# Marine Vapor Control Training Guidelines

API RECOMMENDED PRACTICE 1127
FIRST EDITION, NOVEMBER 1993

**American Petroleum Institute**
1220 **L** Street, Northwest
Washington, D.C. 20005

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**Manufacturing, Distribution and Marketing Department**

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# FOREWORD

This recommended practice was developed under the direction of the API Marine Transportation Committee in cooperation with the Independent Liquid Terminals Association, The American Waterways Operators, and the American Institute of Merchant Shipping. This publication is intended to introduce uniformity in marine vapor control personnel training programs for tank ships, tank barges, and marine terminals required to operate vapor collection systems for the transfer of gasoline, crude oil, and benzene.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution and Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005.

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# Marine Vapor Control Training Guidelines

## SECTION 1—GENERAL

### 1.1 Objective and Scope

The objective of this recommended practice is to provide guidelines for developing marine vapor control (also referred to as marine emission control) shore and shipboard training programs in order to comply with U.S. Coast Guard regulations (33 *Code of Federal Regulations* Part 154.840 and 46 *Code of Federal Regulations* Part 39.10-11). These regulations outline vapor collection system safety requirements for the transfer of crude oil, gasoline, and benzene.

This recommended practice is not intended to be a comprehensive technical document. Where appropriate, training supervisors must expand on the facility-specific procedures to be followed. This recommended practice does review the U.S. Coast Guard regulatory requirements for safe operation of vapor control systems. Persons needing technical information on a particular marine vapor control system must not use this document but must refer to the appropriate manufacturer's technical documents or similar materials. Training supervisors must also be aware that state regulations may sometimes exceed federal guidelines. When this occurs, the state regulations must be followed.

### 1.2 Glossary

Definitions of the technical terms used throughout this document may be found in Appendix D.

### 1.3 Referenced Publications

The most recent editions of the following standards, codes, manuals, and specifications are cited in this recommended practice.

**ABS**[1]

*Cargo Vapor Emission Control Systems on Board Tank Vessels*
*Rules for Building and Classing Steel Vessels*

API

| | |
|---|---|
| RP 1124 | *Ship, Barge, and Terminal Hydrocarbon Vapor Collection Manifolds* |
| RP 1125 | *Overfill Control Systems for Tank Barges* |
| RP 2003 | *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents* |

DOT[2]

*33 Code of Federal Regulations* Parts 154, 155, and 156
46 *Code of Federal Regulations* Parts 1–69 and 90–139

EPA[3]

*40 Code of Federal Regulations* Part 60, Appendix A

**IEEE**[4]

| | |
|---|---|
| IEEE-45 | *Recommended Practice for Electrical Installation on Shipboard* |

ISA[5]

| | |
|---|---|
| RP 12.6 | *Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations* |

### 1.4 Introduction

During the loading of crude oil, petroleum products, and benzene into vessels, the loaded liquid displaces the vapors inside the cargo tanks. These displaced vapors contain residual hydrocarbons left in the compartment at the beginning of the cargo transfer. As the transfer progresses, vapors are generated from the liquid entering the compartment. These hydrocarbons are mixed with air for noninerted vessels. For inerted cargo tanks, the hydrocarbons are mixed with nitrogen, inert exhaust stack gas, carbon dioxide, or some other type of inert gas. The vapors that exit the vessel contribute to air pollution if they are released directly into the atmosphere. The released hydrocarbon vapors may be hazardous to persons who breath them or physically come in contact with them and may cause a fire or explosion if flammable vapors contact an ignition source.

In an effort to control the emission of these vapors, federal, state, and local environmental agencies have mandated the use of marine vapor control systems. These systems collect the vapors as they are generated during loading and either recover them or destroy them by such means as combustion.

[1]American Bureau of Shipping, Two World Trade Center, New York, New York 10048.

[2]Department of Transportation. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

[3]Environmental Protection Agency. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

[4]Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, New York 10017.

[5]Instrument Society of America, 67 Alexander Drive, Box 12277, Research Triangle Park, North Carolina 27709.

The U.S. Environmental Protection Agency (EPA) currently has requirements for collecting emissions from benzene loading (see Appendix E). The EPA is developing additional regulations for collecting emissions from any cargo that is considered a volatile organic compound (VOC). Several states and local jurisdictions are proposing, or already have proposed, requirements for the control of emissions from the loading of gasoline or crude oil. The U.S. Occupational Safety and Health Administration (OSHA), while not requiring marine vapor control, does regulate personnel exposure to certain vapors, and such exposure is limited as a result of marine vapor control.

While the decision to require marine vapor control is made by environmental or health agencies, regulations for marine system safety are the sole responsibility of the U.S. Coast Guard. The U.S. Coast Guard published regulations on June 22, 1990, governing the safety of all aspects of marine vapor control systems, whether located on shore or on vessels. These regulations became effective July 23, 1990, and are applicable to all systems that recover or destroy emissions from the loading of vessels.

The regulations represent a set of minimum requirements for marine emission control installations. All facilities must meet these guidelines. However, some facilities may exceed the minimum standards.

As part of the regulations, the U.S. Coast Guard requires that both vessel and shore personnel are trained in the operation of marine emission control systems. This document provides guidelines for training those personnel.

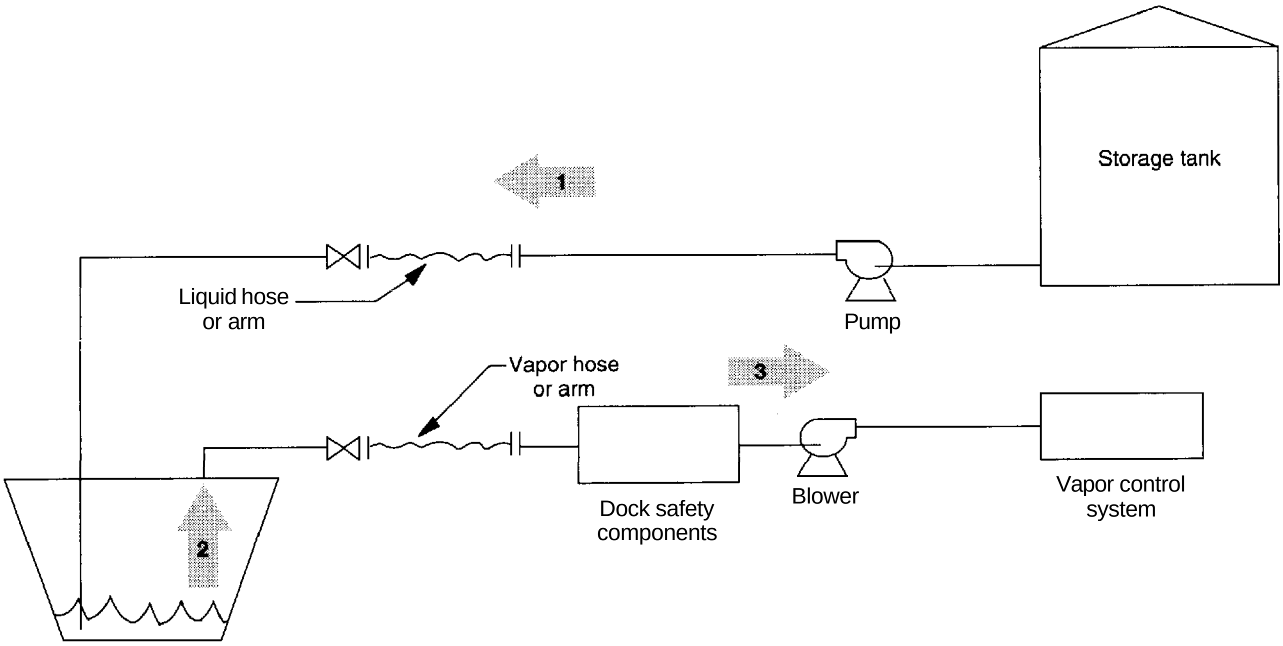
## 1.5 System Overview

The process of loading a vessel with ballast or liquid hydrocarbons results in the displacement of the vapor from the compartment (see Figure I). To prevent the release of vapors into the atmosphere, piping is installed to collect the vapors and direct them to a manifold on deck. As the cargo tanks are loaded with liquid, the vapors are displaced into the piping either by the positive pressure created by the rising liquid or by a negative pressure at the manifold created by a vacuum pump. The rate of vapor flow through the piping is set by the liquid loading rate.

Displaced vapors from the vessel move through the manifold, through a vapor collection hose or arm, through a series of safety devices and a piping system to the terminal's vapor control system. (See Figure 1 for a general system diagram.)

Several technologies are currently used to control hydrocarbon vapors generated from loading vessels, including the following:

a. Combustion in an enclosed refractory-lined chamber.
b. Combustion in an open, smokeless flare.
c. Recovery by carbon adsorption.
d. Recovery by refrigeration.
e. Recovery by lean-oil absorption.
f. Recovery and recycling to plant-fuel gas systems.




1. Liquid is pumped into the vessel.
2. Rising liquid level forces vapors into a vapor collection header on the vessel.
3. Collected vapors are pushed by pressure or pulled by vacuum into a vapor control system.

Figure 1—Marine Emission Control Schematic

### 1.5.1 ENCLOSED COMBUSTION

Enclosed combustion systems are commonly used to reduce hydrocarbon emissions. All combustion and flare systems are referred to generically as destruction systems in the U.S. Coast Guard regulations. Enclosed combustion systems burn the collected vapors in a refractory-lined vessel. These systems completely hide the flame generated from the burning of hydrocarbons. Natural gas or other fuel is added to the stream to increase combustion efficiency, and combustion air is controlled to maintain high temperatures inside the combustion chamber.

Depending on the controls added to the system, combustion efficiency is as high as 99 percent. In addition, the emissions from the combustor are sampled before being emitted into the air.

Enclosed combustion systems are relatively inexpensive when compared to the recovery methods and have relatively low maintenance requirements. However, certain area regulations or a company policy prohibiting flames near loading docks may eliminate combustion systems from consideration.

### 1.5.2 OPEN FLARES

Open flares are the least expensive method for reducing hydrocarbon emissions. These systems burn the collected vapors at the top of a flare stack. The flame is completely open to the atmosphere and is not hidden from view.

Open flares include pilots (small igniting flames) at the top of the flare tip that are fueled by natural gas, propane, or some other available fuel. The pilot ignites the vapors as they exit the piping at the top of the flare. In addition, the open flares also include air blowers that inject air into the vapors as they exit the flare tip. The turbulent mixing of air into the vapors allows the vapors to burn without smoking.

Open flares are 98 percent efficient, as long as the heat content of the vapors being burned is maintained at or above 300 British thermal units per standard cubic foot (BTU/scf). This requires injection of natural gas or some other heat source into the stream before it is burned. For vapor collection systems that use enrichment to maintain the collected vapors above the upper flammability limit, the 300 BTU/scf limit is generally maintained by injection at the dock. For inerting or diluting systems, the fuel has to be added at the flare.

As with enclosed flares, local regulations or company policy may dictate that other means are used to reduce the hydrocarbon emissions.

### 1.5.3 CARBON ADSORPTION SYSTEMS

Carbon adsorption systems effectively recover certain hydrocarbons for return to the storage tanks from which they were taken. All carbon adsorption, refrigeration, lean-oil, and other similar systems are referred to generically as vapor recovery units in the U.S. Coast Guard regulations. These systems have been used successfully in many gasoline truck loading facilities throughout the world.

The recovered vapors are passed through one of two or more carbon beds located at the vapor recovery system. The hydrocarbons are adsorbed by the carbon much like a sponge soaks up water. Like a sponge, at a certain point the carbon is no longer able to hold any additional hydrocarbons. When full capacity is reached, the vapors are directed to a different bed that has the capacity to hold them.

Beds that have reached their capacity to hold hydrocarbons are regenerated to restore their working capacity. This is normally done by subjecting the bed to a vacuum by using a vacuum pump that is a part of the system. The vacuum pump lowers the pressure in the carbon holding tank. The reduced pressure in the tank causes the carbon to "let go of' (desorb) the adsorbed hydrocarbons. The desorbed hydrocarbons are drawn into the vacuum putnp and discharged into an absorption tower.

In the absorption tower, the vapors are absorbed into a liquid stream drawn from a storage tank. Therefore, the recovered vapors end up back in the storage tank from which they were originally taken or in another tank at the shore facility.

Carbon adsorption systems are 98 percent and greater efficient, depending on design parameters set by the company that provides the system. Carbon adsorption systems are more expensive to operate and maintain than combustion systems, but they do provide a payback from the hydrocarbons that are recovered.

Carbon adsorption systems have no hidden or open flames, which is an attractive feature to some companies.

