Safe Operation of Vacuum Trucks Handling Flammable and Combustible Liquids in Petroleum Service

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Introduction

Vacuum truck personnel working in petroleum facilities shall be trained in the safe operation of the vacuum equipment; familiar with the hazards of the products being handled; and aware of relevant facility permit requirements, safety procedures, and emergency response requirements. It is the responsibility of the vacuum truck owner and operator to comply with (1) applicable federal, state, and local regulations; (2) this RP; and (3) facility requirements regarding the safe operation of vacuum trucks, including, but not limited to, the following items:

— construction, inspection, maintenance, and certification of the vacuum tank;

— selection and safe operation of the vacuum truck, vacuum pump, hoses, and accessories;

— regulatory requirements for safe highway operation of the truck;

— proper transportation, handling, and disposal of hazardous materials;

— safe vacuum truck loading, unloading, and transport operations within the facility;

— training and qualification of operators and other assigned vacuum truck personnel.

Although the material contained in this document is intended to be consistent with regulatory requirements, API 2219 is not a compliance document. Each user or operator must ensure compliance with all applicable laws and regulations. The United States Department of Transportation (DOT) *Code of Federal Regulations*, 49 *CFR*, specifies the minimum requirements for the design, construction, maintenance, testing, and operation of vehicles used for handling and transporting hazardous materials within the United States. Criteria for minimum training and qualifications of drivers and operators are also found in 49 *CFR*. The Department of Labor, Occupational Safety, and Health Administration's (OSHA) requirements for safety, health, and hazard awareness applicable to operators and other personnel working with vacuum truck operations are found in the *Code of Federal Regulations*, 29 *CFR* 1910. U.S. Coast Guard regulations in 33 *CFR* 154 for bulk transfer of hazardous materials to and from vessels at marine facilities could include certain vacuum truck transfer operations.

The procedures contained herein are intended to apply to vacuum trucks, skids, and trailers used in flammable and combustible liquid service. These requirements include, but are not limited to, 49 *CFR* parts 178.345–178.348 as well as DOT 407 and DOT 412 (formerly designated MC307 and MC312) cargo tank trailers used in vacuum and transfer operations for handling and transporting flammable and combustible liquids and corrosive materials.

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Safe Operation of Vacuum Trucks in Petroleum Service

1 Scope

1.1 General

This fourth edition of Safe Operation of Vacuum Trucks in Petroleum Service provides information concerning the safe operation of vacuum trucks engaged in all aspects of handling flammable and combustible liquids, associated waste water, produced water, sour water, basic sediment and water (BS&W), caustics, spent acids, or other fluids stemming from petroleum operations, products, powders, and the hazard of dust explosions. This publication discusses the types of vacuum pumps and cargo tanks associated with vacuum truck operations, the common hazards associated with those vacuum truck operations, and representative safe work practices and precautions to help prevent accidents and injuries. Annex F provides brief descriptions of a variety of incidents involving vacuum trucks, including offloading into open areas. These may be useful in reviewing specific operating procedures or developing materials for safety meetings or pre-job briefings.

The scope of this Recommended Practice (RP) includes the use of vacuum/pressure trucks, skids, portable tanks, and trailers (herein referred to as vacuum trucks) to remove flammable and combustible liquids from tanks and equipment and to clean up liquid hydrocarbon spills. The scope includes movement of liquid mixtures (such as "produced water", BS&W, or tank bottoms) that may contain sufficient hydrocarbon material to present comparable hazards.

These safe practices also apply to the operation of portable vacuum tanks, skids, and trailers typically used in emergency flammable and combustible liquid spill cleanup activities. While not included in the specific scope of this standard, Annex E presents information related to pneumatic (air moving) trucks and hoppers, typically used in the petroleum industry for removal of dry materials such as catalysts, dusts, powders, or residue.

1.2 Applicability

Vacuum trucks are used in all segments of the petroleum industry with varied applications. Appropriate safe operating practices may vary because of different hazards associated with the materials to be moved and the facilities serviced. This RP seeks to assist in the development and implementation of practical and safe operating practices that will help identify hazards and reduce risks.

1.3 Basic Vacuum Operations

The two basic types of vacuum truck operations are as follows.

a) Vacuum loading and off-loading operations that eliminate or minimize the introduction of air into the system by:

   1) completely submerging the suction nozzle into the liquid during the transfer process, or

   2) directly connecting the transfer hose to the source or receiving tank, vessel, or container below the surface level of the liquid contained therein.

b) Vacuum truck operations that introduce air into the system during the transfer process, including:

   1) air conveying operations (Annex E) involving the incidental removal of solid materials when the suction hose is either partially submerged or not submerged (or, if submerged, when air is entrained or entrapped in the material) or the intentional removal of solids when used in a vacuum excavation system; or

   2) liquid transfer operations where the end of the hose is not directly connected to the source or receiving tank, container, or vessel or the nozzle is not submerged into the liquid within the tank, container, or vessel; or

3) vacuum truck operations involving spill cleanup of liquids where air enters the transfer hose as liquids are skimmed off the surface (water or land).

1.4 Concept of Hazard vs Risk

Hazards are conditions or properties of materials with the inherent ability to cause harm. Risk involves the potential for exposure to hazards that will result in harm or damage. For example, a hot surface or material can cause thermal skin burns or a corrosive acid can cause chemical skin burns, but these injuries can occur only if there is contact exposure to skin. A person working at an elevated height has “stored energy” and a fall from a height can cause injury, but there is no risk unless a person is working at heights and is thus exposed to the hazard. There is no risk when there is no potential for exposure.

Determining the level of risk for any activity involves understanding hazards and estimating the probability and severity of exposure that could lead to harm or damage. The preceding examples relate the consequences of hazard exposure, severity, and probability to determine risks to people. The same principles can be applied to property risk. For instance, hydrocarbon vapors in a flammable mixture with air can ignite if exposed to a source of ignition resulting in a fire that could damage property as well as cause injury.

The U.S. Department of Transportation and the United Nations provide specific definitions and classifications for “Hazardous Materials”. These more general performance-based concepts are significant in order to understand the potential risk associated with vacuum truck operations.

1.5 Job Hazard Analysis

Those in charge of vacuum truck operations can implement the principles of Hazard vs Risk by conducting a job safety analysis (JSA) to assess hazards and risks associated with specific tasks. This review helps identify hazards so that protective equipment, procedures, and contingency plans can be put in place to mitigate risks associated with identified hazards.

Prior to engaging in job site vacuum truck operations, the relevant written JSAs shall be reviewed by all relevant and responsible parties to help everyone become familiar with the hazards, risks, and exposure protection safeguards. Such JSAs should be periodically reviewed so they remain current and can help to prevent incidents. (See OSHA Publication 3071, *Job Hazard Analysis*, or other JSA-related material from OSHA's web site.)

2 Normative References

The most recent editions of each of the following standards, codes, and publications are referenced in this RP as useful sources of additional information. Further information may be available from the cited Internet World Wide Web sites or references included in the Bibliography.

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

ACGIH [1], *TLVs® and BEIs® Based on Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*

ASME [2], *Boiler And Pressure Vessel Code Section VIII: Pressure Vessels-Division 1*

ASME, *Boiler And Pressure Vessel Code Section XII: Rules for Construction and Continued Service of Transport Tanks*

[1]American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, Ohio, 45240, www.acgih.org.

[2]American Society of Mechanical Engineers International, Three Park Avenue, New York, New York, 10016, www.asme.org, ASME International [Publications], 22 Law Drive, Box 2900, Fairfield, New Jersey, 07007-2900.

NFPA 30 [3], *Flammable and Combustible Liquids Code*

NFPA 77, *Recommended Practice on Static Electricity*

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

NFPA 650, *Pneumatic Conveying Systems for Handling Combustible Particulate Solids*

NTTC [4], *Hazardous Materials Transportation—The Tank Truck Driver's Guide*

NIOSH [5], *Pocket Guide to Chemical Hazards*

Pratt, Thomas H., *Electrostatic Ignitions of Fires and Explosions*, ISBN 0-8169-9948-1, AIChE CCPS

OSHA 29 [6], *Code of Federal Regulations (CFR), Parts 1910*

OSHA 1910.38, *Employee Emergency Plans and Fire Prevention Plans*

OSHA 1910.1000, Subpart Z, *Toxic and Hazardous Substances*

OSHA 1910.132 Subpart I, *Personal Protective Equipment*

OSHA 1910.147, *Control of Hazardous Energy (Lockout/Tagout)*

OSHA 1910.157, Fire Protection

OSHA 1910.1200, *Hazard Communication*

EPA 40 [7], *CFR, Protection of Environment*

U.S. DOT [8], *Federal Motor Carrier Safety Administration* DOT 49, *CFR* Federal Motor Carrier Safety Regulations

For specific requirements, carriers and shippers should consult the most current edition of 49 *CFR*, Parts 100–185. Motor carriers should also consult the *Federal Motor Carrier Safety Regulations*.

3 Definitions

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

3.1
atmospheric pressure
At sea level, atmospheric pressure equals 14.7 psi (105 pascals) or 29.92 in Hg (760 mm Hg).

[3]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169, www.nfpa.org.
[4]National Tank Truck Carriers, Inc., 2200 Mill Road, Alexandria, Virginia, 22314, www.tanktruck.org.
[5]National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, Ohio, 45226, www.cdc.gov/niosh.
[6]U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Ave. NW, Washington, D.C., 20210, www.osha.gov.
[7]U.S. Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue NW, Washington, D.C., 20460, www.epa.gov.
[8]U.S. Department of Transportation, 400 7th Street SW, Washington, D.C., 20590, www.dot.gov.

3.2
bonding
Providing electrical connections between isolated conductive parts of a system to equalize their electrical potential (voltage). A resistance less than 1 megohm [$<1\times10^6$ ohm] is traditionally considered adequate for static dissipation. The targeted goal for bonding should be 0 ohm. For stray current protection, lightning protection, and other electrical systems, the bonding resistance needs to be significantly lower, no more than about 10 ohms.

3.3
BS&W
An abbreviation for “basic sediment and water”, measured as a volume percentage from a liquid sample of the production stream. It includes free water, sediment, and emulsion. BS&W may entrain flammable or combustible hydrocarbons or oily emulsions and then may release those hydrocarbons during service handling.

3.4
CHEMTREC
An acronym for “CHEMical TRansportation Emergency Center”, a system organized and coordinated by the American Chemistry Council to provide chemical-specific information to emergency responders around the clock.

3.5
cyclone separators
Devices that separate oil and water or solid materials from air by cyclone action.

3.6
exposure limit
The maximum concentration limits for toxic substances to which workers may be safely exposed for a prescribed time without protection (e.g. respiratory protection).

Exposure limits are usually expressed in parts per million (volume) or milligrams per cubic meter, averaged for a prescribed time, e.g. 15 minutes, 8 hours. They may also be expressed as ceiling limits, which should not be exceeded. Safety Data Sheets (SDSs) available from employers, manufacturers, or suppliers of the material should identify recommended exposure limits.

Permissible Exposure Limits (PELs) and **Short-Term Exposure Limits (STELs)** are regulatory exposure limits established in the Occupational Safety and Health Administration, U.S. Department of Labor regulations and are those found in the most current editions of OSHA 29 *CFR* 1910.1000 and chemical specific standards.

Threshold Limit Values® (TLVs®) are advisory exposure limit values published by the ACGIH and frequently provided as exposure guidance on SDSs.

3.7
grounding
Providing a means for electrical continuity so currents can dissipate to ground (earth). A resistance less than 1 megohm [$<1\times10^6$ ohm] is traditionally considered adequate for static dissipation. For other purposes, such as grounding electrical systems, lightning protection, etc., much lower resistances are needed. For new equipment, a design target of 10 ohms is considered appropriate.

3.8
hazard
An inherent physical or chemical characteristic (flammability, toxicity, corrosivity, stored chemical, electrical, hydraulic, pressurized, or mechanical energy) or condition that has the potential for causing death or damage to people, property, or the environment.

3.9
hazardous material
A term defined in U.S. DOT and EPA regulations or UN standards to identify materials that trigger specific mandatory or precautionary requirements (equipment, labeling, training, work practice, etc).

3.10
job safety analysis (JSA)
The systematic assessment of work activities and the workplace to identify potential hazards as a step to controlling possible risks.

3.11
liquid
Any material that has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D5 (NFPA 30).

Combustible liquid is any liquid with a closed-cup flash point at or above 100 °F (37.8 °C). Combustible liquids at temperatures at or above their flash points are considered to be flammable.

Flammable liquid is any liquid that has a closed-cup flash point below 100 °F(37.8 °C). (NFPA 30).

3.12
pressure relief (safety) valve (PRV)
A device that limits pressure to a preset level by exhausting surplus air, vapor, or liquid, thereby ensuring that the permissible operating pressure is not exceeded.

3.13
risk
The probability for exposure to a hazard that could result in harm or damage.

3.14
risk assessment
The identification and analysis with judgments of probability and consequences, either qualitative or quantitative, of the likelihood and outcome of specific events or scenarios that can or could result in harm or damage.

3.15
risk-based analysis
A review of potential hazards and needs to eliminate or control such hazards based on a formalized risk assessment.

3.16
vacuum cargo tank
An enclosed space (tank) mounted on a vacuum truck (trailer or skid) from which most of the air (or gas) has been removed by a vacuum pump and where the remaining air (or gas) is maintained at a pressure below atmospheric.

3.17
vacuum, inches Hg
A measurement of the suction produced in a vacuum system where pressure is reduced relative to ambient atmospheric pressure. An inch of mercury (Hg) is a measure of vacuum that equals a solid column of water being lifted 13.6 in. or a “negative” pressure of 0.491 psig.

3.18
vacuum intake (suction air) filters
Filters mounted on the suction flange to prevent airborne solid materials from entering vacuum pump systems.

3.19
vacuum pump
A pump that is designed to remove air (or gas) in order to create a vacuum (pressure below atmospheric) within a vacuum cargo tank.

3.20
vacuum pump exhaust muffler (silencer)
A device that reduces vacuum pump exhaust noise during suction and pressure operations.

3.21
vacuum pump oil separator
A small vessel that captures exhausted oil when the pump is operated under the vacuum mode. When a vacuum pump operates in the pressure mode, the oil separator acts as an oil bath filter to prevent airborne material from entering the vacuum pump.

3.22
vacuum pump relief valve
A device that reduces the potential for damage to the pump from overheating during long duration solid column loading or when there is insufficient cooling air or liquid.

3.23
vacuum pump scrubbers (secondary shutoffs or moisture traps)
Inlet devices that reduce vacuum pump damage and wear by trapping materials that may escape the vacuum pump's primary shutoff trap during loading.

3.24
vacuum truck
A transportable vacuum system consisting of a vacuum pump, vacuum cargo tank, and associated appurtenances and accessory equipment mounted on a motor vehicle.

4 Safe Handling of Hazardous Materials

4.1 Hazardous Materials Awareness

4.1.1 It is the responsibility of vacuum truck owner/operators to train vacuum truck operators in the proper transfer, handling, and transportation of flammable and combustible liquids and hazardous materials.

4.1.2 Vacuum truck owners/operators shall ensure that vacuum truck operators are aware of the physical and chemical characteristics of flammable, combustible, toxic, and corrosive materials in accordance with applicable regulations. These regulations include, but are not limited to:

— OSHA 29 *CFR* 1910.120 (*Hazardous Waste Operations and Emergency Response*),

— OSHA 29 *CFR* 1910.1200 (*Hazard Communication*),

— DOT 49 *CFR* (*Transportation and Hazardous Materials Regulations*).

Training materials addressing some of the regulatory requirements are available from the respective agencies' web sites noted in Section 2 and in the Bibliography.

4.1.3 Care shall be taken to ensure that the materials being loaded are compatible with materials previously loaded and that the mixing of these materials will not create hazards such as fire, explosion, heat, toxic gases, or vapors. Unless the vacuum truck has been thoroughly cleaned and inspected, it should not be used to load materials that are not compatible with those previously handled. The same principles apply when materials are unloaded. Care shall be taken to ensure that the materials being unloaded are compatible with the materials presently or previously contained in the receiving container.

4.1.4 All parties involved with vacuum truck operations shall be aware that combustible liquids transferred at or above their flash point temperatures shall be handled as if they were flammable liquids. When transferring a combustible liquid that is within 15 °F of its flash point, it shall be handled as a flammable liquid. This is especially significant when transferring combustible liquids into non-conductive tanks, containers, or vessels.

4.1.5 All parties involved with vacuum truck operations shall be aware that waste products from petroleum operations may contain trace amounts of flammable or combustible liquids and gases or other hazardous materials that may cause serious injury, illness, or death if not properly handled. In addition, vacuum truck operators shall be aware that when under vacuum, even trace amount of hydrocarbons and hydrogen sulfide gas can be easily released and create flammable and/or toxic atmospheres.

