open manhole. Mechanical robotic cleaning devices are particularly useful in removing sludge from inert tanks.

1. Robotic devices may be provided with low light video, lighting systems and lens washers to assist the remote operator in directing operations.

2. Robotic devices shall have explosion proof motors, ground fault interrupters and shall be bonded to the tank.
3. Robotic devices may be equipped with oxygen, hydrogen sulfide (H₂S), toxic gas and flammable gas and vapor detectors.
4. Operators shall recognize that robotic devices have problems negotiating obstacles within the tank such as piping, columns, supports, roof legs, sumps, etc. and shall take appropriate action to avoid obstructions.

6.6 REMOVAL FROM INSIDE THE TANK

6.6.1 General

Interior tank cleaning requires that workers enter the tank and physically remove the heavy non-recoverable product, sludge and residue by hand. Entry supervisors shall review the potential hazards, determine the safe procedures and requirements; have qualified persons conduct atmospheric testing; assign standby persons, attendants and entrants and designate rescuers before issuing entry permits for removal and cleaning inside the tank.

6.6.2 Entry

Prior to permitting entry into a tank for removal and cleaning, the entry supervisor shall require that a qualified person, authorized on the entry permit, conduct an inspection of the tank's interior to determine if any physical hazards are present.

6.6.2.1 Ventilation shall continue throughout the entire inspection, removal and cleaning activity (except in inert tanks).

6.6.2.2 A qualified person shall conduct atmospheric monitoring for flammable vapors and gas and toxic exposures continuously or periodically, as required by the entry supervisor, at the ventilation exhaust area and inside the tank during cleaning operations.

6.6.2.3 Before the entry supervisor issues a permit for tank cleaning workers to enter the tank under permit required confined space entry conditions, the tank's atmosphere shall be vapor freed and ventilated (except in inert tanks) until vapors leaving the tank are at or below 10% LEL.

6.6.2.4 If the vapors inside the tank rise above 10% LEL, removal and cleaning operations shall stop and workers shall leave the tank. Ventilation shall be continued (except in inert tanks) until the tank's atmosphere is again below 10% LEL, at which time workers may reenter and resume removal and cleaning operations.

6.6.2.5 Removal and cleaning activities shall stop and workers shall immediately leave the tank if the toxic exposure levels inside the tank exceed the applicable permissible limits.

6.6.2.6 Tank cleaning workers, entrants, attendants, standby persons and rescuers shall wear approved respiratory and personal protective equipment, as required, throughout the removal and cleaning operation.

6.6.2.7 Only approved, low voltage electrical lighting or approved flashlights shall be used inside or around tanks during the removal and cleaning process.

6.6.3 Inside Removal of Sludge, Residue and Deposits

The remaining non-recoverable heavy product, sludge, residue and deposits may be removed from the tank by a number of different methods, including, but not limited to the following:

1. Wash, brush, squeegee, or sweep material into buckets, bins, or carts and remove by hand.
2. Spray or wash down material with water hose streams (bond nozzles to the tank) and remove by pump or vacuum (bond equipment to the tank).
3. Wash down material with fuel oil, solvent, or approved chemicals and remove by suction or vacuum (bond equipment to the tank).
4. Use absorbents to remove small amounts of material on floors and walls.
5. If the manhole provides for entry, air or steam powered equipment may be used to remove materials from larger tanks. Use of equipment powered by approved explosion proof electric motors shall require approval of the employer (owner/operator or contractor) and the issuance of a hot work permit by the entry supervisor.

6.7 SLUDGE DISPOSAL

6.7.1 Requirements

Employers (owners/operators and contractors) shall be familiar with applicable government regulations and hazardous waste exemptions and facility requirements and establish and implement appropriate procedures for safe handling, testing, classifying, storing, treating and disposing of material removed from tanks.

6.7.1.1 Employers (owners/operators and contractors) shall assure that qualified persons inspect, test and analyze non-recoverable heavy products, sludge and residue removed from tanks to determine if any potentially hazardous flammable or toxic characteristics are present that would qualify the material to be considered hazardous waste.

6.7.1.2 Entry supervisors shall determine and implement the personal protection and control measures required for safely handling and removing non-recoverable product, sludge and residue from tanks.

6.7.2 Treatment and Disposal

Sludge, non-recoverable product, and residue may be treated on-site or off-site. If not treated on-site, non-recoverable heavy product, sludge and residue must be removed to an approved storage area and, depending on its characteristics, may be considered a hazardous waste. If the sludge, residue, non-recoverable product, or deposits are considered to be hazardous waste, they must be stored, handled, and disposed of according to facility requirements and government regulations. There are a number of methods of treating product, sludge and residue removed from tanks including, but not limited to, the following:

6.7.2.1 Non-recoverable heavy product, sludge and residue may be de-watered and de-oiled by gravity separation, filtration or centrifuging to recover hydrocarbons. Recoverable water is normally sent to a separator and recoverable oil is reprocessed.

6.7.2.2 Non-recoverable heavy product and sludge may be treated on site by incineration or coking.

6.7.2.3 A method used in producing and upstream operations, involves weathering and land farming sludge and residue by treating it with bulking agents and fertilizer and spreading it on the ground in an approved, designated area. This method shall not be used if the sludge or residue is from a tank that contained leaded products.

7 Unique Tanks

7.1 GENERAL

Employers (owners/operators and contractors), entry supervisors and qualified persons shall determine the potential for unusual hazards and develop and institute appropriate control measures for vapor and gas freeing, degassing (where required), ventilating, entering and cleaning very large, unique and specially designed tanks. 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 shall be reviewed and evaluated by a qualified person prior to the start of tank cleaning operations. This recommended practice provides additional guidance for employers (owners/operators and contractors) when establishing requirements for vapor and gas freeing, degassing, ventilating, entering, and cleaning tanks that present unusual or potentially hazardous conditions due to their size, shape, design, and/or configuration, including, but not limited to, the following:

1. Very large storage tanks.
2. Floating roof tanks.

3. Double wall and double bottom tanks.
4. Low pressure storage tanks.
5. Conservation tanks.

7.2 VERY LARGE TANKS

7.2.1 General

The requirements for decommissioning, vapor and gas freeing, degassing (where required), ventilating, entering, cleaning and recommissioning, as described in ANSI/API Standard 2015 and ANSI/API Recommended Practice 2016, apply to all fixed (cone) roof, open top and covered open top tanks. Employers (owners/operators and contractors) shall be aware that very large, multi-million barrel tanks require special consideration and additional tank cleaning precautions and safety procedures due to their great volumes and large size (over 200 feet diameter).

7.2.2 Requirements

Employers (owners/operators and contractors) and entry supervisors shall determine the potential hazards and establish and implement additional specific precautions and procedures required for vapor and gas freeing, degassing (where required), ventilating, entering, and cleaning very large tanks, including, but not limited to, the following:

7.2.2.1 Multiple and simultaneous use of eductors and air blowers to increase air flow when vapor and gas freeing (degassing) and ventilating large tanks.

7.2.2.2 Precautions for entering, testing and working in areas within large tanks that may not have been completely vapor freed and ventilated to required atmospheric limits.

7.2.2.3 Maintaining communications between attendants and testers or entrants in large tanks.

7.2.2.4 Unique rescue situations associated with large tanks.

7.3 FLOATING ROOF TANKS

7.3.1 General

The precautions and procedures for vapor and gas freeing, degassing, ventilating, entry and cleaning described in ANSI/API Standard 2015 and ANSI/API Recommended Practice 2016 shall apply to all open top, covered open top and internal floating roof tanks. Employers (owners/operators and contractors) shall review available information covering experience with leakage and retention of hydrocarbons in roofs of the type of tank to be worked on prior to the start of tank cleaning operations.

7.3.2 Floating Roof Design

Employers (owners/operators and contractors), entry supervisors, testers, entrants, and attendants shall be familiar with specific design and operating aspects of the specific floating roof tank that affect vapor and gas freeing, degassing, ventilation, entry and cleaning activities. Before cleaning a floating roof tank, the employer (owner/operator and contractor), entry supervisor or a qualified person shall review and be familiar with the roof design and develop and implement procedures for inspecting and vapor and gas freeing flotation devices. The types of open top, covered open-top and internal floating roofs vary depending on the tank manufacturer, the intended service and facility design standards.

7.3.2.1 Open-top and covered open-top (external) floating roof designs typically incorporate steel decks with enclosed liquid-tight steel compartments, peripheral pontoons or complete double floating decks (with bulkheads), for flotation. Other types of roof designs include, but are not limited to, the following:

1. Single deck steel pans may be in service on older tanks.
2. Aluminum decks with aluminum tube pontoons or compartments may be found on newer, covered open-top floating roof tanks.

7.3.2.2 Internal floating roofs (decks) may typically be aluminum decks with aluminum tube pontoons or compartments. Other types include, but are not limited to, the following:

1. Steel decks with pontoons.
2. Single deck steel or aluminum pans.
3. Decks constructed of buoyant foam materials enclosed in metallic or plastic sheeting.
4. Honeycomb decks, pontoons, pans and panels; solid buoyant materials or a combination thereof.

7.3.3 Flotation Hazards

Entry supervisors or qualified persons shall review floating roofs for potential hazards and establish safe work procedures prior to beginning tank cleaning operations.

7.3.3.1 Liquids in pontoons may create a physical hazard when the roof is on its legs, as the roof and legs are not designed to carry the additional weight.

7.3.3.2 Buoyant internal floating roofs may contain plastic or other combustible material or material that may absorb hydrocarbon liquids. Employers (owner/operator and contractor), entry supervisors or qualified persons shall review such materials and establish safe work procedures prior to beginning tank cleaning operations involving hot work.

7.3.4 Seals

Floating roof seals are used to close the annular space between the floating roof and the shell to prevent vapors from bypassing the floating roof. The two basic types of floating roof seals are primary seals and secondary seals. Before beginning to clean a floating roof tank, employers (owners/operators and contractors), entry supervisors and qualified persons shall review and be familiar with the roof design and type of seals used on the tank and develop and implement procedures for inspecting seals and controlling vapors.

7.3.4.1 Primary seals include, but are not limited to, combustible flexible foam-filled bags, flexible wiper and metallic shoes. Buoyant primary seals may become soaked or saturated with oil, retain hydrocarbons and emit liquids and flammable vapors after the tank appears to be vapor free.

7.3.4.2 Secondary seals are used on open top floating roof tanks (and often on covered open top floating roof tanks) to further reduce vapor emissions. They are located between the floating roof and the tank shell, above primary seals, and are usually made of sheet metal. Secondary seals have an intermediate vapor space between the seal and the floating roof, that may contain vapors, should the primary seal leak.

7.3.5 Descent onto Floating Roofs

It is generally necessary for workers to descend onto the floating roof while the tank is still in service in order to position the roof support legs so that the roof will land in the high roof position upon being emptied. Requirements for entry onto the tops of floating roofs are similar to the requirements in ANSI/API Standard 2015 for entering into confined spaces.

7.3.5.1 The employer (owner/operator) shall classify and document the area above the top of each internal and covered open top floating roof as either a permit required confined space or a non-permit required confined space. Unless otherwise classified and documented, entry onto internal and covered open top floating roofs shall be considered to be permit required confined space entry, as ingress and egress is restricted and the potential may exist for a hazardous flammable or toxic atmosphere depending on seal conditions, time since the tank was last filled, and other criteria.

7.3.5.2 The owner/operator shall classify and document entry onto open top floating roofs and open top floating roofs with weather covers as confined space entry (either permit required or non-permit required) or as non-confined space entry, depending on prevailing conditions and cover construction. Each owner/operator shall assess the attributes of each open-top (external) floating roof tank and establish the conditions required in order for the space on top of the floating roof to be classified as a non-confined

space. The specific classification at pre-established roof levels will depend on specific criteria, including, but not limited to the following:

1. Roof level and roof condition.
2. Construction and condition of the roof weather cover (allows continuous ventilation).
3. Condition of the seals, pontoons and flotation devices.
4. Time since the tank was last filled, product in the tank and whether product is being added or withdrawn during entry.
5. Ease of egress.
6. External weather conditions.
7. Tank roof level atmospheric test results.

7.3.5.3 It is petroleum industry practice to classify open top floating roofs when they are within 5 feet of the top of the tank as non-confined spaces, provided that none of the requirements for classification as confined space exist. (See ANSI/API Standard 2015 and API 2026 for additional information.)

7.3.6 Floating Roof Hazards

Employers (owners/operators and contractors) and entry supervisors shall be familiar with the potential hazards of entering upon floating roofs and establish and implement appropriate procedures, including but not limited to, the following (see API 2026 for additional information):

7.3.6.1 A qualified person shall initially evaluate the physical condition of the floating roof by visual examination through openings in the fixed roof of internal and covered open top tanks or from the top of the stairway, platform or wind girders of open top tanks.

7.3.6.2 Entry supervisors, qualified persons and entrants shall recognize that physical obstructions, defective roof areas and panels and liquid product or water on top of the roof may be difficult to detect because of restricted visibility.

7.3.6.3 When preplanning tank cleaning, employers (owners/operators or contractors) shall provide sufficient notice to allow for descent onto the floating roof to set legs to be made when the roof is at the highest level that provides space for safe entry. This will maximize natural ventilation and minimize descent and climbing time.

7.3.6.4 Descent onto open top and covered open top floating roofs is usually by means of a moveable stairway on larger tanks and a vertical ladder on smaller tanks. Descent onto internal floating roofs is usually by means of a vertical ladder.

7.3.6.5 Open top and covered open top floating roofs are usually well constructed and unless corroded or otherwise defective, will support the weight of personnel. Many internal floating roofs are of light construction, and walking on the roof surface can be hazardous unless limited to areas designated for that purpose.

7.3.6.6 When descending upon floating roofs that were not designed to support the weight of personnel, employers (owners/operators or contractors) shall provide a lightweight material to be used by the entrant(s) to spread the weight over a greater area of the floating roof.

7.3.6.7 Prior to emptying the tank, the roof support legs and sleeves through the roof shall be examined (to the extent possible) by a qualified person for corrosion or other defects to determine their ability to support the roof. Anti-rotation guidepoles and devices shall also be checked to assure proper function. Temporary roof support may be necessary until legs are repaired or replaced.

7.3.6.8 Positioning pins on legs should be placed in the high roof position, supporting the roof at as high a position as possible above the tank bottom, to facilitate cleaning operations. If the support legs are designed for only one support level or are already in the high roof position, entry for leg positioning will not be necessary (but inspection of the legs shall be required).

7.3.7 Atmospheric Testing

Entry supervisors shall assure that a qualified person conducts atmospheric testing of the space on top of the floating roof prior to the start of each work period and that continuous or periodic monitoring is conducted, as required, during operations on top of floating roofs.

7.3.7.1 When initially testing the atmosphere on the top of floating roofs, testing should be conducted from an opening or platform at the top of the tank using instruments equipped with extension devices, without descending onto the floating roof.

7.3.7.2 Descent onto a floating roof for further testing shall require the entry supervisor to issue an entry permit. Entrants, testers, attendants, standby persons and rescuers shall follow the permit-required confined space entry requirements prescribed in this recommended practice and in the permit.

7.3.8 Vapor and Gas Freeing

Employers (owners/operators and contractors), entry supervisors and tank cleaning workers shall determine the potential hazards and establish the precautions and procedures described in ANSI/API Standard 2015 and ANSI/API Recommended Practice 2016 when pumping out, emptying,

vapor and gas freeing, degassing (where required) and ventilating floating roof tanks.

7.3.8.1 Even though a floating roof tank has been tested and determined to be initially safe for entry, it may not necessarily remain in this condition. With the passage of time, leakage of liquids or vapor from pontoons, buoyant foam panels and other flotation devices, linings and seals, columns and double bottoms may result in toxic or flammable vapors being present in the tank atmosphere, both above and below the floating roof and between double bottoms. A qualified person shall inspect the entire tank and test potential areas that may continue to release hydrocarbon liquid or vapor after initial vapor and gas freeing (degassing).

7.3.8.2 Entry supervisors shall assure that all liquids and vapors (above acceptable limits) are removed from pontoons, columns, sumps, double bottoms, internal piping, seals, foam flotation devices, linings and insulation by inert gas purging, water displacement or ventilation with fresh air before work is permitted in the tank.

CAUTION: Entry into pontoons and other tank spaces shall be considered to be permit required confined space entry until tested and declared to be gas and vapor free and re-designated as non-permit required confined space.

7.3.8.3 A build-up of vapors is more likely under internal floating roof tanks because of the possibility of liquid being retained in the envelope construction of flotation material, pontoons and seals. Employers (owners/operators or contractors) shall establish and entry supervisors shall implement procedures for vapor and gas freeing, degassing (where required), ventilating, atmospheric testing and entry into restricted spaces under floating roofs resting on legs on the bottom of the tank.

7.3.9 Return to Service

When crude oil or flammable petroleum products are pumped into empty floating roof tanks being returned to service (re-commissioned), vapors will collect in the atmosphere above the liquid level and below the floating roof. Some vapors may be expelled through the seals to the space above the floating roof and remain there until dissipated (or released to the atmosphere through the vents on internal floating roof tanks). (See API 2003 for additional information.)

7.3.9.1 The atmosphere below the floating roof will be in the explosive (flammable) range for a short period of time, but will soon become “vapor rich” and exceed the upper explosive (flammable) limit.

7.3.9.2 The atmosphere above the floating roof may be within the explosive (flammable) range at any time during the filling process and remain so for a continued period of time thereafter.

7.3.9.3 When filling internal floating roof tanks, vapor may also be expelled from the eave vents.

7.3.9.4 Employers (owners/operators and contractors) and entry supervisors shall not permit sampling or hand gauging of the tank during filling and for an established period of time (minimum of 30 minutes) after filling is completed.

Note: See ANSI/API Standard 2015 for information concerning a required 30 minutes relaxation time.

7.3.9.5 Employers (owners/operators and contractors) shall observe the precautions concerning initial pumping rates and prevention of splashing to minimize electrostatic generation and to control generation of vapors when refilling floating roof tanks.

7.3.9.6 Employers (owners/operators and contractors) shall institute procedures to prevent the initial refilling of floating roof tanks with crude oil or flammable liquids during lightning storms. The entry supervisor or qualified person shall issue a hot work permit for the use of sources of ignition, including but not limited to, electrical equipment, electrically driven ventilating equipment, hot work and internal combustion engines in the vicinity of the tank during receipt of flammable liquids.

7.4 DOUBLE WALL AND DOUBLE BOTTOM TANKS

7.4.1 Vapor and Gas Freeing

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. Employers (owners/operators or contractors) shall establish and entry supervisors shall implement procedures to assure that these areas are inspected, drained, vapor freed and tested so that liquid and vapors do not reenter the tank during the tank cleaning process.

7.4.1.1 Liquids shall be removed 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.

7.4.1.2 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.

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

7.4.2 Return to Service

Before returning double wall and double bottom tanks to service, the employers (owners/operators or contractors) shall assure that the interstitial space is air dried and tested to assure that there is no leakage. Employers (owners/operators or contractors) shall also assure that any insulation or sand that was removed during the tank cleaning process has been replaced with new material and disposed of properly.

7.5 LOW PRESSURE STORAGE TANKS

7.5.1 General

Many of the methods, procedures and precautions for vapor and gas 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.

7.5.1.1 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.

7.5.1.2 Refrigerated products such as liquefied natural gas, butane, butadiene and propane are stored under a combination of near-atmospheric pressure and low temperatures.

7.5.2 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.

7.5.3 Vapor and Gas Freeing

Employers (owners/operators or contractors) shall establish and entry supervisors shall implement safe operating procedures to be followed when vapor and gas freeing (degassing) low pressure storage tanks. These procedures will vary with the type of tank, its location, requirements for vapor and gas disposal and availability of water and inert gas and shall include, but not be limited to, the following:

7.5.3.1 After recovering as much product as possible from a low-pressure storage tank, the tank shall be isolated from other equipment, except for the pump-out line.

7.5.3.2 Entry supervisors shall assure 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.

7.5.3.3 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 shall be provided to prevent back flow. A qualified person shall determine that the tank is structurally able to hold the weight of the water to be used.

7.5.3.4 After all liquid hydrocarbons are flushed out, the water should be removed through the water draw-off system. The water draw-off valve shall be closed as soon as vapor appears. The tank will now contain gas under pressure.

7.5.3.5 The remaining gas should be vented to a degassing system, if available or required. If gas is vented to the atmosphere, it shall be released at an elevation high enough above ground level (minimum 12 feet [3.7 meters]) to safely disperse the vapors.

7.5.3.6 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.

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

7.5.3.8 Low pressure, non-refrigerated tanks may be gas freed by being completely filled with water after all of the liquid is pumped out and the tank is depressured. 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 12 feet [3.7 meters]) 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.

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

7.5.3.10 If pyrophoric iron sulfide deposits are present, entry supervisors shall assure that the inside of the tank is wetted down with water until all residue has been removed.

7.5.4 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.

7.6 CONSERVATION TANKS

7.6.1 Tank Designs

Conservation tanks, some of which are still in service, were designed to provide for and contain expanding vapors from liquid petroleum products that readily vaporized in ambient temperatures, such as high octane aviation gasoline. 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 following types:

7.6.1.1 Wet Seal Lifter Tank

A fixed (cone) roof tank containing 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.

7.6.1.2 Flexible Diaphragm Tank

A fixed (cone) roof, variable vapor space tank with an internal flexible membrane that provides for 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 connected to the primary tank by piping, whereas older vapor tanks were separated from the primary tank by just the diaphragm. Another type of flexible diaphragm tank is a sphere with an internal membrane.

7.6.1.3 Breather Balloon Tank

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

7.6.2 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. Employers (owners/operators and contractors) and entry supervisors shall take into consideration that 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 must 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 must be adjusted according to each specific situation.

8 Specific Hazardous Substances

8.1 GENERAL

Employers (owners/operators and contractors), entry supervisors and qualified persons shall determine the potential for unusual hazards and develop and institute appropriate control measures for vapor and gas freeing, degassing (where required), ventilating, entering and cleaning tanks that have been used to store specific hazardous substances. In addition, particularly for older tanks, information on the various services in which the tank has been used shall be provided by the owner/operator and reviewed and evaluated by a qualified person prior to the start of tank cleaning operations. This recommended practice provides guidance for employers (owners/operators and contractors) when establishing requirements for vapor and gas freeing, degassing (where required), ventilating, entering and cleaning tanks that present unusual or potentially hazardous conditions due to their products or usage, including, but not limited to, the following:

1. Tanks with pyrophoric iron sulfide deposits.
2. Tanks with products containing hydrogen sulfide (H₂S).
3. Tanks that have been in leaded service.
4. Tanks containing hazardous sludge and residue.

8.2 TANKS WITH PYROPHORIC IRON SULFIDE DEPOSITS

8.2.1 General

Pyrophoric iron sulfide is formed by the action of corrosive sulfur compounds on iron and steel in storage tanks. If a tank has contained asphalt, aromatic tars, sour crude, high sulfur fuel oil, aromatic gases and similar products, the potential exists for the formation of black or brownish colored pyrophoric iron sulfide scale, powder or deposits on the tank walls and roofs and in the tank residue and sludge. After the tank is emptied, preparatory to cleaning and during ventilation, these iron sulfide deposits will dry out and react with oxygen in the air, generating heat and spontaneously igniting when flammable vapors or gases are present.