### 1.5.4 REFRIGERATION SYSTEMS

In refrigeration systems, the recovered vapors are brought in contact with cooling coils. The recovered hydrocarbon is condensed and pumped back into the liquid storage tank from which it came.

The cooling coils are maintained at low temperatures by a refrigerant system similar to the air conditioning systems used in houses, except it operates at much lower temperatures. **A** refrigerant such as Freon[a] is compressed, cooled, and then expanded. This process causes the temperature of the refrigerant to drop to the levels necessary for efficient condensation of the collected vapors.

Refrigerant systems are 98 percent and greater efficient, depending on the temperature of the refrigerant. Typical refrigerant systems are expensive to operate and maintain.

### 1.5.5 LEAN-OIL ABSORPTION

In a lean-oil absorption system, the collected vapors are brought in contact with an oil that absorbs the hydrocarbon from the vapors. The vapors contact the lean oil inside a column filled with a packing material. The purpose of the material is to expose a large surface area of oil to the vapors.

The efficiency of a lean-oil absorption system depends on the lean oil available. If the proper lean oil is selected and available at the dock, high efficiencies are achieved.

Lean-oil systems are relatively inexpensive to operate and maintain, but lean oils are typically not available in significant quantities at the dock. If the lean oil must be regenerated and used repeatedly, the operating costs of the system increase rapidly.

### 1.5.6 RECYCLING TO A PLANT-FUEL GAS SYSTEM

In a recycling system, the collected vapors are compressed and introduced into a plant-fuel gas system. This system can be very effective, especially for facilities with large plant-fuel gas consumption where the vapors will not significantly affect the plant-fuel gas characteristics.

The efficiency of this approach is high when all vapors can be absorbed by the plant-fuel gas system. Installed cost is also attractive. Treating the vapors with methods such as dehydration before mixing with plant-fuel gas may be required, and this will add to equipment cost.

Cleaner vapors such as gasoline or benzene are better suited to this recovery method.

## 1.6 Hazards

The hazards associated with operating marine vapor control systems are identified in 1.6.1 through 1.6.7. These hazards are addressed by the design and operating requirements of the U.S. Coast Guard regulations. A properly designed and operated system minimizes these hazards.

### 1.6.1 FIRE AND EXPLOSION

Marine vapor control systems involve the movement of vapors through a piping system that connects a vessel to shore equipment. An external ignition source or even the failure or malfunction of a marine vapor control system component may result in a fire and/or explosion. In the event of a fire or explosion, failure of in-line safety devices may result in personnel injury, including loss of life; environmental damage from oil spills; and financial loss from damage to the marine vapor control system and possibly to the vessel and terminal.

### 1.6.2 OVER- OR UNDERPRESSURIZATION

As with any closed loading operation, the possibility of overpressurization exists. Pressure increases are the result of any condition that causes the liquid loading rate to exceed the rate at which displaced vapors, including vapor growth, are vented. Overpressure occurs when the pressure increase exceeds the design operating pressure. If the vessel's pressure relief valves malfunction or are set too high, compartment warping, hull failure, and/or rupture occurs. These problems lead to spills, fire, or explosion.

Underpressurization occurs when vapors leave the cargo tank more rapidly than liquid enters the tank. This can occur with any system that utilizes in-line blowers or vacuum systems. Malfunction of the pressure relief valves or improperly high pressure relief set points can result in cargo tank warping, hull failure, and/or rupture. Spills, fire, or explosion then occur.

### 1.6.3 OVERFILLING

Since marine vapor systems involve closed loading operations, the ability of personnel on the vessel to visually observe the level of the liquid in a cargo tank may be limited. Therefore, personnel must have monitoring instrumentation, alarms, and overfill protection equipment such as automatic shutdown systems to prevent the overfilling of cargo tanks. Mechanical devices such as spill valves and rupture disks protect the vessel hull by permitting a controlled release of liquid. Failure of these devices leads to spills, tank rupture, fire, or explosion.

### 1.6.4 MISCONNECTION OF LIQUID AND VAPOR LINES

The proximity of the liquid and vapor lines raises the possibility these lines may be misconnected, even though they are configured differently. Misconnection of these lines leads to liquid entering a vessel through the vapor lines and to the possibility of static ignition of vapors due to free falling of liquid into an empty compartment. Misconnection of lines is addressed further in 2.2.5 and 3.2.6.

### 1.6.5 CONDENSATION IN THE VAPOR LINE

Hydrocarbons and water vapor condense into liquids. Such condensed liquids present a hazard in the form of liquid "slugs" that are propelled down a vapor line, potentially damaging system equipment. The presence of liquids in the vapor lines reduces the cross sectional area of the pipe, thereby increasing the pressure drop and causing increased back pressure on the vessel.

### 1.6.6 PYROPHORIC IRON SULFIDE DEPOSITS

The buildup of pyrophoric iron deposits and the potential for ignition of those deposits exist in systems that use inert gas or are loading high-vapor-pressure crude oils containing hydrogen sulfide. Detection and avoidance of this hazard are difficult; therefore, efforts to minimize the potential are important.

### 1.6.7 STATIC ELECTRICITY DISCHARGE

High initial loading rates, misconnection of liquid and vapor lines, and improper gauging are some of the sources of static discharge. If the vapor content within a tank or pipe is in the explosive range, fire or explosion may result.

# SECTION 2—VESSEL COMPONENTS AND SAFETY AND OPERATING CONCERNS

The following section addresses vessel components and safety and operating concerns associated with marine vapor control systems. Shore components and concerns are covered in Section 3.

## 2.1 Vessel Components

For many years, vessels of various configurations have been used to move a great variety of liquid products from port to port. These vessels have many types of components. Some of the more common ones are listed below:

a. One or more compartments for holding liquid.

b. **A** liquid loading header for connecting product loading hoses. This header system distributes the liquid throughout the vessel and has at least one pipe, or drop, that extends nearly to the bottom of each compartment. This drop reduces the splashing that occurs if the product is allowed to free-fall from the top of the compartment. By reducing splashing, the accumulation of static in the cargo liquid is reduced.

c. Cargo tank hatches left open during loading to monitor the level in the compartment. After loading, all cargo hatches are closed during transit.

d. A pressure relief valve and vacuum relief valve in each compartment to allow for expansion and contraction of the product due to thermal changes during transfer and transit.

e. A cargo transfer system for loading and unloading the liquid cargoes.

f. Inerting systems on some vessels to keep oxygen levels in the compartments at or below 8 percent by volume by filling the compartment with nitrogen, exhaust stack gas, carbon dioxide, or other inert gas.

Vessels that are to be connected to vapor collection systems will have some modifications. These modifications may include the following components, some of which are optional:

a. A vapor collection header to collect vapors generated from each compartment during loading. The header sometimes includes valves to isolate one compartment from another. The header extends from the top of each compartment, comes together into a common line along the length of the vessel, splits at a tee junction, and terminates on both sides of the vessel near the liquid loading connection.

b. Pressure relief and vacuum relief valves. These are sized to relieve vapors at a rate equivalent to the maximum loading rate of the vessel and to break vacuum at the maximum unloading rate of the vessel unloading pumps.

c. On some vessels, closed inspection openings (see Figures C-8 and C-9) consisting of a glass viewing port, typically with an internal wiper blade and a cover to protect the glass when not in use. All vessels must be fitted with a gauging system to aid in determining the cargo level (see Figure C-7).

d. The vessels must be equipped with a type of overfill protection system. Four methods are currently accepted by the U.S. Coast Guard for preventing structural failure due to overfilling (see 2.2.2).

## 2.2 Safety Concerns

### 2.2.1. GENERAL

The addition of closed loading complicates the loading of a vessel. The main safety concerns associated with closed loading are as follows:

a. Overfilling the vessel, since viewing the product level must now be done through smaller glass viewing ports or indirectly by mechanical means.

b. Overpressuring the vessel due to the pressure drop in the vapor collection header on the vessel and the vapor collection system on shore.

c. Underpressuring the vessel due to the addition of blowers, compressors, or eductors in the shore vapor collection system.

The addition of vapor connections on the vessel to accommodate closed loading creates the possibility of the following misconnections:

a. Vapor lines incorrectly connected to liquid headers on the vessel.

b. Liquid lines incorrectly connected to vapor headers on the vessel.

### 2.2.2 OVERFILLING THE VESSEL

#### 2.2.2.1 General

In the past, vessels were loaded through an open cargo system. The vapors were allowed to vent through the compartment openings, and the vessel liquid level was easily determined by visual inspection through the open hatches.

With the introduction of vapor collection, all openings in the vessel must now be closed tightly to prevent fugitive vapor emissions to the atmosphere. Cargo liquid levels are watched through glass viewing ports (see Figures C-8 and C-9). To further aid in determining the cargo level, a ship's compartments are required to have a cargo gauging system that allows the operator to determine the liquid level in any compartment (see note).

Note: Barges that do not have an on-board liquid overfill protection system are required to provide a means of visually indicating the liquid level in the compartment during the final 3.3 feet (1.0 meter) (see Figures C-14A, C-14B, and C-15).

A variety of visual aids are being used. Some of these aids are as follows:

a. Individual ladder rungs color coded to indicate approximate level. This method requires that the ladder is visible from the glass viewing port.
b. Tabs or indicators fixed to the ladder or compartment wall to indicate approximate level.
c. Hinged paddle floats with numbers inscribed on the paddle, so the number is visible if the paddle is raised.
d. Gauge rods magnetically coupled to floats that rise as the level increases. The rods are sometimes color coded to give a better indication of the level in the compartment when viewed from a distance. The gauge rod may be part of a level alarm system if internal magnets are used to activate a proximity switch.
e. Dip sticks.

The U.S. Coast Guard has recognized that it is increasingly difficult to determine the cargo level in closed vessels. In addition, it has recognized the increased likelihood of structural damage to the vessel because of the potential for an overfill. To further reduce the possibility of overfilling, U.S. Coast Guard regulations require the installation of one of the following four protection methods:

a. Spill valves (see Figures C-10 and C-11)
b. Rupture disks (see Figure C-12).
c. On-board monitoring systems.
d. Shore monitoring systems.

### 2.2.2.2 Spill Valves

#### 2.2.2.2.1 General

A spill valve is a device located on the deck of each cargo compartment to prevent overpressurization of the compartment by opening to relieve pressure at a predetermined setting. The pressure relief set point of the spill valve must be greater than the pressure relief set point of the pressure relief valve of the vapor collection header. Spill valves typically are spring loaded, pressure weighted, or have some other means of allowing the valve to reclose once the pressure in the vessel is released. Spill valves must automatically reseat to prevent the release of vapors once the overfill pressure has been released. (See Figures C-10 and C-11 for examples of spill valves.)

#### 2.2.2.2.2 Vessel Person-in-Charge Responsibilities

a. The person in charge of transfer operations on the vessel (vessel PIC) must provide the person in charge of transfer operations on the shore (shore PIC) with information detailing the type of overfill system provided on the vessel.
b. The vessel PIC must advise the shore PIC of the method to be used to indicate a spill valve has opened. Procedures to follow once a spill valve has activated must also be discussed.
c. The vessel PIC must be familiar with the location of each spill valve.
d. The vessel PIC must be familiar with the pressure set point that causes the spill valve to open.
e. The vessel PIC must monitor the level indicators provided on the vessel to prevent overfills from occurring.
f. If a spill valve opens, a spill to the atmosphere is likely to occur. The vessel PIC must be familiar with the procedure he is to follow as the result of a spill.
g. If the spill valve is equipped to allow testing, it must be tested before each loading to make sure it is operating properly. If the spill valve is capable of being isolated or secured in a closed position, the vessel PIC must determine the valve is operational and not isolated.

### 2.2.2.3 Rupture Disks

#### 2.2.2.3.1 General

A rupture disk is a thin metal membrane sandwiched between special flanged holders. (See Figure C-12 for an example of a rupture disk.) The disk is designed and tested to burst open at a set pressure to prevent the overpressurization of the cargo compartment as a result of being liquid-full. Once ruptured, the disk cannot reclose and must be replaced. The pressure relief set point of the rupture disk must be greater than the pressure relief set point of the pressure relief valve of the vapor collection header. Some installations will be isolated by valves to prevent rupture from liquid movement during transfer.

#### 2.2.2.3.2 Vessel PIC Responsibilities

a. The vessel PIC must provide the shore PIC with information detailing the type of overfill system provided on the vessel.
b. The vessel PIC must advise the shore PIC of the method to be used to indicate a rupture disk has opened. Procedures to follow once a rupture disk has activated must be discussed.
c. The vessel PIC must be familiar with the location of each rupture disk.
d. The vessel PIC must be familiar with the pressure set point that causes the rupture disk to open.
e. The vessel PIC must make sure replacement rupture disks are available aboard the vessel and must be familiar with the replacement procedure.
f. The vessel PIC must monitor the level indicators provided on the vessel to prevent overfills from occurring.
g. If a rupture disk opens, a spill to the atmosphere is likely to occur. The vessel PIC must be familiar with the procedure he is to follow as the result of a spill.
h. If an isolation valve is provided to protect the rupture disk during transfer, the vessel PIC must make sure it is open prior to cargo transfer.