4.1.6 All parties involved with vacuum truck operations shall be aware that although BS&W may consist primarily of free water, sediment, and/or emulsion, it may also entrain flammable or combustible hydrocarbons. Care should be exercised to understand the potential ignition and fire hazards associated with the material(s) being handled. If condensate has been mixed with BS&W during the removal process, this can significantly increase the fire hazard.

4.2 Product Information

4.2.1 The facility operator shall make safety data sheets (SDSs) and any other pertinent information about hazards and necessary precautions associated with the specific materials to be handled, available to the vacuum truck operator prior to the job starting. The NIOSH *Pocket Guide to Chemical Hazards* is a useful resource to properties of materials, their hazards, and some exposure limits.

SDSs should provide correct information on materials originally stored in tanks or vessels, but might not accurately reflect the hazards when the material is co-mingled with other chemicals, waste products, tank bottoms, contaminated catalysts, spent acids, or other materials that are being transferred. The vacuum truck operator shall be provided with available and relevant information regarding the properties of the material to be handled.

4.2.2 In emergency situations such as spill response and cleanup, product safety information may be obtained from sources other than the manufacturer or shipper, including, but not limited to: CHEMTREC, Department of Transportation, state and local emergency response agencies, U.S. Coast Guard, fire departments, etc.

4.3 Personal Protective Equipment

4.3.1 Both good practice and OSHA regulations (1910.132) require a hazard determination to evaluate the need for personal protective equipment (PPE). When necessary, appropriate respiratory protection, chemical protective equipment, goggles, gloves, boots, and other required PPE shall be provided by vacuum truck owners and used by vacuum truck operators for protection from exposure to the material being handled. It is the responsibility of vacuum truck owners to ensure that vacuum truck operators are trained and qualified.

4.3.2 Vacuum truck operators shall know which type of personal protective equipment to use under various conditions of potential exposure or known exposure. Personal protective equipment may be required to provide body, eye, and respiratory system protection.

4.3.3 Vacuum truck operators shall be aware of applicable OSHA personal protective equipment requirements including, but not limited to, 29 *CFR* 1010.132, Subpart I, *Personal Protective Equipment*, and PPE elements in regulations listed in 4.4. Vacuum truck operators shall also be aware of the facility's industrial hygiene and safety requirements relevant to the vacuum truck operations being conducted.

4.4 Hazardous Materials Regulations

Vacuum truck owners shall ensure that vacuum truck operators are trained, knowledgeable of and comply with applicable federal, state, and local regulations including, but not limited to, the following:

— 29 *CFR* 1910.1000–1096, Subpart Z, *Toxic and Hazardous Substances* (including Benzene at 1910.1028),

— 29 *CFR* 1910.120, *Hazardous Waste Operations and Emergency Response*,

— 29 *CFR* 1910. 1200, *Hazard Communications*,

— 40 *CFR* 263, *Protection of Environment*,

— 40 *CFR* 311.1, *Worker Protection Standards for Hazardous Waste Operations*,

— 49 *CFR*, *Motor Carrier Safety.*

4.5 Emergency Response

4.5.1 Vacuum truck owners shall ensure that vacuum truck operators are trained or educated in appropriate emergency response actions and regulatory reporting requirements in the event of a fire, spill, release, or other emergency.

4.5.2 Vacuum truck operators shall be trained in the use of portable fire extinguishers. Portable fire extinguishers shall be provided with the vacuum truck and maintained in accordance with applicable regulatory requirements such as 29 *CFR* 1910.157, *Fire Protection*, and also be available at the work site.

4.5.3 Vacuum truck owners shall prepare an emergency response plan conforming to OSHA requirements in 29 *CFR* 1910.38 (*Employee Emergency Plans and Fire Prevention Plans*) and shall train all operators in the use of that plan.

Vacuum truck operators shall be aware of facility emergency reporting and response procedures.

5 Safe Vacuum Truck Operations

5.1 General

5.1.1 Compliance

Vacuum truck owners are responsible to comply with federal, state, and local regulations regarding the construction, maintenance, and operation of vacuum trucks and to ensure that operators and other assigned personnel are trained and qualified for their assigned work.

5.1.2 Hazards of Vacuum Truck Operations

5.1.2.1 Although using vacuum trucks provides a fast, safe, and efficient method of cleaning up spills and removing liquids, tank bottoms, solid materials, and waste from tanks and vessels in petroleum facilities, incidents have occurred during vacuum truck operations. See Annex F for specific examples.

Vacuum truck owners and operators, as well as facility personnel, should be aware of the numerous potential hazards associated with vacuum truck operations in petroleum facilities. Some (but not all) of the potential hazards associated with vacuum truck operations are listed below.

5.1.2.2 Sources of ignition include vacuum truck engine and exhaust heat; pump overheating; faulty or improper electrical devices; static electricity discharges; and outside ignition sources such as smoking, motor vehicles, stationary engines, etc.

5.1.2.3 Potential hazards include spills; flammable atmosphere within and around the vacuum truck, cargo tank or source container; hose failures and discharges of flammable vapors to the atmosphere from the vacuum truck or the source or receiving container; and worker exposures to toxic vapors, liquids, or solids.

5.1.2.4 Consideration for potential hazards associated with the surrounding area and atmospheric conditions during the vacuum truck operations. Discharged vapors can exceed Permissible Exposure Limits (PELs) for exposed workers. Vapors can collect in low spots, particularly during atmospheric inversions with high humidity and no wind. Vapors should not be discharged onto roadways or other areas where sources of ignition may occur.

5.1.2.5 Unloading materials containing flammable components to open pads or pits can release vapors resulting in a fire, explosion, or substance exposure hazard.

5.1.2.6 Toxic vapors that are below hazardous concentrations prior to handling may become concentrated and thereby hazardous at or near the discharge port of the vacuum pump.

5.1.2.7 From a precautionary standpoint, the mixture in the transport container should be treated as a flammable liquid absent positive proof to the contrary.

5.1.2.8 Additional hazards include those typical to tank truck operations such as slips and falls, spills and releases, fires and explosions, and accidents within the facility or vehicle incidents on the highway.

5.1.3 Inspection Requirements

Before beginning operations, vacuum truck operators shall obtain any required permits and inspect vacuum trucks, equipment and loading/off-loading sites to ensure safe operations. See Annexes B and C for inspection, maintenance, and operating requirements.

5.2 Atmospheric Testing

5.2.1 The areas in which vacuum trucks are to operate shall be free of hydrocarbon vapors in the flammable range. The areas where the vacuum truck operator and others work without respirators must also be at or below air-contaminant PELs or STELs. Therefore, testing shall be conducted when appropriate. Where required by facility procedures, permits shall be issued prior to the start of any vacuum truck operations.

Atmospheric testing shall be performed by a qualified person using properly calibrated and adjusted combustible gas indicators, appropriate toxic gas testers, or hydrocarbon vapor analyzers. While combustible gas indicators can provide information indicating that substance levels are too high for personnel exposure, they are not sensitive enough to provide valid information that air concentrations are below personal exposure limits. The atmosphere should be continuously monitored for sources of flammable gas or vapor to determine if a flammable atmosphere exists. The continuous air monitoring will provide the vacuum truck operator an early warning of conditions at the location. Testing shall be conducted before any operation is started, and if necessary, during operations, including, but not limited to, the following.

5.2.2 When operations in the area are subject to change such as automatic pump startup or product receipt into or transfer out of a tank located in the vicinity of the transfer operations. In these situations, consideration should be given to use of lockout/tagout procedures on equipment that could create a hazardous condition or where required by regulation (see 29 *CFR* 1910.147).

5.2.3 When off-loading a waste container where pockets or layers of hydrocarbon, hydrogen sulfide, water, and other hazardous materials may exist.

5.2.4 When atmospheric condition changes, such as wind direction, storm, etc., affect the operation.

5.2.5 When an emergency situation, such as a product or vapor release, occurs within the facility that may affect atmospheric conditions in the transfer area.

Vacuum trucks shall be not be allowed inside diked areas around petroleum storage tanks, other production units, or operations vessels until the areas have been tested for hydrocarbon vapors by qualified persons, determined to be safe and entry authorized, and/or a permit issued if required by facility procedures.

5.3 Conductive and Non-conductive Hose

5.3.1 General

Vacuum truck operators may use either conductive or non-conductive hose, dependent on the material being transferred and subject to 5.3.2 and 5.3.3. Petroleum industry experience indicates that electrostatic ignitions can present a significant hazard when using non-conductive transfer hose. Any isolated (unbonded) conductive object may accumulate a charge and provide a spark gap. Even when using conductive hose, vacuum truck operators shall bond and ground their trucks to reduce the possibility of electrostatic discharges. (See 5.4.)

5.3.2 Conductive Hose

Vacuum hoses constructed of conductive material or thick-walled hoses with imbedded conductive wiring shall be used when transferring flammable and combustible liquids. Conductive hose shall provide suitable electrical resistivity less than 1 megohm ($<1\times10^6$ ohm) per 100 ft (as determined by the hose manufacturer).

Thin-walled, metallic spiral-wound conductive hoses should not be used due to the potential for electrical discharge through the thin plastic that covers the metal spiral.

All hoses, both liquid and exhaust, must be easily identified as conductive by some permanent means, for example, stainless steel banding. The marking must include an identifying serial number, manufacturer name, and most recent certification date.

All vacuum truck hoses must be tested annually, certified, and steel banded or tagged with certification date. The vacuum truck service provider is responsible for the compliance testing, tracking, rejections, and documentation of all hoses transported on the vacuum trucks or supplied by the vacuum truck service provider. Hose testing records must be maintained for at least one year. Hoses provided by parties other than the vacuum truck service provider shall be responsible for compliance testing, tracking, and documentation of all hoses provided (typically used at frequently serviced, stationary sites).

In addition to the annual certification testing specified above, all hoses must be inspected prior to each job and a minimum of once each shift for longer duration jobs by the truck operator. Any hose that does not meet the requirements must be rejected and the supervisor notified. Inspect all hoses for the following.

— Check for wear points exposing braids and kinks on the hose.

— Test continuity of all hoses. Recommended guidance considers up to 10^6 ohms/100 ft (1 megohm/100 ft) to be sufficient to allow for dissipation of static electricity (typical measurements are well below 10^6 ohms, so 10,000 ohms per hose segment has been selected as a practical maximum resistance and providing an adequate conservative contingency).

— Check for abnormal wear or damage to metal hose ends and gasket, and confirm that the locking device functions properly.

— Hose must be fixed with permanent identification tag with the date indicating it has been checked within the required inspection period and include a unique number for tracking the inspections.

5.3.3 Non-conductive Hose

Non-conductive hose shall not be used in transferring either flammable or combustible liquids. Non-conductive hose can accumulate static electricity and act as an ignition source by discharging a static spark if a conductor touches or comes close to a grounded object. Non-conductive hose shall not be used to discharge flammable liquids into open areas such as pits or open tanks, or where any source of flammable vapors may be present near the open end of the hose.

Although not recommended, a facility may permit the use of non-conductive hose to transfer combustible liquids where there is no potential for a flammable atmosphere in the area. If use of non-conductive hose is permitted, all exposed connectors (such as tubes, metal hose flanges, couplings, fittings, and suction nozzles) shall be constructed of conductive materials and each one shall be individually bonded and grounded to the vacuum truck and the source or receiving vessel. As indicated in 5.3.2, conductive hoses shall be used where there is potential for a flammable atmosphere.

5.3.4 Fittings

All Cam-lock type fittings must be securable by locking handles, arms wired closed (through rings), or tape (e.g. Velcro strap) to prevent inadvertent release. Cam-lock metallurgy must be compatible with and suitable for the material being transferred.

Any hose end connection appurtenance (e.g. stingers, strainers, duck bills, etc.) used during a vacuum truck operation must be made of conductive material, approved for use at the respective site, and be continuity tested as bonded with the conductive hose prior to each use. Users may elect to weld bonding tabs to these appurtenances to allow for clamping of bonding cables.

The use of plastic non-conductive dip pipes, funnels, and intermediate collection pans (including kiddie pools) for spill response or draining activities is prohibited. Only properly grounded conductive pipes, funnels, and containers shall be used for intermediate collection of flammable or combustible material to be vacuumed.

5.4 Bonding and Grounding

Bonding and grounding provide controls to help eliminate static electricity. Bonding connects two or more conductive objects by using a conductor such as a bronze or copper wire. This equalizes the potential charge so there is no voltage difference between them. Bonding can also connect parts of equipment or containers that are electrically separated (for example, by gaskets or non-conductive spacers). Bonding equalizes but does not eliminate the static charge. Grounding connects one or more conductive objects directly to the earth. Unlike bonding, proper grounding does drain static charges. The length of time for the charge to drain varies as a function of the charged object. A designated, proven ground source should be used.

Warning—Under no circumstances shall the ground wire on a piece of electrical equipment be used as a ground connection for a vacuum truck. It could introduce hazardous stray currents due to electrical faults or system grounds.

Connectors for bonding and grounding, such as copper wire and clamps, must provide a good conductive path. To ensure this:

— remove all dirt, paint, rust, or corrosion from areas where connections are to be made;

— use connectors that are rated for static electrical service;

— use flexible connectors where there is vibration or continuous movement; and

— connect metal to metal.

Because electrical currents (amperage) associated with static charge accumulations are low, bonding and grounding cables for draining static charges are sized for strength, flexibility, and durability. Typical cables are woven or braided metallic strands generally no larger than #6 AWG. Fixed mechanical connections are preferred for permanent bonding connections with strong alligator or special purpose C-clamps used for temporary bonding and grounding. These often have pointed contacts to displace rust or paint. For more information, consult your specialist safety equipment supplier.

The complete vacuum transfer system needs to be grounded (earthed) to dissipate stray currents to earth and also bonded so that there is a continuous conductive path from the vacuum truck through the hose and nozzle to the tank or source container. A screw-down C-type clamp provides a metal to metal connection that is less likely to be accidentally knocked loose.

5.5 Testing of Bonding and Grounding Static Lines

5.5.1 General

All bonding and grounding static lines will be attached and tested before starting the loading or off-loading process. Testing will include (a) the testing of static lines at the point it is connected to the retractable reel, and (b) the testing of the retractable reel at the point it is connected to the vacuum truck.

A resistance less than 1 megohm [$<1\times10^6$ ohm] is traditionally considered adequate for static dissipation. For other purposes, such as grounding electrical systems, lightning protection, etc., much lower resistances are needed. For new equipment, a design target of 10 ohms is considered appropriate.

The following should be noted.

a) Unbonded conductive objects, such as nozzles, can accumulate high electrostatic charges during transfer operations.

b) Mixed lengths of conductive and non-conductive hose shall not be used, as they can accumulate high electrostatic charges during transfer operations.

c) Bonds and grounds should not be disconnected until all transfer operations have ceased and the suction nozzle, hose or tube is withdrawn from the source or receiving tank or container.

d) The vacuum truck owner shall establish a schedule for inspecting and testing the electrical continuity of grounding and bonding cables and hoses provided with the vacuum truck.

5.5.2 Bonding

5.5.2.1 Bonding prevents the formation of different electrostatic potentials between vacuum trucks and pumps and the source or receiving tank, container, or vessel and intermediate container or vessel by bringing all parts of the connected system to an equivalent electrical potential. This reduces the likelihood of a spark being created in the vicinity of flammable vapors when the suction nozzle or discharge hose is removed from the source or discharge container and/or disconnected from the vacuum trucks, or when any conductive connectors are disconnected. See API 2003 for additional information on static electricity.

5.5.2.2 Whenever liquids or materials are transferred into or from a tank, vessel, or container (other than a surface spill), a bonding cable shall be connected from the vacuum truck to the source or receiving container. Prior to beginning transfer, to ensure proper bonding, the continuity shall be verified with an ohmmeter.

Exception: If both the vacuum truck and the source or receiving container are suitably grounded, and if the transfer is through tight, metal-to-metal connections using conductive hose, fittings, tubes, and suction nozzles without any use of non-conductive gaskets, bonding may be achieved without a need to use separate bonding cables. Bonding should be verified using an ohmmeter or other device specifically designed to confirm an effective bond.

5.5.3 Grounding

Before starting transfer operations, vacuum trucks should be grounded directly to the earth or bonded to another object that is inherently grounded (due to proper contact with the earth), such as a large storage tank or underground piping. Grounding minimizes the electrical potential differences between objects and the earth in order to prevent a static charge. Grounding brings all parts of any system to zero electrical potential by allowing electrical currents to dissipate to earth (ground).

Retractable reels used for vacuum truck grounding cables shall be designed to provide electrical continuity between the grounding clamp or clip at the end of the cable and the vacuum truck regardless of the amount of cable extended. A safe and proper ground to earth may be achieved by connection to any properly grounded object, including, but not limited to, any one or more of the following examples:

— A metal frame of a building, tank, or equipment that is grounded.