8.2.2 Vapor and Gas Freeing Precautions

8.2.2.1 Water Wetting

During vapor and gas freeing and ventilation, wetting dissipates heat buildup and isolates the pyrophoric iron sulfide deposits from air, thereby reducing the possibility for a spontaneous ignition while the tank contains vapors in the explosive (flammable) range. Employers (owners/operators and contractors) and entry supervisors shall establish and imple-

ment procedures to provide for wetting all internal surfaces of these tanks with water, until the flammable vapors have been removed.

8.2.2.2 Inerting

Alternately, employers (owners/operators and contractors) and entry supervisors may establish and implement procedures for the use of inert gas to purge vapors and gas from the tank and to keep air out of the tank. As long as the tank's atmosphere remains inert and below the lower explosive (flammable) limit, there is no potential for pyrophoric ignition. The inert gas purge should be maintained until all pyrophoric iron sulfide scale, dust, deposits and sludge are removed from the tank.

CAUTION: The use of inert gas to blanket sulfur containing products in storage tanks may increase pyrophoric deposit formation in these tanks over a period of time, by reducing the oxygen content of the atmosphere. (See Section 5.6 for inert gas purging requirements.)

8.2.3 Removing Deposits

Employers (owners/operators and contractors) shall establish and entry supervisors shall implement procedures for the removal of pyrophoric iron sulfide deposits from tank shell and roof surfaces using water or steam to prevent ignition, including, but not limited to, the following:

8.2.3.1 Depending on the type of tank and product contained, follow the procedures in this recommended practice to remove as much product as possible through existing lines and then isolate all lines except foam lines (where provided).

8.2.3.2 Install and bond a venturi type eductor (no moving parts) onto an open manhole on the roof (or on a shell manhole) of the tank with an airtight connection.

8.2.3.3 With all other manholes still closed, start the eductor at a low rate of flow to create a slight negative pressure inside the tank.

CAUTION: Keep the negative pressure inside the tank at a minimum to prevent shell and roof plates from buckling and causing major tank damage. This establishes a pressure differential to prevent the release of vapor or gas and hydrogen sulfide (H₂S) at ground level when the second manhole is opened.

8.2.3.4 Connect and bond one (or more) large water spray/fog nozzle(s) or steam nozzle(s) to the open manhole. Without delay, turn on the water spray/fog or steam and immediately turn on the air eductor at full capacity.

8.2.3.5 Steam or water spray/fog the tank so that the interior surfaces are thoroughly wet with condensate throughout

the ventilation operation and until all iron sulfide is removed from the tank.

CAUTION: Spraying/fogging steam or water into tanks produces an electrostatically charged mist. See ANSI/API Standard 2015 and ANSI/API Recommended Practice 2016 for precautionary measures when using steam and for electrical bonding requirements for the air blower and for the water spray/fog and steam injection nozzles.

8.2.3.6 After the tank has been vapor freed, continue the application of the water spray/fog or steam during ventilation. With workers staying outside of the tank, inject high-pressure water streams (with the nozzles bonded to the tank to prevent electrostatic buildup) through the open manhole to knock down all loose pyrophoric iron sulfide dust, scale, deposits and residue and to break up sludge.

CAUTION: Atmospheric testing should be conducted during this operation as the potential exists for the release of hydrogen sulfide (H₂S) and additional flammable vapors from the residue and sludge.

8.2.4 Handling and Disposal of Deposits

Iron sulfide scale, dust, deposits, residue, and sludge removed from the tank shall be kept from contacting air and igniting by wetting (or inerting) until treated or removed to a safe area. Sour water and pyrophoric iron sulfide deposits shall be disposed of in accordance with regulatory requirements and facility procedures.

8.3 CLEANING TANKS WITH PRODUCTS THAT CONTAIN HYDROGEN SULFIDE (H₂S)

8.3.1 General

Hydrogen sulfide (H₂S) is an extremely toxic and flammable gas that occurs in the production, storage and refining of sour crude oil and crude oil fractions. Tank cleaning operations in or around tanks storing products containing hydrogen sulfide (H₂S), including, but not limited to, sour crude oil, sour crude oil fractions, sour stocks, asphalt, residual fuel oil and some naphtha, should be conducted with extreme caution, under permit conditions. Entry supervisors shall designate the appropriate respiratory protection, protective clothing and equipment and assure its use by testers, attendants, entrants, standby persons, rescuers and tank cleaning workers inside and outside of tanks where the potential exists for exposure to hydrogen sulfide (H₂S) during tank cleaning operations.

8.3.2 Testing

Employers (owners/operators and contractors) shall establish and entry supervisors shall implement safe tank cleaning procedures to assure that the potential exposure to hydrogen

sulfide (H₂S) both around and inside the tank is within acceptable limits and that all entry criteria are met before issuing an entry permit.

8.3.2.1 Entry supervisors shall assure that testing is conducted by a qualified person to determine the presence of hydrogen sulfide (H₂S) before any work is started around or inside tanks that have stored products containing hydrogen sulfide (H₂S).

8.3.2.2 Even though initial tests may indicate that the initial hydrogen sulfide (H₂S) in-air concentration is within acceptable limits for both flammable and toxic exposures, the atmosphere within and around the tank shall be monitored continuously or periodically, as determined by the entry supervisor, to determine the presence of hydrogen sulfide (H₂S) during tank cleaning operations.

8.3.2.3 When using water streams to wash down and break up residue and sludge during tank cleaning operations, testing shall be continued as the agitation may release hydrogen sulfide (H₂S).

8.3.3 Sour Water Disposal

When water is used to displace vapor or gas in a tank that contains hydrogen sulfide (H₂S) or to wash down the tank during cleaning, it will absorb hydrogen sulfide (H₂S). Employers (owners/operators and contractors) shall assure that this sour water is handled and disposed of in accordance with regulatory and facility requirements.

8.4 TANKS THAT HAVE BEEN IN LEADED SERVICE

8.4.1 General

All tanks that have stored leaded gasoline, lead additives or other products containing lead, present an organic lead hazard to anyone entering the tank including, but not limited to, entry supervisors, testers, inspectors, attendants, entrants, rescuers and tank cleaning workers. Tanks that were at one time in leaded service and were subsequently switched to unleaded product storage without being cleaned, tested and declared lead free, continue to present an organic lead hazard. Even if these tanks have not stored leaded product for many years, the organic lead hazard can remain indefinitely, primarily in the sludge on the tank bottom, in interstitial spaces, lines and columns and in the residue and deposits on the walls, roof and other structural components of the tank.

8.4.1.1 Tanks that have previously been in leaded service shall not be considered and treated as nonleaded product storage tanks for purposes of entry and work until they have been thoroughly vapor freed, ventilated, cleaned, and tested by a qualified person using a lead-in-air analyzer or other suitable instrument and determined to be lead-hazard free.

8.4.1.2 Tanks that have previously been in leaded service must not be used for the storage of edibles or potables for animal or human consumption. When these tanks are dismantled, their steel must not be used for any purpose that involves contact with edibles and/or potables. (See API 2202 for information on disposal of leaded storage tanks.)

8.4.2 Vapor Freeing Lead Service Tanks

The methods of vapor freeing or degassing (where required) storage tanks that have been in leaded service are the same as those used to vapor free nonleaded product tanks and depend on the type of tank, the product contained and the available resources. Tank cleaning personnel shall be educated to recognize that a tank that is free from flammable vapors is not necessarily a lead vapor free tank. Conversely, a lead vapor free tank may not be a flammable vapor free tank.

8.4.3 Entry Requirements

The safety precautions and procedures for entering storage tanks that have been in leaded service include all the procedures for entering tanks classified as permit-required confined spaces, with the following additional procedures:

8.4.3.1 As a minimum requirement, the tank shall be considered a permit-required confined space throughout the vapor and gas freeing, degassing, ventilation, entry, tank cleaning and lead-in-air testing process. Entry supervisors shall require that testers, entrants, attendants, workers, and rescuers wear positive pressure, full facepiece, (supplied air or SCBA) respiratory equipment when they are inside the tank, regardless of the concentration of flammable vapors, toxic gases and oxygen in the tank's atmosphere, until the tank has been cleaned, dried, tested, and declared vapor, toxic gas, and lead-in-air free.

8.4.3.2 In addition to the respiratory protection requirements, entry supervisors shall require that testers, entrants, attendants and workers wear impervious boots and gloves and clean clothing (including head covering) from the skin out, each day. At the end of the work shift, and during the work shift if clothing becomes contaminated with any liquid, sludge, deposits or residue, entrants and workers shall leave the tank, remove all clothing and equipment and thoroughly wash and shower. Clean clothing, boots, gloves, equipment, and respiratory protection shall be put on before resuming work. Workers shall not eat, smoke, or drink when they are wearing contaminated clothing or gloves.

8.4.4 Lead Freeing Tanks

Employers (owners/operators and contractors) shall establish and entry supervisors shall implement safe tank cleaning procedures to assure that a tank is considered to be lead-hazard free, only when the following conditions are satisfied:

8.4.4.1 The tank has been vapor freed, cleaned, ventilated and dried (free from liquid or puddles).

8.4.4.2 All sludge, deposits, and residue have been removed from the tank. Loose adherent materials have been removed from the parts of the tank that have been in direct contact with sludge—normally the tank bottom, internal piping, and side walls of the first shell ring.

8.4.4.3 Any materials, linings, insulation, wooden supports or concrete bottoms with the potential to absorb liquids and release organic lead vapors have been removed or thoroughly cleaned.

8.4.4.4 The tank bottom, columns, sumps, pontoons, flotation devices, sample lines, internal piping, appurtenances, and interstitial spaces of double wall tanks and double bottom tanks have been inspected and are free of liquids and vapors.

8.4.4.5 Lead-in-air testing, conducted by a qualified person, indicates the organic lead-in-air concentration in the tank's atmosphere is equal to or less than the permissible exposure limit (PEL).

8.4.5 Non-Compliance

A tank that has been cleaned, vapor freed and ventilated shall not be considered lead-hazard free if any of the following conditions prevail:

1. A lead-in-air test has not been conducted.
2. A lead-in-air test was conducted but the results exceed the permissible exposure limit (PEL) for lead.
3. The lead-in-air tests were made in a tank that had been cleaned, but was not yet completely ventilated and dried.
4. Materials, lining, insulation, wooden supports or concrete bottoms were not checked and tested to assure they had not absorbed product containing organic lead.
5. Tank bottoms, appurtenances, columns, pontoons, flotation devices, and internal piping and the interstitial spaces of double wall tanks and double bottom tanks, were not checked and tested to verify they were liquid and vapor free and dry.

8.4.6 Lead-in-Air Testing

A qualified person, using a lead-in-air analyzer or other approved test method, shall conduct a lead-in-air analysis only after the tank has been vapor freed, cleaned and ventilated and after all sludge and loose materials have been removed and the tank is essentially dry and free of liquids or puddles.

8.4.6.1 The analysis used to measure the concentration of lead-in-air must measure organic lead, (not inorganic lead). Test instrument manufacturer's instructions shall be followed

for instrumental analyzers. Analytical methods shall be consistent with regulatory requirements or facility protocol for measuring lead-in-air concentrations (for example, in the United States, refer to NIOSH *Manual of Analytical Methods*, Method 2533).

CAUTION: Flammable (combustible) vapor indicators do not provide any indication of organic lead concentration and must not be used as a substitute for a lead-in-air analyzer.

8.4.6.2 Lead-in-air testing shall be conducted inside the tank after it has been vapor freed, cleaned, ventilated, and dried. Lead-in-air testing shall not be conducted before or during tank cleaning and ventilation as the results will not reflect the true condition of the tank's atmosphere. Forced ventilation should be stopped for a minimum of 15 minutes before the lead-in-air test is conducted.

8.4.6.3 The qualified person conducting the lead-in-air tests shall wear a positive pressure full facepiece respirator (supplied air or SCBA) and appropriate protective clothing, boots, gloves and head covering.

8.4.6.4 To obtain representative samples of the atmosphere within the tank, the test samples shall be collected while the tester is walking around the inside periphery of the tank and across the tank. The tester should be educated to recognize that the primary source of hazardous organic lead in a tank is in the sludge and residue at the bottom and sides of the tank. The tester shall check all suspect areas including, but not limited to, tank bottoms, columns, sumps, wooden supports, pontoons and flotation devices, seals, appurtenances, and insulation. Samples shall not be collected in areas adjacent to open manholes.

8.4.6.5 There is no need to take lead-in-air samples on top of the roof or outside the tank because the results will be well below permissible exposure limits.

8.4.6.6 A qualified person or the entry supervisor shall review the lead-in-air test results and determine if the atmosphere in the tank meets the acceptable regulatory or facility requirements for entry into the tank without respiratory protection. [For example, U.S. DOL OSHA 29 *CFR* 1910.1000 Subpart Z, Toxic and Hazardous Substances, Table Z-1-A, limits personal exposure to the organic lead compounds tetraethyl and tetramethyl lead to an 8-hour time-weighted average of 0.075 milligrams per cubic meter (2 micrograms per cubic foot) and imposes a skin designation.]

8.4.7 Hot Work

A qualified person or the entry supervisor shall issue permits to conduct hot work only after the tank has been declared to be lead-in-air free.

8.4.7.1 Surfaces of the tank (that previously were in contact with lead containing product or material) may emit

organic lead vapors or fumes when heated by cutting, burning, welding or grinding. This potential hazard can be controlled provided that all residue, rust, scale and other foreign material is removed so as to expose bare metal at least 12 inches (30 centimeters) on each side of the area that will become heated.

8.4.7.2 Lead-in-air tests should be conducted periodically during hot work operations as determined by the entry supervisor, to ensure safe conditions. (See API 2202 and API 2207 for further information.)

8.5 TANKS CONTAINING HAZARDOUS SLUDGE AND RESIDUE

8.5.1 Hazardous Substances

Entry supervisors and qualified persons shall determine the personal protection and control measures required to be used by workers to safely remove, handle, store, and dispose of hazardous sludge and residue. Employers (owners/operators and contractors) shall assure that qualified persons inspect, test, analyze, or characterize sludge and residue to be removed from tanks to determine any potentially hazardous flammable or toxic characteristics. Depending on the service the tank has been in, sludge and residue may contain one or more hazardous substances, including, but not limited to, the following:

1. Inorganic or organic lead in leaded product service tanks.
2. Naturally occurring radioactive materials (NORM) in crude oil tanks.
3. Pyrophoric iron sulfides, entrained or trapped hydrogen sulfide (H₂S) and sour water, in tanks that have been in sour crude or high sulfur product service.
4. Flammable or toxic hydrocarbon liquids and gases (entrapped).
5. Trace amounts of carbon dioxide (CO₂) and heavy metals, depending on the products stored in a tank.
6. Asbestos from materials used to insulate a tank.
7. Trace amounts of benzene in sludge, residue and tank components and appurtenances removed from service.

8.5.2 Treating and Disposal

A qualified person shall determine the method of treating and disposing of sludge removed from the tank, including, but not limited to, the following:

8.5.2.1 Sludge may be de-watered and de-oiled by gravity separation, filtration or centrifuging to recover hydrocarbons. Recoverable water is normally sent to a separator.

8.5.2.2 Sludge is often treated on site by incineration or coking. Sludge from tanks in leaded service is normally incinerated in approved commercial waste facilities.

8.5.2.3 If not treated on-site, sludge and residue must be removed to an approved disposal area and, depending on its characteristics, may be considered a hazardous waste.

8.5.3 Hazardous Waste

Employers (owners/operators and contractors) shall be familiar with applicable government regulations (including hazardous waste exemptions) and facility protocol for testing, handling and disposing of sludge and residue that is considered hazardous waste. In addition, employers (owners/operators and contractors) shall be aware that some regulations require that product, sludge, residue, deposits, and tank appurtenances and components (removed from service) be considered characteristically hazardous for benzene.

8.5.3.1 For example, in the United States, the Resource Conservation and Recovery Act (RCRA) regulations require that hazardous waste be stored, shipped, treated and disposed of in an environmentally approved manner.

8.5.3.2 The United States Environmental protection Agency (EPA) has identified specific petroleum industry sludge as hazardous waste requiring special handling under RCRA, including, but not limited to the following:

1. Waste Flammable Liquid NOS (Leaded tank bottom sludge, Flash 140°F) UN 1493.
2. Waste Flammable Liquid NOS (Non-leaded tank bottom sludge, Flash 140°F) UN 1493.
3. Hazardous Waste NOS (Separator sludge) NA 9189.
4. Waste Flammable Solid NOS (Gasoline contaminated soil) UN 1325.

8.5.3.3 The general RCRA requirements for administering hazardous waste are as follows:

1. Companies may not generate, store, transport, treat or dispose of hazardous waste unless notification is provided to the EPA or the applicable state agency implementing the RCRA program.
2. Each company within the United States that generates hazardous waste must develop a plan for its storage, treatment, and disposal. If storage, treatment and disposal occur on-site, the company is considered to operate a hazardous waste management facility and must obtain a permit to do so. If the company disposes of hazardous waste off-site, no permit is required, provided the waste is stored as required by EPA regulations in appropriate containers and shipped off site within 90 days of accumulation.

3. When shipping an EPA designated hazardous waste to an off-site facility, the company that generates the waste is required to prepare and sign a manifest that contains the following information: generator's (company) name, EPA and DOT number and name of the hazardous waste, the off-site facility receiving and handling the hazardous waste, and the total quantity in the shipment.

4. Persons transporting hazardous waste off-site must comply with EPA, DOT, and state regulations for its transportation. The generating company must ascertain that both the transporter and the receiving facility have EPA identification numbers and permits to engage in hazardous waste transport and management activities.

5. The regulations impose extensive hazardous waste record keeping and reporting requirements. Companies that generate, handle, treat or ship leaded sludge must maintain copies of all manifest documents and records and submit annual reports.

6. EPA has delegated implementation of the hazardous waste program to many states in lieu of the federal RCRA program. Any state whose program has been approved by EPA may specify additional and more rigorous requirements. Companies that generate and dispose of hazardous waste should be familiar with applicable state requirements.

9 Control of Ignition Sources

9.1 GENERAL

The potential for unexpected sources of ignition is always present during tank cleaning operations.

9.1.1 Ignition Control

In addition to eliminating or controlling all potential sources of ignition at the tank site, entry supervisors, attendants, standby persons and tank cleaning workers shall also prevent the release of flammable vapors at or near ground level during vapor and gas freeing, degassing, ventilation and cleaning operations. Hot work and other sources of ignition shall be prohibited in areas where flammable vapors may be present or travel and before entry supervisors permit any operations that involve the potential or actual release of flammable vapors from a tank. Supervisors and workers shall be trained and educated to recognize that many hydrocarbon vapors are heavier than air and can travel along the ground for considerable distances to a remote ignition source. Entry supervisors should stop ventilating tanks if atmospheric conditions or the direction of the wind could cause flammable vapors to be dispensed into areas where they might produce a hazardous condition.

9.1.2 Ignition Sources

This section covers control of typical ignition sources, including, but not limited to, operation of internal combustion engines, use of non-explosion proof electrical equipment, non-bonded electrostatic generating equipment, improper lighting, smoking, welding, blast cleaning or grinding and unprotected pyrophoric iron sulfide deposits.

9.2 INTERNAL COMBUSTION ENGINES

9.2.1 Ignition Hazards

Internal combustion engines used to power vehicles, equipment, trailers and vacuum trucks are ignition sources that must be kept a safe distance from the tank being cleaned or controlled in the vicinity of the tank. Additionally, workers should be aware that diesel driven equipment is subject to uncontrolled run-on, should flammable vapors enter the air intake.

Note: Positive air shut-off devices may be used to control diesel powered equipment.

9.2.2 Restrictions

Entry supervisors shall restrict or control the use of internal combustion engines within the work area around the tank and inside the tank dike area until the tank is vapor and gas free, the residue and sludge have been removed and there is no opportunity for flammable vapors or gas to be present in the area.

9.2.2.1 Entry supervisors shall require that vehicles, equipment and vacuum trucks be kept a safe distance from the tank and their placement (preferably upwind and outside of or on top of the dike) is such that flammable vapors or gas will not reach the internal-combustion engine.

9.2.2.2 Entry supervisors shall assure that roads are barricaded and/or posted to restrict travel, as necessary, and that vehicular traffic into the diked area without an authorized hot work permit is prohibited.

9.2.2.3 Entry supervisors shall issue hot work permits to control the use of internal combustion engine driven equipment, such as air compressors, vacuum trucks, vehicles, pumps, etc., in the tank dike area while vapor and gas freeing or degassing is under way.

9.2.3 Vacuum Trucks

Vacuum truck operators and entry supervisors shall assure that vacuum exhaust vapors are degassed or discharged through a hose of adequate size and length, downwind of the truck and away from the storage tank and potential sources of ignition. The vacuum truck suction and discharge hoses shall be electrically bonded and grounded to both the truck and the tank. (See API 2219 for information and requirements for the safe use of vacuum trucks in petroleum facilities.)

9.3 ELECTRICAL MOTORS AND GENERATORS

9.3.1 Ignition Hazards

Non-approved electrical equipment are sources of ignition and shall be restricted from the work area around the tank and inside the dike until the tank is vapor and gas free, the residue and sludge have been removed and there is no opportunity for flammable vapors or gases to be present in the area.

9.3.2 Requirements

Entry supervisors or qualified persons shall approve the use of all electrical motors, generators, extension cords, connectors, switches, and accessories, including, but not limited to, those used to provide power to ventilating equipment, welders, lighting, trailers, electrical tools, work benches, compressors and pumps on the entry and work permits.

9.3.2.1 All electrical motors, generators and equipment shall meet the requirements of NFPA 70 for Class I, Division 1, Group D or Zone 1 locations.

9.3.2.2 Electrically driven equipment shall be provided with ground fault protection and meet the requirements of NFPA 70 for a Class I, Division 1, Group D or Zone 1 locations.

9.3.2.3 Before use, a qualified person shall thoroughly inspect all electrical motors, accessories, and classified, explosion proof equipment to assure they are intrinsically safe and will not be potential sources of ignition or shock hazards.

9.4 ARTIFICIAL LIGHTING

9.4.1 Ignition Hazards

The use of artificial lighting (except approved low voltage lighting and dry-cell flashlights) in or around tanks during vapor and gas freeing, degassing, inspection, testing, or other activities shall be prohibited by the entry supervisor when there is a potential for flammable vapors to exceed 10 percent of the lower explosive (flammable) limit.

9.4.2 Requirements

Entry supervisors or qualified persons shall approve the use of low voltage artificial lighting on the entry or work permits. Before use, a qualified person shall thoroughly inspect the lights, extension cords, connectors, switches, accessories and equipment to ensure that they are not potential sources of ignition and will not create a shock hazard.

9.4.2.1 Lighting equipment shall be provided with ground fault protection.

9.4.2.2 Flashlights and lighting shall meet the requirements of NFPA 70 for Class I, Division 1, Group D or Zone 1 locations.

9.5 ELECTRICAL BONDING

9.5.1 Ignition Hazards

Entry supervisors and workers shall be aware that metallic parts of equipment, accessories and appurtenances used in tank cleaning operations, are capable of generating an electrostatic charge unless they are electrically bonded to the tank to avoid ignition from sparks.

9.5.2 Requirements

Before use, a qualified person shall thoroughly inspect all tank cleaning equipment, nozzles, hoses, couplings and accessories to ensure that they are properly bonded, including, but not limited to, the following: (see API 2027 and API 2003 for additional information).

