Safe Operation of Vacuum Trucks in Petroleum Service

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Safe Operation of Vacuum Trucks in Petroleum Service

Health, Environmental and Safety General Committee
Safety and Fire Protection Subcommittee

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FOREWORD

This publication provides information on the safe operation of vacuum trucks in petroleum service (including flammable and combustible liquids, associated waste water, produced water, sour water, caustics, spent acids, etc.). This publication discusses the types of vacuum pumps and cargo tanks, the common hazards associated with vacuum truck operations and the appropriate safe work practices and precautions for preventing accidents and injuries.

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 recommended practice and (3) facility requirements regarding the safe operation of vacuum trucks; including, but not limited to, the following items:

a. Construction, inspection, maintenance and certification of the vacuum tank.
b. Selection and safe operation of the vacuum truck, vacuum pump, hoses and accessories.
c. Regulatory requirements for safe highway operation of the truck.
d. Proper transportation, handling and disposal of hazardous materials.
e. Safe vacuum truck loading, unloading and transport operations within the facility.
f. Training and qualification of operators and other assigned vacuum truck personnel.

The U. S. 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 DOT 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 29 *CFR* 1910.

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, 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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Suggested revisions are invited and should be submitted to the director of the Health, Environmental and Safety General Committee, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

CONTENTS

CONTENTS

Safe Operation of Vacuum Trucks in Petroleum Service

1 General

1.1 SCOPE

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 has led to the development of the general safety guidelines in this publication. These guidelines are recommended as safe practices for those in the petroleum industry who use vacuum trucks. 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.

Note: Guidelines for pneumatic (air moving) trucks and hoppers, typically used in the petroleum industry for removal of noncombustible dry materials such as catalysts, dusts, powders, residue, etc., are addressed in Appendix E.

1.2 BASIC VACUUM OPERATIONS

There are two basic types of vacuum truck operations, 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.
2. Directly connecting the 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 involving the 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).
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.
3. Vacuum truck operations involving spill cleanup of liquids where air is skimmed off of the surface (water or land) together with the liquids.

2 Referenced Publications

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

API

RP 55	*Conducting Oil and Gas Production Operations Involving Hydrogen Sulfide*
RP 2003	*Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents*
Publ 2013	*Cleaning Mobile Tanks in Flammable or Combustible Liquid Service*
Publ 2015	*Safe Entry and Cleaning of Petroleum Storage Tanks*
Publ 2022	*Fire Hazards of Oil Spills on Waterways*
Publ 2214	*Spark Ignition Properties of Hand Tools*

ASME[1]

	Boiler and Pressure Vessel Code, Section VIII, Division I, Pressure Vessels

DOT[2]

49 *CFR*	*Federal Motor Carrier Safety Regulations*
HM 183	*Requirements for Cargo Tanks*
407	*Cargo Tank Motor Vehicle*
412	*Cargo Tank Motor Vehicle*

EPA[2]

40 *CFR*	*Protection of Environment*

NFPA[3]

30	*Flammable and Combustible Liquids*
505	*Powered Industrial Trucks*
650	*Pneumatic Conveying Systems for Combustible Materials*

NTTC[4]

	Cargo Tank Hazardous Materials Regulations
	Hazardous Materials Transportation—The Tank Truck Driver's Guide

OSHA[2]

29 *CFR*	*Department of Labor, Occupational Safety and Health Standards* (Part 1910)

BOM[2]

30 *CFR*	*Mineral Resources, Oil and Gas Operations*

USDA[2]

	Spark Arrestor Guide, Volume 1

[1]American Society of Mechanical Engineers, 345 E. 47th Street, New York, New York 10017 www.asme.org
[2]Available from the United States Government Printing Office, 732 N. Capitol Street, N.W., #808, Washington, D.C. 20402 www.access.gpo.gov
[3]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269 www.nfpa.org
[4]National Tank Truck Carriers, 2200 Mill Road, Alexandria, Virginia 22314

3 Definitions

The following definitions are applicable to this publication:

3.1 bonding: Connecting two or more conductive objects to equalize their electrical potential.

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

3.3 exposure limit: The maximum airborne concentration limits for toxic substances to which workers may be safely exposed for a prescribed time without protection (i.e., respiratory protection). Exposure limits are usually expressed in parts per million (ppm) or mg/m^3, averaged for a prescribed time, e.g., 15 minutes, and 8 hours. They may also be expressed as ceiling limits, which should not be exceeded. Material Safety Data Sheets (MSDSs) 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 exposure limits established in the U.S. Department of Labor OSHA regulations and are those found in the most current editions of OSHA 29 *CFR* 1910.1000 and chemical-specific standards.

3.4 grounding: Providing a means for electrical currents to dissipate to earth.

3.5 liquid: Any material that has 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. Combustible liquids at temperatures at or above their flash points are considered to be flammable.

Note: Combustible liquids that are handled, used, or stored at temperatures above their flash points are considered flammable and must be treated with special precautions per NFPA 30).

Flammable liquid is any liquid that has a closed-cup flash point below 100°F (see NFPA 30; 1–7).

3.6 pressure relief (safety) valve: Device that limits pressure to a preset level by exhausting surplus air volume, thereby assuring that the permissible operating pressure is not exceeded.

3.7 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.

3.8 vacuum inches Hg: A measurement of the suction produced in a vacuum system 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.

3.9 vacuum intake (suction air) filters: Filters mounted on the suction flange to protect vacuum pumps from airborne solid materials, but not from liquids.

3.10 vacuum pump: A pump that is designed to remove air (or gas) to create a vacuum (or partial vacuum) within a vacuum cargo tank. Vacuum pumps are also capable of producing pressure within a vacuum cargo tank when operated in the pressure (reverse) mode.

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

3.12 vacuum pump oil separator: A small vessel that captures exhausted oil when the pump is operated under the vacuum mode. When the pump operates under the pressure mode, the oil separator acts as an oil bath filter to prevent air borne material from entering the vacuum pump.

3.13 vacuum pump relief valve: 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. Vacuum relief valves must be closed during pressure off-loading.

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

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

3.16 ventilation valve: Ensures that the required (or permissible) vacuum level in the vacuum cargo tank (or suction line) is not exceeded, by allowing air to enter during suction operations.

4 Safe Handling of Hazardous Materials

4.1 HAZARDOUS MATERIALS AWARENESS

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

4.1.1 Vacuum truck owners shall assure 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 and Emergency Response"; 1910.1200 "Hazard Communication"; and DOT 49 *CFR*

Parts 106–7, 171–180, and 397, "Hazardous Materials Regulations."

4.1.2 Vacuum truck operators shall be aware that combustible liquids transferred at or above their flash point temperatures must be handled as if they were flammable liquids.

4.1.3 Vacuum truck operators shall be aware that trace amounts of flammable and combustible liquids and gases, hydrogen sulfide gas, acids, caustics, spent caustics, spent acids, sour water and other liquids, materials and gases present in the petroleum industry 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 amounts of hydrocarbons and hydrogen sulfide gas may be easily separated and create flammable and or toxic atmospheres.