— An existing facility grounding system, such as that installed at a loading rack.

— Fire hydrants, metal light posts, or underground metal piping with at least 10 ft of contact with the earth. In some cases fence posts, metal stakes, etc., may not provide adequate grounding because of insufficient depth or soil conditions, and flange gaskets can isolate piping from a grounding connection.

NOTE Not all fire mains consist of steel pipe underground—some use HDPE. Furthermore, some underground piping may be wrapped in a protective coating. Check before using as a ground connection.

— A corrosion-free metal ground rod of suitable length and diameter (approximately 9 ft long and $^{5}/_{8}$ in. diameter), driven 8 ft into the earth (or to the water table, if less). Resistance of the ground will vary depending on both the type of soil and the amount of moisture present in the soil.

— A metal plate of suitable size and thickness (approximately 2 ft by 2 ft in area and $^{1}/_{4}$ in. thick, if steel or $^{5}/_{8}$ in., if copper) buried in the ground to a depth of at least 2 $^{1}/_{2}$ ft.

5.6 Vacuum Pumps and Blowers

Under normal conditions, the absence of oxygen minimizes the risk of ignition in a vacuum tank. However, operating rotary lobe blowers and vacuum pumps at high speeds creates high air movement and high vacuum levels. This results in high discharge air temperatures and high discharge vapor concentrations that can present a potentially ignitable condition.

5.7 Vacuum Exhaust Venting and Vapor Recovery

5.7.1 General

When flammable, combustible, or toxic liquids are transferred by vacuum pumps, product vapors may be discharged into the atmosphere in full concentration through unrestricted exhausts or in lesser amounts if filtered or separated prior to exhaust. The potential exists for these discharged vapors to form flammable mixtures with air and contact the vacuum truck's engine, hot exhaust pipe, or outside sources of ignition. Also, hydrocarbon vapors may be aspirated by the vacuum truck's diesel engine, causing “dieseling” (a condition where the engine continues to run after being turned off) or “runaway” (a condition that can lead to overspeed and catastrophic engine failure). For more information on controls, see A.4.2. Where there is the potential for vapors to form flammable mixtures with air from the exhaust vents, consider the use of continuous Lower Explosive Limit (LEL) monitoring.

In addition, toxic vapors well below flammable concentrations may still expose the vacuum truck operator or others at levels above PELs, STELs, or TLVs® since one percent LEL equals 10,000 ppm. Vacuum pump exhausts should be vented to an area free of personnel and isolated by barricades or appropriate respirators should be worn, unless atmospheric testing for toxic vapors confirms respirators are not required.

Potential sources of vacuum pump vapors can be unique to the type of vacuum pump used.

a) When liquid ring vacuum pumps are used, flammable vapors may accumulate on top of the discharge separator. The vapors discharged by liquid ring pumps may also be saturated with water (or other service liquid). In addition, if the temperature of the service liquid is higher than the temperature of the incoming vapor, evaporation will occur at the suction port.

b) The air discharged from rotary vane pumps may be saturated with lubricating oil or vapors.

c) Rotary lobe blowers operating at high airflow rates and vacuums may atomize liquid hydrocarbons that are subsequently discharged through the exhaust.

Vacuum pump vapors can be controlled through safe vapor recovery and safe venting methods. In areas where vapor recovery is mandated or desired, exhausted vapors should be directed to a vapor recovery unit. If vapors are vented to atmosphere during loading and off-loading, the travel direction, atmospheric and wind conditions, topography, and all potential sources of ignition must be considered and appropriate protective measures put into place prior to starting operations. Since vacuum truck engines (and auxiliary engines) are ignition sources, vacuum trucks should be operated upwind of any transfer point and outside the path of potential vapor travel.

5.7.2 Venting

A number of methods can be used by vacuum truck operators to safely vent vacuum pump exhaust vapors, including, but not limited to, the following.

a) Operators can prevent diesel engine acceleration, or “runaway”, by locating the vacuum truck upwind of vapor sources and by extending the vacuum pump discharge away from the diesel engine air intake.

b) Vapors may be returned to the source container using conductive hose and closed connections.

c) Vapors may be vented into the atmosphere to a safe location using a safety venturi, mixing vapors with air, so the vapors are discharged at a diluted rate during most of the transfer operation. Caution is required as vapors may reach the flammable range during low flow periods (such as the final few minutes of loading) or under other conditions.

d) Vacuum truck operators may provide vertical exhaust stacks, extending approximately 12 ft above the vacuum truck (or higher if necessary), to dissipate the vapors before they reach ignition sources, personnel, or other potential hazards.

e) Vacuum truck operators may attach a length of exhaust hose to the vacuum exhaust that is sufficiently long enough to reach an area that is free from potential hazards, sources of ignition, and personnel. The hose should be preferably extended 50 ft downwind of the truck and away from the source of the liquid.

5.7.3 Vapor Recovery

In order to prevent ignition from occurring, an analysis should be conducted prior to each specific use of a vapor recovery system to determine the potential hazards. Appropriate safety measures include, but are not limited to, the following.

a) Some vapor recovery units and vapor control systems develop high operating temperatures and may therefore become ignition sources. An appropriate in-line flame arrestor, placed in the vapor recovery line between the vacuum truck discharge exhaust and close to the vapor recovery unit, will mitigate or prevent flashback from the vapor recovery unit into the vacuum truck.

b) Vacuum exhaust vapors shall be vented to vapor recovery units using conductive hose with closed connections and appropriate bonding and grounding.

c) Carbon adsorption canisters connected to the vacuum discharge exhaust may become saturated by lubricating oil or contaminated by vacuum exhaust vapors, resulting in spontaneous combustion. An appropriate flame arrestor shall be placed in the vapor recovery line between the vacuum discharge exhaust and close to the canister to prevent flashback into the vacuum truck cargo tank.

d) Vacuum truck operators shall ensure that carbon adsorption canisters are properly bonded to the vacuum units to prevent buildup of static charges that may create sources of ignition.

e) Vacuum truck operators shall ensure that vapor recovery units, control systems, vapor lines, and canisters are properly rated to handle the amount of flow developed by the vacuum pump so as to minimize back pressure.

See API 2028 for additional guidance.

5.8 Transfer Operations

5.8.1 General

Vacuum truck operators shall be aware of the hazards involved in petroleum product and associated materials transfer operations. They shall be trained in safe product transfer practices and follow company and facility safety procedures when loading and off-loading vacuum trucks.

5.8.2 Loading

5.8.2.1 The loading rate is governed by the size and length of the hose and the vacuum level in the truck. Once an appropriately high vacuum level is reached in the cargo tank and the hose is connected to the source container or submerged into the product, the hydrocarbon liquid is loaded as a solid column with very little air introduced in the system. When following this procedure, the volume of air exhausted from the vacuum pump is usually very small, especially at high vacuum levels. This reduces the potential for a vapor-air mixture in the flammable range. See Annex C for loading procedures.

5.8.2.2 Air Entrainment—During loading, if the hose or suction nozzle is not completely submerged in the liquid or not directly connected to the source container below the liquid level, air is introduced into the product stream.

Depending on the flow rate and the hose diameter, the product may atomize, become suspended in the airflow, and not be deposited in the vacuum tank. When this occurs, the vacuum level inside the truck decreases and large amounts of vapor and air are exhausted into the atmosphere.

5.8.2.3 Vacuum truck operators shall follow safe operating procedures to prevent or minimize the amount of air introduced into the vacuum truck cargo tank during transfer from source containers. This is particularly important at the beginning and the end of product transfer operations when the suction nozzle or the end of the hose may not be completely submerged in the liquid.

5.8.2.4 Vacuum truck operators or whoever is in control of the nozzle shall minimize air intake when skimming product (for example, off of the surface of water or from spills on land) and when the suction nozzle or the end of the hose may not be completely submerged.

5.8.3 Off-Loading

5.8.3.1 The method chosen for off-loading should include a review of the potential hazards of the material (flammability, corrosivity, and/or toxicity) and ensure that where necessary, the procedures properly control vapors. Where flammable materials are involved, closed systems or appropriate ventilation may be necessary. Elimination of potential ignition sources can be achieved by proper grounding, bonding, use of intrinsically safe equipment, and shutting down equipment not in use (such as truck engines when gravity draining). As indicated in C.4, wind direction should be considered when placing trucks for offloading and control of vapors released by the off-loading process. Extension vent hoses may be necessary as mentioned in 5.7 and in C.4.1.5.

5.8.3.2 The three methods of off-loading vacuum trucks are gravity, pressure, and pump-off. Flammable liquids and other hazardous materials should be off-loaded by gravity or an inert gas (typically nitrogen) pressure blanket in order to minimize the amount of air that mixes with the flammable vapors and to prevent the formation of a pressurized flammable vapor–air mixture inside the vacuum cargo tank. Pressure off-loading with an inert gas pressure blanket may also be used for off-loading products that react with air or moisture. See C.4 for more detailed examples off-loading procedures.

a) Gravity Method—Gravity off-loading is safer, easier, and less expensive and is therefore used more frequently than pump-off or pressure off-loading. The gravity method is preferred for off-loading flammable liquids and hazardous materials, as well as for non-flammable and combustible materials.

b) Pressure Method—When pressure off-loading with air or an inert gas blanket, the pressure must not be allowed to exceed the pressure relief valve setting, or if such setting is not known, the maximum allowable working pressure as indicated by the vacuum cargo tank data plate. Outside sources of compressed air, such as provided by an air compressor or air tanks, should not be used to pressurize vacuum truck cargo tanks for off-loading. Pressure off-loading with air is accomplished by reversing the vacuum pump on the truck. Pressure off-loading with air is typically used only when products are not considered to be flammable, hazardous, or toxic.

   NOTE When vacuum pumps are reversed to off-load combustible products, this reverse action may heat combustible liquid hydrocarbons to temperatures above their flash points and they must then be treated as flammable liquids.

c) Pump-off Method—Auxiliary (external) gear or rotary transfer pumps may be used to off-load heavy, viscous products that are difficult to remove by pressure or gravity.

5.8.3.3 Prior to off-loading, vacuum truck operators shall determine or verify that the receiving container has sufficient available capacity to contain the amount of product to be transferred and the pressure must not be allowed to exceed the pressure relief valve setting of the receiving tank.

5.8.3.4 During vacuum cargo tank off-loading, vacuum truck operators shall minimize the amount of air introduced into the receiving container by directly connecting the hose to the receiving container or submerging the end of the transfer hose into the product. This will prevent free-fall of liquids and avoid or minimize splash off-loading to prevent static build up and excessive vapors. If the hose is connected directly to the receiving container, vacuum truck operators shall maintain low flow until the intake is completely submerged.

5.8.4 On-site Transfer

Vacuum trucks may be used to transfer material from one tank or vessel to another without leaving the site. This may be in traditional loading at one point and unloading at another. Alternatively, the truck's equipment may be used as a “portable pump” with direct connection through the truck from one tank or vessel to another. Operators should implement the applicable precautions listed in the sections above for loading (5.8.2), air entrainment (5.8.2.2, 5.8.2.3, and 5.8.2.4), and off-loading (5.8.3). Maintaining static electricity safeguards is especially important where the truck is used as a pump with hose connection between vessels. A conductive path from one vessel to the other will help equalize charges.

5.8.5 Non-Conductive Equipment

Vacuum truck operators shall be aware of the following precautions regarding the use of non-conductive equipment. These precautions are necessary to reduce the potential for ignition during vacuum truck operations because static charges can accumulate with this type of equipment and create a source of ignition.

Some synthetic fabrics, including some flame resistant clothing (FRC), can accumulate static charges. See API 2003 for details on clothing.

The use of non-conductive transfer items such as plastic funnels, strainers, etc. shall be prohibited. All equipment used in the transfer shall be made of conductive materials and be properly bonded. Bonding is not effective on non-conductive objects. The use of non-conductive containers, such as plastic pails, as intermediate collection vessels during vacuum truck operations shall be prohibited. Only conductive containers shall be used and vacuum truck operators shall ensure that these are bonded to the transfer hoses, connectors, nozzles, and the source or receiving tank, vessel, or container.

5.9 Over-pressure and Under-pressure

5.9.1 Care must be taken during vacuum truck operations not to over-pressure or under-pressure the vacuum cargo tank, source container, or receiving container.

5.9.2 Vacuum truck operators shall stay within the operational limits of the equipment as established by the equipment manufacturers to prevent over-pressurizing vacuum cargo tanks. When transferring from a pressurized process container, ensure that the pressure does not exceed the truck PRV setting.

5.9.3 Vacuum truck operators shall ensure that whenever a vacuum cargo tank is switched from vacuum to pressure or, when switching to vacuum after pressurization, the cargo tank is allowed to return to ambient (atmospheric) pressure.

5.9.4 Vacuum truck operators shall ensure that when pressure off-loading the vacuum truck cargo tank, the unloading rate is decreased near the end of the off-loading to avoid over pressuring the receiving tank or vessel. Following the completion of pressure off-loading, any internal built-up pressure within the vacuum truck cargo tank shall be relieved by safe venting to the atmosphere, receiving tank, or vapor recovery unit.

5.9.5 Common vacuum hose accessories, such as strainers and baskets can help prevent possible under-pressure situations when vacuum suction hoses attach themselves to the side or bottom of a tank or vessel being cleaned.

5.10 Gauging and Sampling

5.10.1 Vacuum truck owners shall train vacuum truck operators in safe procedures for gauging and sampling flammable and combustible liquids and toxic materials in and around vacuum truck cargo tanks, source containers, and receipt containers.

5.10.2 This training shall include preventing overfills, worker exposures above PELs or STELs, and static discharges during sampling and gauging operations.

5.10.3 To minimize potential vapor inhalation and exposures above PELs or STELs, all gauging should be done from upwind positions. Appropriate respirators should be worn, if needed.

5.10.4 After filling vacuum truck cargo tanks or receiving containers, vacuum truck operators shall allow at least one minute of relaxation time for static build-up to dissipate before inserting any conductive device for sampling or gauging the contents.

5.10.5 Conductive sampling and gauging equipment shall be bonded to the source or receiving containers prior to insertion therein. Conductive sampling and gauging devices shall be also bonded to (or held firmly in contact with) the vacuum truck during insertion into the cargo tank.

5.11 Non-petroleum Products

5.11.1 Vacuum truck operators shall be aware that hazardous and toxic vapors, mists, or solid materials may be released to the atmosphere during transfer of non-petroleum products.

5.11.2 Vacuum truck operators shall be trained to follow safe operating practices and use appropriate personnel protective equipment when loading and off-loading non-petroleum products such as sour water, produced water, spent acids, spent catalyst, and other materials that may contain trace amounts of flammable liquids, hydrogen sulfide, and other toxic substances.

5.11.3 Vacuum truck operators shall be aware that whenever materials (such as produced water or spent acid) that have the potential to contain trace amounts of hydrocarbon condensates or hydrogen sulfide are placed under a vacuum, flammable vapors, and toxic gases are freely released, creating potential ignition and exposure hazards.

5.12 Operation of Vehicles

5.12.1 Vacuum truck operators shall be trained and properly licensed in accordance with applicable regulations to drive and operate their vehicles within petroleum facilities and on public highways.

5.12.2 Vacuum trucks shall not enter into tank dike areas until such areas have been checked and, as required, tested for hydrocarbon vapors and determined to be safe. Permits shall be obtained prior to entering tank dike and other designated or restricted areas if required by the facility.

5.12.3 Vacuum truck cargo tanks shall be depressurized and vapors vented to a safe area, away from personnel and sources of ignition (or to an approved vapor recovery system), before vacuum trucks are driven onto public highways.

5.12.4 Vacuum trucks have stability problems similar to other tank trucks. Vacuum truck operators must be aware of the effect of speeds, turns, and the changing center of gravity due to the shifting of the liquid load, as these changes can result in instability and rollovers, even at low speeds.

5.12.5 Vacuum truck operators shall maintain proper distances when operating vacuum trucks inside facilities with restricted clearances. Vacuum truck operators must be aware of the overall height, width, and approximate weight (empty and loaded) of their vehicles and operate them safely around stationary equipment, overhead piping, and other potential obstacles. Vacuum truck owners should post the vehicle specifications (weight, height, size, etc.) inside the vacuum trucks.

5.13 Personnel Safety

5.13.1 Vacuum truck personnel working in petroleum facilities shall be trained in the safe operation of the vacuum equipment; shall be familiar with the hazards of the petroleum products, byproducts, wastes, and materials being transferred; and shall be aware of relevant government and facility safety procedures and emergency response requirements.

5.13.2 SDSs for the products being transferred shall be available to vacuum truck operators. Safe air contaminant levels (PELs and STELs) shall be identified and a qualified person shall assess the potential for exposure.

5.13.3 Appropriate personal protective equipment, including respirators, shall be worn when a hazard assessment indicates they may be needed to prevent exposures to toxic materials or air contaminants at or above PELs, STELs, or relevant TLVs®.