#### 2.2.2.4 On-Board Monitoring Systems

##### 2.2.2.4.1 General

On-board monitoring systems use level sensors that are permanently installed in each vessel compartment (see Figures C-13A and C-13B). The level sensors have two alarm points, one that is considered a high-level alarm and another that is considered an overfill alarm. The high-level alarm occurs at no less than 95 percent of the compartment capacity. The overfill alarm sounds early enough to allow the persons in charge of transfer operations to stop the transfer before the cargo tank overfills.

The high-level alarm causes an audible and visual alarm on the vessel. The overfill alarm also causes an audible and visual alarm on the vessel, which signals the persons in charge of transfer operations to stop the loading of the vessel. This shutdown may be automatic or manual.

For many vessels, these systems are totally self-contained, and need no power from the shore. Other systems require power from shore, and a shore connection must be provided. If the shore facility cannot provide power for the overfill system and no other means of preventing overfill is available on the vessel, the loading cannot proceed while collecting vapors. If power to the overfill system fails or if the electrical circuitry to the tank level system fails, the alarm system must activate.

The level monitoring system must be provided with a mechanical means to test the overfill system in each compartment of the vessel.

##### 2.2.2.4.2 Vessel PIC Responsibilities

a. The vessel PIC must provide the shore PIC with information detailing the type of overfill system provided on the vessel.

b. If the vessel has an on-board system requiring power from the shore, the shore PIC must provide a 120 volt power source utilizing an approved explosion-proof receptacle. If power is not available from shore and there are no other means on the vessel to prevent overfill, the vessel may not be loaded while collecting vapors.

c. The vessel PIC must familiarize the shore PIC with the on-board alarm system to ensure that the shore PIC recognizes when a high-level alarm or an overfill alarm occurs.

d. During the pretransfer conference, the vessel PIC must direct the shore PIC in what is expected of him in the event of a high-level alarm and an overfill alarm.

e. Before beginning the loading, the vessel PIC must conduct a functional test of the level alarms in each compartment. The shore PIC must witness and verify that each alarm-level system is operational. If an overfill alarm does not function, the compartment with the level switch that is not working must not be loaded with cargo, unless an additional means of preventing overfill is provided.

#### 2.2.2.5 Shore Facility Monitoring Systems

##### 2.2.2.5.1 General

Shore facility monitoring systems use level sensors that are permanently installed in each compartment of the vessel. Unlike an on-board system, these level sensors are monitored by a signal generated from an overfill control panel located on shore. This panel is maintained and operated by the shore facility.

Before loading, a connection must be made between the vessel and the shore facility overfill control panel. This connection must be made by specific cable set aside for use with the overfill system. The connectors for this system meet the requirements of the International Electrotechnical Commission[5] for systems carrying 50 volts or less (see Figures C-1 and C-2). This prevents the accidental connection to other sources, such as 120 or 240 volts. In the case of the overfill control system, the U.S. Coast Guard regulations require these systems to be intrinsically safe. Intrinsically safe basically means the system does not have sufficient energy to create an incendiary spark; therefore, the system carries considerably less than 50 volts at very low currents.

The level sensor system on the vessel is designed for a capacitance and inductance specified in the U.S. Coast Guard regulations [46 *Code of Federal Regulations* Part 39.20-9(b)(4)]. The shore facility overfill control panel and its connectors are also designed to work with a certain capacitance and inductance. The capacitance and inductance of the equipment on the vessel must not exceed the design limits of the overfill control panel. The capacitance and inductance of both the vessel overfill system and the facility overfill control panel must be posted near the level sensdr system connectors.

The level sensors must have at least one alarm point that is considered an overfill alarm. The overfill alarm occurs early enough to allow the shore PIC to stop the transfer operation prior to 100 percent filling of the vessel. The overfill alarm causes both an audible and visual alarm and an automatic shutdown of the shore facility loading system.

As an option, the overfill panel is equipped so that the level sensors in each compartment cause a high-level alarm. This alarm is typically set to provide adequate warning that an overfill condition is nearing. The high-level alarm causes both audible and visual alarm signals. The vessel PIC must have a set procedure to follow when the vessel's high-level alarm set point is tripped. Generally, the vessel PIC must proceed to the position on the vessel where liquid loading is controlled and provide an indication to the shore PIC to either slow down or stop the liquid loading process.

[5]International Electrotechnical Commission, Bureau Central de la Commission, Electrotechnique Internationale, 1 rue de Varembé, Genéve, Suisse.

#### 2.2.2.5.2 Vessel PIC Responsibilities

a. The vessel PIC must provide the shore PIC with information detailing the type of overfill system provided on the vessel.
b. The vessel PIC must connect the sensing cable to the connection point provided on the vessel. The vessel PIC must make sure the capacitance and inductance of the vessel is compatible with the capacitance and inductance of the overfill control panel.
c. The shore PIC must familiarize the vessel PIC with the shore alarm system, so the vessel PIC recognizes when a high-level alarm or an overfill alarm occurs.
d. During the pretransfer conference, the vessel PIC and shore PIC must discuss what each is expected to do in the event of a high-level alarm and an ove ll alarm.
e. Before beginning the loading, the vessel PIC and shore PIC must conduct a functional test of the level alarms in each compartment. Each overfill alarm must work properly. If an overfill alarm does not function, the compartment with the level switch that is not working must not be loaded with product. If a high-level alarm does not work but the overfill alarm in the same compartment does work, the compartment may be filled if the shore PIC chooses. If the overfill system is not functional and no other means of preventing overfill of the vessel is available, the vessel must not be loaded.

### 2.2.3 OVERPRESSURING THE VESSEL

#### 2.2.3.1 General

As the vessel is filled, the vapors are collected into the vapor piping header. The header is generally a simple piping system connecting the vessel's compartments. On some vessels the various compartments are isolated by ordinary pipeline valves, and in others the vapor header is a continuous length of pipe with no isolation valves.

The individual compartment headers join to a common line running the length of the vessel. This line ends at a manifold connection located near the liquid loading manifold. Vessels generally have vapor connection manifolds on both sides. For identification purposes, the manifold is color coded with red and yellow. The word "VAPOR is stenciled in black letters on the yellow band of paint (see Figure 2).

The vapor header piping is connected by vapor hose or vapor arm to the shore facility vapor connection. This routes the vapors from the vessel compartments to the shore and then to either a recovery system or a combustion system. The shore facility vapor collection system varies in length depending on the location of the recovery or combustion system and the general space available at the dock.

The combination of the piping length and the components in the piping creates a pressure drop through the system when vapors flow. The back pressure created by the system generates the operating pressure inside the vessel compartments. This piping configuration of a closed loading system increases the possibility of overpressuring the vessel.

Operating procedures and precautionary devices added to the shore facility monitor the operating pressure of the system and alarm or shut down vapor collection when the pressure presents a danger to the vessel. These safety devices and operating practices include the following:

a. A high-pressure alarm set to cause an audible and visual alarm if the pressure in the vessel reaches 80 percent of the vessel's pressure relief valve set point. The high-pressure alarm must be tested within the 24 hours prior to loading of the vessel to make sure it is operational.
b. A high high-pressure alarm set to cause an audible and visual alarm and close the remotely operated vapor block valve if the pressure reaches 2 pounds per square inch gauge at the vapor collection header or a lesser setting agreed to by the vessel PIC and shore PIC. This pressure may be set lower if necessary to protect the vessel. The high high-pressure alarm must be tested within the 24 hours prior to loading of the vessel to make sure it is operational.
c. A pressure relief valve installed at the shore facility that is set to relieve if the pressure reaches 2 pounds per square inch gauge or less at the vapor collection header.

In addition to the shore facility safety features, all vessels are outfitted in accordance with 46 ***Code of Federal Regulations*** Part 39.20-11(a)(1), which requires a pressure relief valve that has a capacity of 1.25 times the maximum loading rate in the vapor collection header and opens at a pressure that protects the vessel from structural failure. This pressure relief valve must also include a means for testing that it opens freely and closes again after opening.

Vessels must also be equipped with an additional safety feature to prevent overpressuring the vessel (see note below). This is a high-pressure alarm that senses the pressure in the vapor collection header. The device includes a pressure indicator for pressure monitoring. The set point is no more than 90 percent of the lowest pressure relief valve setting in the cargo tank venting system.

Note: Barges are not required to have this equipment, but some may have a pressure indicator.

It is very important to make sure the vessel's compartments are never isolated from the vapor header and relief valves during loading.

#### 2.2.3.2 Vessel PIC Responsibilities

a. The vessel PIC must make sure all valves in the vapor collection header are open to allow unobstructed flow. The shore PIC shares this responsibility.
b. The vessel PIC must check the pressure relief valve in the vapor collection header to make sure it opens freely and closes after opening. If the relief valve does not open prop-

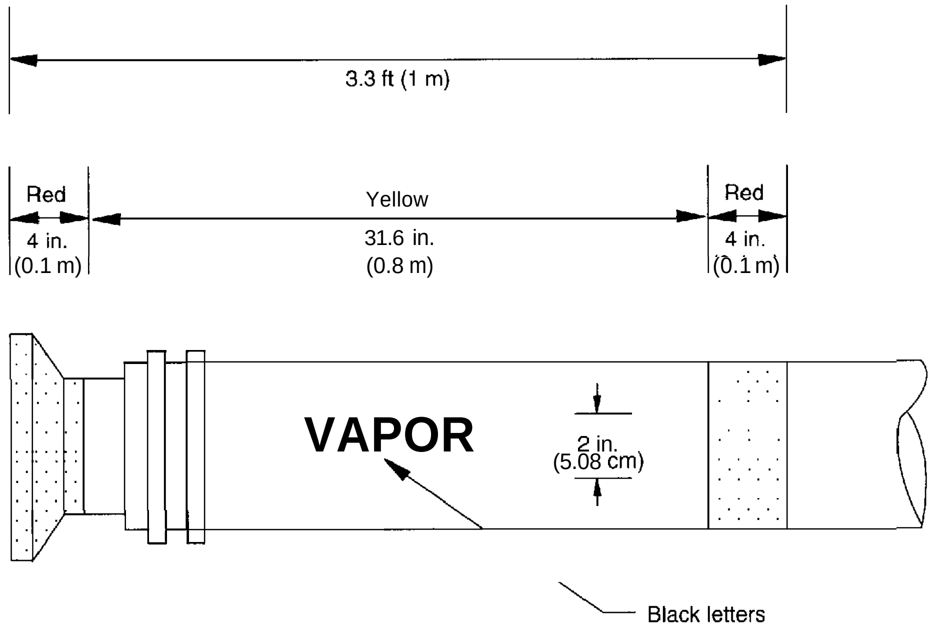



Figure 2—Markings for Vapor Line and Vapor Hose

erly, it must be repaired before loading is allowed to proceed. Some valves may not be built to allow for testing; if so, this step can be bypassed.

c. The vessel PIC must inform the shore PIC of the pressure setting for the pressure relief valve during the pretransfer conference. This allows the shore PIC to verify the proper setting for the high-pressure alarm at the shore facility vapor connection.

d. The vessel PIC must discuss with the shore PIC the procedures to be followed in the event of a high-pressure alarm, a high high-pressure alarm, or the opening of a relief valve. Liquid flow must stop whenever a shutdown of the vapor collection header occurs.

e. The vessel PIC must routinely monitor the vapor header pressure if pressure indicators are provided.

### 2.2.4 UNDERPRESSURING THE VESSEL

#### 2.2.4.1 General

There are two common types of vapor collection systems located on shore, as follows:

a. One uses the pressure in the vessel to push the vapors to a recovery or combustion system.

b. In the other, the pressure drop in the piping from the vessel to the recovery or combustion system is high enough to require a vapor booster, eductor, or blower in the vapor line.

Systems that use devices to move the vapors introduce a new hazard to the vessel. If the device is allowed to run uncontrolled with no liquid flowing into the vessel, it could create a vacuum on the vessel. If the device has vacuum capacity greater than 1.0 pounds per square inch gauge, it could cause structural failure.

Another cause of underpressurization on the vessel is condensation that occurs in long vapor lines with little or no flow. In this case, the vapors in the line condense and form liquid. Since the liquid takes up less space than the vapor from which it was formed, a vacuum begins to form in the line. If the line is allowed to continue to cool and condense for a long period of time, excessive vacuum occurs.