1. Vapor and gas freeing, degassing and ventilation equipment and appurtenances, such as blowers and eductors; inert gas piping and connections; water, fuel oil and steam piping, hoses, nozzles, and connections; flame and detonation arrestors; and flexible vapor intake and exhaust ducts.
2. Vacuum trucks, suction pumps, hoses, couplings and nozzles.
3. Hoses and nozzles used to inject product, steam, chemicals, solvents or water into the tank to dislodge and flush residue and sludge or wet down pyrophoric deposits.
4. Abrasive blasting hoses, nozzles, and equipment.
5. Mechanized portable and robotic cleaning equipment.
6. Welding, cutting, grinding, and hot tapping equipment.

9.6 LIGHTNING STORMS

Entry supervisors and workers shall be aware that lightning is a potential ignition source. When an electrical storm is threatening, or in progress in the area of the facility while a tank is open and being vapor and gas freed, degassed and ventilated and/or being cleaned, the permits shall be automatically cancelled. Entry supervisors shall not reissue the entry and work permits until the danger of ignition by lightning is over. Upon cancellation of the permit, entry supervisors and attendants shall require the following actions to be taken:

1. All work inside and outside the tank shall stop and entrants, testers, attendants and all other workers shall leave the tank.
2. Ventilation, vapor and gas freeing, degassing and or vacuum truck activity shall stop.
3. Unless cleaned and vapor free, the tank shall be closed to prevent release of flammable vapors by natural ventilation during the lightning storm.
4. Supervisors and all workers shall leave the immediate area of the tank and move to a designated safe location.

9.7 PYROPHORIC IRON SULFIDE DEPOSITS

9.7.1 Ignition Hazards

If a tank has contained asphalt, aromatic tars, sour crude, aromatic gases or high sulfur fuel oil, the potential exists for the formation pyrophoric iron sulfide deposits on the tank walls, roofs, columns, lines, appurtenances and in the tank residue and sludge. If these deposits are allowed to dry out and react with the oxygen in the air, they will generate heat and spontaneously ignite.

9.7.2 Requirements

Entry supervisors shall establish and implement the following procedures, as applicable, to control ignition of pyrophoric deposits:

9.7.2.1 Wetting all internal surfaces of these tanks with water dissipates heat buildup and isolates the pyrophoric iron sulfide deposits from air, thereby reducing the possibility for a spontaneous ignition while the tank contains vapors in the explosive (flammable) range.

9.7.2.2 Alternately, inert gas may be used to keep air out of the tank. As long as the tank's atmosphere remains inerted and below the lower explosive (flammable) limit, there is no potential for a pyrophoric ignition.

9.7.2.3 Wetting the internal surfaces with a dilute oxidizing solution is another method used to remove pyrophoric deposits. The concentration and rate of application are critical to the safety of this operation as if either are too high excess exothermic heat will develop resulting in an ignition source.

9.7.2.4 Iron sulfide scale, dust, deposits, residue and sludge removed from the tank, must also be kept from contacting air by wetting (or inerting) until treated or removed to an area where ignition will not be a hazard.

9.8 HOT WORK

9.8.1 Ignition Hazards

Entry supervisors shall be aware that hot work activities in and around the tank, including, but not limited to, welding, cutting, blasting, scraping and grinding, are sources of ignition. Flammable vapors and liquids may enter the hot work area from a number of different sources, both external and internal, while hot work is being conducted.

9.8.2 Requirements

9.8.2.1 Entry supervisors and qualified persons shall assure that permits are issued for hot work activities conducted in and around the tank during tank cleaning operations to control these sources of ignition when the potential exists for the presence of flammable vapors or gas in the atmosphere.

9.8.2.2 Entry supervisors shall require that qualified persons conduct atmospheric testing before and during hot work to assure that any flammable vapors in air are within acceptable limits.

9.9 SMOKING

Except where smoking is prohibited within an entire facility, employers (owners/operators and contractors) shall designate a specific area, remote from potential exposure to flammable vapors or gases, where tank cleaning workers may smoke. Supervisors shall assure that workers do not smoke in non-designated areas.

10 Tank Cleaning Checklist

10.1 GENERAL

This section provides basic information to assist employers (owners/operators and contractors) to develop their own company or facility specific tank cleaning checklist that may be used to develop plans for safe tank cleaning operations. This tank cleaning check list is not intended to cover every aspect of every tank cleaning operation because of the number of variables affecting each facility and each individual tank, including, but not limited to the following;

1. Applicable government regulations.
2. Employer (owner/operator and contractor) policies, procedures and programs.
3. Tank design, condition, location and products stored.
4. Environmental concerns and requirements.
5. Internal and external operations impacting on the tank cleaning.
6. Rescue requirements.
7. Reason for cleaning the tank.

Employers (owners/operators and contractors) should develop a safe work plan for each tank that is to be taken out of service for tank cleaning, covering the entire proposed tank cleaning operation from preplanning to recommissioning.

10.2 PREPLANNING

Employers (owners/operators and contractors) should develop a preplan for the tank cleaning operation, that includes, but is not limited to, the following items:

10.2.1 Engineering and Operations Planning

Employers (owners/operators and contractors) should establish the reasons for tank cleaning, including, but not limited to, inspection, testing removing contaminants, changing products, making modifications, conducting repairs, maintenance, placing tank out of service or dismantling.

1. Determine the duration of the job and establish starting and completion dates for each phase of the tank cleaning operation.
2. Review applicable engineering drawings, including, but not limited to, tank site plot plans, tank and piping details, tank fire protection systems, and electrical utilities.
3. Determine isolation and lockout or tag out requirements, identify all items to be isolated on the plans and drawings and develop an isolation plan and blinding list for the tank to be cleaned.
4. Physically inspect the tank to verify that items not on the plans and drawings are included in the isolation plan and blind list.
5. Determine area or zone electrical classification requirements and safe locations for siting tank cleaning equipment, construction, and utility trailers and vacuum trucks.
6. Determine if degassing vapors is required and establish responsibility for obtaining environmental and other necessary regulatory permits.

10.2.2 Hazard Analysis and Protection Requirements

Employers (owners/operators and contractors) should review MSDSs or equivalent information covering sludge, residue and products stored in the tank to be cleaned, chemicals to be used in the cleaning operation and products stored in adjacent tanks that may impact on the tank cleaning operation. (Figure 10-1: Sample Hazard Assessment Checklist.)

1. Establish safe limits for flammable vapors and toxic gases.
2. Establish requirements for selection, calibration, adjustment, bump testing, use and maintenance of oxygen, combustible vapors, and toxic gas measuring instruments.
3. Determine respiratory protection and personal protective equipment requirements.
4. Determine and assess product, sludge, and residue potential safety and health hazards.
5. Identify potential tank specific physical hazards, including, but not limited to, leaking tank bottom or columns, corroded or faulty tank roof, broken ladder or stairways, non-operable legs on floating roofs, double bottoms or walls, interior piping, mixers, heating coils, and appurtenances.
6. Provide for eating, washing, toilet, shower and change room facilities.

10.2.3 Confined Space Program

Employers (owners/operators and contractors) should review the facility confined space program as related to the tank to be cleaned and the proposed work.

1. Establish requirements to classify and reclassify the tank as a permit required or non-permit required confined space and as a non-confined space.
2. Determine the conditions under which entry upon the floating roof of the tank to be cleaned will be permit-required confined space entry, non-permit required confined space entry or non-confined space entry.

10.2.4 Site Survey

Employers (owners/operators and contractors) should conduct a tank pre-cleaning site survey to assess the following:

1. Determine the tank's location in relation to other tanks, piping, process units, utilities, etc. both within and outside of the facility.
2. Review the scope of work and its impact on the area, including potential flow of vapors or product in event of a release or spill.
3. Determine potential area hazards and their impact on the tank cleaning operation.
4. Review isolation and blinding list and lockout/tagout list against actual equipment configurations to assure all connections and sources of energy are covered.
5. Review available fire protection, accessibility for rescue and impact of a tank cleaning emergency affecting the facility and an outside emergency affecting the tank cleaning. This review should include alarms, emergency notification and evacuation procedures, egress routes and assembly area.
6. Review site congestion, equipment and trailer location, access roads and vehicular traffic concerns.

10.2.5 Employer Responsibilities (Owner/Operator and Contractor)

Employers (owners/operators) should qualify and select contractor(s) and subcontractor(s) and establish tank cleaning procedures, including, but not limited to, the following (Figure 10-2: Sample Tank Cleaning Contractor Screening Checklist):

1. Determine the specific work to be performed by facility employees and by contractor(s).
2. Include the facility tank administrative procedures, operating controls, permit policy, lockout/tagout procedures, safe work practices, environmental requirements,

Sample Hazard Assessment Checklist

Job Site: _____ Tank # _____ Supervisor: _____ Date: _____

Place a check mark next to every source that could pose a hazard to employees working on this job. Based on this hazard assessment, the equipment listed under Personal Protective Equipment shall be required and utilized.

Hazard	Sources				
IMPACT	<input type="checkbox"/> Steel Plate	<input type="checkbox"/> Seal Material	<input type="checkbox"/> Slips/Trips/Falls	<input type="checkbox"/> Grinding/Gauging/Drilling	
PENETRATION	<input type="checkbox"/> Rebar	<input type="checkbox"/> Steel Plate	<input type="checkbox"/> Tools	<input type="checkbox"/> Seal Material	<input type="checkbox"/> Other
COMPRESSION	<input type="checkbox"/> Tools	<input type="checkbox"/> Pipe Fittings	<input type="checkbox"/> Steel Plate	<input type="checkbox"/> Appurtenances	<input type="checkbox"/> Other
CHEMICAL	<input type="checkbox"/> Motor Fuels	<input type="checkbox"/> Compressed Gas	<input type="checkbox"/> Welding Rods	<input type="checkbox"/> Cut/Lube Fluids	<input type="checkbox"/> Other
HEAT	<input type="checkbox"/> Ambient	<input type="checkbox"/> Flash Fire	<input type="checkbox"/> Hot Metal	<input type="checkbox"/> Welding/Cutting	<input type="checkbox"/> Other
DUST/FUMES	<input type="checkbox"/> Grinding	<input type="checkbox"/> Sweeping	<input type="checkbox"/> Welding Fumes	<input type="checkbox"/> Abrasive Blasting	<input type="checkbox"/> Painting
ELECTRICAL	<input type="checkbox"/> Power Tools	<input type="checkbox"/> Generators	<input type="checkbox"/> Weld Leads	<input type="checkbox"/> Ext. Cords	<input type="checkbox"/> Portable Lights

Figure 10-1—Sample Hazard Assessment Checklist

and emergency planning and response procedures as part of the contract.

3. Establish whether the facility, contractor or subcontractors will be responsible for the control and safety of tank cleaning workers or specify the employer's and each contractor's authority and responsibilities if assignments are to be shared.

4. Establish the means of communication at the job site between contractor and facility supervisors and employees.

10.2.6 Permit Requirements

Employers (owners/operators and contractors) should review the facility safe (cold) work, hot work and entry permit system program. (Figure 10-3: Sample Safe Work Checklist.)

1. Determine the types of permits needed, permit retention, requirements for permit authorization, permit issuance and cancellation, information required on per-

mits, and the signatures and acknowledgments required on the permits.

2. Identify and qualify entry supervisors who will issue the permits, and persons who will conduct testing during the tank cleaning operation.

3. Establish requirements for issuing work and entry permits for owner/operator employees, owner/operator contractor (other than the tank cleaning contractor) employees and tank cleaning contractor and sub-contractor employees working both inside and around the tank to be cleaned.

10.2.7 Product Removal

Employers (owners/operators and contractors) should establish procedures for removal of recoverable and non-recoverable product, sludge and residue from the tank through existing connections prior to the start of tank cleaning operations and opening manholes.

1. Determine disposition of recoverable and non-recoverable product.

Sample Tank Cleaning Contractor Screening Checklist

Answer questions Yes (Y) or No (N)

- 1.1 Does contractor have new hire orientation and training program?
- 1.2 Does contractor have random drug testing policy?
- 1.3 Does contractor have HAZWOPER training?
- 1.4 Is contractor Safety Program documented and consistent with safe entry and cleaning of petroleum storage tanks (meets ANSI/API Standard 2015 requirements)?
- 1.5 Does contractor have a medical surveillance program that includes monitoring for benzene exposure?
- 1.6 Does contractor have an experienced, well-trained work force (not temporary hires)?
- 1.7 Does contractor use a formal performance evaluation program?
- 1.8 Does contractor have a disciplinary process?
- 1.9 Can contractor supply references?
- 2.0 Has contractor provided a description of the process contractor proposes to use?
- 2.1 Does contractor have knowledge of the process?
 - 2.1.1 Can contractor draw flow diagram?
 - 2.1.2 Can contractor describe normal safety precautions?
 - 2.1.3 Can contractor describe the process limits in temp., BBLs/day, BS&W, in the product of the process?
 - 2.1.4 Can contractor describe secondary processing required?
 - 2.1.5 Can contractor describe properties of waste streams—both solid and liquid?
- 3.0 What is contractor's Employee Modification Rate (EMR)?
- 4.0 What is contractor's OSHA recordable rate?
- 5.0 Number of years contractor has been in business?
- 6.0 Is supervisor that will run the job qualified and experienced?
- 7.0 What type of quality improvement process is contractor involved in and is there an improvement process in place?

Courtesy: Chevron Marketing.

Figure 10-2—Sample Contractor Screening Checklist

Sample Safe Work Checklist

Facility Name: _____ Permit No: _____ Date: _____ Job #: _____

Permit Issuer: _____ Permit Starts: _____ (AM) (PM) Permit Ends: _____ (AM) (PM)

Tank Number: _____ Tank Status: In Service () Out of Service () Supervisor: _____

Scope of Work: _____

PERSONAL PROTECTIVE EQUIPMENT

- | | |
|--------------------------------------------------------------|------------------------------------------------|
| <input type="checkbox"/> Hard Hat | <input type="checkbox"/> Protective Clothing |
| <input type="checkbox"/> Safety Glasses with Side Shields | <input type="checkbox"/> Safety Shoes/Boots |
| <input type="checkbox"/> Goggles/Face Shield | <input type="checkbox"/> APW SAR, SCBA |
| <input type="checkbox"/> Gloves: Nitrile/Leather/Cloth/Other | <input type="checkbox"/> Lifeline/Harness/Belt |
| <input type="checkbox"/> Hearing Protection | <input type="checkbox"/> Other: _____ |

HAZARD COMMUNICATIONS INFORMATION

- | | |
|-------------------------------------------------------|-------------------------------------------------------|
| <input type="checkbox"/> Customer Guidelines Reviewed | <input type="checkbox"/> MSDS Located at: _____ |
| <input type="checkbox"/> Product in Tank: _____ | <input type="checkbox"/> MSDS Reviewed and Understood |

LOCKOUT/TAGOUT PROCESS—ELECTRICAL/HYDRAULIC/ETC. ENERGIES

- | | |
|----------------------------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> Valves Closed/Locked/Tagged | <input type="checkbox"/> Bleeder Valve Open/Locked/Tagged |
| <input type="checkbox"/> Lines Disconnected/Blinded | <input type="checkbox"/> Pump De-Energized/Locked/Tagged |
| <input type="checkbox"/> System Depressured and Drained | <input type="checkbox"/> Contractor Lock Applied |
| <input type="checkbox"/> Who Handles These Tasks—Contractor or Owner | <input type="checkbox"/> Other: _____ |

HOT WORK—WELDING/GRINDING/CHIPPING

- | | |
|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <input type="checkbox"/> Fire Extinguishers—Location | <input type="checkbox"/> No Gas Cylinders Inside Vessel |
| <input type="checkbox"/> Remove Combustibles from Area | <input type="checkbox"/> Compressors, Ventilation Equipment and
Welding Machine Grounded |
| <input type="checkbox"/> Check Welding Leads/Cables/Hoses | <input type="checkbox"/> Pressurized Fire Hose |
| <input type="checkbox"/> Welding Machines Bonded to Work | <input type="checkbox"/> Intrinsically Safe/Explosion Proof Equipment |
| <input type="checkbox"/> Check Area for Flammables:
LEL % _____ O ₂ % _____ by: _____ | <input type="checkbox"/> Sumps are Covered and Protected |
| <input type="checkbox"/> Welding Hood/Goggles | <input type="checkbox"/> Fire Watch—Name _____ |
| <input type="checkbox"/> Check Area for Sources of Ignition/Sparks | <input type="checkbox"/> Other: _____ |

TANK/CONFINED SPACE ENTRY

- | | | |
|-----------------------------------------------------------------|----------|-------------------------------------------------------------------|
| Atmospheric Testing Results | Readings | <input type="checkbox"/> Pneumatic Tools Air Driven |
| <input type="checkbox"/> O ₂ % (Safe = 19.5 – 23.5%) | _____ | <input type="checkbox"/> Entry Supervisor: _____ |
| <input type="checkbox"/> % LEL (Safe = <10%) | _____ | <input type="checkbox"/> Attendant/Watch: _____ |
| <input type="checkbox"/> H ₂ S ppm (Safe = <10 ppm) | _____ | <input type="checkbox"/> Entry Log Maintained |
| <input type="checkbox"/> CO ppm (Safe = <50 ppm) | _____ | <input type="checkbox"/> Communication Type: _____ |
| <input type="checkbox"/> Other Toxics _____ ppm | _____ | <input type="checkbox"/> Accidental Entry Prevented |
| <input type="checkbox"/> Instrument Readings By: _____ | | <input type="checkbox"/> Rescue Equipment |
| <input type="checkbox"/> Low-Voltage Electrical Equipment | | <input type="checkbox"/> Rescue Service By: _____ |
| <input type="checkbox"/> Ventilation: Type: _____ | | <input type="checkbox"/> GFCI (Required if Using Extension Cords) |

EMERGENCY INFORMATION

- EMERGENCY PHONE: _____ PLANT FIRE/HAZMAT: _____ MEDICAL: _____
- Evacuation Routes/Muster Points Identified Stop Work Immediately if Instructed
- Location of Safety Shower/Eye Wash _____
- CONTRACTOR'S AUTHORIZED REPRESENTATIVE _____

Figure 10-3—Sample Safe Work Checklist

2. Decide how sludge and residue will be classified (hazardous waste) and its on or off-site storage, treatment or disposal.
3. Check to determine if the facility NPDES will allow tank bottom water and wash water to go into the API separator and, if so, assure that contaminated water will not surpass separator requirements.

10.2.8 Equipment and Material Needs

Employers (owners/operators and contractors) should determine required tank cleaning equipment and materials appropriate for the work to be done and for anticipated hazards and exposures, including, but not limited to, the following: (Figure 10-4: Sample Supervisor's Safety Inspection Checklist.)

1. Pumping and vacuum equipment (such as hoses, valves fittings, gaskets, flanges, etc.) appropriate for the anticipated pressures and exposures, to remove product, sludge and residue and containers to collect and store sludge and residue prior to treatment or disposal.
2. Vapor and gas freeing, degassing, purging, inerting and ventilating equipment including, but not limited to, compressed air, steam, water, and inert gas (if used); eductors and blowers; flame and explosion arrestors; combustion, refrigeration or condensation degassing systems; flexible air ducts and flexible emission exhaust ducts.
3. Predetermine required number, size and capacity and location of air blowers and eductors based on tank size and configuration, back-pressure and diameter and length of exhaust duct or vapor recovery line.
4. Chemicals, solvents, water or steam required for sludge removal, vapor and gas freeing and cleaning.
5. Artificial lighting, electrical ground fault interrupters and bonding equipment.
6. Compressed breathing air cylinders or compressors and air compressors for operating air-powered tools and equipment.
7. Temporary supports including, but not limited to, scaffolding, ladders and roof decking.
8. Emergency communication, response and rescue equipment, including, but not limited to, alarms, fixed fire control systems, hose lines, fire extinguishers, first aid kits, spill cleanup materials, rescue systems, retrieval lines, and harnesses.
9. Cleaning materials, including, but not limited to, mops, squeegees, shovels, buckets, rags, wipers, etc.

10.2.9 Emergency Plans

Employers (owners/operators and contractors) should review the facility and contractor's emergency plans and applicable regulatory emergency response requirements. (Figure 10-5: Sample Emergency Action Plan.) (Figure 10-6: Sample Permit Required Confined Space Emergency Action Plan.)

1. Establish an emergency response plan specific to the tank being cleaned that covers emergencies inside and around the tank being cleaned and elsewhere in the facility impacting on the tank cleaning operations, including, but not limited to, medical and first aid, fires, spills and releases and rescue operations.
2. Determine and designate either a qualified outside rescue service or identify employer (owner/operator and contractor) designated rescuers.

10.2.10 Tank Pre-Cleaning Meeting

Employers (owners/operators and contractors) should conduct a tank pre-cleaning meeting including facility, contractor and sub-contractor personnel to review the above information and assign specific responsibility for each phase of the tank cleaning operation.

10.3 REMOVING RECOVERABLE PRODUCT

Employers (owners/operators and contractors) should develop a plan for removing all recoverable product from the tank that includes, but is not limited to, the following items.

10.3.1 Area Protection

Employers (owner/operators and contractors) should limit access to the area around the tank to personnel authorized on the safe (cold) work permits and entry permits.

1. Set up notices and barricade the area around the tank to be cleaned to prevent unauthorized access.
2. Employers should be responsible for authorized and unauthorized access by their own employees.

10.3.2 Entry onto Floating Roofs

Employers (owner/operators and contractors) should determine the requirements for entry upon floating roofs in accordance with the facility's confined space program and classification of the floating roof as permit required confined space, non-permit required confined space or non-confined space.

1. Determine industry and facility requirements for entry onto floating roofs of tanks in service (see API 2026 for additional information).

Sample Supervisor's Safety Inspection Checklist

Region _____ Foreman _____ Date _____
 Job No. _____ Customer _____ Tank No. _____
 Job Description _____

This form is an aid for making inspections, look for, correct, and report other unsafe items.