4.2 PRODUCT INFORMATION

When applicable, the facility operator shall make Material Safety Data Sheets (MSDSs) and any other pertinent information about hazards and necessary precautions associated with the specific materials to be handled, available to the vacuum truck operator.

4.2.1 Frequently, MSDSs will provide correct information on materials originally stored in tanks or vessels, but will not accurately reflect the hazards associated with the co-mingled and waste products, tank bottoms, contaminated catalysts, spent acids or other materials that are being transferred. No vacuum truck operator should be asked to handle such a material unless its composition and hazards are known or it has been tested to determine the presence of hazardous materials. In either case, the vacuum truck operator shall be provided with the information.

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

When necessary, appropriate respiratory protection, chemical protective equipment, goggles, gloves, boots and other required personal protective equipment shall be provided by vacuum truck owners and used by vacuum truck operators for protection from exposure to the product. It is the responsibility of vacuum truck owners to assure that vacuum truck operators are trained and qualified as follows:

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

4.3.1.1 Vacuum truck operators shall be aware of applicable regulations including, but not limited to, 29 *CFR* 1200; 29 *CFR* 1910.120; 40 *CFR* 311.1 and the facility's industrial hygiene and safety requirements.

4.4 HAZARDOUS MATERIALS REGULATIONS

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

a. 29 *CFR* 1910.1000, "Air Contaminants."
b. 29 *CFR* 1910.1028, "Benzene."
c. 29 *CFR* 1910.120, "Hazardous Waste Operations and Emergency Response."
d. 29 *CFR* 1910. 1200, "Hazard Communications."
e. 40 *CFR* 263, "Protection of Environment."
f. 40 *CFR* 311.1, "Worker Protection Standards for Hazardous Waste Operations."
g. 49 *CFR*, Parts 172, 173, 178–179, 382, 383 and 390–397, "Motor Carrier Safety."

4.5 EMERGENCY RESPONSE

Vacuum truck owners shall assure 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.

4.5.1 Vacuum truck operators shall be trained in the use of portable fire extinguishers (provided with the vacuum truck and/or available at the work site).

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

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

4.6 OTHER REQUIREMENTS

Care must be taken to assure 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 which are not compatible with those previously handled. The same principles apply when materials are unloaded. Care must be taken to assure that the materials being unloaded are compatible with the materials presently or previously contained in the receiving container.

5 Safe Vacuum Truck Operations

5.1 GENERAL

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

5.1.1 Hazards of Vacuum Truck Operations

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

Note: See Appendix C 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, including, but not limited, to the following:

a. Sources of ignition, including 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.
b. Potential hazards including 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 the receiving container; and worker exposures to toxic vapors, liquids, or solids.
c. Potential hazards associated with the surrounding area and atmospheric conditions during the vacuum truck operations. There is a potential for discharged vapors to exceed PELs for exposed workers and/or to collect in low spots, particularly during atmospheric inversions and especially with high humidity when no wind is present. In addition, vapors should not be discharged onto roadways or other areas where sources of ignition may inadvertently occur.
d. Toxic vapors that are not hazardous prior to handling but may become concentrated, and thereby hazardous, at or near the discharge port of the vacuum pump.
e. 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 on the highway.

5.1.2 Inspection Requirements

Before beginning operations, vacuum truck operators shall obtain any required permits and inspect vacuum trucks, equipment and loading/off-loading sites to assure safe operations.

Note: See Appendix C for inspection, maintenance and operating requirements).

5.2 ATMOSPHERIC TESTING

The areas where vacuum trucks will operate must 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/STELs. Therefore, testing where appropriate shall be conducted and, where required by facility procedures, permits issued prior to the start of any vacuum truck operations.

If there is any question whether the area is vapor- or toxic-gas-free, 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. Testing shall be conducted prior to starting any operation, and if necessary, during operations, including—but not limited to—the following:

a. When operations in the area are subject to change such as automatic pump start-up 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 locking or tagging out equipment that could create hazardous conditions.
b. When off-loading a waste container where there may be pockets or layers of hydrocarbon, hydrogen sulfide, water, or other hazardous materials.
c. When atmospheric conditions change, such as wind direction, storm, etc. affect the operation.
d. 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 until the areas have been tested for hydrocarbon vapors by qualified persons, determined to be safe, and a permit has been issued if required by facility procedures or OSHA 29 *CFR* 1910.146, “Permit-Required Confined Space.”

5.3 CONDUCTIVE AND NONCONDUCTIVE HOSE

Vacuum truck operators may use either conductive or nonconductive hose. (It is sometimes difficult to distinguish between the two.) Petroleum industry experience indicates that electrostatic ignitions can present a significant hazard when using nonconductive transfer hose. Any isolated conductive object may accumulate a charge and provide a spark gap.

Note: Vacuum trucks should be grounded when possible (see 5.4).

5.3.1 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 when the potential for a flammable atmosphere exists in the area of

operations. Conductive hose shall provide suitable electrical conductance less than or equal to 1 megaohm per 100 feet (as determined by the hose manufacturer).

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

5.3.2 Nonconductive Hose

Nonconductive hose is not recommended for use in transferring either flammable or combustible liquids. Nonconductive 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. Nonconductive hose should 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.

Note: Although not recommended, the facility may permit the use of nonconductive hose to transfer combustible liquids where there is no potential for a flammable atmosphere in the area.

If nonconductive hose is permitted to be used, 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.

5.4 BONDING AND GROUNDING

The complete vacuum transfer system needs to be bonded so that there is a continuous conductive path from the vacuum truck through the hose and nozzle to the tank or source container and grounded to dissipate stray currents to earth.

a. Unbonded conductive objects, such as nozzles and strongbacks, can accumulate high electrostatic charges during transfer operations.
b. 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 the receiving tank or container.
c. The vacuum truck owner shall establish a schedule for inspecting and testing the electrical continuity of grounding and bonding cables provided with the vacuum truck (depending on the use and condition of the cables).

5.4.1 Bonding

Bonding prevents the formation of different electrostatic potentials between vacuum trucks and pumps and the source or receiving tank, 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.

Note: See API RP 2003 for additional information on static electricity.

5.4.1.1 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. To assure proper bonding, the continuity should be verified with an ohmmeter following connection and prior to the start of operations.

Note: 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 the use of nonconductive gaskets, etc., it may not be necessary to use bonding cables. Bonding should be verified using an ohmmeter.

5.4.1.2 When liquid is transferred to or from a nonconductive or lined container (that is not suitably grounded), bonding may be achieved by inserting an uncoated, corrosion-free metallic rod (or similar approved conductor) to the bottom of the fluid in the container. The rod is connected to the vacuum truck with a proper bonding cable and the bonding is verified using an ohmmeter.

5.4.2 Grounding

Prior to starting transfer operations, vacuum trucks need to 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 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 connecting to any properly grounded object including, but not limited to, any one or more of the following examples:

a. The metal frame of a building, tank, or equipment that is grounded.
b. An existing facility grounding system, such as that installed at a loading rack.
c. Fire hydrants, metal light posts, or underground metal piping with at least 10 ft of contact with the earth.