Shore facilities must have operating procedures and precautionary devices to monitor the vacuum of the system and to alarm or shut down vapor collection when the vacuum presents a danger to the vessel. These safety devices and operating practices include the following:

a. A low-pressure alarm set to cause an audible and visual alarm if the vacuum in the vessel reaches 80 percent of the vessel's vacuum relief valve set point. The low-pressure alarm must be tested within the 24 hours prior to loading of the vessel to make sure it is operational.

b. A low low-pressure alarm set to cause audible and visual signals and close the remotely operated vapor shutoff valve if the vacuum reaches –1.0 pounds per square inch gauge at the vapor collection header or a higher setting agreed to by the vessel PIC and shore PIC. This pressure may be set higher if necessary to protect the vessel. The low low-pressure alarm must be tested within the 24 hours prior to loading of the vessel to make sure it is operational.

c. A vacuum relief valve installed at the shore facility and set to relieve if the vacuum reaches –1.0 pounds per square inch gauge or higher at the vapor collection header.

In addition to the shore facility safety features, all vessels are outfitted with a vacuum relief valve in the vapor collection header that has a capacity at either maximum cargo or vapor withdrawal to protect the vessel from structural failure. This vacuum relief valve must also include a means for testing that it opens freely and closes again after opening, if installed after July 23, 1991 [see 46 *Code of Federal Regulatioas* Part *39.20*-11(b)(2)].

Vessels must also be equipped with at least one low-pressure alarm that senses the pressure in the vapor collection system or header (see note below). The alarm includes a pressure indicator for pressure monitoring. The set point varies depending on the condition of the cargo, as follows:

a. Inerted cargo. The low-pressure alarm must not be less than 4 inches water gauge.
b. Noninerted cargo. The low-pressure alarm must not be less than the lowest vacuum relief setting in the cargo tank venting system.

Note: Barges are not required to have this equipment.

#### 2.2.4.2 Vessel PIC Responsibilities

a. The vessel PIC must make sure all valves in the vapor collection header are open to allow unobstructed flow. The shore PIC shares this responsibility.
b. The vessel PIC must check the vacuum relief valve in the vapor collection header to make sure it opens freely and closes after opening. If the vacuum relief valve does not open properly, it must be repaired before loading is allowed to proceed.
c. The vessel PIC must inform the shore PIC of the vacuum setting for the vacuum relief valve during the pretransfer conference. This allows the shore PIC to verify the correct setting for the low-pressure alarm at the shore facility vapor connection.
d. The vessel PIC must discuss with the shore PIC the procedures to follow in the event of a low-pressure alarm, a low low-pressure alarm, or the opening of a relief valve.
e. The vessel PIC must routinely monitor the vapor header pressure if pressure indicators are provided.

### 2.2.5 MISCONNECTION OF HOSES AND LOADING ARMS

#### 2.2.5.1 General

The vessel PIC now has to be concerned with different types of hoses for vapor and liquid. There is the possibility of connecting the vapor hose to the liquid loading line or the liquid hose to the vapor collection line. If this happens, the following two problems can occur:

a. Liquid loaded through the vapor header, which does not have drop lines into the bottom of the vessel, free-falls into the tank creating a static electricity buildup.
b. Vapor drawn through the liquid header is taken from the bottom of the vessel compartments through the drop lines. Liquid loaded in the compartments covers the line and causes a pressure drop or pulls liquid into the vapor collection header.

The U.S. Coast Guard regulations provide the following safety measures to prevent the misconnection of hoses:

a. Each vapor connection on the shore and on the vessel is color coded with a band 3.3 feet (1.0 meter) long painted red and yellow. The yellow band has the word "VAPOR stenciled in black letters 2 inches (5.08 centimeters) tall (see Figure 2).
b. Each vapor hose has the same red and yellow color coding and markings as the vapor connections.
c. The shore vapor connection and the vessel vapor connection each have a metal lug [approximately ½ inch (1.27 centimeters) in diameter and 1 inch (2.54 centimeters) long] welded at the top of the flange (see Figure 3).
d. Each flange connection of the vapor hose has a hole drilled between the bolt holes [approximately ⅝ inch (1.59 centimeters) in diameter] that matches the metal lug on the vapor connections.

#### 2.2.5.2 Vessel PIC Responsibilities

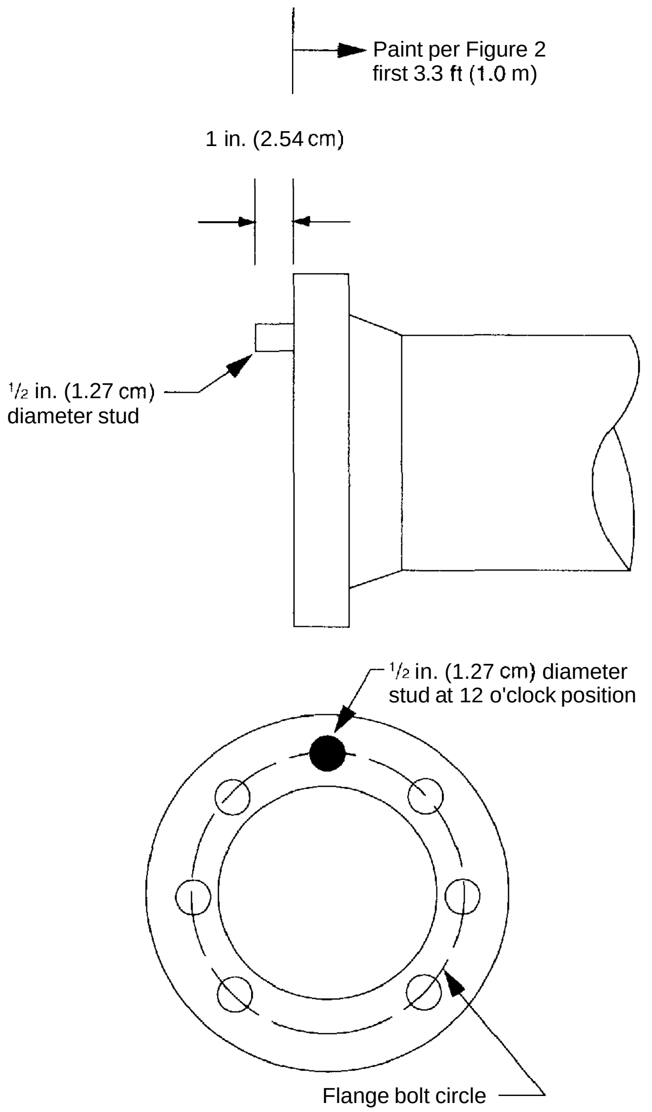
a. The vessel PIC must identify the vapor connections on the vessel by the red and yellow color coding.
b. If the vessel is providing the vapor collection hose, the vessel PIC must be sure the hose or loading arm is attached at the proper shore facility connection.
c. If the shore facility is providing the vapor collection hose, the vessel PIC must be sure the hose is attached to the proper connection on the vessel.
d. The vessel PIC must only connect hoses to the vapor collection system that are properly color coded and labeled as vapor collection hoses.
e. The vessel PIC must inspect the vapor hose to make sure it is properly supported to prevent kinking. In addition, the hose must be inspected for cuts or other damage.

## 2.3 General Operating Concerns

### 2.3.1 CARGO CONTAMINATION

#### 2.3.1.1 General

Many vessels carry more than one type of cargo on a voyage. Contamination can occur through the vapor header line if different cargos are not properly isolated by valves. Vessels may be subjected to wave action that causes significant sloshing of the product and results in commingling of product and/or vapors.




Note: The stud may he located on a flanged valve instead of on the piping flange.

Figure 3—Vessel and Shore Vapor Connection

### 2.3.1.2 Vessel PIC Responsibilities

a. The vessel PIC must be aware of the products that are to be carried in the vessel's compartments.
b. When products are incompatible or are different grades of the same product, the isolation valves in the vapor header must be closed to prevent contamination.

### 2.3.2 VALVE POSITIONING

### 2.3.2.1 General

Another concern associated with closed loading is the accidental loading of a compartment that has the vapor header valves closed. The vessel PIC must pay particular attention to any valves or other devices that hamper removal of vapors from the compartment.

### 2.3.2.2 Vessel PIC Responsibilities

a. The vessel PIC must make sure all isolation valves in the vapor collection header from a compartment are completely open before loading the compartment. The shore PIC shares this responsibility.
b. The vessel PIC on a vessel that has an inert gas system must make sure the system is isolated from the compartment during the collection of vapors [46 Code of Federal *Regulations* Part 39.30(j)].

### 2.3.3 INSPECTION

### 2.3.3.1 General

The new components associated with the collection of vapors must be routinely inspected to make sure they are operational. In addition to those steps discussed in previous sections. the items listed in 2.3.3.2 must be considered.

### 2.3.3.2 Vessel PIC Responsibilities

a. Each flame screen attached to a relief valve must be inspected frequently. The flame screen must be free of rust, dirt, or other forms of plugging. If the screen is plugged, it must be cleaned with a wire brush or, if necessary, removed and replaced. If the flame screen has been punctured, torn, or otherwise damaged, it must be replaced.
b. During freezing weather conditions, each flame screen must be inspected for icing before the vessel is loaded. Ice must be removed, if present, and the flame screen must be monitored frequently for ice formation during the loading.
c. Hoses must be inspected for external damage before beginning the loading. Inspection must determine that the following conditions are met:

1. Hoses must be free of kinking.
2. Hoses must be supported properly to prevent kinking during the loading.
3. Hoses must be monitored during the loading and adjusted as the vessel level lowers.
4. Hoses must not have unrepaired loose covers, bulges, or soft spots.
5. Hoses must not have gouges, cuts, or slashes that penetrate the first layer of hose reinforcement.
6. Hoses must not have external deterioration and, as viewed from each end, must not have internal deterioration.

d. Hoses must be pressure tested yearly at one and one-half times the maximum allowable working pressure. Vapor hoses have at least a maximum allowable working pressure of 5.0 pounds per square inch gauge and must be capable of withstanding 2.0 pounds per square inch gauge vacuum without collapsing.

e. Liquid high-level alarm and overfill sensors must be tested before each loading is started.

f. Pressure and vacuum relief valves must be tested yearly for proper operation.

g. Devices added to the vessel, such as temperature and pressure indicators, must be tested yearly to determine whether they work properly.

### 2.3.4 STATIC ELECTRICITY

#### 2.3.4.1 General

Some products are known accumulators of static electricity. Therefore, it is necessary practice to follow guidelines that minimize the chances of static discharges when loading these products. (See API Recommended Practice 2003 and the *International Safety Guide for Oil Tankers und Terminals*[6] (ISGOTT), Chapters 7.4 and 19, for additional information.)

#### 2.3.4.2 Vessel PIC Responsibilities

a. The vessel PIC and the shore PIC shall determine the initial fill rate for the vessel and the amount of initial fill required before the loading rate is increased (see note). During the initial fill, the vessel PIC must not allow the vessel to be loaded faster than its initially agreed-upon fill rate. The maximum design loading rate is initiated once all splashing and surface turbulence have been eliminated and the load pipes in the compartments are covered.

Note: The start of the maximum loading rate varies according to vessel and/or corporate operating policies.

b. During loading of static accumulating products and for 30 minutes after completing the loading, no metallic dipping, ullaging, or sampling equipment may be introduced into a noninerted tank. These items must not be allowed to remain in the tank during loading. Only nonconducting equipment with no metal parts may be used at any time.

c. The vessel PIC must make sure that any metallic dipping, ullaging, or sampling equipment is firmly grounded to the vessel structure before introduction into the tank. Ropes made of polyrner material are often conductive and must not be used without determining whether they are conductive. It is generally recommended that grounded steel cables or ropes made of natural fibers be used.

d. The vessel PIC must inspect compartments for items such as floats that have broken off level sensors or for other solid material. Floating items act as static accumulators and arc if they come in contact with the compartment sides.

[6]Published hy Witherby and Co. Ltd., 32/36 Aylesbury Street, London, EC1R0ET, England, 1988.

### 2.3.5 CONDENSATE IN THE VAPOR HEADER

#### 2.3.5.1 General

During the design and layout of the vessel vapor collection header, drainage for condensate must be considered. However, in many cases a low point in the vapor header cannot be avoided. If the vapor header has a low point, it must also include a means of removing any condensate or a means of preventing condensate from forming.

If condensate is allowed to build up in the low spots of the vapor header, a back pressure is created on the vessel that could cause the vapor header relief valve to open.

#### 2.3.5.2 Vessel PIC Responsibilities

a. If a low point exists in the vessel vapor header, the vessel PIC must monitor the low point for condensate collection.

b. When condensate collects, the vessel PIC must remove it by whatever means has been included in the vessel design.