PERSONAL PROTECTIVE EQUIP.	OK	REMARKS	PAPERS	OK	REMARKS
Hard Hats	()	_____	Inspection Forms	()	_____
Eye and Face Protection	()	_____	Safety Manual	()	_____
Proper Clothing	()	_____	Accident Records	()	_____
Foot Protection	()	_____	Permit Review/Post/Follow	()	_____
Hearing Protection	()	_____	WELDING AND CUTTING		
Respirators	()	_____	Working Bottles	()	_____
Gloves	()	_____	Hose and Gauges	()	_____
Welder Leathers	()	_____	Weld Machine Grounded	()	_____
Safety Harness and Lines	()	_____	Leads and Connectors	()	_____
Fresh Air Equipment	()	_____	Ground Connection	()	_____
Special Clothing	()	_____	Work Area Fire Hazards	()	_____
FIRE PROTECTION			RIGGING		
Fire Extinguisher Accessible	()	_____	Rope Blocks	()	_____
Fire Hoses	()	_____	Equipment Type and Size	()	_____
Fire Blankets	()	_____	Line Size and Condition	()	_____
Meters-Explosion, O ₂ , H ₂ S, etc.	()	_____	Choker Slings	()	_____
Equipment Grounded	()	_____	Chain Hoist, Come Along	()	_____
Cold Tools Buster, Punches	()	_____	Snatch Blocks	()	_____
GENERAL			Tag Lines	()	_____
Fuel Storage	()	_____	Plate Clamps	()	_____
Bottled Gases	()	_____	Jacks	()	_____
Barricades, Signs	()	_____	Winches, Cable, and Poles	()	_____
Air Movers and Ventilators	()	_____	Chains and Boomers	()	_____
Compressor and Pumps Location	()	_____	MOTOR VEHICLES		
HAND TOOLS			Safety Sticker	()	_____
Extension Cords	()	_____	Emergency Reflectors	()	_____
String Lights	()	_____	Wheel Chock	()	_____
Air Hose-Connection Pinned	()	_____	Wipers, Lights, and Tires	()	_____
Guards and Protective Devices	()	_____	Welding Machine	()	_____
Handles and Striking Faces	()	_____	Brakes	()	_____
Ground Connections-Ground Fault	()	_____	Compressors	()	_____
Grinding Disks, Wheels, Cups	()	_____	Fire Extinguisher	()	_____
Non-Sparking Tools	()	_____	Accident Report and Papers	()	_____
Flashlights—Explosion Proof	()	_____	Spare and Jack	()	_____
Exits Clear—Manway	()	_____	HOUSEKEEPING		
SCAFFOLD AND LADDERS			Work Areas	()	_____
Bracket Lug Welds	()	_____	Dog House	()	_____
Safety Lines or Rails	()	_____	Storage Area	()	_____
Ladders and Tower Base Width	()	_____	Combustible Debris	()	_____
Access Ladder	()	_____	Scrap	()	_____
Toe Boards	()	_____	FIRST AID		
Loose Tool Containers	()	_____	First Aid Kit	()	_____
Barricades and Signs	()	_____	Emergency Names and Numbers	()	_____
Brakes on Wheel Buggy	()	_____	Emergency Transportation	()	_____
Air Spiders	()	_____	Qualified Person (First Aid)	()	_____
SANITATION					
Toilet Facilities	()	_____			
Drinking Water	()	_____			
Wash Up Facilities	()	_____			
Decontamination	()	_____			

Figure 10-4—Sample Supervisor's Safety Inspection Checklist

Sample Emergency Action Plan

Customer: _____ Location: _____
 Job Number: _____ Tank Number: _____
 Start Date: _____ Completion Date: _____

In the event of fire, explosion, leak, or other emergency necessitating the evacuation of employees, the following procedures should be implemented by the supervisor or employee in charge.

1. DE-ENERGIZE EQUIPMENT

- 1.1 Turn off all machinery or equipment you are using or that is near you.
- 1.2 Close valves on compressed gas cylinders.

2. NOTIFICATION

- 2.1 Contact customer, if applicable, to inform of details of the situation.
- 2.2 Contact office, if applicable, to inform of details of the situation.

3. EVACUATION

- 3.1 Calmly proceed to one of the refuge areas listed below. **DO NOT RUN unless it is an extreme emergency!** All personnel should go to the initial refuge area unless conditions make it unsafe to go in that direction, due to wind direction or other circumstances, at which time you should proceed to the secondary refuge area.

3.1.1 Initial Refuge Area: _____

3.1.2 Secondary Refuge Area: _____

- 3.2 Account for all employees.
- 3.3 Coordinate employees rescue and medical duties.
- 3.4 Contact office, if applicable, to inform of details of the situation.
- 3.5 Wait for further instructions.
- 3.6 Resume normal work activities only after "all clear" is received.

4. POSTING REQUIRED AT EACH JOB SITE

- 4.1 Emergency Information Card.
- 4.2 Escape Routes which include refuge area(s).
- 4.3 Wind Direction Indicator.
- 4.4 Emergency Action Plan based on what company advises.

If further information or explanation of duties under this plan is needed, please contact supervisor.

NOTE: Employees should evacuate the danger area and NOT assist in handling the emergency.

Courtesy: ITEQ Tank Service, Inc.

Figure 10-5—Sample Emergency Action Plan

**Sample Site Specific Emergency Action Plan
Permit Required Confined Space Entry
(Post at Point of Entry)**

Project Location: _____ **Physical Address:** _____

Project Manager: _____

Facility Emergency Response: **Telephone #** _____ **Radio Channel** _____

Public Emergency Response: **Fire Department** _____

Emergency Medical _____

Specialized Rescue _____

Confined Space Supervisor: _____

Confined Space Attendant: _____

Confined Space Entrants: _____

Scope of Work: _____

Action Plan

- Attendant will alert project team of potential emergency inside confined space.
- Supervisor will notify facility and/or public emergency response organizations.
- Attendant will don proper PPE to perform rescue operation, if necessary.
- Second attendant will assume man watch duties, supervisor will coordinate rescue, relieved attendant assumes role of rescuer, team assembles to support rescue effort.
- Upon direction, attendant will enter to assist in safe removal of downed worker.
- Rescuer will attach lifeline to downed worker and remove him through egress point.
- Rescue team will aid in removal of downed worker from confined space.
- Rescue team will safely and rapidly decontaminate downed worker.
- Rescue team or medical responders will initiate Basic Life Support on downed worker.
- Following transfer of affected worker, the supervisor will debrief the team and conduct an investigation.
- Following the investigation, the supervisor will submit a written report to the client and Health and Safety.

Courtesy: Landry Service Company

Figure 10-6—Sample Emergency Plan

2. Plan descent upon a floating roof when it is at a high level (preferably within 5 feet of the top of the tank).
3. Verify that the floating roof is safe to walk on or provide appropriate flooring before entering on top of a floating roof.
4. Conduct required testing to assure that the atmospheric conditions on top of the roof are within acceptable limits before entry onto a floating roof.
5. Gauge the tank to determine the amount of water, sludge and recoverable product.
6. Check the integrity of the floating roof to prevent damage to the roof as the tank is emptied.
7. Pull a representative number of the roof legs and check for condition and integrity.
8. Lower the legs of floating roof tanks while the tank is still in service, preferably when the tank is full.
9. Check the roof drain hoses to assure they will not kink or be blocked as the roof is slowly and carefully lowered on its legs.
10. Check that roof drains are functioning after an open top (external) floating roof is on its legs to prevent water accumulating on the roof as the extra weight may damage the roof or cause the roof legs to puncture the tank bottom.

10.3.3 Removing Product through Product Lines

An important safety practice in cleaning tanks is to remove as much recoverable product as possible from the tank before it is opened. Employers (owners/operators and contractors) should establish procedures to first remove recoverable product through fixed connections and then through an open manhole or other large tank openings.

1. Withdraw product through tank suction lines until it is below the outlet level and the main pump nearly loses suction.
2. Depending on the amount of sludge, residue and water in the tank, determine if the remaining recoverable product can be removed using existing tank connections (or if the tank has to be opened).
3. Before and during emptying through fixed connections, obtain samples of recoverable product from the water draw off or stripper valve (or from the open manhole), for testing and determination as to whether or not recovered product can be returned to stock.

10.3.4 Product Removal by Suction Pump

Employers (owners/operators and contractors) should use a portable air or steam (or approved electric) driven suction

pump and conductive hose and couplings to complete the process of emptying the tank of all recoverable product through fixed connections.

1. Internal combustion powered portable pumps shall not be used inside the dike area.
2. Provided that the employer (owner/operator or contractor) permits the use of an approved electric driven portable pump, inspect the explosion proof motor and all electrical connections to assure that they meet area electrical classification requirements before use.
3. Check the integrity of the pump, hose and couplings and inspect the safety features of the system, including, but not limited to, spill retention and check valves to prevent back flow.
4. Conduct atmospheric testing to assure that flammable vapor-in-air (gas-in-air) levels are within acceptable limits and issue a permit to move and position the portable pump and hoses into place in the diked area.
5. Directly connect and bond the portable pump suction hose to an appropriate tank connection, such as a water draw off line, stripper valve, sample line, or other connection, using conductive hose and couplings.
6. Assure that the portable pump is grounded and electrically bonded to both the product tank and the receiving container or tank. Bond the end of the discharge hose to the receiving tank or container.
7. Pump out the remaining liquid from the tank with the portable pump until it loses suction.
8. Collect the liquid in an approved container or tank for disposal or return to stock.

10.3.5 Product Removal by Flotation

Once product has dropped below the level of the fixed tank connections, employers (owners/operators and contractors) may remove remaining recoverable product by pumping water or fuel oil into the tank and floating the product out through a fixed connection.

1. Fuel oil may be used to remove gasoline and other low flash products from tanks through closed connections, however, the potential still exists for flammable vapors when the tank is opened.
2. The remaining recoverable product will float on the water or fuel oil and can be removed through the fixed tank discharge line, water draw, or stripper valves.
3. Water or fuel oil must be injected slowly to prevent electrostatic charge buildup from splash filling.

10.3.6 Product Removal by Vacuum Pump

If the remaining liquid is to be removed from the tank by vacuum equipment, employers (owners/operators and contractors) shall apply the same safety precautions required for portable pumps to vacuum operations (see API 2219 for additional requirements).

1. Vacuum trucks engines are ignition sources and the location of the vacuum truck and control of ignition sources in the area are important safety concerns. The vacuum truck shall be placed up wind, no closer than 50 feet (15 meters) from the tank and preferably outside of or on top of the tank dike.
2. The vacuum process creates static electricity. Conductive hoses and couplings shall be used, the vacuum truck grounded and the vacuum truck and all hoses and couplings shall be electrically bonded to the product tank and the receiving tank or vessel.
3. Vapors discharged from the vacuum truck can be in the explosive (flammable) range and must be discharged at a high level (at least 12 feet [3.7 meters]) above ground or degassed.

10.3.7 Removing Recoverable Product through Open Manholes

If a tank manhole has to be opened to remove recoverable low flash or hazardous product from a tank, employers (owners/operators or contractors) should assure that entry supervisors issue an entry permit for this activity.

1. Install and electrically bond an eductor to a manhole at the top of the tank. Start it at low capacity to create a slight negative pressure in the tank to prevent vapors from escaping at ground level when the bottom manhole is opened.
2. If the tank has a floating roof, install the eductor at the top of the tank and arrange flexible ducting to draw air through a manhole from beneath the floating roof.
3. Electrically bond one bottom manhole cover to the tank and then remove it. Immediately cover the open manhole with a fire blanket or similar barrier to minimize vapor emissions to the atmosphere.
4. As soon as the bottom manhole is opened, increase the airflow to prevent escape of vapors through the bottom manhole.
5. Install a pan just inside the manhole, above the level of the sludge to collect recoverable product. Bond the suction line to the pan, the product tank and the pump or vacuum truck. Install a check valve in the suction line to prevent back flow.

6. Before and during emptying from the open manhole, obtain samples of recoverable product for testing and determination as to whether or not recovered product can be returned to stock.

7. Replace the shell manhole cover when product is completely recovered and stop the eductor in order that the tank does not collapse.

10.4 TANK ISOLATION

Employers (owners/operators and contractors) shall develop a tank isolation plan that identifies all items to be isolated, locked or tagged out, required permits and a list of isolation devices, blinds, locks and tags and identifies those responsible for the isolation operations.

10.4.1 Isolation Requirements

Employers (owners/operators and contractors) should prepare a list of items to be isolated, locked out and tagged out, including, but not limited to, inlet and withdrawal lines; water draw, sample and gauging lines and devices; vapor recovery lines; pumps; valves, vents and relief devices; electronic, hydraulic and mechanical switches and power sources; heating coils and mixers; and appurtenance and connections.

1. Assign responsibility for isolation and lockout/tagout in accordance with facility procedures and tank pre-cleaning agreements between owners/operators and contractors.
2. Assure that all recoverable product has been removed from the tank before isolation.
3. Establish safe work procedures for conducting isolation and lockout/tagout including, but not limited to, opening lines to install blinds, disconnecting and de-energizing power sources and isolating heating coils.
4. Determine and assure workers use appropriate personal protective clothing and respiratory protective equipment during opening and blinding of lines and lockout or tagout of energy sources.

10.4.2 Tank Suction and Discharge Lines

Employer (owners/operators and contractors) shall assure that all suction and discharge lines are closed at the tank at the tank and lockout or tagout devices are installed on the valves.

1. Control ignition sources in the area, before opening any lines.
2. Secure, lockout or tagout all dike valves leading from the area around the tank to be cleaned and cover sewer openings or drains in the diked area that cannot be closed by valves to prevent vapors from entering into the dike area or spills to leave the dike area.

3. Check to be certain lines have been depressurized and drained and that in-line drain valves are open and clear of obstructions.

4. Carefully drain, separate and isolate lines by blinding as close to the tank as possible or by double block and bleeding (closing two adjacent valves and opening the line in between) as close to the tank as possible. Alternately (or if required by facility procedures) valves may be dropped and lines blanked in order to achieve isolation.

5. Review thermal relief requirements (such as breaking, capping or rerouting) for piping being isolated and institute measures to guard against overpressuring piping and related equipment.

6. Install blinds on the side of a blocked valve that is most consistent with pressure testing requirements.

10.4.3 Other Tank Lines, Appurtenances, and Connections

Employers (owners/operators and contractors) shall assure that all other lines and connections at the tank, including, but not limited to, water draw and sample lines, remote gauging system lines, and vapor recover lines are drained and closed and isolated by blinding or installing lockout or tagout devices on the valves.

1. Other lines, including but not limited to, sample lines, gauge lines or other lines that are connected to the tank (but not to an external source) shall be thoroughly purged, cleaned flushed and/or isolated prior to the tank being considered isolated.

2. If the tank has a fixed or semi-fixed fire foam system, inspect the piping to assure that no liquid or vapors are contained therein, but do not disconnect or isolate the system.

3. If necessary, drain and flush the foam line, but do not disconnect the foam system.

4. Check and replace the foam line chamber glass seal if missing, cracked or broken.

10.4.4 Energy Sources

Employers (owners/operators and contractors) shall verify that isolation, lockout and tagout of electrical, hydraulic and mechanical energy sources have been performed according to the isolation and blinding list and that no items were overlooked.

1. Isolate all electrical energy sources, including, but not limited to, pump motors, electric heating coils, mixers and instrumentation devices by disconnecting (or other means

allowed by the facility) and installing lockout or tagout devices on the switches.

2. Isolate all mechanical and thermal energy sources, including, but not limited to, steam, hot water, and hot oil heating coils by disconnecting (or other means allowed by the facility) and installing lockout or tagout devices on the switches.

3. Assure that all stored energy, heat and stored pressure is dissipated prior to isolation.

10.4.5 Cathodic Protection

Employers (owners/operators and contractors) shall assure that if a tank has cathodic protection, safe isolation practices are followed, in the order shown, whenever a tank valve or line is to be disconnected.

1. Turn off the cathodic protection system.

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.

10.4.6 Verification

Employers (owners/operators and contractors) shall establish and implement procedures to verify that isolation has been accomplished.

1. Lines are disconnected, blinded and/or double blocked and bled.

2. Energy sources are disconnected and locked and/or tagged out and de-energized.

10.5 VAPOR-FREEING THE TANK

Vapor and gas freeing occurs after all recoverable product has been removed from a tank and the tank has been isolated. Employers (owners/operators and contractors) shall develop and entry supervisors shall implement procedures for safely vapor and gas freeing and degassing (if required) the tank before tank cleaning commences.

10.5.1 Vapor and Gas Freeing (Degassing) Methods

Employers (owners/operators and contractors) shall select an appropriate method of vapor and gas freeing, degassing and ventilating tanks in accordance with the tank design, size, configuration, usage, physical condition, environmental regulations and facility requirements and conditions. Vapor and gas freeing methods include, but are not limited to, removal of flammable and/or toxic vapors and gases from tanks by

mechanical dilution with air or displacement with inert gas, steam, water or fuel oil.

1. Mechanical vapor and gas freeing and ventilation requirements depend on the tank design, size and characteristics (and are discussed elsewhere in this recommended practice).
2. In order to minimize air pollution, provide degassing, where required by the facility or jurisdiction, by incineration, condensation and recovery or treatment of vapors prior to emission to the atmosphere.
3. Ventilation, which occurs after vapor and gas freeing, provides an appropriate number of air changes (normally 5 air changes per hour) specified in regulations or facility requirements in order to maintain the atmosphere within the tank at acceptable permit limits during tank cleaning operations.
4. Obtain necessary permits for vapor and gas freeing direct to the atmosphere and degassing.

10.5.2 Control of Ignition Sources

Employers (owners/operators and contractors) shall assure that entry supervisors and workers are aware that vapor and gas freeing and degassing is a potentially hazardous phase of tank cleaning because the tank's atmosphere passes through the explosive (flammable) range as the flammable vapors are diluted with air. Flammable vapors and gases that are not degassed are emitted direct to the outside air and may reach a source of ignition. Entry supervisors shall also be aware that the use of air or steam driven mechanical blowers and eductors to dilute and remove vapors is preferred as an electric motor could be a source of ignition. (See ANSI/API Standard 2015 and ANSI/API Recommended Practice 2016 for vapor and gas freeing by displacement or inerting.)

1. Assure that all air moving equipment is electrically bonded to the tank.
2. Control ignition sources around the tank and in the dike area during vapor and gas freeing
3. Conduct continuous or periodic atmospheric testing and degassing equipment testing to monitor conditions, maintaining records of degassing emissions.
4. Do not conduct vapor and gas freeing during thunder and lightning storms.
5. Some degassing systems have the potential to create heat and become a source of ignition, with a potential for flashback into the tank.
6. Provide degassing units with appropriate flame arrestors and follow safe operating practices.

7. If an air compressor is used, place it in a safe location, preferably outside the diked area, up wind and 50 feet from the tank.

8. Establish requirements for use of only approved electrically powered equipment.

9. Assure all equipment permitted to be used meets NFPA 70, Class I, Division 1, Group D, or Zone 1 (or greater) requirements, is explosion proof, is inspected by a qualified person for integrity and is approved for use by the employer (owner/operator or contractor).

10. Ignitable pyrophoric iron sulfides may be present in tanks containing sour products. If so, provide continuous water spray keep tank surfaces wet during vapor and gas freeing, degassing, and ventilation

11. Shut down all hot work and other sources of ignition within the diked area before opening the tank manholes to connect eductors or blowers and flexible intake and exhaust ducts.

12. Supervisors should restrict personnel from working within the diked area around the outside of the tank during vapor and gas freeing (degassing) operations until the level of flammable vapors leaving the tank is 50% LEL or lower and the atmosphere in the diked area is within acceptable permit limits.

10.5.3 Control of Toxic Hazards

Employers (owners/operators and contractors) shall recognize that the potential exists for exposure to toxic hazards during vapor and gas freeing, degassing and ventilation and establish appropriate controls.

1. Specific toxic hazards may be present if the tank has contained crude oil or products containing sulfur; gasoline containing benzene; or products containing organic lead
2. Workers on top of, inside and outside tanks may need to wear protective clothing, eye protection and respiratory protection for H₂S gas, benzene or organic lead exposure.

10.5.4 Blower and Eductor Selection

Employers (owners/operators and contractors) shall assure that the number, size and capacity and location of air blowers and eductors are based on appropriate factors, including, but not limited to, tank size and configuration, vapor characteristics, back pressure and diameter and length of exhaust duct or vapor recovery line. Employers (owners/operators and contractors) shall assure that qualified persons select the air blowers and eductors based on the following criteria:

1. Size and configuration of the tank and the size, location and number of manholes and other tank openings, vents, relief devices, etc.
2. Available facility steam and facility or contractor supplied air to drive blowers or eductors.
3. Characteristics of the vapors.
4. Diameter and length of intake and exhaust ducts (or vapor recovery line) to determine resistance (back pressure).
5. Required or available time to vapor free the tank.
6. Number of required air changes per hour in the confined space to meet regulatory or facility requirements.

10.5.5 Vapor and Gas Freeing (Degassing) the Tank

Entry supervisors shall restrict work activities and control personnel in and around the tank dike area during vapor and gas freeing (degassing) operations.

1. Verify that the tank is ready for opening and issue appropriate entry and work permits.
2. Assure that workers who open manholes and attach and bond eductors, blowers, air intake and vapor exhaust ducts to the tank, wear required respiratory and personal protective equipment and clothing.
3. Have required fire suppression equipment, including fire extinguishers and/or fire hoses ready for use.
4. Connect and electrically bond an air or steam driven eductor onto a roof or shell manhole to suck vapors from the tank.
5. Start the eductor at low capacity to create a slight negative pressure in the tank to avoid creating a vacuum so the tank shell or roof does not collapse. This will prevent vapors and gases from escaping at ground level when the bottom manhole(s) is opened.
6. Increase the eductor airflow only after the bottom manhole is removed. Additional shell manhole covers may be removed to improve vapor and gas freeing (degassing).
7. Take precautions to prevent vapors and gases from escaping when opening side manholes.
8. Alternately, an air or steam powered air blower may be connected and electrically bonded to a bottom shell manhole. This creates higher than atmospheric pressure inside the tank, forcing vapor and gas out of the tank through an open roof or shell manhole.
9. Do not obstruct the shell manhole(s) where fresh air is entering the tank.

10.5.6 Control of Vapors and Gas

Prior to the start of tank cleaning operations, employers (owners/operators and contractors) shall determine whether vapors and gas may be discharged direct to the atmosphere or if degassing is required and establish and implement appropriate controls.

1. Regardless whether eductors or blowers are used, vapors and gas shall be either discharged to the atmosphere at the top of the roof or a high level (at least 12 feet [3.7 meters] above ground level) or to an approved degassing system.
2. Flexible exhaust duct that is at least 8 inches (20 cm) in diameter and no more than 25 feet (7.6 meters) in length, with a minimum of two 90° bends in the duct to maximize circulation inside the tank, should be used. Because every bend in exhaust ducting reduces the airflow, this must also be considered when selecting and sizing air blowers and eductors.
3. Connect the flexible exhaust duct to the open shell manhole (or to an eductor connected to a shell manhole) so that the vapors and gases are discharged upwards (or direct to a degassing system), at least 12 feet (3.7 meters) above ground level and not do settle on the ground.
4. Take precautions to prevent vapors and gases from escaping when flexible exhaust ducts are installed directly onto tank shell manholes.
5. Do not allow vapors or gas to be discharged to areas where they have the potential to reach a source of ignition such as the air intake of any internal combustion equipment operating in the area or enter the intake system of forced air or breathing air compressors.

10.6 ATMOSPHERIC TESTING

Employers (owners/operators and contractors) shall establish testing procedures to be implemented by the entry supervisor in order to determine the oxygen content, flammable vapors and gases and toxic vapors, gases and fumes in the atmosphere in and around the tank being cleaned. The frequency and type of atmospheric testing to be conducted depends on a number of variables, including, but not limited to, the following:

1. The classification of the tank as a confined or non-confined space.
2. The products presently and previously stored in the tank.
3. The method of vapor and gas freeing (and degassing) the tank.
4. The inspection, entry, tank cleaning, maintenance, repair and other operations to be performed around and inside the tank.
5. Applicable government regulations and facility requirements.

10.6.1 Testing Requirements

Employers (owners/operators and contractors) shall establish safe exposure limits for entry onto floating roofs and working inside and around tanks, in accordance with the requirements of this recommended practice and API ANSI/API Standard 2015.

1. Entry supervisors shall assure that qualified persons are assigned to conduct tests and analyze test results.
2. Entry supervisors and testers shall be aware of the permissible exposure limits and requirements when testing hazardous atmospheric concentrations, including, but not limited to, flammable vapors, oxygen, hydrogen sulfide (H₂S), benzene and organic lead.
3. Testers shall verify that testing instruments are appropriate for the atmosphere and potential hazards to be tested, are properly calibrated and adjusted in accordance with the manufacturer's instructions for the hazard to be tested and are inspected, checked and bump tested prior to use.
4. Testers shall record calibration and test results as required by applicable regulations, the employer's (owner/operator or contractor) procedures and permit requirements.
5. Testers shall wear appropriate personal protective equipment, including, but not limited to, approved respiratory protection and personal protective equipment including, but not limited to, clothing, gloves, boots, hard hat, safety harness and life line.
6. Entry supervisors shall issue entry permits for testers to test inside tanks or on top of floating roofs.