Note: Fence posts, etc. may not provide adequate grounding.

d. A corrosion-free metal ground rod of suitable length and diameter (approximately 9-ft long and $\frac{5}{8}$-in. diameter), driven 8 ft into the earth (or to the water table, if less).

Note: Resistance of the ground will vary depending on both the type of soil and the amount of moisture present in the soil.

e. A metal plate of suitable size and thickness (approximately 2 ft^2 in area and ¼-in. thick, if steel; or ⅝-in. thick, if copper) buried in the ground to a depth of at least 2 ½ ft.

5.5 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, resulting in high discharge air temperatures and high discharge vapor concentrations that can present potentially ignitable conditions.

5.6 VACUUM EXHAUST VENTING AND VAPOR RECOVERY

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 concentrations if filtered or separated prior to exhaust. The potential exists for these discharged vapors to form flammable mixtures with air and come into contact with 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).

In addition, toxic vapors at less than flammable concentrations may still expose the vacuum truck operator and others to levels above PELs or STELs. If this occurs, 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.

The following are some exhaust issues 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. Because 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.

5.6.1 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 dieseling 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 because 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 or other potential hazards, and personnel.
e. Vacuum truck operators may attach a length of exhaust hose to the vacuum exhaust that is 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 liquids.

5.6.2 Vapor Recovery

To prevent ignition from occurring, prior to each specific use of a vapor recovery system an analysis should be conducted to determine the potential hazards and appropriate safety measures required, including—but 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 discharge exhaust and close to the vapor recovery unit, will mitigate or prevent flashback 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 absorption canisters connected to the vacuum discharge exhaust may become saturated by lubricating oil or contaminated by vacuum exhaust vapors, resulting in sponta-

neous 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 absorption 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.

5.7 TRANSFER OPERATIONS

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.

5.7.1 Loading

The size and length of the hose and the vacuum level in the truck govern the loading rate. 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. The volume of air exhausted from the vacuum pump following this procedure is usually very small, especially at high vacuum levels, thereby reducing the potential for a vapor-air mixture in the flammable range.

Note: See Appendix C for loading procedures.

5.7.2 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—becoming 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.

5.7.2.1 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 during the end of product transfer operations when the suction nozzle or the end of the hose may not be completely submerged in the liquid.

5.7.2.2 Vacuum truck operators shall take care to minimize air intake when skimming product (e.g., off of the water surface or from spills on land) and when the suction nozzle or the end of the hose may not be completely submerged.

5.7.3 Off-Loading

5.7.3.1 The three methods of off-loading vacuum trucks are gravity, pump-off, and pressure. Flammable liquids and other hazardous materials should be off-loaded by gravity or inert gas (typically nitrogen) pressure blanket, 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.

Note: See Appendix C for off-loading procedures.

5.7.3.1.1 *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 nonflammable and combustible materials.

5.7.3.1.2 *Pressure Method.* When pressure off-loading with air or inert gas blanket, the pressure must not be allowed to exceed the pressure relief valve setting, or if this setting is unknown, the maximum allowable working pressure as indicated by the vacuum cargo tank data plate. Outside sources of compressed air, such as 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.

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

5.7.3.2 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 being transferred.

5.7.3.3 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 buildup 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.

5.7.4 Nonconductive Equipment

Vacuum truck operators shall be aware of the following precautions regarding the use of nonconductive equipment. These precautions are necessary to reduce the potential for ignition during vacuum truck operations because static charges can accumulate on these containers and create a source of ignition.

5.7.4.1 The use of nonconductive 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.

5.7.4.2 The use of nonconductive 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 assure that these are bonded to the transfer hoses, connectors, nozzles, and the source or receiving tank, vessel, or container.

5.8 OVER-PRESSURE AND UNDER-PRESSURE

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

5.8.1 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.

5.8.2 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.

5.8.3 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 GAGING AND SAMPLING

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

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

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

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

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

5.10 NONPETROLEUM PRODUCTS

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

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

5.10.2 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.

5.11 OPERATION OF VEHICLES

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.

5.11.1 Vacuum trucks shall not enter into tank dike areas until such areas have been checked and, if 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.

5.11.2 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.

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

5.11.4 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 hazards. Vacuum truck owners should post the vehicle specifications (weight, height, size, etc.) inside the vacuum truck cab.

5.12 PERSONNEL SAFETY

Vacuum truck personnel working in petroleum facilities shall be:

a. Trained in the safe operation of the vacuum equipment.
b. Familiar with the hazards of the petroleum products, byproducts, wastes and materials being transferred.
c. Aware of relevant government and facility safety procedures and emergency response requirements.

5.12.1 MSDSs 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 exposure potentials.

5.12.2 Appropriate personal protective equipment, including respirators, shall be worn whenever exposures to toxic materials or air contaminant levels at or above PELs or STELs, can be reasonably expected to occur.

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

5.12.4 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. 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.

Note: See *CFR* 49, Part 177, Subpart B, for attendance requirements.

5.12.5 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.

Note: Facility smoking and hot work policies should be followed if they are more restrictive.

APPENDIX A—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 Figures A-1 and A-2).

A.2 Vacuum Truck Cargo Tanks

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 nonhazardous materials.

A.2.1 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.

Note: See Appendix E for requirements for pneumatic cargo truck tanks.

A.2.2 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 gages 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 bleeder valves.