### 2.3.6 VESSEL FILLING RATE

#### 2.3.6.1 General

The vapor piping on the vessel and the vapor piping and components on the shore are all designed for an expected maximum loading rate. The vessel design rate and the shore design rate most likely do not match, since they were developed independently. If the maximum loading rates are exceeded, the increase in flow develops a greater back pressure than the systems are designed for. This increased back pressure must be sensed by the pressure monitoring systems in the shore vapor collection system or in the vessel pressure alarms. If the pressure monitoring systems fail, or are isolated, loading the vessel too rapidly could overpressure it and cause structural failure.

#### 2.3.6.2 Vessel PIC Responsibilities

a. The vessel PIC must know the maximum design loading rate for the vessel vapor collection system.

b. During the pretransfer conference, the vessel PIC must advise the shore PIC of the design loading rate for the vessel.

c. During the loading of the vessel, the maximum loading rate must be the lesser of the vessel design rate and the shore design rate. It is the shore PIC's responsibility to set and maintain this flow rate.

### 2.3.7 SYSTEM EMERGENCY SHUTDOWNS AND ALARMS: WHAT SHOULD BE DONE?

#### 2.3.7.1 General

There are many reasons a marine emission control system experiences a shutdown or an alarm condition. A shutdown provides an audible and visual signal as well as automatically stops the operation of the system, whereas an alarm is generally only an audible and visual signal. Some systems have unique shutdowns and alarms that are not required by the U.S. Coast Guard but make operation safer for the particular vessel's operation. In general, some simple guidelines must be followed for any shutdown or alarm condition. The vessel PIC must be familiar with emergency procedures to be followed in the event of vessel or shore facility shutdown alarms.

#### 2.3.7.2 Vessel PIC Responsibilities

a. If an automatic shutdown occurs, the vessel PIC must stop the flow of liquid to the vessel as soon as possible.
b. When an automatic shutdown or alarm occurs on the vessel, the vessel PIC immediately determines the cause.
c. If an automatic shutdown occurs, the vessel PIC must notify the shore PIC of the cause, and a joint decision must be made either to close the manual isolation valves on the vessel or to restart the system.
d. If an alarm condition occurs, the vessel PIC must notify the shore PIC of the problem. The vessel PIC must take appropriate steps to eliminate the alarm condition as outlined in the marine vapor control procedural manual.
e. If the shutdown occurs from the shore facility monitoring system, the shore PIC must determine the cause and notify the vessel PIC. The shore PIC must take appropriate measures as outlined in the shore facility marine vapor control procedural manual.

### 2.3.8 PRETRANSFER CONFERENCE

#### 2.3.8.1 General

The vessel PIC and the shore PIC must hold a pretransfer conference before the transfer of any product begins. During the pretransfer conference, the following topics must be discussed before the vessel PIC and the shore PIC sign the Declaration of Inspection (DOI):

a. The identity of the product to be transferred.
b. The sequence of transfer operations.
c. The initial, maximum, and topping-off transfer rates.
d The name, title, and location of each person participating in the transfer operation.
e. Details of the transferring and receiving systems.
f. Critical stages of the transfer operation.
g. Federal, state, and local rules that apply to the transfer of the product.
h. Emergency procedures.
i. Discharge containment procedures.
j. Discharge reporting procedures.
k. Watch or shift arrangement.
I. Transfer shutdown procedures.

In addition to discussing the above topics, the following steps must be taken:

a. The electrical insulating flange must be checked to make sure it is fitted between the vapor hose and the shore facility vapor connection. The insulated flange must not be short-circuited by items such as chains touching both flanges.
b. The pressure relief set point and the vacuum relief set point for the vessel must be discussed and high- and low-pressure alarm set points calculated for the vapor collection system.
c. The vessel's Certificate of Inspection must be reviewed to make sure the vessel has the proper endorsement for connection to a vapor collection system.
d. If the vessel is to load benzene vapors, the vessel must have aboard a certificate of leak tightness dated within the last year. If the certificate is not available, the vessel is either loaded under vacuum or the shore facility conducts a leak check of the vessel during the final 20 percent of the loading. If leaks are detected, the vessel must not be loaded again until it provides a certificate of leak tightness or an endorsement that the modifications to make the vessel leak tight cannot be made until the vessel is placed in dry dock.
e. The compartment condition of the vessel must be determined as either inerted or noninerted.

#### 2.3.8.2 Vessel PIC Responsibilities

a. The vessel PIC must be familiar with both the product being loaded and any safety precautions necessary. If there is any doubt concerning safety measures, the vessel PIC must obtain and read the material safety data sheets.
b. The sequence of transfer operations must now include any steps required to accommodate the vapor collection system. Since vacuums are now implied on vessels by some systems, the vessel PIC must determine the correct time to open the manual vapor block valves on the vessel.
c. The vessel PIC must give the transfer rate for the vessel to the shore PIC. The shore facility transfer rate is compared to the vessel transfer rate. Whichever is less sets the transfer rate during vessel loading.
d. The vessel PIC and shore PIC must review the details of the transfer operation and any critical stages. Such items as what to do during shutdown conditions, high-level or overfill alarms, and other details of the system must be discussed.
e. The vessel PIC must be familiar with shutdown procedures, including modifications resulting from the use of the vapor collection system. Requirements for purging of hoses and mandatory wait periods for static reduction or other purposes must be followed.
f. The vessel PIC must provide the following information to the shore PIC in order to determine the initial fill rate:

1. The number of compartments open initially.
2. The size of the drop lines in the compartment.
3. The length of time or amount of product required to satisfy the initial fill period.

g. The vessel PIC must provide the shore PIC with the pressure and vacuum set point for the pressure and vacuum relief valves in order to determine the high-pressure and low-pressure alarm set points for the shore facility.

h. The vessel PIC must provide the shore PIC with the vessel's Certificate of Inspection endorsed for use with certified marine emission control systems.

i. The vessel PIC must provide evidence of leak tightness if the vessel is to load benzene. If the vessel has a certificate of leak tightness, it must be provided to the shore PIC. If a certificate is not provided, the shore PIC has the following options:

1. Do not load the vessel.
2. Load the vessel under vacuum, if the shore facility has the capability.
3. Load the vessel if the shore PIC wishes, provided a leak check is performed by a qualified person using a calibrated fugitive emission analyzer during the last 20 percent of the loading.

j. For inerted vessels, the vessel PIC and shore PIC must witness sampling the vessel's cargo tanks to confirm that oxygen levels are below the required 8 percent by volume. The concentration must be measured twice: at a point 3.3 feet (1.0 meter) below the tank top and at a point equal to one-half the ullage in each inert cargo tank. Areas of a tank formed by partial bulkheads should also be sampled twice.

## 2.3.9 VAPOR BALANCING DURING LIGHTERING

### 2.3.9.1 General

It is not uncommon for one vessel to load cargo directly into a second vessel. This procedure is referred to as lightering. During lightering, the vapors generated from the vessel receiving cargo are vapor balanced back to the vessel discharging cargo. The vessel PICs of both vessels must follow certain procedures during this operation.

When both vessels are inerted, it is required that precautions are taken to make sure the vessels remain inert. To aid in this, the vessel discharging cargo (also called the service or lightering vessel) is required to have an on-board oxygen analyzer to monitor the vapors collected from the vessel receiving cargo. The analyzer includes an audible alarm that sounds if the oxygen level increases to 8 percent by volume and also includes a visual indicator of the oxygen level. The analyzer must be calibrated within the 24 hours prior to the product transfer.

Noninerted vessels are required to have a detonation arrester located in the vapor line, but an oxygen analyzer is not required. The detonation arrester is located on the vessel discharging cargo.

During ballasting or loading, both noninerted and inerted vapor balance systems must prevent the pressure in the vapor space of any cargo tank connected to the vapor collection line from exceeding 80 percent of the lowest setting of any pressure relief valve.

### 2.3.9.2 Vessel PIC Responsibilities

#### 2.3.9.2.1 Inerted Vessels

a. The vessel PIC must not allow vapor balancing if the vessel discharging cargo has inerted compartments and the vessel receiving cargo has noninerted compartments.

b. The vessel PIC must test the oxygen concentrations in the compartments of the vessel being loaded before the transfer begins. The oxygen level in the compartment must not exceed 8 percent by volume. Oxygen samples must be taken at a point 3.3 feet (1 meter) below the tank top and at a point equal to one-half the ullage. If partial bulkheads exist in the compartment, the oxygen concentration must be sampled in each section formed by the bulkhead [46 ***Code of Federal Regulations*** Part 39.40-5(b)(1)].

c. If samples show oxygen levels above 8 percent, the vessel PIC must have the oxygen levels in the compartments lowered. If this is not possible, the vessel must be treated as noninert.

e. If both vessels are inerted, the vessel PIC must inert the the vapor collection hose between vessels prior to connection.

f. The PIC of the vessel discharging cargo must make sure the oxygen analyzer has been calibrated within the 24 hours prior to the product transfer.

g. The PIC of the vessel discharging cargo must monitor the oxygen concentration during the loading. If the 8 percent alarm point is reached, the vessel PIC must stop the product transfer. The transfer cannot be restarted until the oxygen content in the tanks of the vessel receiving cargo is reduced below 8 percent by volume. In addition, the vapor hose must be inerted before restarting the transfer operation.

#### 2.3.9.2.2 NonInerted Vessels

If a detonation occurs or a flame is sensed at the inlet to the detonation arrester, the vessel PIC must remove the detonation arrester and inspect for damage.

#### 2.3.9.2.3 All Vessels

a. The vessel PIC must make sure that an electrically insulated flange kit is installed at the hose connection or connections of the vessel discharging cargo or that a length of nonconductive hose, in good condition, is between the vessels.

b. The PIC of the vessel discharging cargo must control the liquid transfer rate. The liquid transfer rate must not exceed the maximum allowable transfer rate for the vessel receiving cargo. The maximum loading rate must be determined at a pretransfer conference.

c. The PIC of the receiving vessel (vessel receiving cargo) must not open the isolation valve at the vapor collection manifold until the pressure in the vapor collection system on the vessel receiving cargo exceeds the pressure in the vapor collection system on the vessel discharging cargo (vessel receiving vapor).

d. The pressure in the compartments must not exceed 80 percent of the lowest setting of any pressure relief valve during the ballasting or cargo transfer.

e. All impressed current cathodic protection systems must be de-energized during the cargo transfer.

f. Compartment washing is prohibited unless the compartments on both vessels are inerted or the compartments are isolated from the vapor collection line.

g. All procedures concerning the prevention of static electricity must be followed during the cargo transfer, including maintaining an initial fill rate until the liquid drop pipes on the receiving vessel are covered (see Section 2.3.4).

# SECTION 3—SHORE COMPONENTS AND SAFETY AND OPERATING CONCERNS

The following section addresses the components and safety and operating concerns associated with the shore facilities of marine vapor control systems. Vessel components and concerns are covered in Section 2.

## 3.1 Shore Components

Many components make up the equipment located on the shore side of marine emission control systems. Since these are not associated with the vessel, they are commonly referred to as facility components.

These components have several configurations, but they are mainly concerned with the following three areas:

a. Components to monitor and maintain the pressure in the piping within a range that prevents the vessel from being overpressure or underpressure.

b. Components that interconnect with vessel equipment to prevent ove lling the vessel.

c. Components that are concerned with either preventing a detonation in the piping or with isolating and stopping a detonation if it occurs.

## 3.2 Safety Concerns

### 3.2.1 GENERAL

The addition of vapor collection requires the vessel be closed during loading. Specific safety concerns associated with closed loading are as follows:

a. Overfilling the vessel, since viewing of the cargo level must now be done through smaller glass enclosures or indirectly by mechanical means.

b. Overpressuring the vessel due to the pressure drop in the vapor collection header on the vessel and the vapor collection system on shore.

c. Underpressuring the vessel due to the addition of blowers, compressors, or eductors in the shore vapor collection system.

The vapors generated during vessel loading are often in the flammable range. These vapors could ignite, if not handled properly, causing flame propagation or a detonation in the piping.

The addition of vapor connections on the vessel creates the following possibilities of misconnections:

a. Vapor lines incorrectly connected to liquid headers on the vessel.

b. Liquid lines incorrectly connected to vapor headers on the vessel.

### 3.2.2 OVERFILLING THE VESSEL

Since vessels that recover vapors must be closed, detecting the level of cargo in the vessel is more difficult. Open loading procedures allowed for easier visual determination of the level in the vessel's compartments. Closed loading systems for vessels generally have only small glass-enclosed viewing ports to visually monitor the level. Since it is more difficult to monitor the level through a viewing port, the possibility of overfilling the vessel increases.