10.6.2 Testing Limitations

Entry supervisors and testers shall be aware of the limitations of instruments used to test hazardous atmospheric concentrations of flammable vapors and gases and toxic substances.

1. Flammable vapor tests are not accurate if conducted in oxygen deficient or oxygen enriched atmospheres.
2. Organic lead tests must be conducted only after the tank is thoroughly cleaned and dry, not before or during cleaning.
3. Inorganic lead testers can not be used for organic lead testing.
4. Flammable (combustible) vapor indicators can not be used for testing benzene levels.
5. Specific instruments must be used to test for specific substances.

6. Testers should be aware that hydrocarbon vapors are heavier than air and tend to settle in low places.

10.6.3 Testing Procedure

Testers shall be aware that sequential testing requires that oxygen be tested first, then flammable vapors or gases and finally toxic hazards. Testers should consider the following testing procedure when conducting these tests:

1. From outside the tank, test the vapors or gas being discharged from the tank during vapor and gas freeing or degassing operations. If initial external test results are acceptable, shut down the eductors or blowers for at least 15 minutes to establish equilibrium inside the tank.
2. Then test the atmosphere inside the tank through the tank shell manhole, without entering the tank. If results and conditions are acceptable, the entry supervisor shall issue a permit for the tester to enter the tank.
3. Test the tank interior atmosphere in areas away from manholes, in low areas and in critical and suspect areas, including, but not limited to, leaking tank bottoms, roof supports and columns, sumps, interior piping, roof seals, roof drains and pontoons.
4. Test the atmosphere above internal and covered floating roofs by inserting a remote sensor through roof openings or, after an entry permit is issued, by descending onto the roof or onto the ladder or stairway.
5. If test results are not acceptable, vapor and gas freeing, degassing and ventilation shall continue for an appropriate amount of time as determined by the entry supervisor.
6. Atmospheric testing shall be repeated and the test results must be acceptable before the entry supervisor issues any permits to enter the tank for cleaning or work.

10.6.4 Testing Inert Atmospheres

Entry supervisors and testers shall be aware that inert atmospheres will produce false readings and that special test equipment and procedures are required.

1. The entry supervisor shall issue a permit as entry into inert atmospheres for test purposes is always considered to be permit required confined space entry.
2. Testers shall be aware that the amount of oxygen present in an inert atmosphere is important when conducting tests using special instruments.
3. Testers shall be aware that normal flammable (combustible) vapor indicators will not work in inert atmospheres with little or no oxygen.

10.6.5 Test Criteria

Atmospheric testing should be conducted at the start of each work day, at the start of each shift and continuously or periodically, as required, during work, to monitor conditions resulting from changes in the tank, including, but not limited to, the following:

1. Increase or decrease in flammable vapor and gas or toxic exposure levels due to atmospheric changes including, but not limited to, humidity, wind speed, and direction and temperature increases or decreases.
2. Releases of liquids, vapors and gases from agitation of sludge and residue, leaking tank bottoms, piping, columns, or pontoons or hydrocarbons absorbed in seals and insulation.
3. Flammable or toxic vapors, gases or liquids entering the tank from outside sources.
4. Release of fumes from hot work being conducted inside or around the tank.

10.7 CLEANING THE TANK

Employers (owners/operators and contractors) shall establish safe work procedures and appropriate limits for worker's exposure to hydrocarbon vapors and gases and toxic gases, both outside of tanks and entry into tanks during tank cleaning operations, in accordance with the requirements of this recommended practice, ANSI/API Standard 2015, applicable regulations and facility requirements.

10.7.1 Permit Requirements

Upon assuring that testing for atmospheric concentrations of flammable vapors and gases, oxygen hydrogen sulfide (H₂S), benzene and organic lead has been properly conducted and conditions are safe for entry, the entry supervisor shall issue an entry permit for tank cleaning to begin. (Figure 10-7: Sample General Entry Permit.) (Figure 10-8: Sample Confined Space Entry Permit.) (Figure 10-9: Sample Confined Entry Permit.)

1. All permit requirements are to be satisfied throughout the duration of the permit.
2. The physical integrity and condition of the tank shall remain satisfactory during entry.
3. Ventilation shall be continued throughout the cleaning operation.
4. Control shall be maintained over potential ignition sources during operations.
5. The permit shall be cancelled and tank cleaning operations immediately stopped, ventilation stopped and the manholes secured whenever permit conditions change,

including, but not limited to, lightning storms, wind shifts, or atmospheric conditions above permit limits, permit expiration, or emergencies that impact on the tank cleaning operations.

6. The permit shall not be reissued until conditions are stabilized, testing is conducted and permit requirements are again satisfied.

10.7.2 Personal Protection Requirements

The entry supervisor or qualified person shall designate the appropriate respiratory protection and personal protective equipment to be worn by workers cleaning tanks from the outside and inside.

1. Entry supervisors shall not allow workers to enter the tank or conduct any tank cleaning activities without required protection.
2. If using air supplied respiratory equipment, entry supervisors and attendants shall ensure that entrants do not remove their face masks while they are in areas where there is a potential for toxic vapors or gas or an oxygen deficiency.
3. Entry supervisors shall locate breathing air compressors upwind of the tank with the air intake elevated above ground level and clear of any exhausts from internal combustion engines, vapors discharged from the tank, vapors emitted from vacuum equipment operations and vapors released by nearby tanks during product receipts.
4. Personal protective equipment subject to contamination shall be managed and cleaned in accordance with the employer PPE program and applicable regulations.

10.7.3 Sludge and Residue Removal from Outside the Tank

Employers (owners/operators and contractors) shall determine the requirements and arrange for the storage, handling and disposal of sludge, residue, non-recoverable product, wastewater and tank cleaning chemicals and solvents before tank cleaning operations begin. Entry supervisors shall issue permits for all removal operations and activities.

1. Where appropriate, samples of sludge and residue should be tested to determine hazard characteristics and disposal requirements.
2. Water, fuel oil, steam, or approved chemicals may be injected into the tank through fixed connections to assist in making the sludge less viscous so it can be vacuumed or suction pumped out. Entry supervisors shall determine and apply required safety precautions to the use of portable pumps and vacuum equipment (see API 2219 for

Sample General Entry Permit

(Side 1)

Facility Name: _____ **Tank/Equipment No.:** _____

Permit No.: _____ **Location:** _____

This Permit CANNOT be Renewed Past (Time and Date): _____

Work and Methods Approved: _____ Permit Requested by: _____
 (Operating Supv./Date) (Maintenance Supv./Date)

Possible Hazards	Check for		Limits	Date/Time Test Results	Date/Time Test Results	Date/Time Test Results
	Initially	Daily				
Chemical Hazards						
Flammable Vapors	()	()	10% LEL Maximum	_____	_____	_____
Hydrogen Sulfide	()	()	10 ppm Maximum	_____	_____	_____
Carbon Monoxide	()	()	35 ppm Maximum	_____	_____	_____
Benzene	()	()	1 ppm Maximum	_____	_____	_____
Xylene/Toluene	()	()	100 ppm Maximum	_____	_____	_____
Total Hydrocarbons	()	()	300 ppm Maximum	_____	_____	_____
Oxygen Deficiency	()	()	19.5% Minimum	_____	_____	_____
Tetraethyl Lead	()	()	0.1 mg/m ³ Maximum	_____	_____	_____
Other _____	()	()	_____	_____	_____	_____
Physical Hazards						
Dust/Sludge	()	()	_____	_____	_____	_____
Temperature	()	()	_____	_____	_____	_____
Blinds/Isolation	()	()	_____	_____	_____	_____
Electrical Lockout/Tagout	()	()	_____	_____	_____	_____
Other _____	()	()	_____	_____	_____	_____

PROTECTIVE EQUIPMENT REQUIRED _____ Hard Hat, Safety Glasses, Long Sleeves
 Other: _____

TODAY'S DATE AND SIGNATURE INDICATES _____ Date: _____
 THAT THIS EQUIPMENT IS SAFE TO ENTER _____ Operator: _____

THIS EQUIPMENT HAS BEEN TAGGED FOR ENTRY

Figure 10-7—Sample General Entry Permit (Page 1 of 2)

Sample General Entry Permit**(Side 2)****INSTRUCTIONS AND RESPONSIBILITIES FOR USE OF THIS PERMIT**

(Refer to Refinery Standard for Details)

MAINTENANCE SUPERVISOR OR COMPANY REPRESENTATIVE MUST:

1. Initiate permit showing "Equip. No." and "Location."
2. Review conditions with operating Supervisor and SIGN and date at top left in the "Permit Requested By" Section.
3. Ensure that all mechanics understand conditions.
4. Notify Operating Supervisor on any change of conditions that may require different testing.
5. Notify Operating Supervisor when interior work is complete and ready to head up.

OPERATING SHIFT SUPERVISOR MUST:

1. Review permit with Maintenance Supervisor.
2. Indicate required initial checks and daily rechecks by _____ in the "Check For" columns.
3. Indicate anticipated life of permit by completing both the "Permit Cannot Be Renewed Past" sections at top and bottom of permit.
4. Specify special "Protective Equipment Required" and reasons.
5. Review and SIGN blind list for approval prior to entry.
6. SIGN and date entry permit at top left "Work and Methods Approved" section indicating approval to proceed.

DESIGNATED RESPONSIBLE OPERATOR MUST:

1. Hang "Danger, Do Not Enter" tags at each location at the time Mechanics open the equipment or as instructed by Refinery Std.
2. Sign and date the "Equipment Safe To Enter" column to indicate final OK and hang approved entry permit.
3. Remove and file the bottom stub in the control room. Remove the "Danger, Do Not Enter" tag, if posted.
4. Perform daily re-testing (if qualified) each day for life of permit and SIGN permit when all tests prove OK.
5. Should conditions become unsafe, pull all entry permits and hang "Danger, Do Not Enter" tags, or as instructed by Refinery Std.

FIRE INSPECTOR OR TESTING OPERATOR MUST:

1. Sign for each test or check performed when OK in the column under the current "Date/Time."
2. Report to responsible operator when all requested tests and checks OK.
3. Remove entry permit if any check not OK, and report immediately to responsible operator (leave "Danger, Do Not Enter" tag in place, if posted).

ALL PERSONS MUST:

REVIEW PERMIT COMPLETELY BEFORE ENTRY, particularly noting final OK signature by designated responsible operator for the current date and time as well as required daily tests, checks, and protective equipment.

Figure 10-7—Sample General Entry Permit (Page 2 of 2)

WORK AUTHORIZED: SUPERVISOR _____ FACILITY REP. _____

Sample Confined Space Entry Permit

GENERAL

Customer _____ Location _____
 Date _____ Permit # _____ Good: from _____ to _____
 Reason for Permit and Description of Work to be Done: _____

Authorized Entrants and Job Description:

CONTRACTOR NOTIFICATION
 Don Miller & Associates, Inc. Notified of: Permit Conditions () Potential Hazards () N/A ()

EMPLOYEE TRAINING AND PRE-ENTRY BRIEFING

- All entrants have trained for confined space entry and rescue? YES () NO ()
- Pre-entry briefing and planning conducted? DATE _____ LOCATION _____
- Does this job require special training? YES () NO ()

SPECIAL TOOLS/EQUIPMENT, LIGHTING, AND COMMUNICATION DEVICES

- Are all electrical devices intrinsically safe? YES () NO ()
- Have all power cords and tools been visually inspected? YES () NO ()

VESSEL PERPARATION

- Work area isolated with signs/ barriers? YES () N/A ()
- All energy sources locked/tagged out? YES () N/A ()
- All lines capped/blinded? YES () N/A ()
- Vessel contents drained/flushed/neutralized? YES () N/A ()
- Ventilation provided 30 minutes before entry? YES () N/A ()

PRE-ENTRY ATMOSPHERIC TESTING (See back of form for additional atmospheric testing results.)

- Test for Flammable Level: % LEL _____ Time _____ Initials _____
- Test for Oxygen Content: % O₂ _____ Time _____ Initials _____
- Test for Toxic Concentration: PPM _____ Time _____ Initials _____

Identity of Toxic: _____

- Continuous Monitoring Required? NO () YES () Sampling Time Interval _____ minutes

EMERGENCY?RESCUE PROCEDURES

- Location of customers emergency/rescue plan: _____
- Emergency/Rescue Team ON Site () OFF Site () Phone # _____

SAFETY EQUIPMENT

Personal Protective Equipment Required: _____ Area Safety Equipment Required: _____

PERMIT AUTHORIZATION

I certify that I have inspected the work area and reviewed all safety precautions on this permit.

 Representative

 Customer's Representative

Courtesy: Don Miller & Assoc.

Figure 10-8—Sample Confined Space Entry Permit

Sample Confined Entry Permit

Permit Valid for 12 Hours Only

This permit is to be kept at the job site with a copy maintained in the project trailer.

Date and Time: _____ Job Site/Space ID: _____

Job Scope: _____

LANSCO Rescue Plan Reviewed with Team Members () Yes () No Comments: _____

Plant Rescue Notification: () Radio () Telephone () Other _____

CONFINED SPACE ISOLATION

Project manager and supervisor will ensure that all product flow, moving mechanical equipment, and electrical energy is completely stopped and is properly tagged, locked out, blocked, blinded, or disconnected before permitting entry.

- Pumps Valves Lines () Disconnected () Blinded () Locked () Tagged () Blocked
() Verified/Authenticated: When _____ Who _____
- Electrical Sources () Locked () Tagged () De-energized () Disconnected
- Mechanical Devices () Blocked () Locked () Tagged () Disconnected () Other
- Stored Energy () Blocked () Released () De-energized () Disconnected
- Entry Area () Manways/Openings Posted Properly () Barrier Tape at Each Manway/Opening
() Barrier Tape Set Up Around Work Area to Restrict Unauthorized Entry
() Motorized Equipment Staged Away From Manways/Openings
() Other Requirements

VENTILATION/PURGING OF CONFINED SPACE

Project manager and supervisor will ensure that proper ventilation has been established and is maintained prior to confined space entry and occupation.

- Type of Confined Space: () Coned Roof () Covered Floating () Open Floating () Other
- Ventilation: () Transvector () Blower () Natural () Mount on Roof () Mount on Side
- Discharge () Horizontal () Vertical () With Duct () Vapor Recovery

SPECIALIZED ENTRY EQUIPMENT

Project manager and supervisor will ensure that the proper type of equipment is provided and utilized by all entrants:

- () Tripod () Fall Arrester () Chest Harness () Full Body Harness () Lifeline
- () Retrieval System () Approved Lighting () Communications () Non-Sparking Tools
- () Other _____

ATMOSPHERIC MONITORING

Project manager and supervisor will ensure that the atmosphere is routinely monitored at least three times per shift. Person monitoring the atmosphere will initial each entry:

Atmosphere	Reading/Time	Reading/Time	Reading/Time
Oxygen > 19.5%	_____	_____	_____
LEL < 10%	_____	_____	_____
H ₂ S < 10 ppm	_____	_____	_____
Benzene < 0.5 ppm	_____	_____	_____
Other Monitoring	_____	_____	_____

Courtesy: Landry Service Company

Figure 10-9—Sample Confined Entry Permit (Page 1 of 2)

Sample Confined Entry Permit (Continued)

Permit Valid for 12 Hours Only

PERSONAL PROTECTIVE EQUIPMENT

Project manager and supervisor will ensure that the proper equipment is provided and utilized by the team members. Entrants and Attendants (manhole-watch) will utilize same level of protection.

- () Nornex () Tyvek () Slicker () Boots () Gloves () Helmet
- () Other () 1/2 Mask APR w/Cartridge () Full Face APR w/Cartridge
- () Airline with Escape Cylinder () 30 Minute Rated SCBA (Attendant)

CONFINED SPACE PERMIT REVIEW

I have reviewed the work authorized by this permit and the information contained herein. Written instructions and safety procedures have been received and are understood. This permit is not valid unless all appropriate items are completed.

Project Manager: _____ Supervisor: _____

Reviewed by: _____

ACCOUNTABILITY LOG OF ENTRANTS/ATTENDANTS

Manwatch/Attendant Record

<u>Name of Attendant</u>	<u>Time On</u>	<u>Time Off</u>	<u>Time On</u>	<u>Time Off</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

ENTRANT RECORD

<u>Name of Entrant</u>	<u>Time In</u>	<u>Time Out</u>	<u>Job Task</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Figure 10-9—Sample Confined Entry Permit (Page 2 of 2)

additional requirements) to control ignition, prevent static electricity and reduce vapors.

3. Vacuum trucks and air, steam or approved electrically driven suction pumps may be used to remove pumpable sludge and residue from the tank through fixed bottom connections or through open manholes. Vacuum truck engines and suction pumps operated by non-approved electric or internal combustion engines are ignition sources and their location in the tank cleaning area is an important safety control. The vacuum truck and pumps shall be placed up wind, no closer than 50 feet to the tank and preferably outside of or on top of the tank dike.

4. Removal of sludge, residue and non-recoverable product by vacuum or suction pump creates static electricity. Conductive hoses and couplings shall be used, the vacuum truck and suction pump shall be grounded and the vacuum truck, pump and all hoses and couplings shall be electrically bonded to the product tank and the receiving tank or container.

5. Vapors discharged from the vacuum truck can be in the explosive (flammable) range and must be discharged at a high level (at least 12 feet [3.7 meters]) above ground or degassed.

6. After as much sludge, residue and non-recoverable product as possible has been removed through fixed connections, a qualified person shall test the vapors being emitted from the tank for flammable vapor and toxic hazard concentrations. If the LEL is below 10% and toxic exposures are acceptable, a side manhole should be bonded to the tank and then opened and cleaning may be started from outside the tank. Continue ventilation during cleaning operations to minimize escape of vapors through the open manhole.

7. A water hose stream with a rotating nozzle or a steam hose may be used to soften and breakup sludge and residue. The entry supervisor shall assure that the hose nozzles are electrically bonded to the tank. Workers should minimize the amount of water so as to reduce water treatment and disposal requirements. Float loose sludge and residue to the open manhole where it can be removed by vacuum, suction pump or by hand to approved containers.

8. Softening, agitating, moving and breaking up sludge, residue and non-recoverable product may release additional flammable and toxic vapors. If the LEL of the vapors being emitted from the tank rises above 20%, entry supervisors shall stop work, but do not disconnect the bonding cables, hoses or any equipment. Continue vapor and gas freeing, degassing and ventilation until vapors being emitted are again below 10% LEL and then resume cleaning from outside the tank, without entry.

9. The entry supervisor shall issue an entry permit in order for workers to break the plane of the manhole for any reason, while cleaning from the outside of the tank. An entry permit shall not be issued, and workers shall not enter the tank (break the plane of the manhole) if the flammable vapor level is above 10% LEL.

10.7.4 Cleaning the Tank from the Inside

After as much sludge and residue has been removed from the tank without entry, entry supervisors shall issue permits for workers or robotic equipment to enter the tank to remove the remaining sludge, residue and non-recoverable product.

1. Entry supervisors shall assign and indicate the names of entrants, attendants and standby persons on the permit and designate rescuers in event of an emergency.

2. Entry supervisors shall determine the respiratory protection and personal protective clothing and equipment required, note this on the entry permit and assure that it is used by entrants, attendants, standby persons, and rescuers.

3. Entry supervisors shall determine the entry requirements, indicate these on the permit, and issue an entry permit to workers only if toxic levels are within acceptable limits and the vapor-in-air (gas-in-air) concentration is 0% LEL.

4. Breaking up and removing sludge and residue and using cleaning solvents and chemicals inside the tank may release additional flammable vapors and toxic vapors and gas. Entry supervisors shall require periodic or continuous monitoring of the atmosphere inside the tank during tank cleaning operations. If the LEL rises above 10% or if toxic exposures rise above permissible limits, the entry permit shall be cancelled, work shall immediately stop and entrants shall leave the tank.

5. Vapor and gas freeing, degassing and ventilation shall be continued in order to reduce the vapor level inside the tank. As soon as testing indicates that vapors are again at 0% LEL and the atmosphere in the tank is within permissible toxic limits, the entry supervisor shall re-issue the entry permit, workers may re-enter the tank and resume cleaning.

6. Entry supervisors shall determine the entry requirements and issue an entry permit for the use of robotic cleaning equipment inside the tank only if the vapor-in-air (gas-in-air) concentration in the tank is at or below 10% LEL. If the LEL rises above 20% during the robotic cleaning operation, the entry permit shall be cancelled, the robotic equipment shall stop operations and vapor and gas freeing, degassing and ventilation shall continue until the vapor-in-air (gas-in-air) level is again at or below 10% LEL and the permit can be re-issued.

7. Attendants shall monitor entrants throughout tank cleaning operations for heat stress in hot weather, cold stress in cold weather, signs of toxic exposure, and other requirements.

8. Upon entry and before beginning cleaning operations, workers shall lower swing lines to the bottom of the tank or provide support with angle frames. Entrants shall inspect for overhead obstructions and hidden hazards, such as openings in the floor covered by sludge, submerged piping, etc.

9. If hose streams or used inside the tank to break or sludge, residue and deposits, entry supervisors shall require that the hose nozzles are bonded to the tank. Entrants shall leave the bonds connected when leaving the tank for short breaks, or if the vapor levels rise above permitted limits and continued ventilation is required.

10. Workers may be required to scrape or hydro-blast internal tank components in preparation for repair or maintenance. In such cases, blasting nozzles shall be bonded to the tank or the component to prevent an electrostatic charge.

11. Workers shall be aware that tank piping, nozzles, columns, floating roofs, pontoons, seals and support members may contain hydrocarbons and should be inspected and cleaned if needed. Cylindrical supports (columns) should be closely inspected to assure that product has not entered the supports through imperfect welds while the tank was in service. Columns may be tapped for inspection and drainage and a plug then installed for future testing purposes.

12. Workers shall be alert for leaking tank bottoms with entrapped hydrocarbons or sludge. Particular attention should be given to welds attaching support and column striker plates to the tank floor to assure that product has not leaked below the floor.

13. Workers shall clean and flush all internal lines that can trap hydrocarbons, including articulated and hose-type roof drains, to ensure that product has not accumulated in low points providing a source of hydrocarbons that may subsequently ignite when hot work is performed after the tank is gas freed and cleaned.

14. Workers shall check all pontoons for leaks and if contaminated with liquid or vapor, removed them from the tank and vapor free and clean them outside of the tank.

15. Workers shall inspect and if necessary, clean residue and deposits from areas on top of the floating roof and on walls above the floating roof.

16. Workers shall wash, brush, or sweep sludge, residue, and deposits into piles and remove them by container, wheelbarrow, or handcart.

17. Workers should provide a final wash down with water, kerosene, approved solvents, or chemicals, then wipe all puddles and surfaces dry and air dry the tank.

18. When the tank is clean, workers shall remove all used cleaning materials including, but not limited to, absorbents, rags, tools, and containers and if required by regulations or facility procedures, handle contaminated materials as hazardous waste.

19. The entry supervisor shall assure that the tank is inspected thoroughly for wet spots before benzene testing and organic lead vapor testing is conducted. It may be necessary to inspect for additional sources of vapor and continue ventilation and cleaning until satisfactory benzene and lead levels are attained.