5.13.4 All personnel shall leave the vacuum truck cab during loading and off-loading operations.

5.13.5 When transferring flammable liquids or hazardous materials, vacuum truck operators shall remain positioned between the vacuum truck and the source or receiving tank, vessel, or container and within 25 ft of the vacuum truck throughout the operation. If this is not possible due to the job site conditions or design of the vacuum truck, then an observer shall be so positioned and be in verbal communication with the vacuum truck operator. Vacuum truck operators shall monitor the transfer operation and be ready to quickly close the product valve and stop the pump in the event of a blocked line or release of material through a broken hose or connection. (See 49 *CFR*, Part 177, Subpart B, for attendance requirements.)

5.13.6 Smoking, or any other sources of ignition, shall not be permitted within at least 100 ft (depending on local procedures and atmospheric conditions) of the truck, the discharge of the vacuum pump, or any other vapor source. Facility smoking and hot work policies should be followed if they are more restrictive.

Annex A
(informative)

Vacuum Truck Design and Equipment

A.1 General

Vacuum trucks are frequently used in the petroleum industry to remove and transport a variety of products and wastes, including flammable and combustible hydrocarbon liquids, caustics, waste products, and hazardous materials. Typical vacuum truck operations in the petroleum industry include product removal during tank and vessel cleaning operations, spill recovery and material transfer. See Figure A.1 and Figure A.2.

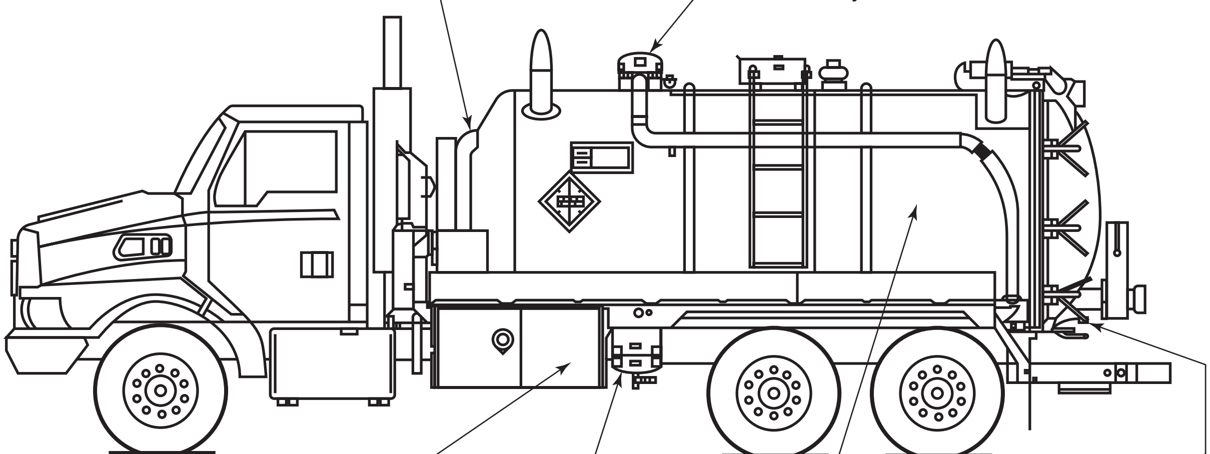

Figure A.1—Typical Vacuum Truck with Rotary Vane Pump

A.2 Vacuum Truck Cargo Tanks

A.2.1 General

Pressure tested vacuum cargo tanks are primarily used to collect and transport hydrocarbon liquids and hazardous wastes and products, whereas pneumatic cargo tanks are typically used to collect and transport non-hazardous materials.

A.2.2 Cargo Tank Construction Requirements

Vacuum cargo tanks used for highway transportation of liquid hydrocarbons and hazardous products and waste should be constructed of stainless or carbon steel in accordance with DOT 407 and DOT 412 (formerly designated MC307 and MC312) requirements. Vacuum trucks used in petroleum service should have shells or interior linings that are compatible with the materials to be conveyed. Vacuum cargo tanks used to carry flammable and combustible liquids should have shells constructed to meet ASME, Section VIII, Division I (or Canadian National Board) minimum requirements of 25 psi design pressure and 40 psi test pressure (as evidenced by a plate on the outer tank shell). Fiberglass reinforced plastic cargo tanks (non-DOT approved) should be used only for transporting the specific hazard class materials listed in the applicable DOT exemption. See Annex F for requirements for pneumatic cargo truck tanks.

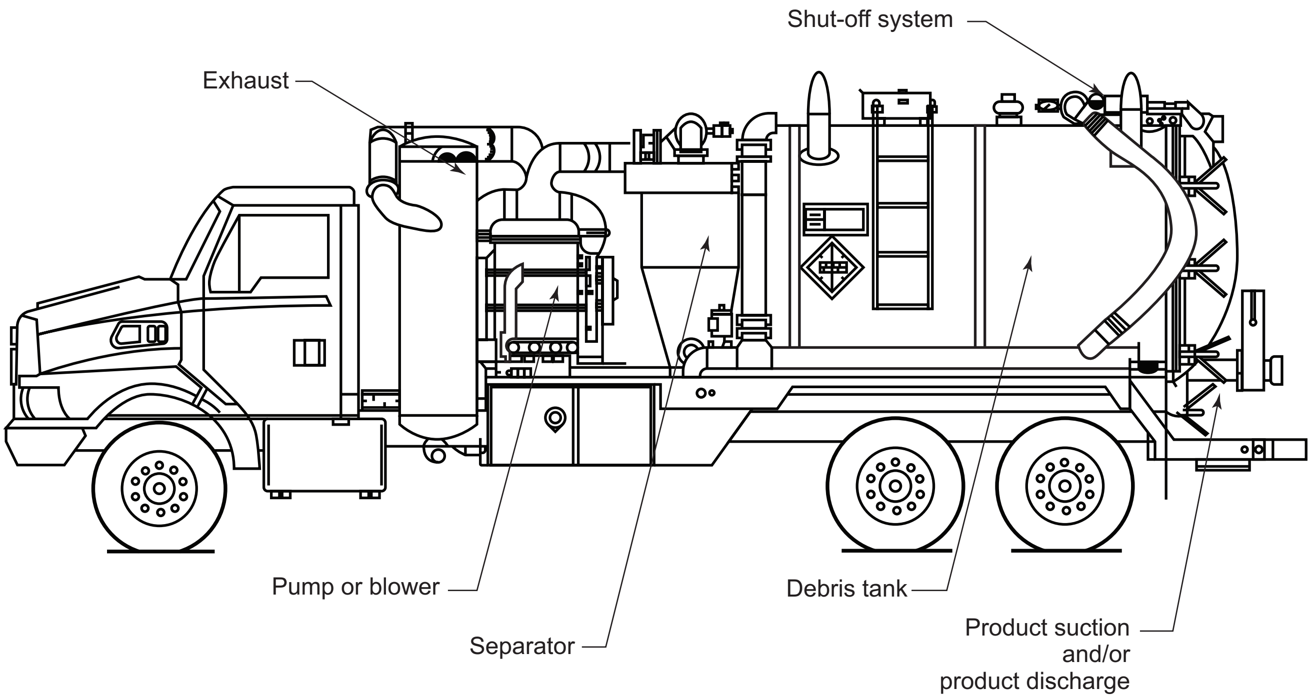

Figure A.2—Typical Vacuum Truck with Liquid Ring Pump or Rotary Lobe Blower

A.2.3 Cargo Tank Equipment and Accessories

Vacuum truck cargo tanks are provided with a variety of equipment, accessories, and systems to prevent or minimize liquid or material carry-over into the vacuum pump during loading and off-loading. These include baffles, deflector plates, moisture traps, cyclones, filters, screens, baskets, bags and cartridges, internal and secondary shutoffs, and external scrubbers. Vacuum cargo tanks should have properly maintained and accurate level indicators to prevent overloading and properly operating gauges to monitor vacuum and pressure levels in the tank. Vacuum cargo tanks should be protected from overpressure by ASME relief valves or rupture discs. Vacuum cargo tanks may also be provided with a means of manual depressurizing by opening the scrubber drain valves, isolation valves, or the bleeder valves.

A.3 Vacuum Pumps and Blowers

A.3.1 General

Vacuum trucks used in liquid hydrocarbon service are typically equipped with one of three major types of vacuum pumps (sliding vane, liquid ring, or rotary lobe), which are designed for specific applications, operating pressures, and vacuums. These pumps are usually powered from the vehicle engine through an auxiliary drive and universal shaft by belts, hydraulic drives, or flexible couplings. Regardless of design, the maximum vacuum attainable for any given pump is dependent on barometric pressure and altitude above sea level.

A.3.2 Sliding Vane Vacuum Pumps

Sliding vane vacuum pumps have been used for many years to transfer liquid hydrocarbons. See Figure A.3. Sliding vane pumps typically operate at speeds up to 1,500 rpm, providing approximately 500 cfm airflow at high vacuum levels. Cooling needs to be provided in order to minimize the risk of auto-ignition from heat build-up inside the pump. Sliding vane pumps are typically liquid cooled to allow for continuous use under high vacuum levels. Cooling may also be provided by forced air blown against the external fins of air-cooled sliding vane pumps.

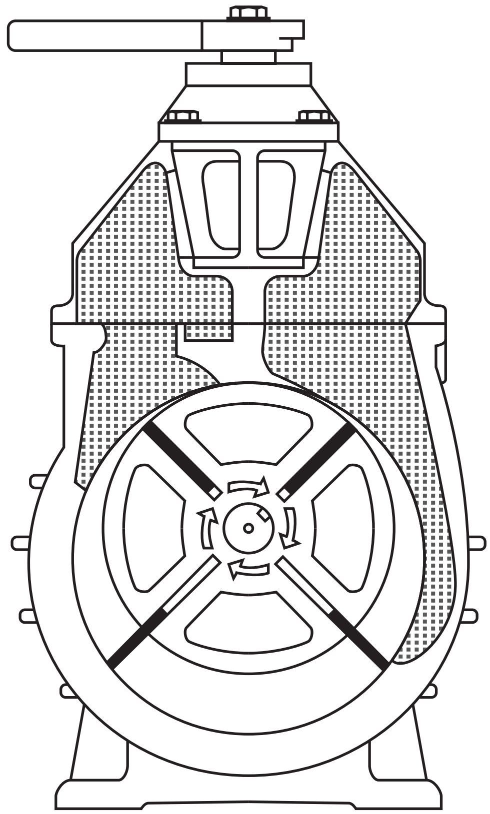

Figure A.3—Typical Sliding (Rotary) Vane Pump

Sliding vane pumps usually have fiber vanes that are attached to an eccentrically mounted, slotted rotor. As the rotor turns within the pump housing, the vanes are held in positive contact with the sides of the cylinder by centrifugal force. During rotation, the air space volume on one side of the cylinder increases during one half of the revolution while the volume decreases on the other side, creating pressure and vacuum, respectively. A constant supply of oil is maintained in the cylinder to lubricate the vanes and minimize wear as the vanes are pushed outward against the pump housing by centrifugal force. The use of lubricating oil results in oil-saturated air that needs to be separated or filtered prior to discharge.

A.3.3 Liquid Ring Vacuum Pumps

Liquid ring pumps are used to transfer liquids or solid materials. Liquid ring pumps typically operate at speeds up to 700 rpm, providing approximately 5,000 cfm airflow at high vacuum levels. Liquid ring vacuum pumps have a single, multi-blade impeller mounted eccentrically inside a casing (see Figure A.4) partially filled with a service liquid (typically water). The pump casing has both a suction and a discharge port. As the pump impeller rotates, the liquid is pushed outward against the pump casing by centrifugal force. Air and service liquid move continuously in and out of the impeller, creating both suction and discharge. As the pump rotates, the air and vapor entering the pump is compressed against the service liquid or gel and discharged through a discharge port. The service liquid serves to seal the pump. However, excess hydrocarbon vapor may be exhausted into the atmosphere. Although liquid ring pumps have low operating temperatures, heat may build up during the compression cycle and must be dissipated so as to minimize the risk of auto-ignition.

The service liquid in liquid ring pumps circulates in a closed loop through a reservoir to maintain the proper level in the pump. During operation, hydrocarbon vapor present in the inlet air stream is absorbed through the service liquid and expelled to the reservoir, reducing the amount of vapor concentration in the discharge air. Some systems provide for service liquid make-up as the separator is constantly discharging air that may contain small amounts of service liquid and absorbed product. Additionally, service liquid that becomes contaminated by absorbed hydrocarbons or other hazardous materials must be properly disposed of in accordance with appropriate regulatory requirements.

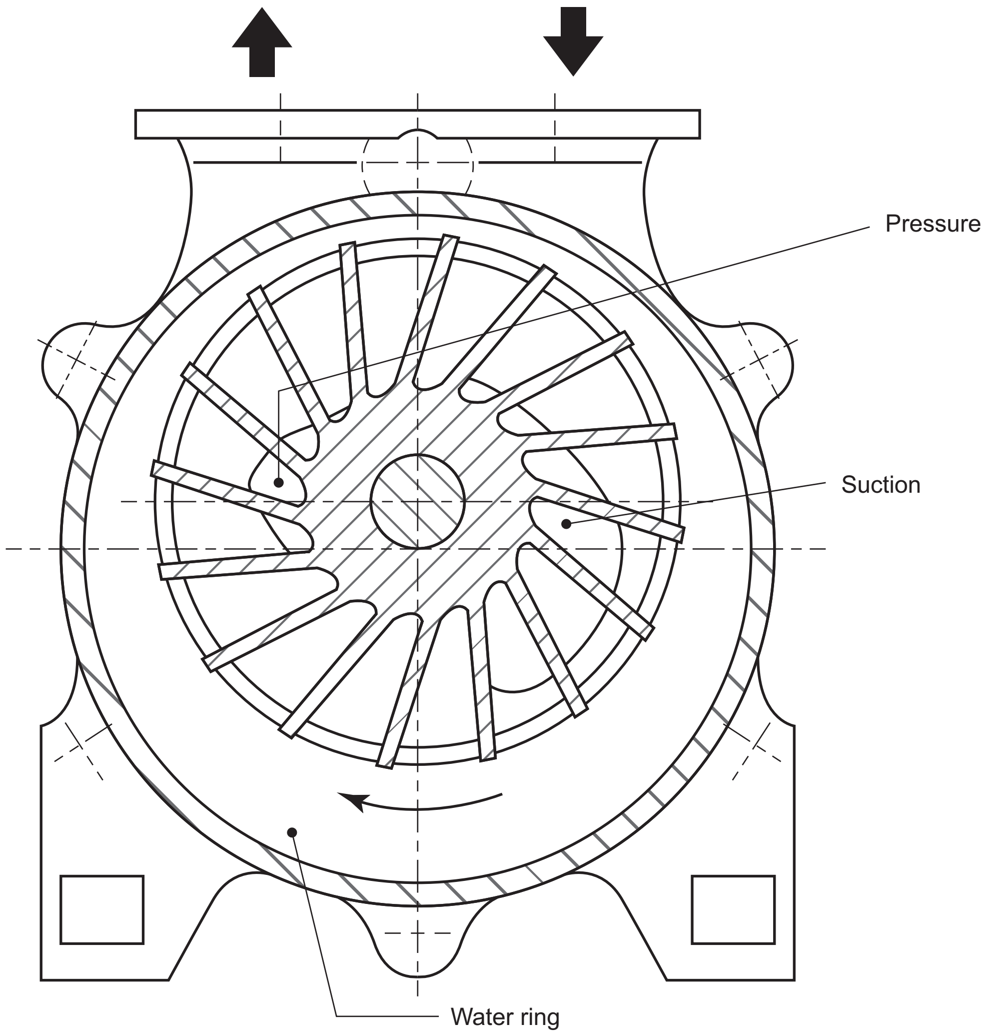

Figure A.4—Liquid Ring Pump

A.3.4 Rotary Lobe Blowers

Rotary lobe blowers are typically used to transfer solid materials, but may also be used for liquids. Rotary lobe blowers used on pneumatic conveyors are designed to operate at high vacuum/pressure ratios in order to handle bulk solid materials. Rotary lobe blowers operate up to 3,600 rpm and provide up to 7,000 cfm airflow at high vacuum levels. Rotary lobe blowers may have to be operated at lower speeds, reduced airflow rates (below 1,000 cfm) and lower vacuum pressure ratios in order to safely transfer hydrocarbon liquids. Although rotary lobe blowers are normally operated at 1,800 rpm, as speeds increase over 3,600 rpm, the resultant high vacuum/pressure ratio atomizes liquid hydrocarbons, creating a potentially hazardous condition both inside the blower and at the exhaust.

NOTE Some manufacturers have developed small rotary lobe blowers producing high vacuum at low air capacity rates and lower vacuum/pressure ratios for use in transferring hydrocarbon liquids.