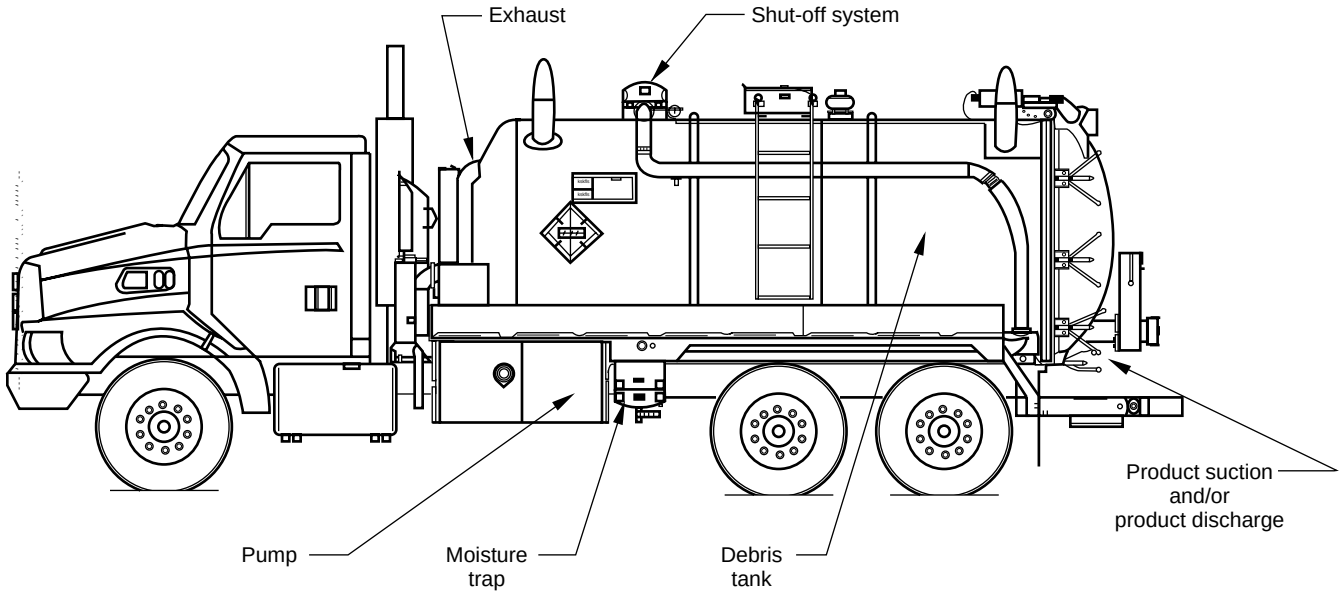

Figure A-1—Typical Vacuum Truck with Rotary Vane Pump

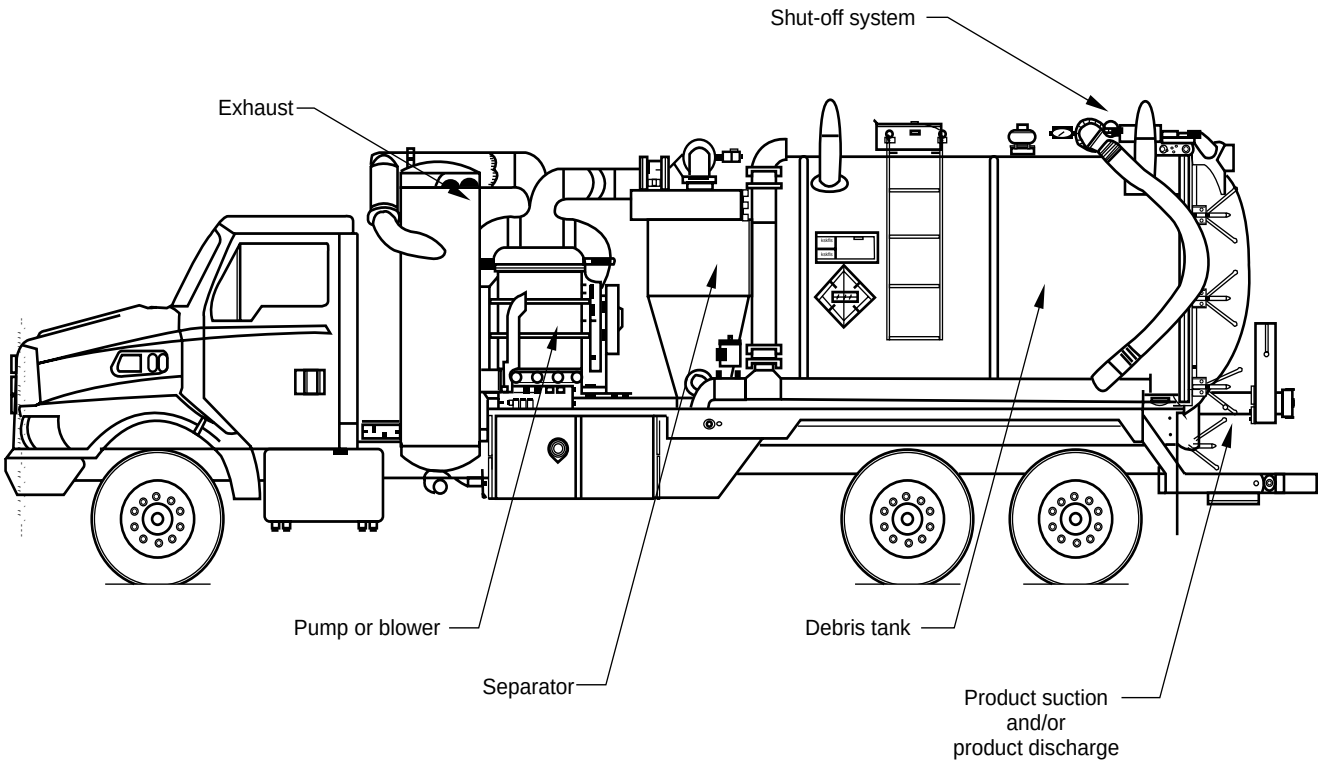

Figure A-2—Typical Vacuum Truck with Liquid Ring Pump or Rotary Lobe Blower

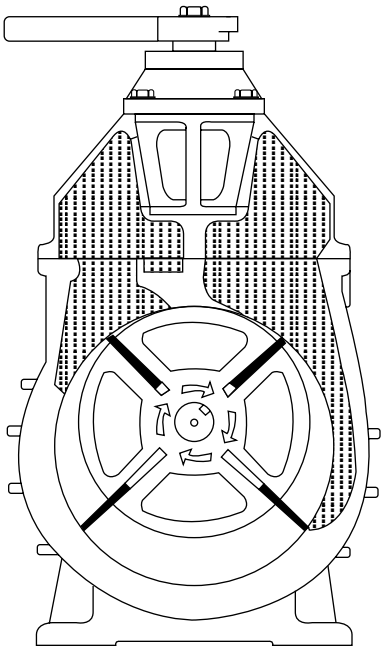

Figure A-3—Sliding (Rotary) Vane Pump

A.3 Vacuum Pumps and Blowers

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.3.1 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-cubic-feet-per-minute (cfm) airflow at high vacuum levels. Cooling is necessary to minimize the risk of autoignition from heat buildup inside the pump. Sliding vane pumps are typically liquid-cooled to allow for continuous use under high vacuum levels.

Note: Cooling may also be provided by forced air blown against the external fins of air-cooled sliding vane pumps.