U.S. Coast Guard regulations recognize four methods of preventing the overfilling of a vessel. In many instances, vessels use more than one of the recognized means, so a backup system exists to prevent damage to the vessel. The four recognized methods are as follows:

a. Level switches inside the tanks that connect to an on-board monitoring system.

b. Level switches inside the tanks that connect to a shore facility monitoring system.

c. Rupture disks located on the tanks (see Figure C-12).

d. Spill valves located on the tanks (see Figures C-10 and C-11).

#### 3.2.2.1 On-Board Monitoring Systems

##### 3.2.2.1.1 General

On-board monitoring systems have level sensors located in each tank. The level sensors have at least one alarm point that is considered an overfill alarm. The overfill alarm occurs at a level that allows the loading to be stopped before a spill occurs. The overfill alarm creates an audible alarm and a red flashing beacon or other type of red light. It also requires a shutdown of the loading system. This shutdown is either automatic or consists of manually closing the liquid valves on the vessel loading lines. Manual closing is done by the personnel on the vessel. Caution should be exercised in any procedure that closes manifold valves if pumps are still in operation.

Vessels with on-board systems are also equipped so the level sensors in each tank sense a level lower than the overfill. This warning alarm is referred to as a high-level alarm. This alarm occurs at a level no lower than 95 percent of the vessel's tank capacity and provides adequate warning that an overfill condition is nearing. The high-level alarm causes an audible and visual alarm. The vessel personnel must be trained in the appropriate action to take when the high-level alarm occurs. Each vessel may follow different procedures in the event of a high-level alarm.

In most instances, on-board systems are totally self-contained and need no power from the shore. However, if the vessel's system does not have a power source, it is the responsibility of the shore facility to provide a 120-volt power source to the vessel. This must be done using approved explosion-proof receptacles, so that no sparks occur during the connection.

#### 3.2.2.1.2 Shore PIC Responsibilities

a. The shore PIC is required to determine what type of overfill system is provided by the vessel.

b. If the vessel has an on-board system requiring power from the shore, the shore PIC must provide a 120-volt power source. The source must be an approved explosion-proof receptacle.

c. If the vessel has an on-board system, the shore PIC must determine during the pretransfer conference if the vessel has both high-level and overfill alarms.

d. Once the number of alarms is determined, the shore PIC must familiarize himself with the alarm system so that he understands when a high-level alarm or an overfill alarm occurs without being instructed from the vessel.

e. During the pretransfer conference, the shore PIC must determine what he is expected to do if a high-level alarm and/or overfill alarm occurs.

f. Before beginning the loading, the shore PIC must witness a functional test of the level alarms in each tank. Each overfill alarm must work properly. If an overfill alarm does not function, the tank with the level switch that is not working must not be loaded with product. If a high-level alarm does not work but the overfill alarm in the same tank does work, this tank is filled if the shore PIC chooses. If the overfill system is not working and no other means of preventing overfill of the vessel is available, the vessel must not be loaded.

### 3.2.2.2 Shore Facility Monitoring Systems

#### 3.2.2.2.1 General

Shore facility monitoring systems use level sensors installed in the vessel. The level sensors may be identical to the ones used for the on-board system discussed above. The difference is the signal monitoring each level sensor is generated from a level control panel located on the shore. This panel is maintained and operated by the shore facility.

Before loading, a connection must be made between the vessel and the shore level control panel. This connection is a specific cable set aside for use with the system and must not be used with any other system at the shore facility. The connectors for this system meet the requirements of the International Electrotechnical Commission for systems carrying 50 volts or less (see Figures C-1 and C-2). This prevents the accidental connection to other power sources such as 120 or 240 volts. The U.S. Coast Guard regulations require these systems to be intrinsically safe. Intrinsically safe basically means the system does not have sufficient energy to create an incendiary spark; therefore, the system carries considerably less than 50 volts at very low current.

The level sensors are required to have at least one alarm point that is considered an overfill alarm. The overfill alarm occurs early enough to allow the person in charge of transfer operations to stop the transfer operation before the compartment reaches 100 percent capacity. The overfill alarm causes an audible and visual alarm. It also initiates a shutdown of the shore loading system. This shutdown is automatic or consists of manually closing the liquid valves leading to the vessel. This manual closing must be done by the personnel on the dock and must take no more than 30 seconds for a shore facility that started operating after November 1, 1980. Older facilities have 60 seconds to shut down liquid loading during an emergency [33 *Code of Federal Regulations* Part 154.550(c)(2)].

The overfill control panels are equipped so the level sensors in each tank also cause a high-level alarm. This alarm occurs prior to the overfill alarm and provides adequate warning that an overfill condition is nearing. Since the high-level alarm is optional, some vessels may not provide high-level sensors. In this case, the level control panel high-level alarms (not the overfill alarms) have to be bypassed. The high-level alarm causes an audible and visual alarm. The shore PIC must have a set procedure to follow when the vessel's high-level set point is tripped. Generally, the shore PIC must proceed to the point where liquid loading is controlled and await a signal from the vessel PIC either to slow down or stop the loading of the vessel.

#### 3.2.2.2.2 Shore PIC Responsibilities

a. The shore PIC is required to determine what type of overfill system is provided by the vessel.

b. If the vessel is equipped for hookup to a shore-controlled system, the shore PIC must connect the sensing cable and energize the level control system and control panel.
c. During the pretransfer conference, the shore PIC must explain the shore level alarm system to the vessel PIC.
d. During the pretransfer conference, the shore PIC and vessel personnel must determine what appropriate actions each must take in the event of a high-level alarm and/or an overfill alarm.
e. Before beginning the loading, the shore PIC and vessel personnel must conduct a functional test of the level alarms in each tank. Each overfill alarm must work properly. If an overfill alarm does not function, the tank with the level switch that is not working must not be loaded with product. If a high-level alarm does not work but the overfill alarm in the same tank does work, this tank is filled if the shore PIC chooses. If the alarm system is not functional and no other means of preventing overfill of the vessel is available, the vessel must not be filled.

### 3.2.2.3 Spill Valves

#### 3.2.2.3.1 General

Vessels that are equipped with spill valves instead of a level monitoring system are acceptable to the U.S. Coast Guard. The spill valves are designed to open and allow liquid to flow out, rather than allow the loading to rupture the vessel. The spill valve opens at a preset pressure that prevents structural damage to the vessel. The spill valve closes once the pressure in the compartment has dropped below the set point. These systems do not prevent the actual overfilling of the vessel. The small spill created by the valve is considered preferable to the spill that occurs from the rupture of a vessel.

#### 3.2.2.3.2 Shore PIC Responsibilities

a. The shore PIC is required to determine what type of overfill system is provided by the vessel.
b. If the vessel has only a spill valve, the shore PIC must determine what he is expected to do in the event the spill valve opens.
c. Before beginning the loading, the shore PIC must witness a functional test of the spill valve to make sure it is operational. (If spill valves are not equipped for testing, this step may be bypassed.)
d. If a spill valve opens, there is a cargo spill. The shore PIC must be familiar with the procedure he is to follow as the result of a spill.

### 3.2.2.4 Rupture Disks

#### 3.2.2.4.1 General

Vessels equipped with rupture disks instead of a level monitoring system are acceptable to the U.S. Coast Guard. The rupture disks are designed to open and allow liquid to flow out, rather than allow the loading to damage the vessel structurally. The rupture disk is a metallic plate that breaks at a set pressure; therefore, it does not close after the vessel pressure returns to normal. These systems do not prevent the actual overfilling of the vessel. The spill created by the disk is considered preferable to the spill that could occur from the rupture of a vessel.

#### 3.2.2.4.2 Shore PIC Responsibilities

a. The shore PIC is required to determine what type of overfill system is provided by the vessel.
b. If the vessel has only a rupture disk, the shore PIC must determine what he is expected to do if the rupture disk breaks.
c. If a rupture disk breaks, there is a cargo spill. The shore PIC must be familiar with the procedure he is to follow as the result of a spill.

## 3.2.3 OVERPRESSURING THE VESSEL

After the vapors are collected from the vessel, they are gathered into shore vapor headers. These vapor headers include several safety features that create pressure drop. In addition, some collection systems include very long piping systems. As the vessel is loaded, the vapors leaving the compartment must now be moved through the vapor collection piping header. The back pressure from the piping header causes pressure in the vessel being loaded and creates the possibility of overpressuring the vessel.

### 3.2.3.1 Overpressure Due to Loading

There have been documented occurrences of vessels with vapor collection headers being loaded with the isolation valves in the vapor header closed. This does not give the vapor an escape path as the liquid level increases. As the liquid level rises, the vapor is forced into a smaller and smaller area. To compensate for the smaller area, the pressure in the vapor space increases.

The U.S. Coast Guard regulations require each vessel compartment to have a pressure and vacuum relief valve that is set at pressures low enough to prevent structural damage to the vessel. On some vessels, a single pressure and vacuum relief system protects all compartments.

In addition to the methods just mentioned, shore facility vapor collection piping with valves and other devices can cause overpressure in the vessel in several other ways, as follows:

a. Vapor collection valves left closed.
b. Failure of blowers required to move the vapors.
c. Failure of components associated with vapor recovery or vapor combustion systems.
d. Vapor collection lines plugged with polymer or other foreign matter.

e. Lines blocked with condensed liquid.

Any of the above items alone or in combination could provide increased back pressure on the vessel. If the vessel relief valve also fails, structural failure of the vessel is possible.

#### 3.2.3.2 Overpressure Due to Inerting, Enriching, or Diluting

Systems that include inerting, enriching, or diluting as a means of preventing the vapors from being combustible can cause overpressure without liquid being loaded. If the inerting, enriching, or diluting gas is allowed to flow to the vessel's compartments with vapor collection valves blocking flow to the recovery or combustion systems, the gases increase the vessel pressure. Depending on the supply pressure of the gases, the pressure could be high enough to cause structural failure of the vessel.

#### 3.2.3.3 Preventing Overpressure

#### 3.2.3.3.1 Pressure Sensors

#### 3.2.3.3.1.1 General

Each vapor collection system must be equipped with a high-pressure sensor and a high high-pressure sensor.

The high-pressure sensor is set to create an alarm if the pressure in the vessel reaches 80 percent of the pressure setting of the relief valve located on the vessel. This sensor must be reset based on each vessel's relief point.

For example, calculate as follows the set point for the high-pressure alarm if the pressure relief valve on the vessel is set for 1.5 pounds per square inch gauge (psig):

$$80\% \text{ of } 1.5 \text{ psig} = 0.8 \times 1.5 = 1.2 \text{ psig} = \text{set point}$$

If the vapor collection hose, vapor collection arm, or vessel vapor piping has significant pressure drop at design flow rates, subtract the total amount of pressure drop from the calculated pressure set point. The vessel vapor manifold pressure drop is provided by the vessel PIC at the pretransfer conference.

Calculate as follows the corrected set point for the high-pressure alarm if the pressure relief valve on the vessel is set for 1.5 pounds per square inch gauge and the pressure drop in the vapor collection hose and vessel manifold is 0.2 pounds per square inch gauge (psig) at the maximum flow rate:

$$80\% \text{ of } 1.5 \text{ psig} = 0.8 \times 1.5 = 1.2 \text{ psig}$$
$$\text{additional pressure drop} = 0.2 \text{ psig at maximum flow}$$
$$1.2 - 0.2 = 1.0 \text{ psig} = \text{set point}$$

The pressure sensor creates an audible and visual alarm to signal that a pressure problem is occurring (see note). The high-pressure sensor and audible and visual alarms must be checked within the 24 hours prior to loading a vessel.

Note: The high-pressure sensor is set at a pressure lower than calculated if desired by the operator but is not set higher.

The high high-pressure sensor is set to cause an alarm if the pressure in the vessel reaches 2.0 pounds per square inch gauge (see note). The high high-pressure sensor both creates an audible and visual alarms and closes the automatic vapor block valve. The high high-pressure sensor and audible and visual alarms must be checked within the 24 hours prior to loading a vessel.

Note: The high high-pressure sensor is set at a pressure lower than 2.0 pounds per square inch gauge if desired by the operator but is not set higher.