Rotary lobe blowers typically have two (or three) figure eight shaped, gear-driven lobe impellers, mounted on parallel shafts, rotating in opposite directions inside a casing. See Figure A.5 and Figure A.6. As each lobe passes the blower inlet, incoming air is trapped between the lobe and the casing, producing a vacuum. The trapped air is then moved through the blower casing to the outlet and discharged. With constant speed operation, the displaced volume is basically the same even though there may be temperature or barometric pressure variances. Rotary lobe blowers operate mechanically with no service liquid. Therefore, during operation, any hydrocarbon vapors present in the incoming air may be discharged direct to the atmosphere.

Collection bags or filters used on rotary lobe blower operations that become contaminated by absorbed hydrocarbons or other hazardous materials must be properly disposed of in accordance with appropriate regulatory requirements.

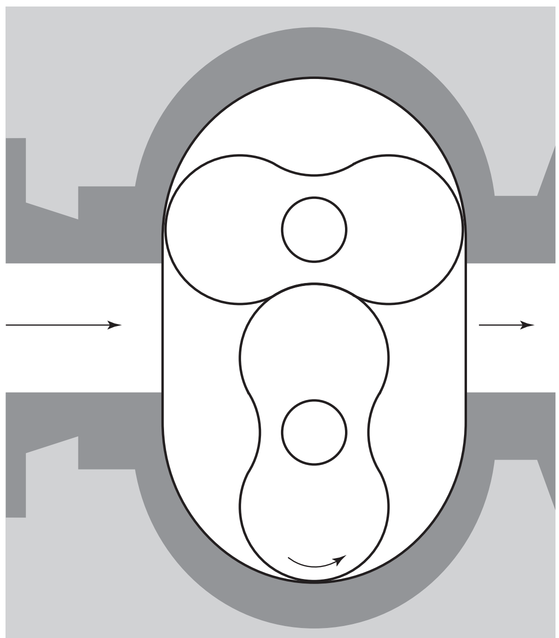

Figure A.5—Rotary Lobe Blower (Two-lobe Impeller)

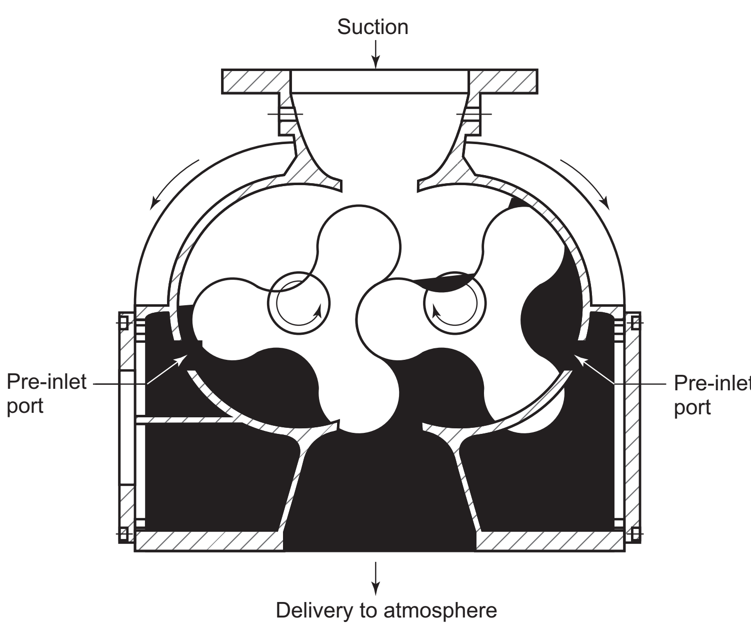

Figure A.6—Rotary Lobe Blower (Three-lobe Impeller)

A.4 Vacuum Truck Ignition Control

A.4.1 Diesel powered vacuum truck engines and auxiliary diesel powered vacuum units are preferred for use in flammable and combustible liquid service. This is because the limited electrical systems of diesel engines provide for reduced ignition and fire hazards as compared with those of gasoline engines. Diesel engines, however, are not totally free from ignition sources. Electrical devices and external wiring, especially on the truck chassis near the vacuum cargo tank, must be maintained in good condition to prevent breaks that may cause electrical arcing.

A.4.2 Diesel engine “runaway” or “dieseling” will occur if high concentrations of flammable vapors enter the diesel engine air intake. Several companies manufacture manual or automatic emergency shutdown devices that close the air intake to protect engines from dieseling. Their effectiveness is only as good as the initial design, installation, and maintenance. If engine power is not needed for vacuum truck operation, the engine should be shut down. If engine power is needed, dieseling and runaway can best be avoided by locating the vehicle upwind of vapor sources and by extending the vacuum pump discharge away from the engine air intake. In some work areas, shutdown devices are required by 30 *CFR* 250.80 and 250.100.

A.4.3 When installed, spark-arresting exhaust systems should be inspected frequently to ensure proper operation. USDA *Forest Service Spark Arrestor Guide General Purpose and Locomotive, Volume 1* provides guidance. Shielded ignition systems, flame arrestors, and spark-arresting exhaust systems are not foolproof and should not be considered as substitutes for maintaining vapor-free work areas.

A.5 Vapor Control and Recovery Equipment

Exhausted vapors may be directed from the vacuum discharge to portable or facility vapor recovery units. In these cases, flame arrestors shall be located in the vapor recovery line, near the vapor recovery unit, to prevent flashback into the vacuum truck.

Alternately, carbon adsorber canisters may be connected to the vacuum discharge exhaust. If used, these canisters must be properly rated in order to handle the amount of airflow generated by the vacuum pump. The canisters should be bonded to the vacuum units to prevent static charge build-up. The canisters should be inspected and replaced before they become saturated by lubricating oil or contaminated by exhaust vapors, as spontaneous combustion could occur.

An analysis should be conducted to determine the proper safety measures required prior to each specific use of vapor control canisters and vapor recovery systems.

A.6 Vacuum Transfer Hoses, Tubes, Suction Nozzles, and Connectors

A.6.1 Vacuum transfer hoses, tubes, and suction nozzles are designed to transfer specific liquids and dry materials. Some are designed to transfer only solid materials such as gravel, sand, and powders, while others are designed for septic and sewerage operations. When transferring flammable and combustible liquids or other hazardous products, especially when there is potential for a flammable atmosphere in the area, it is important to select appropriate hoses, tubes, suction nozzles, and connectors. Although vacuum transfer hoses and suction tubes are available in diameters from 2 to 8 in., 3 and 4 in. diameter hoses are most commonly used in petroleum facilities.

A.6.2 Vacuum truck operators may use either conductive or non-conductive hose. It is sometimes difficult to distinguish between the two. Conductive hoses are constructed of conductive material or have thick walls with imbedded conductive wiring. Conductive hoses should provide a suitable electrical conductance less than or equal to one megohm (1×10^6 Ω) per 100 ft (determined by the hose manufacturer).Thin-walled, metallic spiral-wound, conductive hoses are also available. However, use of these types of hoses is discouraged since they could discharge static electricity through the thin plastic that covers the metal spiral.

A.6.3 When using conductive hose, operators should ensure that suction nozzles, tubes, metal hose flanges, couplings, fittings, and nozzles are constructed of conductive materials and are securely connected so as to provide a continuous bond through the system from the vacuum truck to the source or receiving container.

A.6.4 Use of non-conductive hose to handle flammable and combustible materials should generally not be allowed due to potentials for accumulation and discharges of static electricity that can act as sources of ignition. Even where there appears to be minimal potential for the creation of a flammable atmosphere, prudent use of non-conductive hose requires that all exposed connectors, such as suction nozzles, tubes, metal hose flanges, couplings, and fittings are constructed of conductive materials and each one is individually bonded and grounded to the vacuum truck and the source or receiving container.

A.7 Vacuum Truck Regulatory Requirements

A.7.1 The design, construction, inspection, maintenance, and operation of vacuum trucks must comply with applicable federal, state, and local regulations.

A.7.2 Vacuum cargo tanks that carry hazardous dry materials or flammable and combustible liquids on U.S. highways outside of petroleum facilities must meet the construction requirements of 49 *CFR* Parts 178.345–178.348, DOT 407, or DOT 412 (formerly DOT 307 and 312) for transporting hazardous waste. Many tanks previously manufactured to DOT 307 and DOT 312 requirements are still in service. These requirements include items such as relief, isolation, emergency, and safety valves; rollover protection; lighting and reflectors; rear valve protection; and required placard and document holders. A DOT hazardous material code name plate should be attached to the tank per 49 *CFR* 178.345-14(b) and a specification plate shall also be attached per 49 *CFR* 178.345-14(c).

A.7.3 Vacuum trucks that leave the facility, and operate on public highways, must be properly placarded (either full or empty), have the required shipping documents available, and meet other regulatory requirements for highway travel. Empty trucks are exempt IF they previously carried a non-regulated material or have been properly flushed and cleaned of hazardous material and contain no residue of a hazardous material.

A.7.4 Other sections of 49 *CFR* applicable to vacuum truck construction, equipment, and operation include, but are not limited to, the following:

— Part 172, *Hazardous Materials Tables and Hazardous Materials Communications Regulations*;

— Part 178, *Design and Construction, Cargo Tanks*;

— Parts 100–185, *Hazardous Material Regulation*;

— Parts 40 and 300–399, *Federal Motor Carrier Safety Regulations (FMCSR)*.

A.8 Vacuum Truck Engines

Vacuum trucks are designed using on-road vehicles with on-road engines. On-road vehicles designed with on-road engines that conform to U.S. EPA emission standards for on-road certification for 2007 or the U.S. EPA emission standards for on-road certification for 2010 will have a diesel particulate filter (DPF). A diesel particulate filter is an emission control technology that is designed to remove diesel particulate matter or soot from the exhaust gases of a diesel engine. The DPF is designed to physically capture, trap, and store exhaust particles in the filter and permit exhaust gases to flow through. Through normal operations, the collected particles will restrict the filter and the filter must be regenerated. Regeneration is the process of burning the collected particles by raising the exhaust temperature. The particulate matter will begin to burn at 600 °F. The two types of regeneration are passive and active. The passive regeneration will take place automatically when the engine needs a cleaning. The active regeneration occurs when the vehicle is not moving and the engine is idling and is initiated by the engine control software.

Vacuum truck operators should be aware if the vehicle's engine is in the regeneration process because of the higher temperatures. The vacuum truck operator should not load or unload during the period of time the engine is regenerating.

Annex B
(informative)

Vacuum Truck Preventative Maintenance

B.1 General

As with any equipment used in critical service, vacuum truck tractors, engines, electrical systems, vacuum pumps, cargo tanks, valves, filters, separators, auxiliary pumps, hoses, nozzles, connectors, bonding and grounding cables, and other appurtenances must receive appropriate preventive maintenance and comply with applicable regulations. The use of “should” in this section is meant as a reminder of requirements. Vacuum trucks should be inspected, tested, and maintained by vacuum truck owners in accordance with applicable regulations such as federal and state DOT, local government, etc. (whichever are more restrictive). Typical preventive maintenance items for vacuum trucks include, but are not limited to, the following.

B.2 Air Tanks

Vacuum truck air tanks should be checked regularly, depending on service and atmospheric conditions, for accumulated water or liquid. Air tanks may require daily draining of water during cold weather, especially if an air dryer is not installed or is not working properly.

B.3 Lights and Electrical

Proper lighting is necessary, not only for driving after dark or under other low-visibility conditions but also for safe loading and off-loading. Lights and reflectors should be kept clean and inoperative lighting replaced as soon as possible. The condition of the electrical system should be inspected regularly to prevent ignition sources. Inoperative or defective wiring should be repaired or replaced prior to conducting transfer operations.

B.4 Vacuum Pumps and Appurtenances

The manufacturers' recommendations should be followed regarding installation, operation, pressure limitations, testing, and maintenance of vacuum pumps. Correct lubrication of the pump, bearings and associated equipment is very important. The three major causes of vacuum pump failure are (1) lack of or improper lubrication, (2) overheating, and (3) foreign materials contaminating the pump.

Pumps should be checked for leaks; proper valve seating; housing cylinder wear; and vane, lobe impeller, or rotor wear. Repairs or replacements should be made as necessary. If pumps are belt driven, belts should be inspected regularly for wear depending on their condition, use, and service and adjusted to reduce friction and heat build-up resulting from slippage. Cast iron rings in liquid ring pumps used for transferring hydrocarbon liquids, spent acids, etc. should be checked for corrosion. Traps, scrubbers, mufflers, filters, and separators should be regularly inspected and maintained to ensure proper operation and prevent contamination of the pump. Hoses should be inspected for cracks, leaks, and worn casings and tested for conductivity. Nozzles, fittings, and connections should be checked to ensure that there is no blockage and they will allow tight, conductive connections.

B.5 Vacuum Truck Cargo Tank

Vacuum truck cargo tanks, gauges, pressure and vacuum relief valves, and appurtenances should be regularly inspected, tested, and maintained by vacuum truck owners depending on their condition and service. Proper maintenance of door gaskets, float shutoffs, and level indicators is also important. Maintenance should be performed in accordance with appropriate regulations, such as DOT HM 183.

Good practice dictates the need for maintenance while other inspection and maintenance requirements are mandatory and should be performed in accordance with appropriate regulations. Regulations such as DOT HM 183 establish many different testing, inspection, and maintenance requirements for tank trucks, including vacuum trucks and vacuum cargo tanks. These are too numerous to be covered in this document. Additional information is provided by the National Tank Carriers Inc. in their *Cargo Tank Maintenance Manual*.

Annex C
(informative)

Safe Vacuum Truck Operations

C.1 Pre-operation Inspection

C.1.1 Vacuum truck owners and vacuum truck operators should check the following items, as a minimum, before vacuum trucks are operated.

C.1.2 Prior to selecting a vacuum truck for a specific job, vacuum truck owners should ensure that:

a) Pressure valves, relief valves, and shutoff valves are properly sized for the pump, tank, and work performed; are correctly installed; and have been inspected to be in proper operating condition.

b) Electrical continuity checks of the truck's grounding and bonding cables and conductive hoses have been performed on a regularly scheduled basis depending on their condition and service.

c) Where provided, intake filters, vapor recovery canisters, flame arrestors, secondary moisture traps, screens, mufflers, exhaust filters, etc., are properly sized, installed, and in good condition.

C.1.3 Prior to using a vacuum truck, vacuum truck operators should check that:

a) All valves operate freely, are leak-tight and, where appropriate, can be capped while in transit.

b) Floats for liquid level indicators, internal shutoffs, and scrubber shutoffs move freely and are working properly.

c) Rubber seats on interior shutoffs and exterior scrubber shutoffs are in good condition and seat properly. All connections and other equipment are leak-free and in good working order.

d) Rear door and dome gaskets are in good condition and seal tightly when the domes are closed. This may be checked by applying pressure to the cargo tank.

e) Hoses, connections, and fittings are in good condition; diameters are not smaller than the pump intake; and their conductance and materials of construction are appropriate for the application.

f) Bonding and grounding cables are checked for continuity.

g) Any debris or loose components that may be present in the interior of the vacuum truck cargo tank have been removed.

h) The cargo tank has been properly cleaned after previous off-loading to prevent reactions between incompatible products and contamination of the product to be loaded. The cargo tank should be free of moisture or water if products to be loaded react with water.

i) Hoses have been drained and are appropriately capped for transit.

C.1.4 Prior to commencing vacuum truck operations, personnel associated with the operations should conduct a job safety analysis (sometimes also referred to as a job hazard analysis) to identify potential hazard exposures and ensure protective equipment, procedures, and contingency plans are in place to mitigate risks associated with identified hazards. The entire crew engaged in the vacuum truck operations, including third-party workers, should review the most current JSA to gain familiarity with the hazards, risks, and the appropriate safeguards. (See OSHA

Publication 3071, *Job Hazard Analysis*, or other JSA-related material from OSHA's web site for more information on hazard analyses.)

C.2 Facility Loading and Off-loading Procedures

Vacuum truck operators transfer many different petroleum products, byproducts, wastes, and spilled materials, often in the same facility. The facility operator should provide the vacuum truck operator with instructions that include, but are not limited to, the following items.

a) The exact location, tank, or vessel in the facility where the truck is to proceed and park to load or off-load.

   NOTE Fires have occurred when a vacuum truck was parked too close to the source of flammable vapors, e.g. tank manholes and vents.

b) The requirements for entry of the vacuum truck into restricted areas within the facility.

c) Whether the product is to be reprocessed or transported to a separator or waste disposal area.

d) The applicable facility permits required for the job and product transfer, on and off premises.

e) The product to be transferred and product safety information including, but not limited to, toxicity, corrosiveness, flammability, reactivity, or combustibility. Where a specific product is involved, an SDS may be used to provide this information; however, when the material being transferred is a mixture of many products, a contaminated product, or a waste product, an SDS may not be available and other appropriate information will be required.

f) The specific personal protective equipment required, if any.

g) Applicable facility safety and emergency response procedures, including the telephone number or other means of contacting facility personnel or appropriate emergency responders.