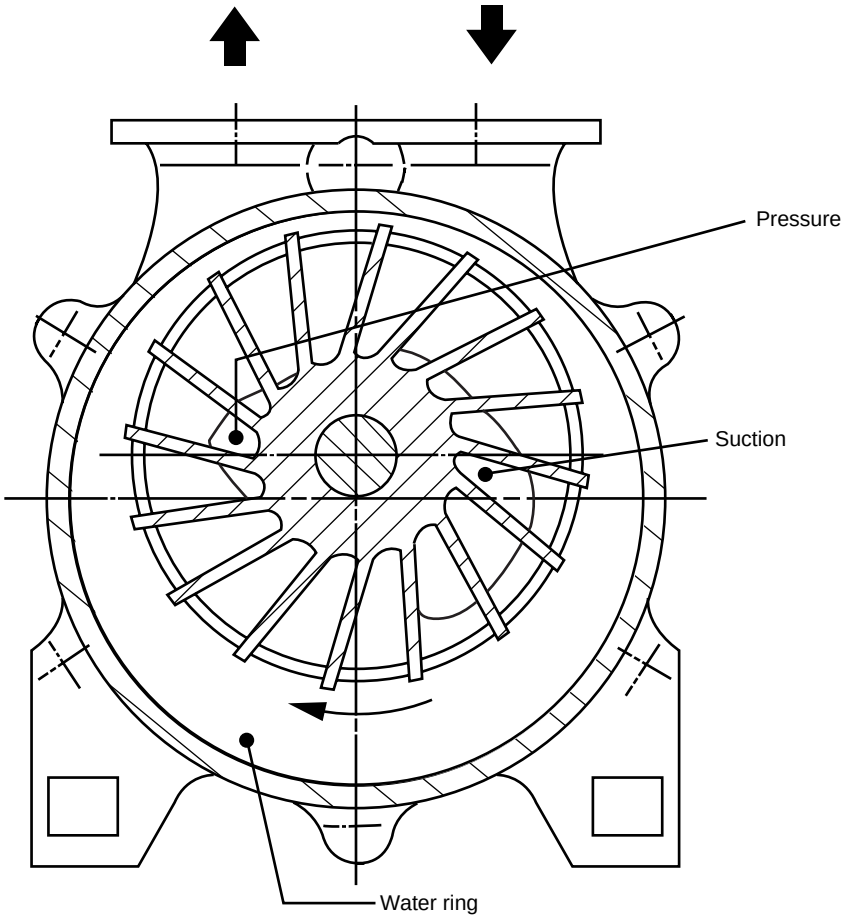

Figure A-4—Liquid Ring Pump

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, respectively creating pressure and vacuum. 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.3.2 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 multiblade impeller mounted eccentrically inside a casing partially filled with a service liquid (typically water). See Figure A-4. The pump casing has 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 moves continuously in and out of the impeller, creating 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 to minimize the risk of autoignition.

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 con-

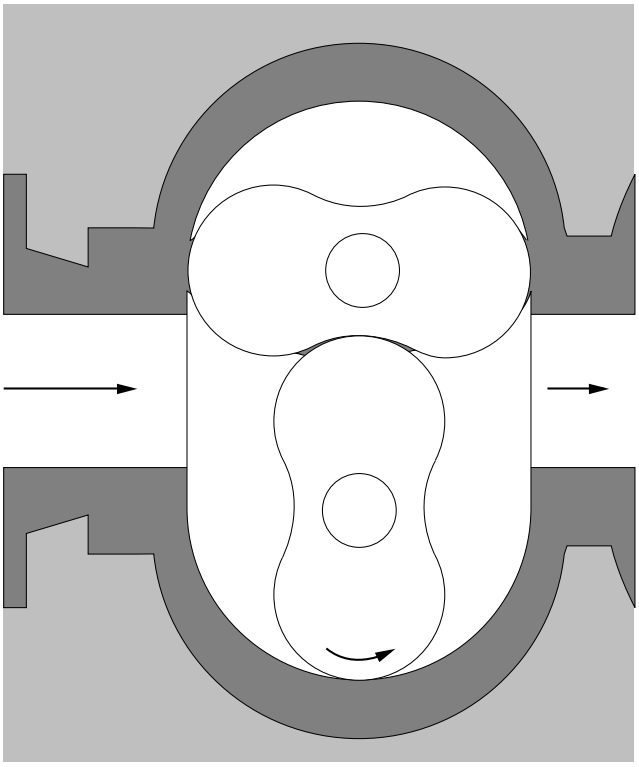

Figure A-5—Rotary Lobe Blower (2-Lobe Impeller)

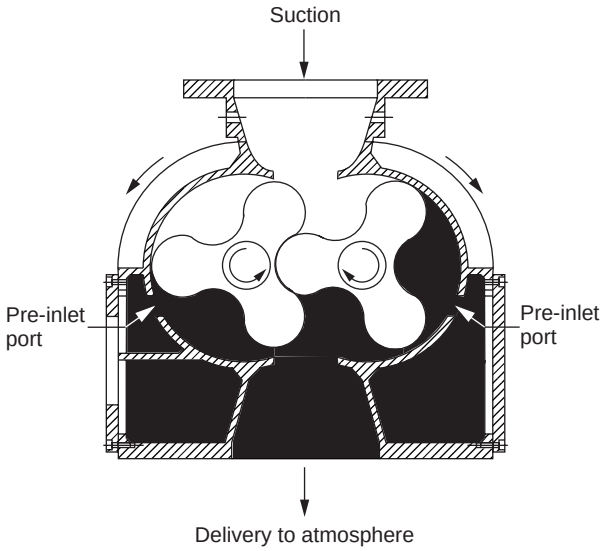

Figure A-6—Rotary Lobe Blower (3-Lobe Impeller)

centration 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.

A.3.3 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 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 to safely transfer hydrocarbon liquids. Although rotary lobe blowers are normally operated at 1,800 rpm, as speeds increase to more than 3,600 rpm, the resultant high vacuum/pressure ratio atomizes liquid hydrocarbons, and creates potentially hazardous conditions 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 Figures A-5 and 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 directly to the atmosphere.

Rotary lobe blowers are usually limited to approximately 16" Hg vacuum because operation at higher levels can cause extreme discharge temperatures, resulting in distortion of the impeller and casing. Additionally, 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.

A.4 Vacuum Truck Ignition Control

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 which may cause electrical arcing.

A.4.1 Dieseling or "running away" will occur if high concentrations of flammable vapors enter the diesel engine air intake. Several companies manufacture manual or automatic emergency shut-down devices that close the air intake to protect engines from dieseling. Their effectiveness is only as good as the initial design, installation, and maintenance. Dieseling can be best avoided by locating the vehicle upwind of vapor sources and by extending the vacuum pump discharge away from the engine air intake.

Note: Shutdown devices are required in some work areas per 30 *CFR* Parts 250.80 and 250.100.

A.4.2 When installed, spark-arresting exhaust systems (see USDA Forest Service's *Spark Arrestor Guide*, Volume 1, April, 1988), should be inspected frequently to ensure proper operation. 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

A.5.1 Exhausted vapors may be directed from the vacuum discharge to portable or facility vapor recovery units. In these cases, flame arrestors should be located in the vapor recovery line near the vapor recovery unit, to prevent flashback into the vacuum truck.

A.5.2 Alternately, carbon absorber canisters may be connected to the vacuum discharge exhaust. If so, these canisters must be properly rated to handle the amount of airflow generated by the vacuum pump. The canisters should be bonded to the vacuum units to prevent static charge buildup. The canisters should be inspected and replaced prior to becoming saturated by lubricating oil or contaminated by exhaust vapors, because spontaneous combustion could occur.

A.5.3 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

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 that range from 2 to 8 in., 3-in. and 4-in.-diameter hoses are most commonly used in petroleum facilities.

A.6.1 Vacuum truck operators use either conductive or nonconductive hose (note that 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 1 megaohm per 100 feet (determined by the hose manufacturer). Thin-walled, metallic-spiral wound, conductive hoses are also available; however, these may be ineffective as they may discharge static electricity through the thin plastic covering the metal spiral.

A.6.2 When using conductive hose, assure 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. Use of nonconductive hose to handle flammable and combustible materials should generally not be allowed because of 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, all exposed connectors, such as suction nozzles, tubes, metal hose flanges, couplings and fittings, should be constructed of conductive materials. Each connector should be individually bonded and grounded to the vacuum truck and the source or receiving container.