20. Entry supervisors shall assure that any tank classified as a confined space is not left open and unattended. At the end of the workday or when the permit expires, the entry supervisor shall assure that the tank is closed and secured by replacing all open manhole covers with at least 4 bolts. At the start of the next workday, the entry supervisor shall require that the tank is ventilated and the atmosphere is retested and permissible entry levels are achieved before reissuing the entry permit.

10.8 WORKING INSIDE AND AROUND THE TANK

10.8.1 Permit Requirements

Entry supervisors and qualified persons shall issue hot work, safe (cold) work and entry permits for work inside and around tanks and workers shall follow all permit requirements. (Figure 10-10: Sample Safe (Cold) Work, Hot Work, and Entry Permit.)

1. A qualified person shall conduct atmospheric testing around the outside of the tank and in the immediate area where work is to be performed, either outside of or inside the tank, and permit issuers shall assure that acceptable exposure levels are met before permits are issued or reissued.

2. Permit issuers shall consider the need for continuous or periodic flammable vapor and toxic exposure monitoring during entry, hot work or safe (cold) work operations.

3. If an entry into a tank or onto a floating roof is considered confined space entry, the entry supervisor shall issue a separate entry permit in addition to the hot work or safe (cold) work permits.

4. If a large opening is provided in the side of the tank to permit equipment and materials to enter the tank, the entry

Sample Safe (Cold) Work, Hot Work, and Entry Permit

SECTION (1) DESCRIPTION OF WORK

Facility Name: _____ Address: _____

Permission is Granted To: _____

Description of Work: _____

Specific Work Location: _____

Check: Date Permit Valid _____ Permit is Void:

 Work Begins at _____ (A.M.) (P.M.) 1. When start delayed or work

() Hot Work Permit Expires at _____ (A.M.) (P.M.) Stopped for _____ Hr(s)

() Safe Work Permit (May) (May Not) Be Reissued for 2. When _____

() Entry Similar Period 3. Other _____

SECTION (2) PRECAUTIONARY MEASURE TO BE ACCOMPLISHED PRIOR TO AUTHORIZATION:

<p>All non-applicable items to be initialed by permit issuer in N/A column (Yes) (N/A)</p> <p>A. Proposed work checked with supervisor/engineering employee in charge () ()</p> <p>C. Standby fire protection equipment or fire watch required () ()</p> <p>E. Piping and conduit (and underground) drawings checked before excavation or work () ()</p> <p>G. Precautions taken against release of vapors, gas, product, dust, contaminants, or hazardous materials () ()</p> <p>I. Lockout/tagout (attach list) electric, hydraulic, mechanical, steam, or air activated equipment () ()</p> <p>K. Sewer and pipe openings covered or protected () ()</p> <p>M. Entrants, standbys, rescuers, and entry supervisor identified (attach list) () ()</p> <p>O. Proper means of access and egress provided () ()</p> <p>Q. Lines, valves, vessels, equipment (attach list)</p> <ul style="list-style-type: none"> • Depressured or pressure reduced to safe level () () • Drained or purged vapor free or inerted () () • Blinded, blanked, or double blocked and bled () () • Disconnected () () <p>S. MSDS reviewed and workers trained for physical health hazards () ()</p>	<p>All applicable items to be acknowledged as in place and initialed by contractor or employee performing work in (Yes) column (Yes) (N/A)</p> <p>B. Welding or cutting equipment safety grounded, sparks, and flash protected () ()</p> <p>D. Special warning/caution/barrier signs posted (list type/location on back) () ()</p> <p>F. Vapor/Exposure tests required [See Section (3)] () ()</p> <p>H. Other precautions in place prior to permit issuance () ()</p> <p>J. Gauge glass columns, pressure relief, and sample lines drained, protected, closed, or disconnected () ()</p> <p>L. Ventilation equipment installed degassing system installed () ()</p> <p>N. Facilities and materials available for hazardous materials spill clean up () ()</p> <p>P. Emergency rescue and method of notification provided () ()</p> <p>R. Check personal protective equipment required</p> <table border="0" style="width: 100%;"> <tr> <td>() Rubber boots</td> <td>() Respirator</td> </tr> <tr> <td>() Rescue harness/lifeline</td> <td>() Cartridge</td> </tr> <tr> <td>() Coveralls/apron</td> <td>() Supplied air</td> </tr> <tr> <td>() Gloves</td> <td>() SCBA</td> </tr> <tr> <td>() Hard hat</td> <td>() Safety glasses</td> </tr> <tr> <td>() Chem. goggles</td> <td>_____</td> </tr> <tr> <td>() Hearing protection</td> <td>() Shower/eye wash</td> </tr> </table> <p>T. Other requirements (list) _____</p>	() Rubber boots	() Respirator	() Rescue harness/lifeline	() Cartridge	() Coveralls/apron	() Supplied air	() Gloves	() SCBA	() Hard hat	() Safety glasses	() Chem. goggles	_____	() Hearing protection	() Shower/eye wash
() Rubber boots	() Respirator														
() Rescue harness/lifeline	() Cartridge														
() Coveralls/apron	() Supplied air														
() Gloves	() SCBA														
() Hard hat	() Safety glasses														
() Chem. goggles	_____														
() Hearing protection	() Shower/eye wash														

This acknowledges that above items initialed "Yes" have been satisfied prior to the start of work and still continue in effect throughout the course of work specified in this permit.

Signature of employee or contractor performing work

SECTION (3) FLAMMABLE AND HAZARDOUS VAPOR EXPOSURE AND OXYGEN TESTS

() HC	() O ₂	() H ₂ S	() Benzene	() _____
Indicate oxygen, vapor % LEL, and toxic exposure PEL "limits" for work permitted				
	(Flam. Vapor)	(Oxygen)	(Benzene)	() _____
Permitted limits	_____	_____	_____	_____
Time tested	_____	_____	_____	_____
Rest results	_____	_____	_____	_____
Tester initials	_____	_____	_____	_____
Observer initials	_____	_____	_____	_____

Repeat () () Vapor Tests Every () Hours or Every () Minutes Or () Continuously

SECTION (4) AUTHORIZATIONS

For work performed by contractor, contractor supervisor shall sign and assume all obligations herein implied. Company supervisor shall sign for work done by company.

_____ Permit Issuer or Entry Supervisor	_____ Contractor Representative or Employee Supervisor	_____ Work Authorized by Facility Representative
-----------------------------------------------	--------------------------------------------------------------	--------------------------------------------------------

SECTION 5 REISSUE OF PERMIT

Time/Date of Reissue _____ Safety Checked (Permit Issuer) _____

Figure 10-10—Sample Safe (Cold) Work, Hot Work, and Entry Permit

supervisor shall determine whether the tank should continue to be classified as a confined space or should be reclassified as a non-confined space.

5. Entry supervisors shall designate and identify entrants, attendants, standby personnel and rescuers on the entry permit.
6. Permit issuers shall specify entry, hot work, safe (cold) work and personal protection requirements on the permits, including, but not limited to, respiratory protection, protective clothing, fire protection equipment and need for a fire watch and conditions under which permits expire or are cancelled.
7. Entry supervisors shall provide for communications between entrants and attendants during work in tanks designated as confined spaces and a means for attendants to contact rescuers in an emergency.
8. When permits are required to operate equipment in and around the tank, permit issuers should assure that the permits reflect appropriate controls, restrictions and requirements depending on the classification and condition of the tank.
9. Permit issuers shall assure that workers wear and use appropriate respiratory and personal protection as needed for exposure to residue and dust from scraping, wire brushing and grinding and toxic fumes generated by heating materials, including, but not limited to, welding rods or coatings, blast cleaning and cutting.

10.8.2 Ventilation

Unless the openings in the tank provide sufficient natural ventilation, entry supervisors shall continue the use of mechanical ventilation while entrants and workers are inside the tank.

1. Entry supervisors shall assure that a sufficient amount of air changes are provided in the work space (normally 5 air changes per hour unless regulatory or facility requirements are different) to assure safe atmospheric and operating conditions,
2. Entry supervisors shall consider the need for local or work area ventilation while work is being conducted inside the tank.
3. Where applicable, the employer shall notify appropriate government agencies that the tank is ready for inspection before being returned to service.

10.8.3 Hot Work

Entry supervisors and hot work permit issuers shall assure that qualified persons have checked and inspected the condition and cleanliness of the tank and conducted atmospheric

testing to assure that entry and hot work requirements are satisfied before issuing permits for hot work inside tanks.

1. A qualified person shall survey areas inside the tank for fire hazards including, but not limited to, oily rags, combustible debris, entrapped hydrocarbons beneath leaking tank bottoms, in double walls, components and appurtenances, floating roofs, piping, seals, insulation, pontoons, columns, sumps and roof supports.
2. For hot work outside the tank, permit issuers shall assure that sewers and drains have been covered and, if applicable, remove or cover soil saturated with hydrocarbons.
3. Hot work permit issuers should be aware that air operated tool and equipment are preferred for use inside tanks. Permit issuers shall issue appropriate hot work permits for workers to use electric powered tools and equipment and internal combustion equipment inside tanks.
4. Prior to conducting hot work inside tanks, workers shall thoroughly clean the area in which hot work will be performed in tanks to remove any remaining residues from waxy substances, crude and heavy oils to prevent ignition.
5. Prior to conducting hot work inside tanks that stored leaded gasoline, other leaded products or materials containing lead, workers should first scrape or clean an area at least 12 inches (30 centimeters) to bare metal, on each side of the area to be heated. Alternately, workers may wear supplied air or SCBA respiratory equipment and appropriate protective clothing for hot work.
6. Permit issuers shall be aware of industry and applicable regulatory requirements before issuing permits for hot work on tank bottoms (refer to API Publication 2207 for additional information).
7. Permit issuers shall specify and workers shall wear and use appropriate respiratory protection and protective clothing to do hot work on the outside of tanks that have been painted with lead based paint.

10.9 RETURNING THE TANK TO SERVICE

Prior to preparing to return a tank to service, employers (owners/operators and contractors) shall develop and implement procedures for tank inspection and preparation.

10.9.1 Inspection

The entry supervisor or permit issuer shall assign a qualified person to check the tank to assure that it has been thoroughly cleaned, all repairs and maintenance have been completed, door sheets welded back into place and tested, floating roof components are in place, all internals have been

replaced, all valves are in operating position, and that appurtenances and systems are in place.

1. The qualified person shall thoroughly inspect the inside of the tank, the top of fixed and internal or external floating roof and remove any tools, trash, scraps, cleaning materials and foreign objects from the tank and roof.
2. The qualified person shall check that all gauging and alarm systems, valves and relief devices are in place and working.

10.9.2 Preparation

The employer (owner/operator and contractor) shall develop and implement procedures for assuring that the tank is ready to be returned to service.

1. The entry supervisor or permit issuer shall assure that a qualified person closes and properly bolts all manholes using new, approved bolts and gaskets.
2. Permit issuers shall cancel all outstanding permits.
3. Using the lockout/tagout list as reference, a qualified person shall inspect the tank and tank area to assure that all locks and tags used for lockout or tagout procedure have been removed and energy may be restored.
4. The permit issuer shall advise the facility that the tank is ready for conducting any required mechanical integrity tests (for example, hydro-testing).
5. After notification that mechanical integrity testing is satisfactory, qualified persons shall check the blinding list, remove any blinds and reconnect the piping, assuring that flanges are properly connected and bolted using new, approved bolts and gaskets.
6. The employer (owner/operator or contractor) shall stencil the tank cleaning date on the tank shell.

10.10 RECOMMISSIONING

Employers (owners/operators) shall develop procedures and assign responsibilities for refilling and recommissioning tanks following tank cleaning operations and a tank recommissioning safety check. (Figure 10-11: Sample Final Tank Cleaning Inspection Checklist.)

10.10.1 Refilling

Employers (owners/operators) shall develop operating procedures and preplan pipeline and marine receipts to assure that tanks are refilled with the correct product and not refilled to overflowing.

1. Employers (owners/operators) shall minimize the number of personnel in the area immediately adjacent to the tank during the filling operation, especially if the filling operation is for the purposes of hydro-testing the tank.

2. Qualified persons shall assure that discharge, drain, sample and water draw valves are closed before filling starts.

3. Qualified persons shall line-up tank and manifold valves for filling.

4. Qualified persons shall begin filling the tank slowly until the tank fill line is well submerged to avoid turbulence and generation of electrostatic charges by limiting incoming product velocity to 3 feet (0.9 meters) per second until the product level in the tank is one foot above the fill line opening. The actual flow rate in gallons per minute or barrels per hour will depend on the size of the piping and type and size of the tank inlet diffuser.

5. Qualified persons shall assure that if the tank has a floating roof, it is filled slowly to avoid tilting or canting, until the roof lifts off its support legs and is moving freely.

6. Qualified persons shall maintain control of ignition sources in the area when filling tanks with flammable liquids and not fill tanks with flammable liquids during a lightning storm.

10.10.2 Atmospheric Hazards

Qualified persons filling tanks shall be aware that the atmosphere above the liquid level has the potential to be in the explosive (flammable) range when filling tanks with flammable products, combustible products heated above their flash points or products containing hydrogen sulfide (H₂S) and also may contain toxic exposure hazards.

1. In a floating roof tank, the atmosphere in the area between the underside of the floating roof and the top of the liquid should remain above the explosive (flammable) limit (vapor rich) throughout the filling period.

2. In a fixed (cone) roof tank, the atmosphere in the area between the product and the fixed roof will initially be below the explosive (flammable) limit and will then pass into the explosive (flammable) range. As the tank continues to fill, the atmosphere above the liquid level should eventually should rise above the explosive (flammable) limit and become vapor rich.

3. Depending on the tightness and condition of the seals and vents, the atmosphere in the area above an internal floating roof or covered open top floating roof may have similar flammability characteristics as the space in a cone roof tank during filling.

4. The atmosphere in the area above an open top floating roof should normally remain below the explosive (flammable) limits depending on the condition and integrity of the roof's seals and vents, however the atmosphere may not be within acceptable limits for toxic exposures.

Sample Final Tank Cleaning Inspection Checklist

The company operator and project manager shall initial each item as computed and verified. The completed forms are to be delivered by the project manager to operations and the customer, immediately upon completion of the tank cleaning project.

	Customer	Manager	
1.	_____	_____	Manways are clean and free of all hydrocarbons
2.	_____	_____	Tank interior is clean and free of all hydrocarbons
	_____	_____	A. Legs (Interior/Exterior)
	_____	_____	B. Shell (to seal area to floating roof) (8 ft of shell on cone roof tank)
	_____	_____	C. Seal area
	_____	_____	D. Floor
	_____	_____	E. Suction/fill lines/roof drain (swing line)
	_____	_____	F. Sample system
	_____	_____	G. Mixers
3.	_____	_____	Pontoons are clean and free of all insulation and hydrocarbons
4.	_____	_____	Roof surface is clean and free of all hydrocarbons

Courtesy: Landry Service Company

Figure 10-11—Sample Final Tank Cleaning Inspection Checklist

10.10.3 Entry onto Floating Roofs

Employers (owners/operators) shall establish and implement requirements for entry onto the tops of floating roofs that are similar to the requirements in ANSI/API Standard 2015 for entering into permit required and non-permit required confined spaces.

1. Employers (owners/operators) shall classify the area above the top of each internal and covered open top floating roof as either a permit required confined space or a non-permit required confined space.

Note: Unless otherwise specifically classified and documented, entry onto internal and covered open top floating roofs shall be considered to be permit required confined space entry. This is based on the premise that ingress and egress is restricted and the potential may exist for a hazardous flammable or toxic atmosphere, depending on product, seal conditions, time since the tank was last filled and other criteria.

2. Employers (owners/operators) shall assure that workers do not enter onto the tops of floating roofs that are classified as confined spaces for a period of approximately 18 hours after the roofs are refloated.
3. Prior to ascent onto floating roofs classified as confined space, a qualified person shall check the oxygen, flammable vapor and toxic gas concentrations at various levels above the floating roof to determine the exposure levels.
4. Entrants shall wear appropriate respiratory protection unless testing has determined that entry onto a floating roof without respiratory protective equipment is safe.
5. Employers (owners/operators) shall classify entry onto open top floating roofs and open top floating roofs with weather covers as permit required or non-permit required confined space entry or non-confined space entry, depending on prevailing conditions.

Note: The specific classification of a floating roof at pre-established roof levels will depend on the following criteria: roof level; roof condition, the construction of the roof weather cover; the condition of the seals; the time since the tank was last filled; ease of egress; whether product is being added or withdrawn; external weather conditions; and tank roof level atmospheric test results.

6. Employers (owners/operators) shall assess the attributes of each open-top (external) floating roof tank and establish and document the requirements for the space on top of the floating roof to be classified as a non-confined space. It is industry practice to classify open top floating roofs within 5 feet (1.5 meters) of the top of the tank as non-confined spaces, provided that none of the requirements for classification as confined space exist. (See API Publication 2026 for additional information.)

10.10.4 Precautions and Requirements

Employers (owners/operators) shall establish and implement appropriate safe operating procedures for tank recommissioning, including, but not limited to, the following:

1. Qualified persons shall allow appropriate relaxation time, depending on the product, rate of fill, weather conditions and size and type of tank, for any electrostatic charges built up during filling to dissipate before manually gauging, sampling or taking the temperature of the product in the tank.
2. Qualified persons shall check the tank and lines frequently for leaks during the filling process, especially at manholes, lines and valves that were opened for tank cleaning.
3. The employer (owner/operator) shall assign a qualified person to inspect and confirm that housekeeping in the tank and dike area is satisfactory, sludge, residue, and contaminated materials, components and appurtenances removed from the tank have been disposed of properly. Employers (owner/operator) shall also assure that contractor(s) have removed all of their equipment, tools and trash from inside the tank and from the work area.
4. The employer (owner/operator) shall assure that all required documentation has been completed, all required reports filed, a post tank cleaning review has been performed and any necessary changes have been made to the tank cleaning and confined space entry programs.

10.11 RECOMMISSIONING SAFETY CHECK

Employers (owners/operators and contractors) shall develop and implement procedures for conducting a thorough formal recommissioning safety check prior to recommissioning the tank, using a written check list signed by qualified persons, including, but not limited to, the following items:

10.11.1 General

1. Tank foundations have been inspected and confirmed to be in satisfactory condition.
2. Dike walls have been reinstated and the dike drainage system is serviceable.
3. The dike drain valve is closed or open in accordance with facility operating practices.
4. Required inspections, tests, maintenance and repairs to the tank have been completed.
5. Materials and debris from tank cleaning operations and subsequent inspection and work have been removed from inside the tank, from the roof of the tank, from any internal or external floating roofs and from the vicinity of the tank.

6. Equipment, materials and debris have been removed from the dike area and contaminated items disposed of properly.

10.11.2 Mechanical

1. Internal or external floating roof has been installed or replaced in accordance with the manufacturer's and facility's requirements.
2. Tank piping, fittings and valves have been correctly reinstalled and are serviceable.
3. Side entry and bottom internal mixers have been correctly reinstalled.
4. Internal and external stairways, ladders and walkways and handrails on stairways and around the tank roof or wind girder meet structural requirements, are in good condition and are securely attached.
5. Ladders are correctly positioned, in good condition and securely attached.
6. Floating roof legs are in good condition, are in position and are correctly set.
7. Automatic vents and relief devices have been inspected, tested and correctly installed.
8. Roof drain sumps are free of debris and all non-return/check valves are operational.
9. Pontoons have been inspected, tested and are clean and free of liquid or vapors and all pontoon manhole covers and drain plugs have been replaced correctly.
10. Floating roof seals, secondary containment and shunts are in place.
11. Any ventilation openings at the top of the shell or on the tank roof have the correct "free area" mesh/screen fitted and are clear and free from blockage.
12. Roof manhole covers and covers on roof fittings are properly closed.
13. Shell manhole covers are bolted closed and water drawoffs, sample lines and drains are properly closed and locked or sealed as required by the facility.

10.11.3 Electrical

1. The tank shell is grounded (earthed) and electrical continuity checked.
2. Tank and associated piping cathodic protection systems have been reinstated and checked for continuity.
3. Grounding (earthing) cables associated with the external or internal floating roof are securely connected and checked for continuity.

4. Shunts from the floating roof to the tank wall are correctly installed and checked for conductivity.

5. Electrical fittings associated with side entry mixers, internal mixers, gauging and alarm systems, etc. have been correctly installed and checked for conductivity.

10.11.4 Electronics

1. Tank automatic level gauging equipment has been reinstalled and functioning correctly.
2. High and low level alarm systems have been reinstalled and are functioning correctly.
3. Tank temperature measurement instrumentation has been correctly reinstalled.
4. Instrumentation associated with the side entry mixers and other tank appurtenances has been correctly replaced.

10.11.5 Fire Protection

1. Foam lines and associated fittings have been checked for cleanliness, structural integrity and are operational.
2. Water spray systems have been reinstalled, checked and operational.
3. If required by facility policy, insurance or fire regulations, fire protection systems have been tested and certified to meet requirements of pre-fire plan and codes/standards.
4. Flame arrestors have been inspected, tested and reinstalled.

10.11.6 Operational

1. The tank has been inspected internally and is acceptable for service.
2. The tank has been inspected externally, including the fixed roof and floating roof and is acceptable for service.
3. Roof drain, water draw-off, sample line, inlet, drain, thermal relief, suction and discharge valves are serviceable, properly identified and locked or sealed in the proper position (closed or open) in accordance with facility lock-out and operating procedures.
4. Emergency roof drains on single roofs have been primed with water or closed and blinded off (if determined by the facility to be unnecessary).
5. Emergency roof drains on double deck roofs are fitted with the correct mesh screen and are clear of obstructions.
6. Roof drain valves are placed in the open or closed position in accordance with facility operating procedures.

10.11.7 Records

1. Checklists, punch lists and isolation lists have been checked for any remaining open items.
2. All reports and records, including, but not limited to, copies of permits, atmospheric test and monitoring results, tank integrity, hazardous waste management, fire protection, relief valves and emergency venting, etc. have been completed and filed as required by facility policy and government regulations.
3. The tank cleaning date has been stenciled or painted on the manhole cover or tank.

11 Oxygen, Combustible Gas, and Toxic Substance Instruments

11.1 GENERAL

This section provides general information related to oxygen monitors, combustible gas (flammable vapor) indicators and toxic substance indicators used during tank cleaning operations.

11.2 OXYGEN MONITORS

Oxygen monitors may be individual units or units in combination with combustible gas indicators.

11.2.1 Types

The basic types of analyzers used to monitor oxygen include, but are not limited to, the following:

1. Electrolytic sensors (most common).
2. Paramagnetic sensors.
3. Chemical absorption liquids (least desirable).

11.2.2 Use and Limitations

Oxygen monitors are used to determine the amount of oxygen in the atmosphere. Entry supervisors and testers shall be familiar with the use and limitations of oxygen monitors, including, but not limited to, the following:

11.2.2.1 Providing that toxic and flammable vapor exposures are within permissible limits, a proper amount of oxygen (approximately 20.9%) is required in the atmosphere in order to permit safe entry into tanks (or upon floating roofs) without air supplied respiratory protection.

11.2.2.2 When testing for flammable vapors, the amount of oxygen in the atmosphere must be between 10% and 21% for the combustible gas indicator to operate properly.