C.3 Vacuum Truck Cargo Tank Loading

C.3.1 Vacuum truck operators should remain within the mechanical operational limits of the equipment (as established by equipment manufacturers) to prevent over-pressurizing tanks or releasing product and vapor. Vacuum truck owners should ensure that vacuum truck operators are trained and aware of the applicable regulatory requirements and the following minimum safe operating procedures when loading vacuum cargo tanks.

C.3.2 Obtain required facility permits and work orders for this activity, as appropriate.

C.3.3 Position the vacuum truck in a safe, authorized position, at least 25 ft upwind or crosswind from the source container or spill. Set the brakes and chock the wheels. When removing flammable liquids from a tank, container, or vessel located in a diked area, the vacuum truck should be positioned at least 50 ft upwind from the tank, preferably on top of the dike or outside the dike.

C.3.4 Ground the vacuum truck using the static line. If the transfer is between two trucks or between the vacuum truck and a metal tank or vessel, ensure that the source truck, tank, or vessel is both grounded and also bonded to the receiving vacuum truck.

C.3.5 Place an appropriate portable fire extinguisher (minimum 20 lb BC) ready for use within close proximity of the operation.

C.3.6 Ensure that metal hose couplings, nozzles, etc., are tightly connected. The suction hose should be connected directly to a pipe connection or fitting on the source container at a level below the product liquid level or the suction nozzle should be fully submerged into the product.

C.3.7 Use approved conductive hose, couplings, connectors, and nozzles that are in good condition for the product transfer. Check the conductivity from the vacuum truck to the source container with an ohmmeter or other approved testing device. If thin-walled conductive hose or non-conductive hose is permitted to be used by the facility, ensure all conductive couplings, connections, and nozzles are properly and individually bonded to the source container and grounded. See 5.3 and 5.4 for additional information.

C.3.8 Determine the amount of product to be transferred and ensure the vacuum truck cargo tank has sufficient capacity. Bond gauging equipment to the source container prior to insertion.

C.3.9 If the amount of product to be transferred is greater than the capacity available in the vacuum truck cargo tank, calculate the flow rate (gallons per minute) and estimate the time when the cargo tank will be approximately 90% filled. Monitor tank gauges and the transfer time in order to stop transfer operations when the cargo tank is full and before a spill or release occurs.

C.3.10 Using a vacuum flow chart for the pump in use, determine the amount of vacuum and flow rate required to transfer the liquid. Calculating the ability of the vacuum pump to make the transfer at the proposed lift is important for safe operation. If the ability to pull sufficient vacuum is marginal, operators may be tempted to bounce the hose end in and out of the liquid in an attempt to establish suction. This condition permits large amounts of air entrainment, creating a potentially hazardous condition. See Table C.1 and Table C.2 for an example of how to use charts to determine vacuum/pressure flow rates for different lifts, vacuums, and various hose diameters and lengths .

Table C.1—Example Vacuum/Flow Rate Table

			Approx. Flow (gpm) per 100 ft Straight Hose		
Approximate Lift (ft)	Vacuum (in. hg)	Pressure (psi)	3 in. hose diameter	4 in. hose diameter	6 in. hose diameter
4.5	4	2.00	135	287	835
9.0	8	4.00	196	418	1,214
13.6	12	6.00	244	520	1,511
18.1	16	8.00	285	608	1,765
22.7	20	10.00	322	685	1,991
27.2	24	12.00	355	756	2,197
31.7	28	14.00	386	822	2,388

NOTE How to calculate flow rates in gallons per minute (gpm) using the vacuum/flow rate table:

a) In Table C.1, determine the hydraulic lift in ft and the matching inches of Hg vacuum for this lift.

b) Determine the maximum, continuous operation, inches of Hg vacuum for the pump in use.

c) Subtract the inches of Hg determined in (a), from the maximum inches of Hg in (b).

d) Using Table C.1, find the appropriate gpm flow rate for 100 ft of "x" diameter hose, based on the calculated inches of Hg in (c).

EXAMPLE Determine the flow rate for 50 ft long, 4 in. diameter hose with a lift (head) of 18 ft using a vacuum pump rated at 24 in. Hg.

Step 1. Lift (18 ft) = (16 in. Hg) (Table C.1)

Step 2. Vacuum pump rating (24 in. Hg) – (16 in. Hg) = 8 in. Hg (Table C.1)

Step 3. 8 in. Hg provides flow of 418 gpm in a straight 4 in. diameter hose (Table C.1).

Step 4. The flow rate (Table C.2) in a 50 ft long hose is 145.4% of that in a 100 ft long hose. 145.4 % $\times$ 418 = 608 gpm (flow rate in 50 ft, 4 in. diameter hose).

Table C.2—Hose Flow Rate Adjustment Chart

Hose Length (ft)	% of Flow—100 ft Hose
20	220.0%
25	211.4%
50	145.4%
75	116.8%
100	100.0%
150	80.3%
200	68.8%

C.3.11 After developing the flow rate for a 100 ft long hose, calculate the adjustment needed in order to determine the flow rate to be obtained for the specific diameter and length of hose to be used for the specific transfer.

C.3.12 Open the top isolation valves and close all other valves, then set the pump to operate in the vacuum mode.

C.3.13 If the hose is not already directly connected to the source vessel at a level below the product level, submerge the suction nozzle hose into the product. Minimize entrained air with liquids entering the vacuum truck cargo tank by keeping the suction hose submerged or connected during the entire operation.

C.3.14 Start the power source, engage the vacuum pump, and allow the vacuum inside the cargo tank to build up to maximum level. As soon as sufficient vacuum is built up in the cargo tank, shut off the vacuum system, open the inlet valve, and begin loading. If sufficient vacuum cannot be sustained, continue operating the vacuum pump until the loading is completed.

C.3.15 When the hose is partially submerged (when product levels reach the bottom of the source container or when product is being skimmed off of the surface), minimize the amount of air introduced into the system by adjusting the vacuum pump airflow rating in proportion to the hose diameter. See Table C.3 for suggested airflow rates when the air enters the system.

Table C.3—Suggested Vacuum Pump Airflow Rate/Hose Diameter Adjustment Required When the Suction Hose is Partially Submerged (Skimming) to Minimize the Amount of Air Entering the Vacuum System

Air Flow	300 cfm VP	500 cfm VP	700 cfm VP	1,000 cfm VP
2 in. diameter hose	X			
3 in. diameter hose		X		
4 in. diameter hose			X	
6 in. diameter hose				X

C.3.16 Use a suction screen or filter, where required, to prevent undesired materials such as rocks and debris from entering the vacuum truck tank. Ensure that the screen is bonded to the tank and/or to the conductive hose coupling and nozzle to prevent a static spark hazard.

C.3.17 Where vapor recovery is mandated, exhausted vapors may be directed back to the source tank (or vessel). In such cases, locate a suitable flame arrestor in the vapor recovery line close to and between the source container and the vacuum exhaust to prevent flashback into the vacuum truck tank. For information on flame arrestors in piping, refer to API 2028.

C.3.18 Alternately, exhausted vapors may be directed to a portable or facility vapor recovery unit. In such cases, locate a suitable flame arrestor in the vapor recovery line between the vacuum discharge exhaust and the vapor recovery unit, in an appropriate position close to the vapor recovery unit, to prevent flashback into the vacuum truck tank. The potential exists for carbon adsorber vapor recovery units to become saturated by vacuum pump lubricating oil or contaminated by exhaust vapors, resulting in spontaneous combustion. For information on flame arrestors in piping, refer to API 2028.

C.3.19 In some cases, the vacuum discharge exhaust may be fitted with a carbon adsorption canister. If such canisters are used, they must be properly rated for the airflow capacity of the vacuum pump and positively bonded to the vacuum unit to prevent buildup of static charges. The potential exists for carbon adsorber canisters connected to the vacuum discharge exhaust to become saturated by vacuum pump lubricating oil or contaminated by exhaust vapors, resulting in spontaneous combustion. Therefore, an approved flame arrester is required on the inlet to the carbon canister to prevent flames from traveling to the vacuum truck. For information on flame arrestors in piping, refer to API 2028.

C.3.20 Where vapor recovery is not required and vapors are vented to the atmosphere, direct the released vapors away from ignition sources such as the vacuum truck's engine and motor vehicle paths of travel and away from areas where people are present.

C.3.21 The potential travel path of vapors discharged during off-loading; atmospheric and wind conditions; topography of the surrounding area, including low spots where vapors may collect; and potential ignition sources must be considered prior to starting operations. Vent only to a hazard-free area (depending on atmospheric conditions) by either of the following methods.

a) Attach a length of exhaust hose sufficient to reach an area that is away from the source of the liquids, at least 50 ft downwind of the truck and free from sources of ignition, personnel exposure, or other hazards.

b) Use a safety venturi and vertical exhaust stack to discharge vapors at a diluted rate, at the top of the receiving container, at least 12 ft above the ground level and directed downwind and away from sources of ignition and other hazards during the loading operation.

C.3.22 When transferring flammable liquids or hazardous materials, stay within 25 ft of the truck (between the vacuum truck and the source tank, vessel, or container) throughout the operation. If this is not possible due to the job site conditions or design of the vacuum truck, then an observer shall be so positioned and be in verbal communication with the vacuum truck operator. This is required in order to quickly close the product valve and stop the pump in the event of a blocked line, release of material through a broken hose, or connection or other emergency.

C.3.23 Exercise caution as vapors may reach the flammable range during low flow periods, such as the final few minutes of loading, or under other conditions.

C.3.24 Load the tank until the liquid level indicator shows full or the internal shutoff device engages. When the tank is full, close the inlet valve.

C.3.25 Disengage the vacuum pump and bleed off the vacuum by opening the bleeder valve, equalizing the tank pressure. Close the isolation valve and disengage the power source.

C.3.26 Disconnect the suction hose and drain any liquid back into a proper container. Close and cap the bleeder valve. Open the outside scrubber (liquid-entry preventer) drain valves. Catch any liquid for proper disposal. Immediately report any spills or releases to facility management.

C.3.27 Wait at least one minute to allow for static dissipation before disconnecting the bonding cable and then disconnect the grounding static line.

C.3.28 Remove the wheel chocks and ensure that the vacuum truck is properly placarded and that the shipping papers are in order for materials carried before leaving the facility.

C.4 Cargo Tank Off-loading

C.4.1 General Off-loading Procedures

C.4.1.1 Vacuum trucks may be off-loaded by gravity, pressurizing with air or inert gas, or by using pressure from reversing the vacuum pump or from an external pump. Vacuum truck operators should remain within the mechanical operational limits of the equipment (as established by equipment manufacturers) to prevent over-pressurizing tanks or releasing product and vapor. See also attendant requirements specified in 5.13.5. Vacuum truck owners should ensure that vacuum truck operators are trained and aware of the applicable regulatory requirements and the following minimum safe operating procedures when off-loading vacuum cargo tanks.

C.4.1.2 Review the fire and health hazards of the material to be off-loaded and the off-loading method and facilities to be used. Obtain appropriate permits and work orders for this activity, as required by the facility. Avoid open dumping of potentially flammable or toxic materials without a specific hazard review and control of ignition sources and exposures.

C.4.1.3 Where vapor recovery is mandated, exhausted vapors may be directed to a portable or facility vapor recovery unit. In such cases, locate a suitable flame arrestor in the vapor recovery line between the vacuum discharge exhaust and the vapor recovery unit in an appropriate position close to the vapor recovery unit to prevent flashback into the vacuum truck tank. The potential exists for carbon adsorber vapor recovery units to become saturated by vacuum pump lubricating oil or contaminated by exhaust vapors, resulting in spontaneous combustion.

C.4.1.4 Where vapor recovery is not required and vapors are vented to the atmosphere, direct the released vapors away from ignition sources such as the vacuum truck's engine and motor vehicle paths of travel and away from areas where people are present.

C.4.1.5 The potential travel path of vapors discharged during off-loading; atmospheric and wind conditions; topography of the surrounding area, including low spots where vapors may collect; and potential ignition sources must be considered prior to starting operations. Vent only to a hazard-free area (depending on atmospheric conditions) by either of the following methods.

a) Attach a length of exhaust hose sufficient to reach an area that is away from the source of the liquids, at least 50 ft downwind of the truck, and free from sources of ignition, personnel exposure, or other hazards.

b) Use a safety venturi and vertical exhaust stack to discharge vapors at a diluted rate, at the top of the receiving container, at least 12 ft above the ground level, directed downwind and away from sources of ignition and other hazards during the loading operation.

C.4.1.6 Position the vacuum truck in a safe, authorized position upwind or crosswind from the receiving container. When transferring flammable liquids into a container located within a diked area, place the vacuum truck at least 50 ft upwind from the tank, preferably on top of or outside of the dike.

C.4.1.7 Set the vacuum truck brakes and chock the wheels.

C.4.1.8 Ground the vacuum truck using the static line. If the transfer is between two trucks or between the vacuum truck and a metal tank or vessel, ensure that the source vacuum truck is both grounded and also bonded to the receiving truck, tank, or vessel. See 5.4 for further information.

C.4.1.9 Place an appropriate portable fire extinguisher (minimum 20 lb BC), ready for use, within close proximity of the operation.

C.4.1.10 Ensure that metal hose couplings, nozzles, etc., are tightly connected. The transfer hose should be connected directly to a pipe connection or fitting on the receiving container at a level below the product liquid level or the end of the hose should be fully submerged into the liquid.

C.4.1.11 Use approved conductive hose, couplings, connectors, and nozzles that are in good condition for the product transfer. Check the conductivity from the vacuum truck to the receiving container with an ohmmeter or other approved testing device. If thin-walled conductive hose or non-conductive hose is permitted by the facility to be used, ensure that all conductive couplings, connections, and nozzles are properly and individually bonded to the source container and grounded, if necessary. See 5.3 and 5.4 for additional information.

C.4.1.12 Determine the amount of product to be transferred and ensure the receiving container tank has sufficient capacity. Bond gauging equipment to the receiving container prior to insertion.

C.4.1.13 If the amount of product to be transferred is greater than the capacity available in the receiving container, calculate the flow rate and estimate the time when the container will be approximately 90 % full. Monitor tank gauges and the transfer time in order to stop transfer operations before the receiving container is full in order to avoid a spill or release.

C.4.1.14 When off-loading flammable liquids or hazardous materials, stay within 25 ft of the truck (between the vacuum truck and the receiving container) throughout the operation. This is required in order to quickly stop product flow in the event of a blocked line, release of material through a broken hose or connection, overflow, or other emergency.

C.4.1.15 Exercise caution as vapors may reach the flammable range during low flow and vapor producing periods such as the first few minutes of off-loading or under other conditions.

C.4.1.16 Load the receiving container until all product is transferred out of the vacuum truck cargo tank or the container reaches full capacity (the receiving container liquid level indicator shows full or the high-level alarm signal activates). Do not overfill the receiving container.

C.4.1.17 When the receiving container is full and the transfer is completed, close the inlet valve, disengage vacuum pump, and disengage power source. Disconnect the transfer hose and drain any liquid into a proper container. Immediately report any releases or spills to facility management.

C.4.1.18 Disconnect the bonding cable and then disconnect the grounding static line.

C.4.1.19 Remove the wheel chocks and vent the vacuum truck tank to a safe location. Ensure that the vacuum truck is properly placarded as empty and that the shipping papers are in order before leaving the facility.

C.4.2 Gravity Off-loading

C.4.2.1 The following gravity off-loading procedures are in addition to the general off-loading procedures in C.4.1.

C.4.2.2 Open the bleeder/isolation valve to vent the vacuum truck. Vent vapors into the atmosphere to a safe location or return vapors to the receiving container.

C.4.2.3 Open the discharge valve and empty the vacuum truck cargo tank by gravity. Close the discharge valve when off-loading is complete.

C.4.3 Reverse Vacuum Pressure Off-loading

C.4.3.1 The following reverse vacuum pressure off-loading procedures are in addition to the general off-loading procedures in C.4.1.

C.4.3.2 Use a vacuum flow chart for the pump in use to determine the amount of pressure and flow rate required for the transfer. See Tables C.1 and C.2 for an example of how to use charts to determine vacuum/pressure flow rates for different lifts, vacuums, and various hose diameters and lengths.

C.4.3.3 Close all bleed and drain valves.

C.4.3.4 Start the power source and engage vacuum pump operating in pressure (reverse) mode.

C.4.3.5 Pressure the vacuum truck cargo tank. Do not exceed the pressure relief valve setting or the maximum allowable working pressure as indicated by the tank data plate, whichever is lower.

C.4.3.6 Open the truck discharge valve to off-load. Start discharge at a slow speed until the end of the discharge hose is submerged to minimize spraying or splashing of product or materials.