A.7 Vacuum Truck Regulatory Requirements

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

A.7.1 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 DOT 407 or DOT 412 (formerly DOT MC 307 and MC 312) for transporting hazardous waste.

Note: Many tanks previously manufactured to DOT MC 307 and DOT MC 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.

A.7.2 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.

A.7.3 Sections of 49 *CFR*, applicable to vacuum truck construction and equipment, 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"

APPENDIX B—VACUUM TRUCK PREVENTIVE 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. 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 shall 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 shall 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 shall be repaired or replaced prior to conducting transfer operations.

B.4 Vacuum Pumps and Appurtenances

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

Pumps should be checked for leaks, proper valve seating, housing cylinder wear and vane, lobe impeller or rotor wear, and repairs or replacements made, if required. If pumps are belt-driven, all belts should be inspected regularly for wear and replaced depending on their condition, use and service. Belts should be adjusted for proper tension to reduce friction and heat buildup as a result of 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 assure 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 assure that there is no blockage and that they will allow tight, conductive connections.

B.5 Vacuum Truck Cargo-Tank

Vacuum truck cargo tanks, gages, pressure and vacuum relief valves, and appurtenances shall be regularly inspected, tested and maintained by vacuum truck owners depending on their condition and service and in accordance with appropriate regulations, such as DOT HM 183.

Note: Regulations such as DOT HM 183 establish many different testing, inspection and maintenance requirements for tank trucks, including vacuum trucks and vacuum cargo tanks, which are too numerous to be covered in this document. Additional information is also provided by the *Cargo Tank Maintenance Manual*, which is available from the National Tank Truck Carriers Inc.

Proper maintenance of door gaskets, float shutoffs, and level indicators is important.

APPENDIX C—SAFE VACUUM TRUCK OPERATIONS

C.1 Pre-Operation Inspection

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

C.1.1 Prior to selecting a vacuum truck for a specific job, vacuum truck owners should ensure that:

a. Pressure valves, relief valves, and shut-off valves are properly sized for the pump, tank and work performed, are correctly installed, and have been inspected to be in proper operating conditions.
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. Intake filters, vapor recovery canisters, flame arrestors, secondary moisture traps, screens, mufflers, exhaust filters, etc., where provided, are properly sized, installed, and in good condition.

C.1.2 Prior to using a vacuum truck, vacuum truck operators should verify the following:

a. All valves operate freely and are leak-tight.
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.

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

C.2 Facility Loading and Off-Loading Procedures

Vacuum truck operators transfer many different petroleum products, by-products, 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 to load or off-load.
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.

Note: Where a specific product is involved, an MSDS 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 MSDS 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 numbers or other means of contacting facility personnel or appropriate emergency responders.

C.3 Vacuum Truck Cargo Tank Loading Procedures

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 minimum safe operating procedures for loading vacuum cargo tanks as follows:

C.3.1 Obtain required facility permits and work orders for this activity, as appropriate.

C.3.2 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.3.3 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, insure that the source truck, tank, or vessel is both grounded and bonded to the receiving vacuum truck.

Table C-1—Vacuum/Flow Rate Table

Approximate Flow (gpm) per 100 ft Straight Hose					
Approx. Lift (ft)	Vacuum ("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	1214
13.6	12	6.00	244	520	1511
18.1	16	8.00	285	608	1765
22.7	20	10.00	322	685	1991
27.2	24	12.00	355	756	2197
31.7	28	14.00	386	822	2388

Note: How to Calculate Flow Rates in Gallons per Minute (gpm) Using the Vacuum/Flow Rate Table—

a. In Table 1-A, determine the hydraulic lift in feet and the matching "Hg vacuum for this lift.

b. Determine the maximum, continuous operation, "Hg vacuum for the pump in use.

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

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

C.3.4 Place an appropriate portable fire extinguisher (minimum 20 lb. BC), ready for use, within close proximity of the operation.

C.3.5 Verify 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.3.6 Use approved conductive hose, couplings, connectors and nozzles, which are in good condition, for the product transfer. The conductivity from the vacuum truck to the source container may be checked with an ohmmeter. If thin-walled conductive hose or nonconductive hose is permitted to be used by the facility, ensure that all conductive couplings, connections, and nozzles are properly and individually bonded to the source container and are grounded.

Note: See Section 5 for further information.

C.3.7 Determine the amount of product to be transferred and ensure that the vacuum truck cargo tank has sufficient capacity. Bond gaging equipment to the source container prior to insertion.

C.3.8 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 gages and the transfer time to stop transfer operations when the cargo tank is full, and before a spill or release occurs.

C.3.9 Using a vacuum flow chart for the pump in use, determine the amount of vacuum and flow rate required to transfer the liquid.

Note: See Table C-1 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.3.10 After developing the flow rate for a 100-ft long hose, calculate the adjustment needed to determine the flow rate for the specific diameter and length of hose that will be used for the specific transfer.

Note: See Table C-2 for Hose Flow Rate Adjustment.

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

Note:

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" Hg.

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

Step 2. Vacuum pump rating (24" Hg) minus (16" Hg) = 8" Hg (Table C-1).

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

Step 4. The flow rate in a 50-ft long hose is 145.4% of that in a 100-ft long hose (Table C-1). 145.4% x 445 = 647 gpm (flow rate in 50-ft, 4-in. diameter hose)

C.3.11 Open the top isolation valves, close all other valves, and set the pump to operate in the vacuum mode.

C.3.12 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. Keep the suction hose submerged or connected during the entire operation to minimize the amount of entrained air in liquids entering the vacuum truck cargo tank.

C.3.13 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.3.14 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 air flow rating in proportion to the hose diameter.

Note: See Table C-3, for suggested airflow rates when air enters the system.

Table C-3—Suggested Vacuum Pump Airflow Rate and Hose Diameter

Air Flow Hose Diameter (in inches)	300 cfm VP	500 cfm VP	700 cfm VP	1000 cfm VP
2	X			
3		X		
4			X	
6				X

C.3.15 Use a suction screen or filter, where required, to prevent undesired materials such as rocks and debris from entering the vacuum truck tank.

Note: 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.3.16 When vapor recovery is mandated, exhausted vapors may be directed back to the source tank (or vessel). In such a case, 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.

C.3.17 Alternately, exhausted vapors may be directed to a portable or facility vapor recovery unit. In such a case, 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.

Note: The potential exists for carbon absorber vapor recovery units to become saturated by vacuum pump lubricating oil or contaminated by exhaust vapors, resulting in spontaneous combustion.

C.3.18 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.

Note: The potential exists for carbon-absorber canisters connected to the vacuum discharge exhaust to become saturated by vacuum pump lubricating oil, or contaminated by exhaust vapors, resulting in spontaneous combustion.

C.3.19 Where vapor recovery is not required and vapors are vented to the atmosphere, direct the released vapors away from sources of ignition, such as the vacuum truck's engine and motor vehicle paths of travel, and away from areas where people are present.

C.3.20 The potential travel path of any vapors discharged during 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 hazards, sources of ignition, and personnel exposure.