11.2.2.3 When purging, inert gas and steam will displace both vapors and air in tanks. The oxygen level must be measured to assure that:

1. There is either no oxygen or insufficient oxygen to support combustion in inert or steam filled spaces.
2. There is sufficient oxygen for flammable vapor and gas testing.
3. There is sufficient oxygen to enter tanks that have been purged with steam or inert gas and subsequently have been ventilated.

11.2.3 Operating Procedures

Employers (owners/operators and contractors) shall assure that oxygen monitors are maintained, inspected, adjusted, calibrated, and tested in accordance with manufacture's instructions. Qualified persons and entry supervisors shall be familiar with the general operating procedures, including, but not limited to, the following:

1. Turn on the instrument and check battery levels (or power source) before each use.
2. Check the instrument and, if necessary, adjust the reading for zero oxygen. The zero setting, which is important when checking inert atmospheres, can be checked using nitrogen.
3. Allow sufficient time for the sample to reach the instrument (particularly if an extension sample hose is used) and check that the oxygen meter indicates a normal reading of approximately 21% oxygen in clean, fresh air and adjust the setting, if necessary.
4. Replace the oxygen sensor if the instrument can no longer be adjusted to 21% oxygen in fresh air and recheck the adjustment and setting.
5. Enter the date and adjustment information in the instrument record.
6. Provide flexible sample line made of material that is resistant to water and to the type of hydrocarbons present in the tank. Check the sample tube to assure it is not cracked, blocked or contaminated.
7. Conduct frequent adjustment checks in fresh air during use to assure accurate readings.

11.3 COMBUSTIBLE GAS (FLAMMABLE VAPOR) INDICATORS

Combustible gas indicators may be individual units or units in combination with oxygen monitors.

11.3.1 Types of Indicators

Two types of combustible gas indicators are normally used, depending whether or not there is sufficient oxygen in the atmosphere being tested.

11.3.1.1 Catalytic Filament (CF)

Catalytic filament (CF) combustible gas indicators measure vapor-in-air (gas-in-air) levels at concentrations below the LEL. The sensing element is usually a metallic filament heated by an electric current whose heat increases depending on the concentration of the gas passing over it. This increases the electrical resistance of the filament and provides a direct measurement of the concentration of vapor-in-air (gas-in-air). As this instrument requires oxygen for the gas to burn, it cannot be used in inert or low level oxygen atmospheres.

11.3.1.2 Non-Catalytic Filament and Refractive Index Meters

Either a non-catalytic filament gas indicator or a refractive index meter must be used to measure the concentration of vapor in inert or low level oxygen atmospheres. These instruments measure hydrocarbon gas by a percent of volume.

11.3.2 Uses

Combustible gas indicators are used to determine the amount of flammable vapors present in the atmosphere. Entry supervisors and testers shall be familiar with the use and limitations of combustible gas indicators, including, but not limited to, the following:

11.3.2.1 When testing for flammable vapors, the oxygen level in the atmosphere must be between 10% and 21% for the combustible gas indicator to operate properly. The indicator will not give an accurate reading in atmospheres with low or high oxygen levels.

11.3.2.2 CF combustible gas indicators have a scale ranging from 0% to 100% of the LEL [lower explosive (flammable) limit] and indicate the amount of flammable vapor-in-air (gas-in-air) as a percentage of the lower explosive (flammable) limit (vapors in the LEL are too lean to burn).

11.3.2.3 CF combustible gas indicators also indicate if the vapor-in-air (gas-in-air) levels are within the explosive (flammable) limit (vapors in the flammable range are able to burn) or above the explosive (flammable) range (vapors above the flammable limit are too rich to burn).

1. When measuring atmospheres where the vapor-in-air (gas-in-air) levels are above the lower explosive (flammable) limit, the instrument will move quickly to the 100% on the meter and stay there to indicate that vapors-in-air levels are in the explosive (flammable) range.

2. If the vapor-in-air (gas-in-air) levels in the atmosphere are above the upper explosive (flammable) limit, the instrument needle/reading will move quickly to the flammable/explosive (flammable) range, stay there for an instant, and then the needle/reading will very rapidly return to zero.

11.3.2.4 CF combustible gas indicators may give false readings when measuring previously inerted atmospheres that have not been completely ventilated. The oxygen reading must be taken first to ensure that enough oxygen is present (minimum 10%) to give an accurate flammable vapor reading.

11.3.2.5 The results of tests for flammable vapor will vary as the concentration and composition of vapors in the tank's atmosphere varies.

1. Even though CF combustible gas indicators respond to any flammable vapor/air mixture below the explosive (flammable) range, the instruments provide accurate measurement only for the specific hydrocarbons for which they have been calibrated. Therefore, the calibration gas used to calibrate the instruments must be appropriate for the hydrocarbon vapors to be tested.

2. The user should consult the instrument manufacturer's literature for information concerning the selection and use of calibration gas as well as information on adjusting, calibrating and maintaining the unit.

Note: CF calibration curves (available from the manufacturer) may be used to adjust readings when the instrument has been calibrated using a gas different from that being tested.

11.3.3 Limitations

A number of factors may affect the accuracy of combustible gas indicators, including, but not limited to, the following:

11.3.3.1 Combustible gas indicators will not detect vapor-in-air (gas-in-air) from combustible liquids (flash point above 100°F) including, but not limited to, lubricating oil, metal working fluids, diesel oil, or fuel oil, at ambient temperatures. However, measurable flammable vapors may be released to the atmosphere in elevated temperatures or during hot work, if these materials are present and heated.

11.3.3.2 The readings will be inaccurate if the combustible gas indicator has not been calibrated using the correct calibration gas, or has been adjusted incorrectly following calibration. For example, an instrument calibrated using pentane (to measure gasoline vapors) will give readings that are 70–80% too high if used to measure hydrogen or carbon monoxide gas and approximately 50% too low if used to measure xylene or toluene vapors.

11.3.3.3 Combustible gas atmospheres tested at elevated temperatures, such as in a heated tank, may give erroneous results that require specific analysis and additional safety factors.

11.3.3.4 Certain contaminants, including, but not limited to, liquids, organic lead, welding fumes, and dusts, may poison the catalytic filament in the instrument, resulting in no readings, low readings or inaccurate readings. The use of liquid traps and appropriate inhibitor, dust and charcoal filters will mitigate potential contamination.

11.3.3.5 An inert atmosphere with low oxygen content (10% or lower) will cause combustible gas indicators to give false readings.

11.3.3.6 Many instruments have a sampling line that is attached to the instrument body by a screw thread coupling. This coupling must be fitted properly and kept tight so that air cannot be drawn into the sample gas, thereby diluting the sample gas and resulting in a false reading.

11.3.3.7 The electrical classification of the instrument may not be suitable for use in oxygen-enriched atmospheres.

11.3.3.8 There must be sufficient air present to give a correct reading. Heated atmospheres containing very large proportions of water vapor may result in false readings similar to that obtained from the effect of inert gas. Water vapor from steaming or water mist/spray operations can also affect the instrument giving erroneous results. Flammable vapor testing should be conducted after steaming or water mist/spraying operations are completed and atmospheric conditions have reached equilibrium, using an attachment to prevent contamination from moisture.

11.3.4 Operating Procedures

Employers (owners/operators and contractors) shall assure that combustible gas indicators are maintained, inspected, adjusted, calibrated and tested in accordance with manufacturer's instructions. Qualified persons and entry supervisors shall be familiar with the general operating procedures, including, but not limited to, the following:

11.3.4.1 Check the oxygen level in the ambient atmosphere to assure it is within the operating limits (normally between 10% and 25% oxygen) of the indicator being used.

11.3.4.2 Turn on the instrument and check battery levels (or power source) before each use.

11.3.4.3 Check the air intake to assure that it is open and clean. Block the air intake with a finger to stop the flow of air in order to check that the air flow alarm or signal works and there are no leaks.

11.3.4.4 Adjust the LEL meter to zero LEL in clean, uncontaminated air and check the LEL alarm.

11.3.4.5 Check the combustible gas reading on a predetermined schedule (daily or before each use if used less often) using appropriate calibration gas and adjust the LEL meter, as necessary.

11.3.4.6 Provide a flexible sample line made of material that is resistant to both water and the type of hydrocarbons present in the tank. Check the sample tube to assure it is not cracked, blocked or contaminated. Allow sufficient time for the sample to reach the instrument through the sample line.

11.3.4.7 Prior to conducting testing for entry or reentry, "bump test" the instrument by subjecting it to a small amount of calibration test gas (or challenge gas) to verify that the sensors and alarms respond and function correctly.

11.3.4.8 Conduct frequent checks during use to assure accurate readings.

11.3.4.9 Enter date, adjustment, and calibration and tester information into the instrument record.

11.4 TOXIC SUBSTANCE TESTING INSTRUMENTS

Qualified persons shall use appropriate toxic substance testing instruments and procedures to determine the level of toxic substances present in the atmosphere, including, but not limited to, organic lead, benzene, hydrogen sulfide (H₂S), dust and fumes.

11.4.1 Use and Limitations

The accuracy and response times of detector tubes and direct-reading instruments vary greatly. Detector tubes may be used to indicate the presence of hazardous substances but cannot accurately determine the concentration of these substances, especially if more than one substance of a similar nature is present (for example, benzene and xylene) in the same atmosphere.

11.4.1.1 Combustible Gas Indicators

Combustible gas indicators shall not be used to measure toxic substances as they will not measure the very low concentrations of toxic substances present in hydrocarbons (in parts per million) that may pose potential health hazards. Even when the combustible gas indicator measures a flammable vapor-in-air (gas-in-air) level of 0% LEL, the concentration of toxic substances in the atmosphere can be well above the permissible exposure limit (PEL) or threshold limit value (TLV).

11.4.1.2 Organic Lead Analyzers

All organic lead-in-air analyzers use the principal of chemical ionization. There are no direct-reading organic lead-in-air indicators. At the time of publication, there are only a few U.S. manufacturers of lead-in-air analyzers/test

kits for measuring organic lead concentrations in the atmosphere. API is concerned that the availability of these analyzers is diminishing rapidly. If there are any manufacturers in addition to the following, either domestic or international, providing lead-in-air analyzers, please contact API (Health and Environmental Affairs Department, Safe and Fire Protection Subcommittee), so that the information can be made available to users.

- Bendix Environmental Science Div., 1400 Taylor Ave., Baltimore MD 21204.
- Core Laboratories, 19 Roszel Road, Princeton, New Jersey 08540.
- Fisher Safety, 2000 Park Lane, Pittsburgh, PA 15275.
- RAE Systems, 600 W. Maude Ave., Sunnyvale CA 94066.
- Sensidyne, 16333 Bay Vista Drive, Clearwater, Florida 34620.

11.4.1.3 Benzene Indicators

Benzene indicators include direct reading portable gas chromatographs, infrared absorption and photo or flame ionization analyzers. Direct reading charcoal indicator tubes will not give exact measurements of benzene exposures, as other aromatics may be present in the atmosphere and affect the test sample.

11.4.1.4 Hydrogen Sulfide (H₂S) Indicators

There are a variety of direct reading hydrogen sulfide (H₂S) indicators used in the petroleum industry including, but not limited to, electrolytic, photo ionization and solid state sensor.

11.4.1.5 Other Instruments

There are many other types of monitors, testing instruments and detector tube devices used for measuring dusts, fumes and NORM.

11.4.2 Operating Procedures

Employers (owners/operators and contractors) shall assure that toxic substance testing instruments are maintained, inspected, adjusted, calibrated and tested in accordance with manufacture's instructions. Qualified persons shall use appropriate toxic substance testing instruments depending on the substance to be measured. Qualified persons and entry supervisors shall be familiar with the general operating procedures of these instruments in order to assure accurate measurements, including, but not limited to the following:

11.4.2.1 Testers shall be aware of the potential exposure hazards and shall use appropriate, approved respiratory protection, and personal protective equipment when measuring toxic substances.

11.4.2.2 Where used, provide flexible sample lines made of material that is resistant to water and to the type of hydrocarbons and toxic substances present in the tank. Check the sample tube to assure it is not cracked, blocked or contaminated.

11.4.2.3 Enter date, tester's name, and appropriate adjustment or calibration information into the instrument record.

12 Floating Roof Hazards Associated with Tank Cleaning

12.1 GENERAL

This recommended practice covers potential hazards associated with both external and internal floating roof tanks that have been landed on their legs and under which personnel will enter to perform routine tank cleaning, inspection, maintenance and repair tasks, including, but not limited to, the following:

1. Potential failure mechanisms contributing to collapsing floating roofs.
2. Highly divergent risks associated with various seal/roof combinations.
3. Procedures required to prevent or mitigate roof collapse.

This recommended practice also provides procedures for inspecting floating roofs prior to entry into external and internal floating roof tanks that have not yet been cleaned or gas freed and procedures for supporting floating roofs to prevent roof collapse during entry.

12.2 APPLICABILITY

This recommended practice covers floating roofs in the following types of tanks:

12.2.1 All flat bottom, vertical cylindrical storage tanks with internal or external floating roofs. These tanks are usually built to API 650 standards and repaired in accordance with API 653 standards.

12.2.2 All types of aluminum and steel roofs including pan, annular pontoon, double deck and high center deck roofs for both internal and external floating roof designs.

12.3 FLOATING ROOF STABILITY

Employers (owners/operators and contractors), entry supervisors, and qualified persons shall be aware that lateral

and rotational stabilization and support are the three requirements for a roof to remain in a stable position. (Figure 12-1: Example of Floating Roof Supports.)

12.3.1 Support

The legs on which the roof rests must be adequately attached to the floating roof and the positioning pins must be capable of carrying the weight of the roof. The legs should be straight and vertical, free from severe corrosion, pinned properly, and the floating roof should be in reasonable condition with no severely corroded or cracked welds in the vicinity of the legs.

12.3.2 Lateral Movement

The roof should be stabilized against lateral movement, as small lateral movements tend to increase the probability of roof collapse. The gap of 6 to 12 inches between the floating roof and the inside of the tank allows the floating roof to move laterally if it is not restrained. Resistance to lateral movement is provided by some types of floating roofs seals or by wedges or bracing.

12.3.3 Rotation

The roof must be stabilized against rotation around its axis of symmetry. In newer tanks, rotational stability may be provided by an anti-rotation device or sampling well pipe (usually 6–8 in. diameter) that goes from the gauge platform on the top of the tank to the tank bottom. Older tank designs use other anti-rotation methods.

12.4 FLOATING ROOF LEGS

12.4.1 General

Floating roof legs are typically 3 to 4 inch diameter pipes with 2 holes drilled through each pipe at 2 different locations to allow the legs to be set a high or a low position. All or most of the legs must fail simultaneously in order for a floating roof to collapse. Entry supervisors and qualified persons shall be aware that regardless of the type of roof, (pan, pontoon, or double deck) there are two different types of leg configurations that impact on roof stability. (Figure 12-2: Examples of Floating Roof Support Legs.)

12.4.2 Setting Legs

Entry supervisors shall assure that leg pins are set at the high leg position for maintenance work and any other activity requiring workers to enter under the roof, after the roof is landed.

12.4.2.1 Legs at the center of annular pontoon roofs or pan roofs have little resistance to bending forces. This is because the flexibility of the deck does not provide much resistance and allows large deflections with little force.

12.4.2.2 The legs that pass through a pontoon have significant resistance to lateral movement. This is because their deflection is limited by the top and bottom of the pontoon that is much more rigid than a single sheet of steel (such as a pan roof).

12.5 ROOF FAILURE AND COLLAPSE

12.5.1 General

Employers (owners/operators and contractors), entry supervisors and qualified persons shall be aware of the potential for failure or collapse of floating roofs including, but not limited to, excessive loading, improper leg pinning, stability, roof design, deterioration due to corrosion and seal design, and condition.

12.5.2 Excessive Loading

External floating roofs are typically designed for only 25 pounds per square foot, including both dead and live loads. Internal floating roofs are designed to carry even less of a load.

12.5.2.1 Liquid on the Roof

A uniform layer of rain water on a floating roof, only 4 inches deep, provides a load of 25 psf. If the roof design includes the weight of the roof itself (dead load of 25 psf) plus a live load of 25 psf, it would not require much additional liquid on the roof to increase the load significantly and cause collapse. To prevent an overload failure, entry supervisors shall not permit personnel to enter on top of or under a floating roof if a significant amount of liquid (water or product) is present.

12.5.2.2 Liquid in Pontoons or Compartments

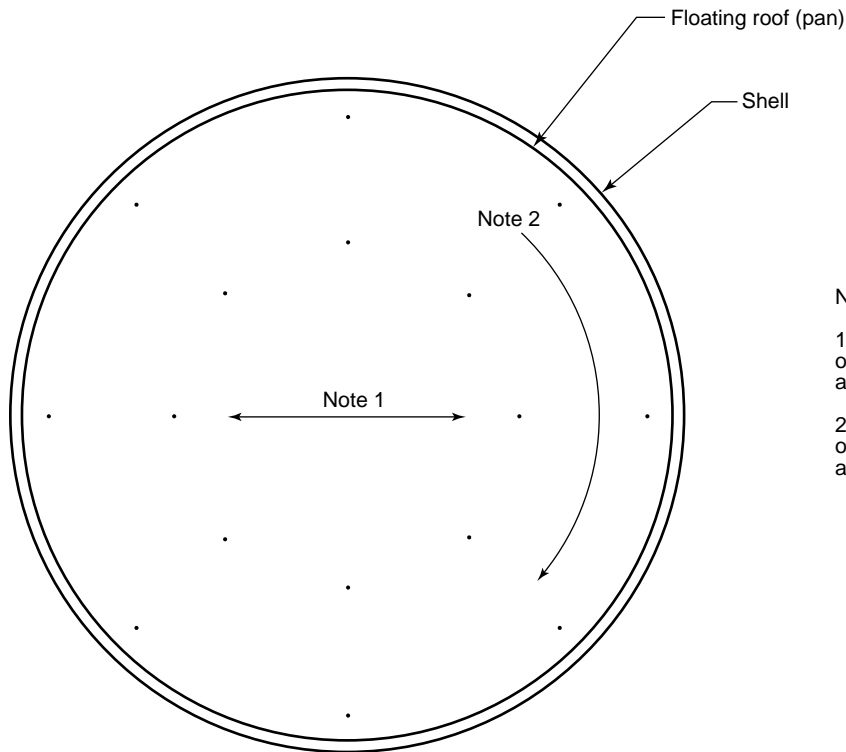
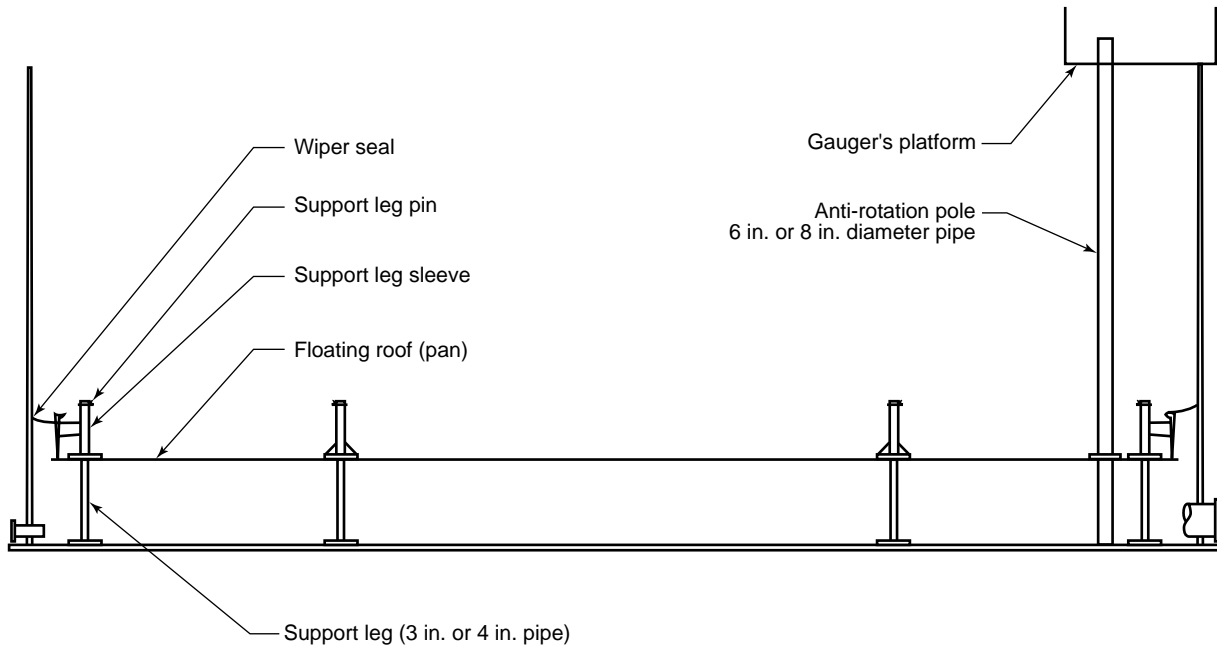
Entry supervisors shall assure that a qualified person checks pontoons and compartments for liquid product or water as the additional weight may cause spontaneous failure.

12.5.2.3 Repairs

Work on top of the roof may add excessive loads to the roof. In general, entry supervisors should not permit work to be conducted on top of and below the floating roof simultaneously unless appropriate protection is provided.

12.5.3 Leg Pinning

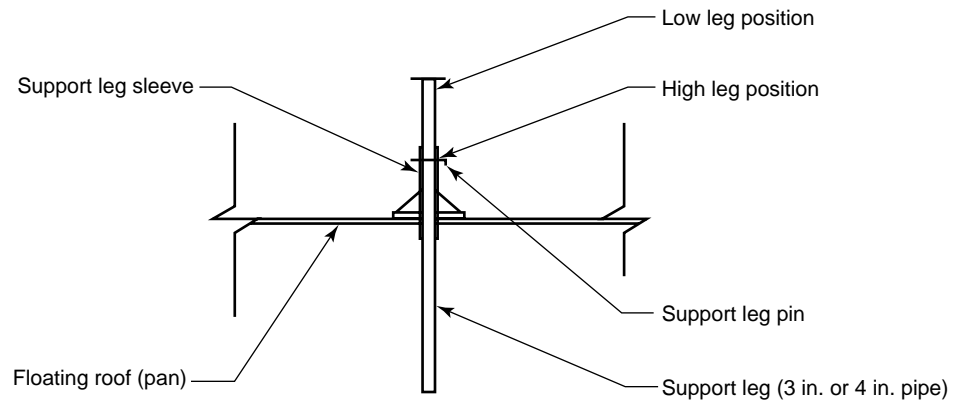
Floating roofs whose legs are not pinned properly or are not pinned at the same relative position, will usually collapse upon landing. While a floating roof will tolerate some unpinned legs that carry no load, partial or total collapse will occur if too many legs are improperly pinned or misarranged in a particular configuration.



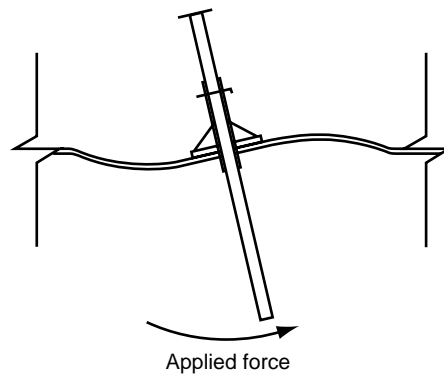
Notes:

1. Lateral instability is the movement of the roof of about 6–12 in. due to the annular gap.
2. Rotation instability is the movement of the roof due to rotation about its axis of symmetry.