#### 3.2.3.3.1.2 Shore PIC Responsibilities

a. The shore PIC must determine the pressure setting of the pressure relief valve located on the vessel. He must then calculate the proper set point for the high-pressure sensor, correcting for pressure drop in the vapor collection hose or arm, and for vessel piping.

b. The shore PIC must mechanically test, or make sure the responsible personnel have tested, the high-pressure sensor and the high high-pressure sensor and their audible and visual alarms within the 24 hours prior to loading a vessel.

c. The shore PIC must routinely monitor the vapor header pressure using the pressure indicator located at the vapor hose or arm connection.

d. The shore PIC must be familiar with the required procedure to follow when the high-pressure alarm occurs. The procedure must be discussed during the pretransfer conference with the vessel PIC.

e. The shore PIC must make sure liquid loading is stopped within 30 seconds of the occurrence of a high high-pressure alarm because the remotely operated vapor block valve closes. Failure to stop cargo transfer will cause vessel overpressurization.

f. The shore PIC must make sure all valves in the vapor collection header on the vessel and at the shore facility are open to allow unobstructed flow.

g. If the pressure sensors have isolation valves to allow for removal or pressure sensor testing, the shore PIC must make sure each isolation valve is positioned correctly before loading is started.

#### 3.2.3.3.2 Pressure Relief Valve

#### 3.2.3.3.2.1 General

If the vapor collection system includes an inerting, enriching, or diluting system, it must have a pressure relief valve installed between the point where the vapor hose or arm is connected and the point where inerting, enriching, or diluting gas is injected.

The pressure relief valve must be set to open at a pressure no greater than 2.0 pounds per square inch gauge. A pressure lower than 2.0 pounds per square inch gauge is used if desired. The pressure relief valve is sized to relieve the maximum amount of inerting, enriching, or diluting gas injected into the vapor collection header.

The relief valve must also be fitted with either a flame arrester or flame screen at its outlet. This prevents the passage of a flame from the atmosphere into the vapor collection piping header.

#### 3.2.3.3.2.2 Shore PIC Responsibilities

a. The shore PIC should be sure the relief valve is tested annually and is operating properly.
b. The shore PIC must periodically inspect the flame screen or flame arrester at the relief valve outlet and clean, if necessary.
c. If the relief valve has outlet piping, the shore PIC must inspect it periodically to make sure it is unobstructed.
d. If icing conditions exist, the shore PIC must remove ice from flame screens, flame arresters, and piping before loading is started. These items must be inspected more frequently if ice is recurring.

### 3.2.4 UNDERPRESSURING THE VESSEL

The following two types of vapor collection systems are commonly used:

a. The pressure in the vessel is used to push the vapors to a recovery or combustion system.
b. The pressure drop in the piping from the vessel to the recovery or combustion system is too high and requires a vapor booster or blower to move the vapors through the vapor line.

When vapor boosters are required, they generally create a vacuum in the vapor collection header. In some designs, this vacuum extends by requirement into the vessel being loaded, and even those that do not load under vacuum can accidentally cause a vacuum in the vessel. The use of vapor boosters creates the possibility of underpressuring the vessel.

#### 3.2.4.1 Causes

Systems using blowers to move the vapors bring a new hazard to the vessel. If the blower is allowed to run uncontrolled with no liquid flowing into the vessel, the blower could create a vacuum on the vessel. It is also possible for the blower to remove vapors at a rate greater than the liquid loading rate. This will also cause a vacuum.

Another way of causing a vacuum on the vessel is through condensation in long vapor lines that do not have flow. In this case, the vapors in the line condense and form liquid. Since the liquid takes up less space than the vapor from which it was formed, a vacuum begins to form in the line. If the line is allowed to continue to cool and condense for a long period of time, a vacuum greater than –1.0 pounds per square inch gauge is created.

#### 3.2.4.2 Preventing Underpressure

The system components listed in 3.2.4.2.1 and 3.2.4.2.2 are required by the U.S. Coast Guard regulations to help prevent underpressuring the vessel.

#### 3.2.4.2.1 Pressure Sensors

#### 3.2.4.2.1.1 General

Each vapor collection system is equipped with a low-pressure sensor and a low low-pressure sensor.

The low-pressure sensor is set to create an alarm if the pressure in the vessel reaches 80 percent of the vacuum setting of the vacuum relief valve located on the vessel. This sensor must be reset based on each vessel's relief point.

For example, calculate as follows the set point for the low-pressure alarm if the vacuum relief valve on the vessel is set for 0.5 pounds per square inch gauge (psig) vacuum:

$$80\% \text{ of } -0.5 \text{ psig} = 0.8 \times -0.5 = -0.4 \text{ psig} = \text{set point}$$

If the vapor collection hose, vapor collection arm, or vessel vapor collection piping has a significant pressure drop at design flow rates, subtract the total amount of pressure drop from the calculated pressure set point. The vessel vapor manifold pressure drop is provided by the vessel PIC at the pretransfer conference.

Calculate as follows the corrected set point for the low-pressure alarm if the vacuum relief valve on the vessel is set for 0.5 pounds per square inch gauge (psig) vacuum, and the pressure drop in the vapor collection hose and vessel piping manifold is 0.2 pounds per square inch gauge at the maximum flow rate:

$$80\% \text{ of } -0.5 \text{ psig} = 0.8 \times -0.5 = -0.4 \text{ psig}$$
$$\text{hose pressure drop} = 0.2 \text{ psig at maximum flow}$$
$$-0.4 - 0.2 = -0.6 \text{ psig vacuum} = \text{set point (see note)}$$

Note: Since the –0.4 pounds per square inch gauge vacuum set point is more conservative than the –0.6 pounds per square inch gauge vacuum set point, the pressure drop in the vapor hoses and headers can he ignored.

The low-pressure sensor creates an audible and visual alarm to signal that a pressure problem is occurring (see note). The low-pressure sensor and audible and visual alarm must be checked within the 24 hours prior to loading a vessel.

Note: If the operator prefers, the low-pressure sensor may be set at a pressure higher than calculated but may not be set lower.

The low low-pressure sensor is set to create an alarm if the vacuum in the vessel reaches –1.0 pounds per square inch gauge (see note). The low low-pressure sensor both creates an audible and visual alarm and closes the automatic vapor block valve. The low low-pressure sensor and audible and visual alarm must be checked within the 24 hours prior to loading a vessel.

Note: If the operator prefers, the low low-pressure sensor may be set at a pressure higher than −1.0 pounds per square inch gauge but may not be set lower.

#### 3.2.4.2.1.2 Shore PIC Responsibilities

a. The shore PIC must determine the pressure setting of the vacuum relief valve located on the vessel. He must then calculate the proper set point for the low-pressure sensor.
b. The shore PIC must mechanically test, or make sure that the responsible personnel have tested, the low-pressure sensor and low low-pressure sensor and their audible and visual alarms within the 24 hours prior to loading a vessel.
c. The shore PIC must routinely monitor the vapor header pressure using the pressure indicator located at the vapor hose or arm connection.
d. The shore PIC must be familiar with the required procedure to follow when the low-pressure alarm occurs. The procedure must be discussed with the vessel PIC during the pretransfer conference.
e. The shore PIC must make sure liquid loading is stopped within 30 seconds of the occurrence of a low low-pressure alarm because the remotely operated vapor block valve will close, stopping vapor removal from the vessel. This may cause vessel overpressure if liquid loading continues.
f. The shore PIC must make sure all valves in the vapor collection header and vessel manifold are closed when the system is stopped for long periods of time. This prevents condensation from creating vacuum problems at the vessel.

### 3.2.4.2.2 Vacuum Relief Valve

#### 3.2.4.2.2.1 General

If the vapor collection system includes a compressor, blower, or eductor that has the capacity to generate −1.0 pounds per square inch gauge vacuum, the system must have a vacuum relief valve installed between the point where the vapor hose or arm is connected and the compressor, blower, or eductor.

The vacuum relief valve is set at no less than −1.0 pounds per square inch gauge vacuum, or a higher pressure if desired (see note). The vacuum relief valve is sized to relieve the flow that is caused when the blower is running at maximum capacity and generating a vacuum of −1.0 pounds per square inch gauge at the inlet of the vacuum relief valve.

The vacuum relief valve must also be fitted with a flame screen at its outlet. The screen prevents the passage of a flame from the atmosphere into the vapor collection piping header.

Note: Vacuum relief valves designed to work with undersea pipeline systems collecting vapors from vessels moored offshore may have a lower vacuum setting. For more information on these types of systems, refer to their design manuals.

#### 3.2.4.2.2.2 Shore PIC Responsibilities

a. The shore PIC should be sure the vacuum relief valve is tested annually and is operating properly.
b. The shore PIC must periodically inspect the flame screen or flame arrester at the vacuum relief valve outlet and clean, if necessary.
c. If the vacuum relief valve has outlet piping, the shore PIC must inspect it periodically to make sure it is unobstructed.
d. The shore PIC must make sure all valves in the vapor collection header and the vessel manifold are closed when the system is stopped for long periods of time. This prevents condensation from creating vacuum problems at the vessel.
e. If icing conditions exist, the shore PIC must remove ice from flame screens, flame arresters, and piping before loading is started. These items must be inspected more frequently if ice is recurring.

### 3.2.5 PREVENTING FLAME PROPAGATION AND DETONATION

Detonations are discussed in some detail in Appendix B. In general, they are the result of burning combustible mixtures in an enclosed system, such as piping. Detonations produce extremely high-pressure waves and velocities that are greater than sonic velocity. Appendix A discusses how combustion occurs. It is recommended that Appendix A and Appendix B be read before proceeding with this section.

During the loading of a vessel, the vapor inside is transferred from the vessel into the vapor collection system. The vapors flowing from the vessel have a wide variety of composition. If the vessel has been cleaned and purged before loading, the vapor space is most likely either air or an inert material such as nitrogen or flue gas. During the initial loading of a vessel, the vapors from the vessel are the same composition that existed in the vessel when it arrived at the dock. If the vessel is inert on arrival, the vapors that exit initially are not combustible, since they have no air.

As the vessel fills, the vapor pressure of the liquid being loaded causes some of the liquid to vaporize. The higher the vapor pressure, the greater the rate of vaporization. The following is an example. A vessel is initially inerted with nitrogen, and the outlet concentration will change during the loading. At the beginning of the loading, the exiting vapors only consist of nitrogen. As the liquid being loaded enters the compartment, the vaporized liquid mixes with the nitrogen, and the exiting vapors begin to contain some of the vaporized liquid. The concentration of the vaporized liquid in the nitrogen increases until the nitrogen is saturated. Once saturated, the nitrogen no longer holds any additional hydrocarbon.

If inerted vessels are loaded and the infiltration of oxygen is prevented, the vapors being removed from the vapor space are never in the flammable range since insufficient oxygen is available to support combustion in the vapor. If air is allowed to enter the inerted mixture, the mixture could reach levels where the combination of air, inert gas, and hydrocarbon leaving the vapor space could be in the flammable range. In this case, any ignition source could cause combustion. For more information on combustion, see Appendix A.

If the vessel is initially gas-freed and filled with air, the same concentration change occurs as occurred with the nitrogen example above. The vapors exiting the vessel change from pure air to a mixture of air saturated with hydrocarbon generated from vaporization of the liquid loading the vessel. During the course of this change, the percentage of hydrocarbon in the vapor increases and may reach the flammable range. (See Appendix A for a discussion of upper and lower flammability limits.) At this point, the vapor is combustible, and only a source of ignition is required to cause combustion. As the loading continues and the air becomes saturated, it is possible the percentage of hydrocarbon in the vapor increases until it is above the upper flammability limit. If additional air is not permitted to mix with the vapors, they are no longer combustible.

Even inerted vessels could have combustible mixtures exiting from them, if improper operation permits air to enter the vapor space. Because of the probability of combustible mixtures existing, the U.S. Coast Guard regulations have included precautionary measures to eliminate or isolate any possible sources of ignition and to stop detonations when they occur. (See Appendix B for a discussion of detonations.) In addition, where practical, the U.S. Coast Guard regulations have attempted to eliminate combustible mixtures altogether.

The various types of safety measures built into the system are generally divided into two categories. One category is referred to as active devices, or those requiring working components or sensors in order to be effective. The following are examples of active devices:

a. Inerting systems.
b. Diluting systems.
c. Enriching systems.
d. Detonation arresting valves.

The other category is passive devices, or those requiring no moving parts or sensors for operation. The only passive devices currently available are detonation arresters. The various types of active and passive devices are discussed in more detail in 3.2.5.1 and 3.2.5.2.

### 3.2.5.1 Active Devices

#### 3.2.5.1.1 Inerting Systems

##### 3.2.5.1.1.1 General

An inerting system adds noncombustible gas to the stream to reduce the oxygen level in the vapor leaving the vessel. Typical inerting gases are nitrogen, carbon dioxide, flue gases, or gases from an inert gas generator.

The amount of inert gas injected into the stream is controlled by measuring the oxygen percentage in the stream. The oxygen percentage must always be less than 8 percent. If the oxygen level reaches 8 percent, an alarm must signal the operator that injection rates are too low. This alarm causes an audible and visual signal to the operator. If the oxygen level continues to increase after the alarm and reaches 9 percent, a second alarm occurs (see note). This alarm causes an audible and visual signal and also causes the remotely operated vapor block valve in the vapor collection header to close. Since the flow of vapor is stopped, the liquid flow must be stopped to prevent overpressuring the vessel.