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

C.3.21 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. This will permit the operator 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.3.22 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.3.23 Load the tank until the liquid level indicator shows full or the internal shut-off device engages. When the tank is full, close the inlet valve.

C.3.24 Disengage the vacuum pump and bleed off the vacuum by opening the bleeder valve, to equalize the tank pressure. Close the isolation valve and disengage the power source.

C.3.25 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.3.26 Disconnect the bonding cable and then disconnect the grounding static line.

C.3.27 Remove the wheel chocks and assure that the vacuum truck is properly placarded, and that the shipping papers are in order for materials carried, prior to leaving the facility.

C.4 Cargo Tank Off-Loading

C.4.1 GENERAL OFF-LOADING PROCEDURES

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. 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.4.1.1 Obtain appropriate permits and work orders for this activity, as required by the facility.

C.4.1.2 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.4.1.3 Set the brakes and chock the wheels.

C.4.1.4 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 vacuum truck is both grounded and bonded to the receiving truck, tank or vessel.

C.4.1.5 Place an appropriate portable fire extinguisher (minimum 20 lb. BC), ready for use, within close proximity to the operation.

C.4.1.6 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 product.

C.4.1.7 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 receiving container with an ohmmeter. If thin-walled conductive hose or nonconductive 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

Note: See Section 6 for further information.

C.4.1.8 Determine the amount of product to be transferred and ensure that the receiving container tank has sufficient capacity. Bond the gaging equipment to the receiving container prior to insertion.

C.4.1.9 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 gages and the transfer time to stop transfer operations before the receiving container is full—so as to avoid a spill or release.

C.4.1.10 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.

Note: The potential exists for carbon-absorber vapor recovery units to become saturated by vacuum pump lubricating oil, or contaminated by exhaust vapors, resulting in spontaneous combustion.

C.4.1.11 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. The potential travel path of vapors that are 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 hazards, sources of ignition and personnel exposure.

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.4.1.12 When off-loading flammable liquids or hazardous materials, the truck operator should stay within 25 ft of the truck (between the vacuum truck and the receiving container) throughout the operation. This is required in case it is necessary 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.4.1.13 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.4.1.14 Load the receiving container until all product is transferred out of the vacuum truck cargo tank; or when the container reaches full capacity (when the receiving container's liquid level indicator shows "full" or the high-level alarm signal activates). Do not overfill the receiving container.

C.4.1.15 When the receiving container is full and the transfer is completed, close the inlet valve. Disconnect the transfer hose and drain any liquid into a proper container. Immediately report any releases or spills to facility management.

C.4.1.16 Disconnect the bonding cable and then disconnect the grounding static line.

C.4.1.17 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, prior to leaving the facility.

C.4.2 GRAVITY OFF-LOADING PROCEDURES

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

C.4.2.1 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.4.2.2 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 PROCEDURES

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

C.4.3.1 Use a vacuum flow chart for the pump in use to determine the amount of pressure and flow rate required for the transfer.

Note: See Table C-1, Vacuum Flow Rate Table, as an example of how to use charts to determine vacuum/pressure flow rates for different lifts, vacuums and various hose diameters and lengths.

C.4.3.2 Close all bleed and drain valves.

C.4.3.3 Start the power source and engage the vacuum pump, to operate in pressure (reverse) mode.

C.4.3.4 Pressure the vacuum truck cargo tank. Do not exceed the pressure-relief valve setting or the maximum allowable working pressure that is indicated by the tank data plate, whichever is lower.

C.4.3.5 Open the truck discharge valve to off-load. Start discharging at a slow speed until the end of the discharge hose is submerged to minimize spraying or splashing of product or materials.

C.4.3.6 Stay clear of the discharge line hook-up because liquid products, rocks, and debris may be discharged under considerable pressure.

C.4.3.7 When pressure off-loading, decrease the pump-off rate near the end of the transfer to avoid over-pressuring the receiving container.

C.4.3.8 Close the discharge valve when off-loading is complete. Disengage the vacuum pump and bleed off the pressure by opening the bleeder valve, to equalize the tank pressure. Close the isolation valve and disengage the power source.

C.4.3.9 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 PROCEDURES

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

C.4.4.1 Close all bleed and drain valves.

C.4.4.2 Connect the source of pressurized air or inert gas to the vacuum truck inlet valve.

C.4.4.3 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.4.4.4 Open the truck discharge valve to begin off-loading. 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 because liquid products, rocks, and debris may be discharged under considerable pressure.

C.4.4.5 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.4.4.6 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 to equalize the tank pressure. Close the isolation valve and disengage the power source.

C.4.4.7 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.4.4.8 When venting 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. 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 must be considered prior to starting operations.

C.4.4.9 When off-loading using inert gas, the vacuum truck cargo tank should be placarded, or warning posted—such as a tag attached to the cargo tank opening—to the effect that the tank contains inert gas.

C.4.5 EXTERNAL TRANSFER (AUXILIARY) PUMP OFF-LOADING PROCEDURES

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

C.4.5.1 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.

Note: See Table C-1 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.4.5.2 Close all bleed and drain valves.

C.4.5.3 Start the power source and engage the auxiliary pump, operating in pressure mode.

C.4.5.4 Open the truck discharge valve to begin off-loading. Start discharging 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 because liquid products, rocks, and debris may be discharged under considerable pressure.

C.4.5.5 Decrease the pump-off rate near the end of the transfer to avoid over-pressuring the receiving container.

C.4.5.6 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.4.5.7 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.

APPENDIX D—SAFE OPERATION OF VACUUM TRUCKS AT SERVICE STATIONS, ETC.

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 as a result of 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

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.

Note: See 5.6 for additional information.

D.2.1 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 least 10% of the lower flammable limit.) Entry of personnel without appropriate respirators, or entry of vehicles into such an area 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.

D.2.2 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.

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, are 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.

Note: See 5.6.2 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 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.

Note: Where a specific product is involved, an MSDS may 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 MSDS may be unavailable and other appropriate information will be required.

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 numbers or other means of contacting facility personnel and appropriate emergency responders.

D.4.2 VACUUM TRUCK (TANK TRUCK) LOADING PROCEDURES

Vacuum truck (tank truck) operators should be aware of the following minimum safe work practices when transferring products from underground tanks:

D.4.2.1 Position the vacuum truck (tank truck) on level ground, at least 25 ft away from, and preferably upwind of, the underground tank.

Note: The location of the vacuum (tank) truck is 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 a depressed or enclosed area, or near a public roadway.

D.4.2.2 Assure 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 prevent motor vehicles and unauthorized personnel from entering.

D.4.2.3 Obtain a permit for this activity if required by local regulations or company procedures.

D.4.2.4 Set the brakes on the vacuum truck (tank truck) and place chocks under the wheels to prevent accidental movement. Bond (and ground) the vacuum truck (tank truck) to the fill box, or fill pipe, of the underground tank being emptied.

D.4.2.5 Gage the underground tank(s) to be emptied to determine if 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 so that the product transfer is stopped prior to overfilling the vacuum tank (or tank truck compartment).