Figure 12-1—Example of Floating Roof Supports

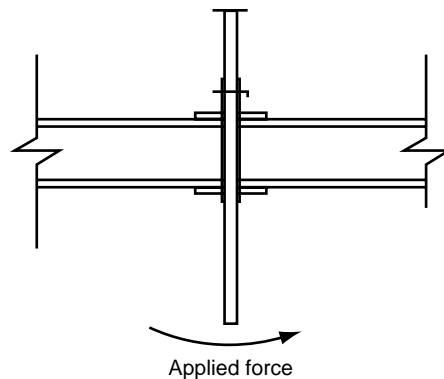


Support Leg in Pan Floating Roof



Note: Deck is weak in bending and allows easy lateral deflection of the support leg.

Support Leg in Pan Floating Roof



Note: To deflect a leg in this section requires actual failure of the support leg by bending.

Support Leg in Pontoon or Double Deck Floating Roof

Figure 12-2—Examples of Floating Roof Support Legs

12.5.3.1 Pan Style Roof Legs

The legs on pan style roofs must be properly and securely pinned as they offer little or no bending resistance (e.g., the legs act as if they have a swivel joint at the attachment to the pan due to the flexibility of the single thickness deck).

12.5.3.2 Inspection

Before lowering the roof, a qualified person shall assure that legs are properly pinned and the steel cotter pins that hold the legs are not corroded.

12.5.4 Stability

The stability of the roof when it is landed depends upon the vertical support of the legs and the rotational resistance offered by the seals and the anti-rotation device.

12.5.4.1 Anti-Rotation Device

If the anti rotation pole or device is removed or fails (due to corrosion or weld failure), the roof will collapse with little or no external forces applied to it.

12.5.4.2 Repairs

Work on top of the roof may add excessive movement to the roof. Entry supervisors shall assure that back up systems are provided to stabilize the roof to prevent failure in the event repairs require removing the anti rotation device for repairs, relocation, maintenance or for some other purpose.

12.5.4.3 Roof/Seal Combinations

Roof collapse may occur from the inherent instability of certain types of roof-seal combinations after the roof is landed.

1. The least stable combination of roof type and seal is a pan roof with a wiper type seal. The wiper type seal allows roof lateral movement and provides little or no resistance against rotation.
2. Other roof-seal combinations are less likely to fail.

12.5.5 Floating Roof Design

12.5.5.1 Annular Pontoon and Double Deck Roofs

Floating roofs with annular pontoons or double decks are unlikely to collapse spontaneously by rotation, even without a guide pole.

12.5.5.2 Pan-Type Roofs

Employers (contractors) and entry supervisors shall be aware that pan type floating roofs are the least stable.

1. Internal pan type floating roofs with single wiper seals have a high potential for failure.
2. Some external pan and wiper seal floating roofs also have a high potential for failure.

12.5.6 Deterioration

Employers (owners/operators and contractors) and entry supervisors shall be aware that failures of floating roofs and legs from internal corrosion or welding cracks may occur.

12.5.6.1 Corrosion

Severe corrosion may occur in tanks that have been in corrosive service, including, but not limited to, crude oil, sour water and waste water tanks. Corrosion is not very likely to occur in refined product storage tanks. Legs pins should be checked for corrosion prior to setting legs and the roof deck, supports, pontoons and compartments checked for corrosion and cracking before lowering the roof.

12.5.6.2 Welds

Welds attaching the anti rotation devices or other critical components may have cracks. Some welding cracks are not readily noticed by visual inspection and will require a qualified person to use other approved means of identification.

12.5.7 Seals

Employers (contractors) and entry supervisors shall be aware that internal floating roof seals impact on the resistance of the roof to both lateral and rotational movement. Resistance to rotation and lateral movement is also reduced when seals are removed for repairs or replacement.

12.5.7.1 Shoe Seals

Shoe seals are designed to produce a positive outward radial force per unit of circumference that provides resistance of the roof to both lateral and rotational movement.

12.5.7.2 Log Seals

Log seals are basically large rings filled with vapor, liquid or polyurethane foam. New log seals provide resistance to both lateral and rotational stability. Qualified persons conducting inspections shall be aware that with service, these seals will eventually fail at the outer membrane and sag in sections around the circumference, losing all resistance.

12.6 ENTRY ONTO OR BELOW FLOATING ROOFS (AND INTO PONTOONS)

12.6.1 General

Employers (owners/operators and contractors) shall assure 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 of personnel onto or under floating roofs and into pontoons, the entry supervisor shall implement procedures to inspect and, when necessary, support the roof as required by this recommended practice and in accordance with industry practices.

12.6.2 Requirements

12.6.2.1 Entry

Entry into the tank either below or above the roof or into pontoons shall be minimized. The entry supervisor shall permit entry on or under the floating roof only by those individuals who are trained and qualified to comply with the requirements of this recommended practice. Workers may temporarily stop work if they believe that a temporary support or jack stand is not working properly or if any other safety concerns arise.

12.6.2.2 Hazards

No ungrounded or non-bonded conductors (metal objects) or items that may be caught on protrusions including, but not limited to, personal jewelry such as wedding rings and earrings, shall be brought into the tank.

12.7 INSPECTIONS

12.7.1 General

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

12.7.2 Above the Roof Inspections

A qualified person shall 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.

12.7.2.1 Water or Product

The inspection shall assure 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.

12.7.2.2 Floating Roof Legs

The inspection shall verify that all legs are pinned and that they are all pinned at the high leg position or the low leg position.

1. The inspection shall include check for non-vertical alignment of the legs.
2. The entry supervisor shall assure that any legs that have been identified as excessively miss-aligned or improperly pinned are designated as requiring a temporary support under the roof.

12.7.2.3 Anti Rotation System

The 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 utilize an anti-turn pole or cable that should be checked to insure proper alignment and attachment to the tank shell.

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

12.7.2.4 Rim Seals

Rim seals provide lateral support to the roof. A damaged seal may remove 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.

1. The inspection shall verify that the rim seal has not failed in any locations around the floating roof. If failure has occurred, the entry supervisor shall consider blocking the rim space from the top of the roof before entering under the roof.
2. A shoe seal provides the maximum resistance to rotation and will not allow the roof to begin rotation without an applied external force.
3. A wiper seal provides little to no resistance to roof rotation.
4. 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.

12.7.3 Below the Roof Inspections

A qualified person shall conduct the following visual inspections from outside the tank, through a shell or roof manhole, without entry into the confined space.

12.7.3.1 Floating Roof Legs

An inspection shall 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 shall be more closely inspected to verify their condition. The entry supervisor shall assure that any specific leg, whose condition is questionable, shall be identified as requiring temporary support.

12.7.3.2 Anti Rotation System

An inspection shall 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 shall assure that the system is either in good working order or have it replaced with a back-up anti-rotation system prior to issuing an entry permit.

12.7.3.3 Rim Seals

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

1. If a secondary seal shielded the primary seal from being inspected from the top of the tank, the primary seal shall be inspected through the shell manhole.
2. If the rim seal has failed in any locations around the floating roof, the entry supervisor shall assure that the floating roof rim open space is blocked on the top of the floating roof, before permitting entry under the roof.
3. Floating roofs with pan-wiper seals or pan-log seal combinations should have back up support systems installed, if work is to be performed under the roof.

12.8 FLOATING ROOF TEMPORARY SUPPORT REQUIREMENTS

12.8.1 Entry

The entry supervisor shall 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, in order to prevent collapse. The entry supervisor shall issue a permit required confined space entry permit to allow for the establishment of the required supporting system.

12.8.1.1 Before Cleaning Tanks

Entry for testing, inspection and installing a temporary roof support system is often required prior to starting tank cleaning operations.

1. Because the condition of the roof is not usually known and it could collapse on entrants, some form of stability should be provided. The entry supervisor shall assure that the amount of time spent in the tank to provide this stability is minimized because the atmosphere is often hazardous.
2. Methods of providing stability while minimizing entrant exposure to hazardous atmospheres include, but are not limited to, wedging the roof at 4 points equally spaced around the circumference with tapered wedges and strapping 4 x 4 posts to the roof legs. The wedges protect against lateral movement and the posts provide vertical support in the event that some of the legs collapse.

12.8.1.2 After Cleaning Tanks

After a tank is cleaned, the entry supervisor may require cribbing and/or back-up support systems to be installed to ensure the roof is properly supported during repair, maintenance, and construction. Additional support may be justified because the exposure time inside the tank is greater and work may occur imposing loads on the roof as well as causing vibrations and movement.

12.8.2 Cribbing

Entry supervisors shall be aware that cribbing can provide effective protection for personnel working under floating roofs. The crib stack may be temporarily placed at the entry manhole until other roof support measures are in place.

12.8.2.1 Functions

The crib stack performs the following three functions:

1. Ensures that the entry manhole will remain clear and open during a roof collapse.
2. Serves as a guide to the exit as the space under the roof will be completely dark following roof collapse.
3. Protects personnel inside the tank within a 30 foot radius of the manhole.

12.8.2.2 Cribbing Hazards

Entry supervisors shall be aware that there are reasons not to have cribbing, including, but not limited to, the following:

1. Installing cribbing in tanks with hazardous atmospheres may create excessive exposure and inhibit work due to the requirement for personal protective equipment.

2. The use of cribbing in tanks that are being retrofitted with double bottoms requires either pouring a slab under the crib stacks or using multiple pours both of which increase job costs and breach the integrity of the concrete double bottom spacer.

12.8.3 Backup Support Systems

Entry supervisors shall be aware that, depending on the mechanical condition of the anti rotation devices, seals, and legs, there may be a need to have back up support systems to prevent floating roof collapse. Back up support systems include, but are not limited to, vertical load back up, lateral movement back up, and anti rotational back up. (Figure 12-3: Examples of Radial Beams with Anti-Rotational Brackets.)

Note: One mechanical backup system may be used to perform some or all of these three functions.

12.8.3.1 Vertical Load Backup

The need to have vertical back up depends on the condition of the support legs. Backup should not be required provided that the legs are properly designed, pinned, in good condition and with no additional loads acting on the roof from liquid, personnel, or equipment.

1. Floating roof designs typically provide a safety factor of approximately 100 percent, when considering dead loading of the roof. Therefore, an inspection by a qualified person that verifies that the legs are properly pinned and not severely corroded should obviate the need for a vertical load back up system. A qualified person should conduct a hammer test or ultrasonic testing to establish the condition of legs.

2. Crib stacks may be used as a vertical load back up system although it should not be necessary to build the crib stack up to the underside of the roof (within 6 inches should be adequate).

12.8.3.2 Lateral Movement Backup

Entry supervisors shall assure that lateral movement backup is provided for all floating roofs that do not have shoe seals. (Figure 12-4: Example Floating Roof Leg Blocks.)

1. Wooden wedges can be used to block tanks that are not cleaned and gas freed.

2. Temporary fabrications, such as radial steel beams welded to the roof and extending to within 1 inch of the shell, may be used on tanks that have been cleaned and gas freed.

12.8.3.3 Anti Rotation Backup

The entry supervisor shall 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.

1. Tanks that have not yet been cleaned should have wooden wedges installed at 4 equally spaced points around the perimeter of the floating roof.

2. The degree and extent of external forces acting on the roofs of tanks that are clean and gas free for repairs will be more severe and require better back up systems. There are many different methods of providing for anti-rotation, since fabrication can be done inside the tank.

12.8.4 Temporary Floating Roof Leg Supports

A qualified person shall assure that all temporary floating roof leg wood supports are 4 x 4 (inches) dry timber (green timber shall not be used), strapped to the legs at both the top and bottom of the leg. The qualified person shall assure that the strapping does not allow the wood supports to freely move from side to side. (Figure 12-5: Example of Temporary Lateral Support Beam.)

12.8.4.1 Positions of Temporary Wood Supports

1. Shell Manhole

The entry supervisor shall assure that the three legs nearest to the shell manhole have a temporary wood support strapped to them.

2. Rim Block Points

The entry supervisor shall assure 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.

12.8.4.2 Blocking Targeted Legs

The entry supervisor shall assure that any leg identified needing support has a temporary wood support to provide backup in case the steel leg becomes unstable.

1. Pan Type Floating Roof Leg Blocking

The entry supervisor shall assure that temporary wood supports are provided for one half ($1/2$) of the legs supporting single deck floating roofs in order to provide enough support to hold the dead load of the single deck should the primary supports unexpectedly fail.

2. Pontoon Type (Annular or High Center Deck) Floating Roofs Blocking

The entry supervisor shall assure that floating roofs with annular pontoons are supported with a minimum of 8 evenly spaced temporary wood supports in addition to required targeted supports.

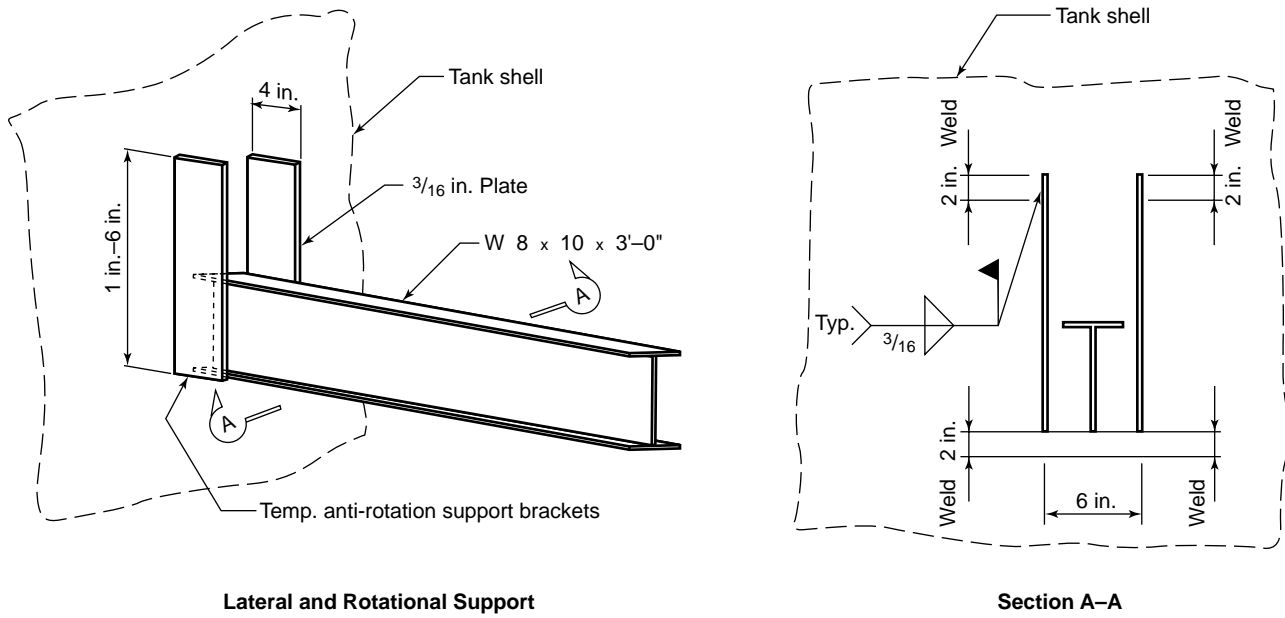


Figure 12-3—Examples of Radial Beams with Anti-Rotation Brackets

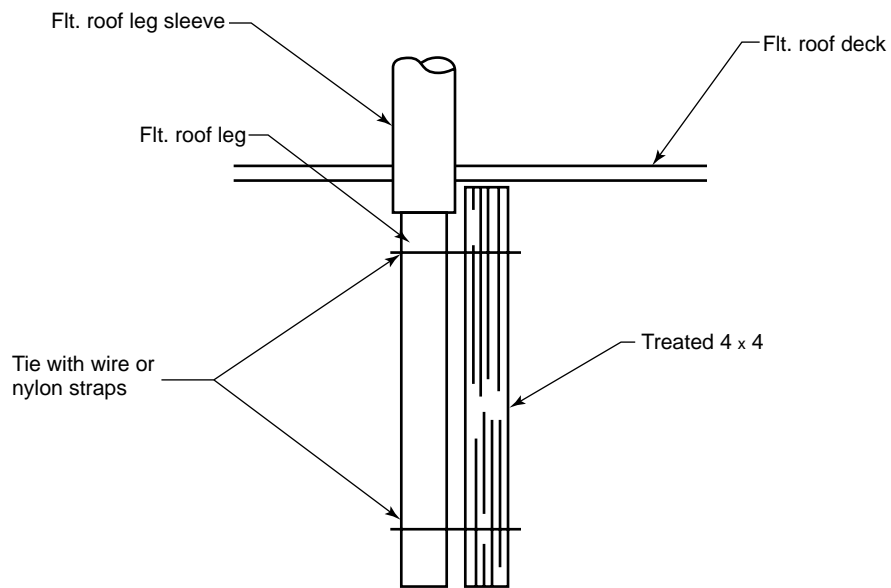


Figure 12-4—Example of Floating Roof Leg Blocks

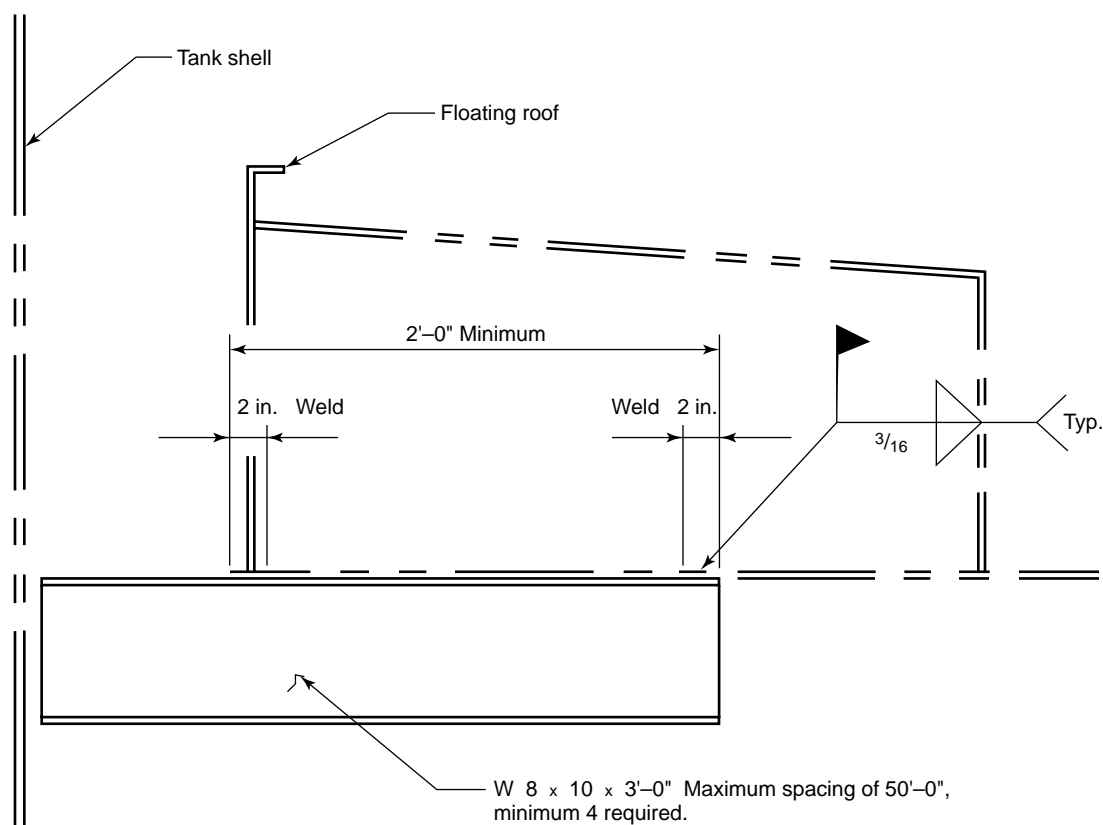


Figure 12-5—Example of Temp. Lateral Support Beam

3. Double Deck Floating Roofs Blocking

The entry supervisor shall assure that floating roofs with double deck pontoons are supported with a minimum of eight evenly spaced temporary wood supports in addition to required targeted supports.

12.8.4.3 Limitations of Leg Blocking

Without anti-rotation and rim blocking systems in place, temporary wood supports are not stable and cannot provide adequate support. The entry supervisor shall assure that temporary wood supports are not considered as substitutes for the stability provided by the rim seal blocking and anti-rotation system.

12.8.4.4 Removal of Temporary Bracing

The entry supervisor shall assure that all temporary wood supports are removed following completion of the tank cleaning operations.

12.8.5 Rim Space Blocking

12.8.5.1 Placement

The placement of rim space blocks shall be such that they remain in place and cannot drop out of the rim space, even if the roof moves. (Figure 12-6: Example of Rim Wedges.)

1. Blocks inserted from the top of the roof will usually meet this requirement.
2. Using rubber or wooden mallets, a qualified person shall drive wood wedge blocks into the rim space in four equally spaced locations around the floating roof.

12.8.5.2 Requirement

Rim space blocking shall be clearly identified by florescent tape as to location and left in place.

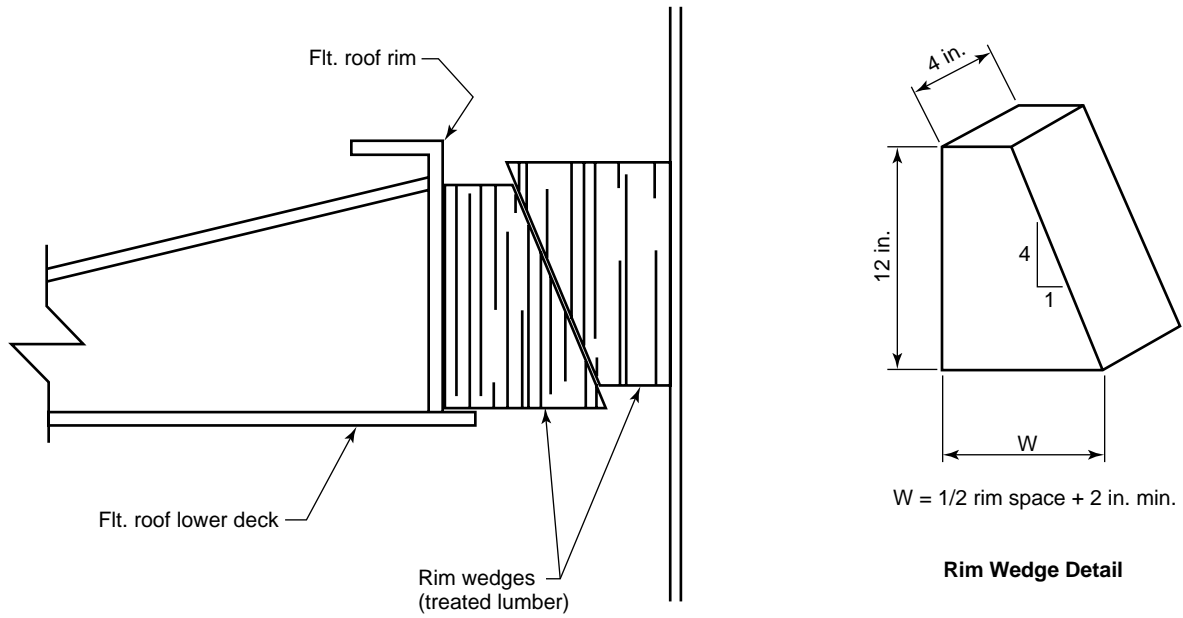


Figure 12-6—Example of Rim Wedges

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