C.4.3.7 Stay clear of the discharge line hook-up as liquid products, rocks, and debris may be discharged under considerable pressure.

C.4.3.8 When pressure off-loading, decrease the pump-off rate near the end of the transfer to avoid over pressuring the receiving container.

C.4.3.9 Close the discharge valve when off-loading is complete. Disengage the vacuum pump and bleed off the pressure by opening the bleeder valve, equalizing the tank pressure. Close the isolation valve and disengage the power source.

C.4.3.10 Following completion of pressure off-loading, any internal built-up pressure within the vacuum truck cargo tank must be relieved by safely venting to the atmosphere, receiving tank, or vapor recovery unit.

C.4.4 Air and Inert Gas Pressure Off-loading

C.4.4.1 The following air and inert gas pressure off-loading procedures are in addition to the general off-loading procedures in C.4.1.

C.4.4.2 Close all bleed and drain valves.

C.4.4.3 Connect the source of pressurized air or inert gas to the vacuum truck inlet valve.

C.4.4.4 Pressure the vacuum truck cargo tank. Do not exceed either the pressure relief valve setting or the maximum allowable working pressure as indicated by the tank data plate, whichever is lower.

C.4.4.5 Open the truck discharge valve to off-load. Start discharge at a slow rate of speed until the end of the discharge hose is submerged to minimize spraying or splashing of product or materials. Stay clear of the discharge line hook-up as liquid products, rocks, and debris may be discharged under considerable pressure.

C.4.4.6 When off-loading using pressurized air or inert gas, decrease the pressure near the end of the transfer to avoid over-pressuring the receiving container.

C.4.4.7 Close the discharge valve when off-loading is complete. Disengage the source of air or inert gas and bleed off the pressure by opening the bleeder valve, equalizing the tank pressure. Close the isolation valve and disengage the power source.

C.4.4.8 Following completion of pressure off-loading, any internal built-up pressure within the vacuum truck cargo tank must be relieved by safely venting to the atmosphere, receiving tank, or vapor recovery unit.

C.4.4.9 When venting to the atmosphere, direct the released vapors away from ignition sources such as the vacuum truck's engine and paths of motor vehicle travel, and away from areas where people are present. The potential travel path of the released vapors; atmospheric and wind conditions; topography of the surrounding area, including low spots where vapors may collect; and potential ignition sources all must be considered prior to starting operations.

C.4.4.10 When offloading using inert gas, the vacuum truck cargo tank should be placarded or warnings posted, such as a tag attached to the cargo tank opening, to indicate the tank contains inert gas.

C.4.5 External Transfer (Auxiliary) Pump Off-loading

C.4.5.1 The following external (auxiliary) transfer pump off-loading procedures are in addition to the general off-loading procedures in C.4.1.

C.4.5.2 Use a vacuum flow chart for the auxiliary pump to be used to determine the amount of pressure and flow rate required for the transfer. See Table C.1 and Table C.2 for an example of how to use charts to determine vacuum/pressure flow rates for different lifts, vacuums, and various hose diameters and lengths.

C.4.5.3 Close all bleed and drain valves.

C.4.5.4 Start the power source and engage auxiliary pump, operating in pressure mode.

C.4.5.5 Open the truck discharge valve to off-load. Start discharge at a slow speed until the end of the discharge hose is submerged to minimize spraying or splashing of product or materials. Stay clear of the discharge line hook-up as liquid products, rocks, and debris may be discharged under considerable pressure.

C.4.5.6 Decrease the pump-off rate near the end of the transfer to avoid over-pressuring the receiving container.

C.4.5.7 Close the discharge valve when off-loading is complete. Disengage the auxiliary pump and equalize the tank pressure by opening the bleeder valve. Close the isolation valve and disengage the power source.

C.4.5.8 Following completion of off-loading, any internal built-up pressure within the vacuum truck cargo tank must be relieved by safely venting to the atmosphere, receiving tank, or vapor recovery unit.

Annex D
(informative)

Safe Operation of Vacuum Trucks to Remove Flammable and Combustible Liquids from Underground Tanks at Service Station and Commercial Facilities

D.1 General

Vacuum trucks (or tank trucks with transfer pumps) are often used to remove flammable and combustible liquids, hazardous waste and contaminated water from underground (and other) storage tanks at service stations and commercial facilities where potential hazards may exist due to external sources and close proximity to the public. Vacuum truck and tank truck owners should ensure that operators are trained and aware of the safety procedures applicable to the removal of these products from underground tanks at service stations and commercial facilities. Safe operations are especially important where access by the public and persons other than facility employees is possible.

D.2 Vapor Releases, Spills, and Leaks

D.2.1 Because transfer of flammable and combustible liquids from underground storage tanks requires a running engine, it is essential that strict operating procedures and controls be established and maintained during all phases of the removal operation to prevent any release of liquid or vapors from reaching sources of ignition. See 5.7 for additional information.

D.2.2 Release of vapors, spills, and leaks are the primary potential hazards in the transfer of flammable and combustible liquids from underground tanks. Should these occur, a qualified person (truck operator, emergency responder, or other individual) should use a properly calibrated and adjusted combustible gas detector to determine the extent of the area that is in the potentially flammable range. This would be any area with an atmosphere containing a vapor–air mixture, which is at or greater than 10 % of the lower flammable limit. Entry into such an area by personnel without appropriate respirators or entry of vehicles should be restricted until all flammable vapors have dissipated and the area is determined to be safe. Testing with a hydrocarbon vapor analyzer is recommended to confirm human exposures will be at or below PELs. In addition, operating any equipment that might be a source of ignition should also be prohibited until flammable vapors have dissipated.

D.2.3 During the transfer operations, the vacuum truck (tank truck) operator and facility personnel should continuously observe and monitor operations, buildings, vehicles, and equipment located downwind of the transfer operation and any other areas into which vapors may travel where a potential source of ignition could be present or occur. Even diesel engines can “run away” and become ignition sources if they aspirate significant concentrations of hydrocarbon vapors.

D.3 Vapor Recovery

The use of vapor recovery controls, such as the return of vapors through a closed system to the underground tank or the collection of vapors in a vapor recovery device, is required where mandated by regulations or company policy. An analysis should be made of the potential hazards of the specific vapor recovery method or system to be used and safety procedures established prior to the start of operations. See 5.7.3 for additional information.

D.4 Product Removal from Underground Tanks

D.4.1 Pre-Operation Inspection and Information

All of the items listed in C.1 are applicable to product transfer from underground storage tanks. In addition, vacuum and tank truck operators should be trained and aware of the following safe practices.

a) The specific location and configuration of the underground tank or tanks to be emptied, the exact product to be transferred, and appropriate product safety information including, but not limited to, toxicity, corrosiveness, flammability, reactivity, or combustibility. Where a specific product is involved, an SDS should be used to provide this information; however, when the material being transferred is a mixture of products, a contaminated product, or a waste product, an SDS may not be available and other appropriate information should be provided.

b) The requirements to test the atmosphere for airborne hydrocarbon vapors or toxic gas to determine if operator exposures will be at or below PELs without respirators.

c) The applicable requirements for personal protective equipment, including respirators, if any.

d) Where the product is to be transported and whether it is considered product or hazardous waste.

e) The applicable company and regulatory permits required for the job and product transport.

f) Appropriate facility safety and emergency response procedures, including the telephone number or other means of contacting facility personnel and appropriate emergency responders.

D.4.2 Vacuum Truck (Tank Truck) Loading

D.4.2.1 To minimize risk to themselves and others vacuum truck (tank truck) operators should be aware of the following minimum safe work practices when transferring products from underground tanks.

D.4.2.2 Position the vacuum truck (tank truck) on level ground, at least 25 ft away from and preferably upwind of the underground tank. The appropriate location of the truck will be dependent on atmospheric conditions, wind, topography, and outside activities.

Do not locate the vacuum truck near buildings, service station ingress and egress routes, pump islands, aboveground storage tanks, underground tank vent pipes, in depressed or enclosed areas, or near public roadways.

D.4.2.3 Ensure that the area is free of potential hazards (such as public access) and sources of ignition including all electrical devices on the vacuum truck, heaters, open lights, smoking, fires, other running engines, motor vehicles, compressors, dispenser pumps, etc. Use rope, tape, or traffic cones to designate an area approximately 25 ft in radius around the vacuum truck and the underground tank to delineate an exclusion zone for motor vehicles and unauthorized personnel.

D.4.2.4 Obtain a permit for this activity if required by local regulations or company procedures. Lock and tag out tank inlet and suction lines as appropriate. Pumps and mixers should be isolated and locked out.

D.4.2.5 Set the brakes on the vacuum truck (tank truck) and place chocks under the wheels to prevent accidental movement. Bond (and ground) the truck to the fill box or fill pipe of the underground tank being emptied.

D.4.2.6 Gauge the underground tank(s) to be emptied to determine that the vacuum truck cargo tank (tank truck compartment) has sufficient capacity to hold the product to be removed, allowing a safe margin of approximate 10 % outage for temperature expansion and to prevent overflow. If the amount of product exceeds the available capacity, careful monitoring is necessary in order that the product transfer is stopped prior to overfilling the vacuum tank (or tank truck compartment).

D.4.2.7 Using a vacuum flow chart (or transfer pump specifications) for the pump in use, determine the amount of vacuum and flow rate required to transfer the liquid. Table C.1 and Table C.2 provide an example of how to use charts to determine vacuum/pressure flow rates for different lifts, vacuums, and various hose diameters and lengths.

D.4.2.8 After developing the flow rate for a 100 ft long hose, calculate the adjustment needed in order to determine the flow rate to be obtained for the specific diameter and length of hose to be used for the specific transfer. See Table C.2 for Hose Flow Rate Adjustment. Calculate the approximate time required for the transfer.

D.4.2.9 Place an appropriate portable fire extinguisher (minimum 20 lb BC), ready for use in the event of an emergency, within close proximity of the operation (for example, placed between the storage tank fill pipe connection and the vacuum truck or tank truck).

D.4.2.10 Use approved conductive hose, couplings, connectors, and nozzles that are in good condition, for the product transfer. If thin-walled conductive hose or non-conductive hose is used, ensure that all conductive couplings, connections and nozzles are properly and individually bonded to the source container. See Section 4 for further information. The suction hose may be equipped with a check valve to prevent any discharge of product upon disconnection.

D.4.2.11 Connect the suction hose from the vacuum tank inlet valve (transfer pump) to a suction tube of sufficient length (13 ft minimum) to reach the bottom of the underground tank. Ensure that all hose couplings, nozzles, etc., are tightly connected. Open the underground tank fill connection and insert the suction tube. In areas where vapor recovery is required, use of a modified coaxial fitting is recommended.

D.4.2.12 Ensure that the suction tube or hose is either directly connected to or held in constant contact with the rim of the underground tank opening or that a bonding cable is used to provide a positive connection between the tube or hose and the underground tank during product transfer. Do not connect bond clamp to underground tank openings as flammable vapors may be present.

D.4.2.13 Where vapor recovery is mandated, the vacuum truck may be fitted with a carbon adsorption canister. If used, canisters must be properly rated for the airflow capacity of the vacuum pump and positively bonded to the vacuum units to prevent static charge buildup. The potential exists for carbon adsorber canisters to become saturated by vacuum pump lubricating oil or contaminated by exhaust vapors, resulting in spontaneous combustion.

D.4.2.14 Exhausted vapors may be directed back to the underground tank. In such cases, a suitable flame arrestor should be provided in the vapor recovery line, close to and between the underground tank and the vacuum exhaust, to prevent flashback into the vacuum truck cargo tank (tank truck compartment). Alternately, exhausted vapors may be directed to a portable or facility vapor recovery unit in areas where vapor recovery is mandated or desired. In such cases, a suitable flame arrestor should be located in the vapor recovery line between the vacuum discharge exhaust and the vapor recovery unit, in an appropriate position close to the vapor recovery unit, to prevent flashback into the vacuum truck cargo tank (tank truck compartment). Alternative vapor treatment options such as vapor incineration, may be permitted by the Authority Having Jurisdiction (AHJ).

D.4.2.15 Where vapor recovery is not required and vapors are vented to the atmosphere, released vapors should be directed away from ignition sources, such as the truck's engine and paths of motor vehicle travel, and away from areas where people are present. The potential travel paths of vapors discharged during off-loading; atmospheric and wind conditions; topography of the surrounding area, including low spots where vapors may collect; and potential ignition sources must all be considered prior to starting operations. Vapors should be vented only to a hazard-free area (depending on atmospheric conditions) by either of the following methods.

a) Attach a hose to the vacuum exhaust that is of sufficient length to direct the vapors away from the source of the liquids. This should be at least 50 ft downwind of the truck and other potential sources of ignition, into an area that is free from hazards and personnel exposure.

b) Use a safety venturi and vertical exhaust stack that extends at least 12 ft above the vacuum truck to discharge vapors at a diluted rate, downwind, and away from sources of ignition and other hazards during the loading operation. Non-conductive exhaust stacks are recommended where the possibility exists of contacting overhead electric power lines.

D.4.2.16 When using a vacuum truck, open top isolation valves and close all other valves. Position the pump to operate in the vacuum mode. Start the power source, engage the vacuum pump, and allow the vacuum inside the tank to build up to maximum level. Operators should stay within the operational limits of the equipment as established by the equipment manufacturers to prevent over-pressurizing tanks. If the vacuum is sufficient, shut off the vacuum system, open the vacuum tank inlet valve, and begin loading. Otherwise, continue operating the vacuum pump until loading is completed. When using a transfer pump, ensure the pump is correctly positioned and engage the power.

D.4.2.17 Use a suction screen, where required, to prevent undesired materials such as dirt, rocks, rust, and debris from entering the vacuum tank. If the vapor air mixture in the underground tank is within the flammable range, the suction screen could create a static spark hazard.

D.4.2.18 Minimize entrained air (air entrapment) with liquids from entering the vacuum truck cargo tank (tank truck compartment) by keeping the suction tube submerged in the product during the entire operation. If the tube is partially submerged (such as when product levels reach the bottom of the underground tank or when cleaning up a spill), control air entrainment by reducing the vacuum pump airflow rating (transfer pump speed) according to the tube and hose diameter as suggested in Table C.3.

D.4.2.19 Stay within 25 ft of the truck (between the truck and the underground tank) throughout the operation in order to quickly close the product valve and stop the pump in the event of a blocked line or release of material through a broken hose or connection.

D.4.2.20 Load the vacuum truck cargo tank (tank truck compartment) until the liquid level indicator shows 90 % full or the internal shutoff device engages. When the vacuum truck cargo tank (tank truck compartment) is full, close the inlet valve.

D.4.2.21 Bleed off the vacuum by opening the bleeder valve, equalizing the vacuum tank pressure. Close the isolation valve and disengage the power source. If using a transfer pump, stop power.

D.4.2.22 Disconnect the suction and vapor recovery hoses and drain any remaining product in the hoses back into an approved container for proper disposal. Close and cap the bleeder valve. Open the outside scrubber (liquid-entry preventer) drain valves and catch any released liquid into an approved container for proper disposal. Immediately report any spills or releases of product to the facility manager.

D.4.2.23 Disconnect the bonding cables and then disconnect the grounding static line.

D.4.2.24 Before leaving the facility, the vacuum truck (tank truck) operator should cap both ends of hoses stored on the truck, remove the wheel chocks, ensure that the cargo tank is properly placarded for highway transportation, and ensure that the shipping papers are in order for the materials being transported.

Annex E
(informative)

Pneumatic Conveyor Trucks

E.1 General

In the petroleum industry, non-liquid, solid materials (pellets, catalysts, powders, dusts, etc.) and large diameter trash and debris are typically transferred by pneumatic conveyor (air-moving) trucks, often referred to as “dry-vac” trucks. The hazard review for these types of equipment and operations should consider the possibility of certain materials being pyrophoric (such as some unregenerated catalysts).

Conveying solids at high velocity can generate high levels of static within the transfer system and in the receiving container. If the solids can create a dust explosion hazard or flammable vapors are present, there is potential for a serious incident.

E.2 Pneumatic Conveyor Trucks and Cargo Tanks

E.2.1 High airflow pneumatic conveyor truck cargo tanks are not usually constructed to DOT and ASME specifications, nor do they operate the same as vacuum trucks. These tanks are therefore not recommended for transferring or transporting flammable and combustible liquids.

E.2.2 Requirements for pneumatic conveyor truck engines and motor-driven pneumatic conveyor equipment should meet or exceed NFPA 505, *Standard for Powered Industrial Trucks*.

E.2.3 Spark arrestors that are provided on the exhaust stacks of diesel powered pneumatic conveyor trucks should be cleaned or replaced according to manufacturer's recommendations.

E.2.4 The receiving tank, bins, or hoppers on pneumatic conveyor cargo trucks should have filtered open vents unless the vents are connected back to the truck.