D.4.2.6 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.

Note: See Table C-1 for an example of how to use charts to determine vacuum/pressure flow rates for different lifts, vacuums and various hose diameters and lengths.

D.4.2.7 After developing the flow rate for a 100-ft long hose, calculate the adjustment needed 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.4.2.8 Place an appropriate portable fire extinguisher (minimum 20 lb. BC), ready for use in the event of an emergency, within close proximity to the operation (e.g., placed between the storage tank fill pipe connection and the vacuum truck or tank truck).

D.4.2.9 Use approved conductive hose, couplings, connectors, and nozzles that are in good condition, for the product transfer. If thin-walled conductive hose or nonconductive hose is used, assure that all-conductive coupling, 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.4.2.10 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. Assure that all hose couplings, nozzles, etc. are tightly connected. Open the underground tank-fill connection and insert the suction tube.

Note: In areas where vapor recovery is required, use of a modified coaxial fitting is recommended.

D.4.2.11 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.

D.4.2.12 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.

Note: The potential exists for carbon absorber canisters to become saturated by vacuum pump lubricating oil, or contaminated by exhaust vapors, resulting in spontaneous combustion.

D.4.2.13 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).

D.4.2.14 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, paths of motor vehicle travel, and away from areas where people are present. The potential travel path of vapors that are 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. 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, away from sources of ignition and other hazards, during the loading operation.

D.4.2.15 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.

Note: Operators shall stay within the operational limits of the equipment as established by the equipment manufacturers to prevent overpressurizing 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.4.2.16 Use a suction screen, where required, to prevent undesired materials such as dirt, rocks, rust and debris from entering the vacuum tank.

Note: If the vapor air mixture in the underground tank is within the flammable range, the suction screen could create a static spark hazard.

D.4.2.17 Minimize entrained air (air entrapment) with liquids entering the vacuum truck cargo tank (tank truck compartment), by keeping the suction tube submerged into 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 air flow rating (transfer pump speed) according to the tube and hose diameter (as suggested in Table C-3).

D.4.2.18 Stay within 25 ft of the truck (between the truck and the underground tank) throughout the operation 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.4.2.19 Load the vacuum truck cargo tank (tank truck compartment) until the liquid level indicator shows 90% full or the internal shut-off device engages. When the vacuum truck cargo tank (tank truck compartment) is full, close the inlet valve.

D.4.2.20 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.4.2.21 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 in an approved container for proper disposal. Immediately report any spills or releases of product to the facility manager.

D.4.2.22 Disconnect the bonding cables and then disconnect the grounding static line.

D.4.2.23 Prior to leaving the facility, the vacuum truck (tank truck) operator should remove the wheel chocks, assure that the cargo tank is properly placarded for highway transportation, and that the shipping papers are in order for the materials being transported.

APPENDIX E—PNEUMATIC CONVEYOR TRUCKS

E.1 General

In the petroleum industry, nonliquid, 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.

E.2 Pneumatic Conveyor Trucks and Cargo Tanks

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.2.1 Requirements for pneumatic conveyor truck engines and motor driven pneumatic conveyor equipment should meet or exceed NFPA 505.

E.2.2 Spark arrestors that are provided on the exhaust stacks of diesel powered pneumatic conveyor trucks should be cleaned or replaced according to the manufacturer's recommendations.

E.2.3 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 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.

E.3.1.1 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 cfm to 5,000 cfm (although they typically operate below 1,000 rpm), and high vacuum levels.

Note: Some manufacturers have recently 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:

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" 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 airflow 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.

d. For these 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

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 assure 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. Do not open pneumatic conveyor truck cargo tank (or hopper) hatches or valves or disconnect hoses while under pressure.

d. Be aware of the hazard of over-pressuring the receiving container or tank due to blocked or improperly sized vents.

e. Do not attempt to convey material before the compressor reaches proper operating speed.

f. Blower failure may be caused by operating too fast, too slow or at excessive high pressure.
g. Remove surface dust from engines and motor driven equipment at regular intervals during operation. Do not clean equipment 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 noncombustible dry waste or heavy nonflammable tank bottoms. This operation requires continuous monitoring of hydrocarbon vapor/air concentrations, by a qualified person, at the point of pick-up—to ensure that the incoming air stream to the pneumatic truck is kept below 20% LFL (Lower Flammable Limit) to minimize the risk of ignition.

E.4.1 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 trained and aware of the following safe practices:

a. The specific 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.

Note: Where a specific product is involved, an MSDS may 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 MSDS may not be available and other appropriate information will 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 numbers or other means of contacting facility personnel and appropriate emergency responders.

E.4.2 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.4.2.1 When loading and off-loading, assure that the pneumatic truck tank or hoppers and the receiving containers, have sufficient capacity for the amount of materials to be transferred.

E.4.2.2 When off-loading, check that the receiving container has adequate venting capacity for the flow rate of the air used to unload.

E.4.2.3 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.4.2.4 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.4.2.5 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.4.2.6 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.

E.4.2.7 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.4.2.8 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.4.2.9 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.4.2.10 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.4.2.11 When transferring flammable liquids or hazardous materials, stay within 25 ft of the pneumatic conveyor truck (between the truck and the source) throughout the operation. This will permit the operator 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.4.2.12 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.4.2.13 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.4.2.14 The pneumatic truck cargo tank or hoppers should be loaded until the level gage 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.4.2.15 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.4.2.16 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.4.2.17 When loading/off-loading is completed, assure all valves are closed and disconnect all hoses, bonding and grounding cables.

E.4.2.18 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.

APPENDIX F—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 not always recognized that even trace amounts of hydrocarbon condensate, when placed under vacuum, can produce flammable vapor in air mixtures; and that appropriate precautions are required.

The following are examples of incidents that have occurred during vacuum truck operations:

F.2 Spills

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

F.2.2 Defective float valves on both inside and outside vacuum cargo tank scrubbers prevented the 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 previously been used for two other jobs; and the fire occurred before it could be taken out of service and replaced.

F.3.4 Either an impact spark or a static spark caused an off-loading fire from a coupling that disconnected when an off-loading hose was dropped into a storage tank. Another cause of a fire were sparks created by the whipping action of the discharge hose during off-loading.

F.3.5 Reports of internal explosions or fires within vacuum truck cargo tanks are very rare; however, incidents that have been reported point out the need for exercising great care in the mixing of incompatible materials, and the vacuum-removal of dusts. Static ignition has occurred while dry, powdered sulfur was being suctioned from a pit—resulting in an explosion within the vacuum truck. Other internal ignitions have occurred from pick-up of flint-type rocks and other sparking objects.

F.3.6 A fire occurred when a nonconductive hose was used to vacuum product from a small container. Apparently, sparks created a source of ignition at the point where the hose and the edge of the container came into contact.

F.4 Hose Failures

F.4.1 A vacuum truck operator suffered 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 Miscellaneous Incidents

F.5.1 Light ends, including 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 a vacuum.

F.5.2 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.5.3 A vacuum truck was being used to remove product from a pipeline when the line was activated and over-pressured the vacuum tank.

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