E.3 Pneumatic Conveyor Blowers and Pumps

E.3.1 In order to handle bulk solid materials, the rotary lobe blowers and liquid ring vacuum pumps used on pneumatic conveyor trucks may move up to 10 times the volume of air as compared to conventional liquid vacuum trucks.

Rotary lobe blowers used on pneumatic conveyor trucks have speeds up to 3,600 rpm, air capacity ranges up to 7,000 cfm, and high vacuum levels. Liquid ring pumps used on pneumatic conveyor trucks have ranges of approximately 650 to 5,000 cfm (although they typically operate below 1,000 rpm) and high vacuum levels. Some manufacturers have developed small pneumatic lobe blowers that create high vacuum at low air capacity rates and lower vacuum/pressure ratios for transferring liquids.

E.3.2 Because pneumatic conveyor trucks and conventional liquid vacuum trucks both develop negative pressure inside their tanks, pneumatic conveyor trucks are sometimes considered for use in liquid hydrocarbon transfer operations. There are a number of safety concerns with this practice, as described below.

a) Operating rotary lobe blowers at high speeds creates high air movement and vacuum levels (or high pressure/vacuum ratios). This results in excessively high blower discharge air temperatures (approximately 290 °F at 15 in. Hg vacuum) that could create a source of ignition for exhaust vapors (unless the pumps are specifically designed to control high temperatures).

b) Operating rotary lobe blowers at high airflows and high vacuum levels atomizes flammable and combustible liquids. These particles are too light to condense in the vacuum tank and are subsequently exhausted into the atmosphere, with potential environmental and safety hazards. Even high flash, heavy combustible liquids can produce mists with potentially explosive hazards with high airflow, high vacuum pneumatic systems.

c) The pneumatic lobe blower systems typically used on pneumatic conveyor trucks, generate high airflow velocities at the hose inlet and work best when the loading hose is allowed to suck up air as well as solid materials (such as in skimming). This creates a potential for flammable vapor–air mixtures in the pneumatic cargo tank and at the exhaust vent.

E.3.3 For the above reasons, if rotary lobe blowers are used to transfer hydrocarbon liquids, they should be limited to lower speeds (below 1,000 cfm), lower vacuum levels, and lower vacuum/pressure ratios so as to maintain discharge temperatures in the 150 °F range.

E.4 Safe Operation of Pneumatic Conveyor Trucks

E.4.1 General

The same basic safe operating procedures applicable to vacuum trucks apply to pneumatic conveyor trucks operating in petroleum industry facilities. Pneumatic conveyor truck owners should ensure that operators are trained and aware of the appropriate safe practices, including loading and off-loading methods, when operating pneumatic conveyor trucks. For example, seemingly similar dry materials can have very different flow characteristics that affect maximum loading/off-loading rates.

The following are some specific safety issues unique to pneumatic conveyor trucks.

a) Pneumatic loading/off-loading is not suitable for products that attract or react with moisture unless a closed circuit off-loading system is used.

b) Reduced pressure (or reduced loading/unloading rates) may be required for products that react with heat produced by the vacuum or blower system.

c) Pneumatic conveyor truck cargo tank (or hopper) hatches or valves or disconnect hoses must not be opened while under pressure.

d) Awareness is required to avoid hazardous over-pressuring in the receiving container or tank due to blocked or improperly sized vents.

e) Attempts to convey material before the compressor reaches proper operating speed may result in malfunction.

f) Blower failure may be caused by operating too fast, too slow, or at excessive high pressure.

g) Surface dust should be removed from engines and motor driven equipment at regular intervals during operation. Equipment should not be cleaned with compressed air in Class II hazardous locations.

In specific situations, where the flammable and combustible liquids have been previously removed by vacuum trucks or other methods, pneumatic conveyor trucks may be used to remove non-combustible dry waste or heavy non-flammable tank bottoms. This operation requires continuous monitoring of hydrocarbon vapor–air concentrations at the point of pick-up to ensure that the incoming air stream to the pneumatic truck is kept below 10 % LFL (Lower Flammable Limit) in order to minimize the risk of ignition.

E.4.2 Pre-operation Information

All of the items listed in C.1 are applicable to product transfer using pneumatic conveyor trucks. In addition, truck operators should be trained and aware of the following safe practices.

a) The specific location and configuration of the source container to be emptied, the exact product to be transferred and appropriate product safety information including, but not limited to, toxicity, corrosiveness, flammability, reactivity, or combustibility. Where a specific product is involved, an SDS should be used to provide this information; however, when the material being transferred is a mixture of products, a contaminated product ,or a waste product, an SDS may not be available and other appropriate information may be required.

b) The hazards of the working environment and applicable requirements for personal protective equipment, including hearing protection required for high noise levels associated with pneumatic equipment operations.

c) Where the product is to be transported and whether it is considered hazardous product or hazardous waste.

d) The applicable company and regulatory permits required for the job and product transport.

e) Applicable facility safety and emergency response procedures, including the telephone number or other means of contacting facility personnel and appropriate emergency responders.

E.4.3 Loading and Off-loading Pneumatic Conveyor Trucks

Pneumatic conveyor truck owners should ensure that operators are trained and aware of the following minimum safety procedures when loading and off-loading pneumatic conveyor trucks.

E.4.3.1 When loading and off-loading, ensure that the pneumatic truck tank or hoppers and the receiving containers have sufficient capacity for the amount of materials to be transferred.

E.4.3.2 When off-loading, check that the receiving container has adequate venting capacity for the flow rate of the air used to unload.

E.4.3.3 Position the pneumatic truck in a safe, authorized location where it will not be a source of ignition in the event of a spill or release in the vicinity. Set the brakes and chock the wheels of the pneumatic conveyor truck. Obtain a facility safe work permit or work order, if required.

E.4.3.4 Place a portable fire extinguisher (minimum 20 lb), ready for use and of appropriate class for the material being handled, within close proximity of the operation.

E.4.3.5 Securely close all hatchway covers on the pneumatic conveyor truck cargo tank. Check that there is no pressure inside the tank and attached piping by venting through the blow-down valve.

E.4.3.6 Electrically bond and ground all pneumatic equipment, including but not limited to, pneumatic conveyor trucks, motors, and compressors; cargo tanks and hoppers; conveyor tubes, hoses, connectors, and nozzles; and source and receiving containers. Failure to properly bond and ground the conveying system and any other conductive objects within the pneumatic conveying system can result in accumulation of static charges sufficient to ignite flammable or explosive atmospheres.

E.4.3.7 Connect the conveyor tube between the truck cargo tank and the source container or off-loading point. Flexible tubing used for loading/off-loading should be electrically conductive.

E.4.3.8 For off-loading, connect the air hose between the blower and the truck cargo tank. Close all valves (except the discharge valve) and blow air through the empty delivery line into the receiving tank or hopper to check that the line pressure is at or close to zero, indicating that the delivery line or receiving tank valve is not restricted.

E.4.3.9 For loading, check that the pneumatic conveyor cargo tank pressurizing valve is closed. For off-loading, open the pressurizing valve fully, so that air can enter the cargo compartment.

E.4.3.10 Start the compressor and slowly open the product valve. Gradually build up to the proper pressure or vacuum. Adjust the product valve and suction/discharge line valve to obtain maximum efficiency.

E.4.3.11 If transferring flammable liquids or hazardous materials, stay within 25 ft of the pneumatic conveyor truck (between the truck and the source tank, container or vessel) throughout the operation in order to quickly close the product valve and stop the blower in the event of a blocked line or release of material through a broken hose or connection.

E.4.3.12 In locations with environmental and air quality restrictions, ensure that there is no unauthorized release of dust, vapors, or hazardous substances into the atmosphere or on the ground or water during transfer operations. Immediately report any releases to facility management.

E.4.3.13 During off-loading, when the pneumatic conveyor truck cargo tank (or hoppers) are empty, the pressure will drop in the line and the blower noise will change. Reopen and close the product valves to ensure all truck cargo tank compartments or hoppers are empty.

E.4.3.14 The pneumatic truck cargo tank or hoppers should be loaded until the level gauge shows full or the internal shutoff device engages. When the tank is full, close the inlet valve and bleed off the vacuum using the relief valve. Then disengage the vacuum pump and the power source.

E.4.3.15 After off-loading, close the pneumatic conveyor truck cargo tank pressurization valve and vent the pressure from the cargo tank into the receiving container. After checking that the delivery line is blown clean and the line pressure is zero, turn off the blower. Depressurize the cargo tank completely by opening the blow-down valve.

E.4.3.16 After off-loading, open the pneumatic conveyor truck cargo tank hatchways and visually check that all compartments (or hoppers) have been emptied. Be aware of the hazards presented by the materials conveyed and use appropriate personal protective equipment for potential exposures.

E.4.3.17 When loading/off-loading is completed, ensure all valves are closed and disconnect all hoses, bonding, and grounding cables.

E.4.3.18 Before leaving the facility prior to highway travel, the pneumatic conveyor truck operator should ensure that required documentation has been completed and the vehicle is properly placarded for the product being transported, or is placarded as empty.

E.5 Vacuum Excavation Trucks

E.5.1 Due to the nature of the specialized equipment, it is critical that the manufacturer's safety instructions are followed.

E.5.2 Vacuum excavation (sometimes called air, water, or hydro excavation) uses pressurized air or water and a vacuum system to dig in sensitive areas. This allows discovery of existing buried piping or utilities without damage. The process requires either compressed air (ca. 200 to 300 psi) or high pressure water (ca. 2500 psi or greater) and vacuum removal. Systems can be self-contained or separate. The fluid blast agent (air or water) loosens soil and substrate while the vacuum truck removes it from the excavation site. Typically a hand-held wand is used.

E.5.3 When using vacuum excavation trucks in locations where potential exists for exposing buried hydrocarbons, contaminated materials, or toxic substances, established safety procedures should be followed to minimize risks. These should include the use of PPE, the grounding/bonding of equipment, availability of a properly calibrated and adjusted combustible gas detector, and a plan for decontamination.

Annex F
(informative)

Vacuum Truck Operating Experience and Incidents

F.1 General

Fires and explosions have occurred during vacuum truck operations. In numerous instances, vacuum truck engines and related equipment were the ignition sources and flammable vapors from the cargo were the fuel sources. Many of these fires were caused either by operating the vacuum truck too close to the spill, pickup, or discharge point, or by failing to vent the vacuum pump discharge to a hazard-free area. In addition, it is sometimes not recognized that even trace amounts of hydrocarbon condensate, when placed under vacuum, can release flammable vapor into air mixtures and that appropriate precautions are required.

The following are examples of some types of incidents that have occurred during vacuum truck operations.

F.2 Spills

F.2.1 Vacuum truck with pressure on its cargo tank was hooked up to a full storage tank. When the inlet valve was opened, the pressure from the cargo tank vented into (e.g. pressurized) the storage tank and product in the storage tank was released through the tank vent. Vapors from the spill were then ignited.

F.2.2 Defective float valves on a vacuum cargo tank's inside and outside scrubbers prevented vacuum from being shut off to the cargo tank when it was filled. As a result, product was released onto the ground under the truck by the vacuum pump discharge.

F.2.3 A vacuum truck was connected to a slop tank manifold to off-load. Because of a high liquid level in the slop tank, the product gravitated into the vacuum truck when the slop tank and vacuum truck discharge valves were opened. The vacuum truck overfilled and product was released under the truck from an open bleeder line.

F.3 Vapor Ignitions

F.3.1 During transfer operations, a vacuum truck operator entered the vacuum truck cab and lit a cigarette resulting in a flash fire.

F.3.2 A vacuum truck entered a dike area within a tank block during a tank cleaning operation. While vacuuming flammable liquids from the tank sump, a fire started that destroyed the vacuum truck. The ignition source was the vacuum truck engine and the fuel was vapor from the truck's vacuum exhaust vent.

F.3.3 A small fire occurred at the outlet of the vent scrubber used to reduce emissions from the vent pipe of a vacuum truck. An activated charcoal canister was installed on the vent line to remove vapors. The canister had been used for two previous jobs and the fire occurred before it could be taken out of service and replaced.

F.3.4 An employee was unloading refinery waste from a vacuum truck. A vapor cloud formed from the light hydrocarbon being unloaded. The vapor was carried downwind by air currents to the tractor of the vacuum truck, where it ignited. The employee incurred fatal burns.

F.3.5 Two vacuum trucks transported basic sediment and water (BS&W) in 50-barrel vacuum trucks from gas leases to an authorized commercial disposal facility. The BS&W apparently contained a significant amount of gas well condensate that was not identified or recognized by the drivers. The drivers discharged wastes by opening the valves at the rear of the vacuum trucks, allowing the BS&W to gravity drain onto a sloped concrete pad leading to an open concrete pit without using hoses. This method of drainage released sufficient hydrocarbon vapors to form a flammable mixture in air. The drivers left the engines of the vacuum trucks running. Investigators concluded that intake of flammable vapors caused one or both of the diesel engines to race, then backfire, igniting the vapor cloud and causing a flash fire. Three men died and four other workers incurred serious burns. More information can be found in U.S. Chemical Safety and Hazard Investigation Board (CSB) Report 2003-06-I-TX *Vapor Cloud Deflagration and Fire*.

F.4 Hose Failures

F.4.1 A vacuum truck operator received a broken leg from a whipping discharge hose when the hose coupling failed at the pump-off manifold.

F.4.2 A vacuum truck operator received serious leg burns when a cam-lock coupling failed.

F.4.3 A vacuum pump, driven by a hydraulic pump, was mounted on a truck's transmission power takeoff. The hydraulic hose to the vacuum pump failed and sprayed hydraulic fluid on the truck exhaust system. The fluid ignited and the fire destroyed the vacuum truck.

F.5 Electrostatic Incidents

F.5.1 A fire occurred when a non-conductive hose was used to vacuum product from a small container. The incident report concluded that sparks at the point where the hose and the edge of the container came into contact created a source of ignition.

F.5.2 An off-loading fire was caused either by an impact spark when an off-loading hose was dropped into a storage tank or by static discharged when disconnecting a coupling. Another cause of a fire was sparks created by the whipping action of a discharge hose during off-loading.

F.5.3 Reports of internal explosions or fires within vacuum truck cargo tanks are rare. However, incidents that have been reported point out the need for exercising care in the mixing of incompatible materials and the vacuum removal of dusts. In one instance, a static ignition occurred while dry, powdered sulfur was being suctioned from a pit, resulting in an explosion within the vacuum truck. Other internal ignitions have occurred when flint-type rocks or other sparking objects were picked up in the vacuum operation and sparked when discharged inside the vacuum truck tank.

F.5.4 A pneumatic conveyor truck was used to transfer Perlite insulation out of a tank containing cryogenic process equipment. A static charge occurred between the metal "strongback" taped to the plastic suction hose, causing ignition of flammable vapors in the tank. The vapors were the result of small leaks in the process equipment. The employee standing at the tank manway was seriously injured.

F.6 Miscellaneous Incidents

F.6.1 Light ends and hydrogen sulfide gas were released when a vacuum truck was loading spent caustic. The problem was corrected by pumping the product into a truck instead of loading under vacuum.

F.6.2 A vacuum truck operator's sleeve caught on the vacuum pump as the operator attempted to tighten the pump packing resulting in injuries to the operator.

F.6.3 A vacuum truck was being used to remove product from a pipeline when the line was activated and over-pressured the vacuum tank.

F.6.4 A vacuum truck intended to remove light crude oil from a pipeline. The control valve was incorrectly set to discharge instead of vacuum. This resulted in a hydrocarbon release from pressured piping into an area where welding provided a source of ignition. A welder incurred fatal burns.

F.6.5 A vacuum truck was being prepared to pick up a load in freezing winter weather. The main suction/discharge connection on the vacuum tank's rear bulkhead was malfunctioning. It is presumed the valve was frozen in the partially open position. The workers chose to use a propane torch to free the valve. Flame propagation through the partially open valve ignited an explosive mixture in the vacuum tank. The ignition blew off the vacuum tank's rear door. The door struck two workers resulting in fatal injuries to both. A third worker also incurred fatal injuries in the incident.

F.6.6 Personnel were purging, cleaning, and dismantling equipment after well testing activities were completed. The crew was preparing to enter the pressure tank to collect samples and to clean the tank. The tank had been purged with propane to remove sour vapors from the vessel. After the H2S was reduced to an acceptable level, a vacuum truck was used to draw air into the pressure tank to purge the propane. The crew tried to open the manway door but could not due to residual vacuum in the vessel. When the manway door was finally pried open, a high velocity rush of air entered the vessel followed by an explosion and fire. Four workers suffered first and second degree burns to their neck and head areas. Investigators determined that pressure tank grounding was removed before the job was completed and testing of samples taken from inside the vessel indicated presence of iron sulfides.

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Sources for additional information supplementing the guidelines provided in this document include, but are not limited to, the following publications.

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