Note: The 8 percent and 9 percent oxygen levels for the alarms are valid for gasoline, crude oil, and benzene. Systems designed for other materials may require different set points.

The oxygen level in the stream is monitored by either one or two oxygen analyzers, depending on the inert gas injection method. If inert gas is controlled either automatically or manually, two redundant analyzers are required, one to check the other. If inert gas is injected at a fixed rate or is ratio-controlled based on the flow of vapors from the vessel, only one analyzer is required.

Each analyzer must be calibrated within the 24 hours prior to the loading of a vessel. At the beginning of the loading, all analyzers must be working. If the system is equipped with two analyzers and one of the two stops working during the loading of a vessel, the vessel loading may be finished using the remaining analyzer. If the second analyzer stops working during the remainder of the loading, the loading of the vessel must be stopped until both analyzers are repaired. If the system is equipped with only one analyzer and the analyzer fails, the loading of the vessel must be stopped until the analyzer is repaired.

##### 3.2.5.1.1.2 Shore PIC Responsibilities

a. The shore PIC must either calibrate the oxygen analyzers or determine that personnel responsible for calibration have done so.
b. The shore PIC must make sure the analyzer calibration occurred within the 24 hours prior to the loading of the vessel.
c. The shore PIC must be familiar with the proper steps to take if the high-oxygen-level alarm occurs.
d. The shore PIC must stop liquid loading within 30 seconds [60 seconds for older terminals (see 33 Code of Federal Regulations Part 154.550)] of the occurrence of the high high-oxygen-level alarm. Vapor collection is stopped automatically by closing the remotely operated vapor block valve.
e. If the system has two analyzers and one stops working, the shore PIC must notify the personnel responsible for repairing the analyzer. Loading of that vessel or vessels may

be finished, but no other vessels may be loaded until the analyzer is repaired.

f. If the second analyzer fails while the vessel loading is finishing, the shore PIC must stop loading until both analyzers are repaired.

g. If the system has only one analyzer and it fails during the loading of a vessel, the shore PIC must stop loading until the analyzer is repaired.

h. If an inerted vessel is to be loaded, the oxygen level of the vessel compartments being loaded must be tested before the transfer begins. The oxygen level in each compartment must not exceed 8 percent by volume. Oxygen samples must be taken at a point 3.3 feet (1.0 meter) below the tank top and at a point equal to one-half the ullage. If partial bulkheads exist in the compartment, the oxygen concentration must be sampled in each section formed by the bulkhead [see 46 ***Code of Federal Regulations*** Part 39.40-5(b)(1)].

#### 3.2.5.1.2 Diluting Systems

##### 3.2.5.1.2.1 General

A diluting system adds air to the stream to reduce the hydrocarbon concentration in the vapor leaving the vessel. The intent of this approach is to reduce the vapor hydrocarbon concentration below the lower flammability limit. By doing this, the stream is no longer combustible.

The amount of diluting air injected into the stream is controlled by measuring the hydrocarbon percentage in the stream. The hydrocarbon percentage must always be less than 30 percent of the lower flammability limit (LFL). If the hydrocarbon concentration reaches 30 percent of the LFL, an alarm occurs notifying the operator that injection rates are too low. This alarm causes an audible and visual signal to the operator. If the hydrocarbon concentration continues to increase after the alarm and reaches 50 percent of the LFL, a second alarm occurs. This alarm causes an audible and visual signal and also causes the remotely operated vapor block valve in the vapor collection header to close. Since the system is shut down, including the flow of vapor, the cargo transfer must be stopped to prevent vessel overpressurization.

The hydrocarbon concentration in the stream is monitored by either one or two hydrocarbon analyzers, depending on the air injection method. If air injection is controlled either automatically or manually, two redundant analyzers are required, one to check the other. If air is injected at a fixed rate or is ratio-controlled based on the flow of vapors from the vessel, only one analyzer is required.

Each analyzer must be calibrated within the 24 hours prior to the loading of a vessel. At the beginning of the loading, all analyzers must be working. If the system is equipped with two analyzers and one of the two stops working during the loading, the vessel loading may be completed using only the remaining analyzer. If the second analyzer stops working during the remainder of the loading, the loading must be stopped until both analyzers are repaired. If the system is equipped with only one analyzer and that analyzer fails, the loading must be stopped until the analyzer is repaired.

##### 3.2.5.1.2.2 Shore PIC Responsibilities

a. The shore PIC must either calibrate the hydrocarbon analyzers or determine that personnel responsible for calibration have done so.

b. The shore PIC must make sure the analyzer calibration occurred within the 24 hours prior to the loading of the vessel.

c. The shore PIC must be familiar with the proper steps to take when the high-hydrocarbon-level alarm occurs.

d. The shore PIC must be sure to stop liquid loading within 30 or 60 seconds (see 33 ***Code of Federal Regulations*** Part 154.550) of the occurrence of the high high-hydrocarbon-level alarm. Vapor collection is stopped automatically by closing the remotely operated vapor block valve.

e. If the system has two analyzers and one stops working, the shore PIC must notify the personnel responsible for repairing the analyzer. Loading of that vessel or vessels may be finished, but no other vessels may be loaded until the analyzer is repaired.

f. If the second analyzer fails while the vessel loading is finishing, the shore PIC must stop loading until both analyzers are repaired.

g. If the system has only one analyzer and it fails during the loading of a vessel, the shore PIC must stop loading until the analyzer is repaired.

#### 3.2.5.1.3 Enriching Systems

##### 3.2.5.1.3.1 General

An enriching system adds a hydrocarbon to the stream to increase the hydrocarbon level in the vapor leaving the vessel. The intent of this approach is to increase the vapor concentration above the upper flammability limit (UFL). By doing this, the stream is no longer combustible. Typical hydrocarbons injected into the vapor stream leaving the vessel are natural gas and propane, and some systems use vaporized gasoline. The amount of hydrocarbon injected into the stream is controlled by measuring either the hydrocarbon concentration or the oxygen concentration in the stream.

If the hydrocarbon concentration is measured, the hydrocarbon concentration must always be more than 170 percent of the UFL. If the hydrocarbon concentration drops to 170 percent, an alarm occurs notifying the shore PIC that injection rates are too low. This alarm causes an audible and visual signal to the shore PIC. If the hydrocarbon concentration continues to decrease after the alarm and reaches 150 percent of the UFL, a second alarm occurs. This alarm causes an audible and visual signal and also causes the remotely operated vapor block valve in the vapor collection header to close. Since the flow of vapor is shut down, the cargo transfer must be stopped or vessel overpressurization occurs.

An indirect measurement of hydrocarbon concentration in the stream is determined by measuring the oxygen content of the stream. Since air is roughly 21 percent oxygen and 79 percent nitrogen, the amount of nitrogen is calculated if the oxygen is measured. Knowing both oxygen and nitrogen concentrations allows us to determine the amount of hydrocarbon in the stream. If the oxygen percentage is measured, it must always be less than 15.5 percent by volume. If the oxygen level increases to 15.5 percent, an alarm occurs notifying the shore PIC that injection rates are too low. This alarm causes an audible and visual signal to the shore PIC. If the oxygen level continues to increase after the alarm and reaches 16.5 percent oxygen by volume, a second alarm occurs. This alarm causes an audible and visual signal and also causes the remotely operated vapor block valve in the vapor collection header to close. Since the flow of vapor is shut down, the cargo transfer must be stopped or the vessel is overpressured.

The hydrocarbon concentration or oxygen concentration in the stream is monitored by either one or two analyzers, depending on the enriching gas injection method. If enriching gas injection is controlled either automatically or manually, two redundant analyzers are required, one to check the other. If enriching gas is injected at a fixed rate or is ratio-controlled based on the flow of vapors from the vessel, only one analyzer is required.

Each analyzer must be calibrated within the 24 hours prior to the loading of a vessel. At the beginning of the loading, all analyzers must be working. If the system is equipped with two analyzers and one of the two stops working during the loading of a vessel, loading of that vessel may be completed using only the remaining analyzer. If the second analyzer stops working during the remainder of the loading, the loading of the vessel must be stopped until both analyzers are repaired. If the system is equipped with only one analyzer and that analyzer fails, the loading of the vessel must be stopped until the analyzer is repaired.

Enriching gas requires another control feature that is not required for inerting or diluting systems. A check valve or an alarm indicating backflow based on differential pressure must be provided to prevent backflow of the enriching gas into the vessel being loaded. This differential pressure sensor causes both an audible and visual alarm and the remotely operated vapor block valve to close. The differential pressure sensor must be checked mechanically within the 24 hours prior to loading a vessel to make sure the alarms are working and the valve closes properly.

#### 3.2.5.1.3.2 Shore PIC Responsibilities

a. The shore PIC must either calibrate the hydrocarbon or oxygen analyzers or determine that personnel responsible for calibration have done so.

b. The shore PIC must make sure the analyzer calibration occurred within the 24 hours prior to loading a vessel.

c. The shore PIC must be familiar with the proper steps to take when the low-hydrocarbon-level or high-oxygen-level alarm occurs.

d. The shore PIC must stop liquid loading within 30 or 60 seconds (see 33 *Code of Federal Regulations* Part 154.550) of the occurrence of the low low-hydrocarbon-level or the high high-oxygen-level alarm. Vapor collection is stopped automatically by closing the remotely operated vapor block valve.

e. If the system has two analyzers and one stops working, the shore PIC must notify the personnel responsible for repairing the analyzer. Loading of the current vessel or vessels may be finished, but no other vessels may be loaded until the analyzer is repaired.

f. If the second analyzer fails while the vessel loading is finishing, the shore PIC must stop loading until both analyzers are repaired.

g. If the system has only one analyzer and it fails during the loading of a vessel, the shore PIC must stop loading until the analyzer is repaired.

h. If a differential pressure device is used to sense backflow of enriching gas, it must be tested mechanically within the 24 hours prior to loading a vessel.

i. If an enriching gas backflow creates a shutdown alarm. the shore PIC must be familiar with methods used to stop the backflow to the vessel.

### 3.2.5.1.4 Detonation Arresting Valves

#### 3.2.5.1.4.1 General

Detonation arresting valves are a means of stopping and containing a detonation after it has occurred. These valves must be rigorously tested as required by U.S. Coast Guard procedures specifying that the valves be subjected to and actually stop detonations in piping systems. After successfully passing the required testing, the valve manufacturer receives a letter from the U.S. Coast Guard accepting the detonation arresting valve, if properly installed, for use in marine emission control applications.

A detonation arresting valve closes very quickly (in approximately 0.25 seconds). It receives a signal to close from pressure sensors mounted on the vapor collection system. If a detonation occurs, it causes a pressure surge that actuates the detonation arresting valves. A detonation arresting valve generally is located at the dock near the point where the vapor hose is attached. Others may be located at a point that isolates the dock from vapor recovery units, at combustion systems, and at vapor balance storage tanks. In some applications, detonation arresting valves may be located on each side of the blower.

Detonation arresting valves are by design single action devices. The valves can be operated by a service system to verify movement. If the valves are activated through a detonation or by accident, they must be serviced according to the manufacturer's guidelines. This includes replenishing or refilling charge bottles. If a detonation occurs, the valve should be removed, inspected, and reconditioned before it is returned to service. If the valve is accidentally tripped, the cause should be determined and corrected.

### 3.2.5.1.4.2 Shore PIC Responsibilities

a. The detonation stopping valve system has normal maintenance requirements, which are covered in the operations manual provided with these valves. The shore **PIC** must be sure the devices are maintained according to the manual.

b. If a detonation occurs, the shore **PIC** must stop liquid loading since the quick closing valves stop the flow of vapors.

c. If a detonation occurs or is thought to have occurred, the shore PIC should secure the system until the cause is determined and corrected.

d. If a detonation occurs, the valves are triggered. A series of steps must be followed in order to make the valves operational again, including removing the valves for inspection. Before restarting the loading operation, the shore **PIC** must make sure the devices are properly placed back in service according to the operations manual provided by the vendor.

## 3.2.5.2 Passive Devices

### 3.2.5.2.1 Detonation Arresters

### 3.2.5.2.1.1 General

Detonation arresters are large metallic devices mounted directly in the piping (see Figures C-3, C-4, and C-5). These devices are a means of stopping a detonation after it has occurred. The detonation arresters must be tested to the rigorous standards outlined in Appendix A of 33 *Code of* Federal Regulations Part 154.800. These standards require the detonation arrester be subjected to and actually stop detonations in the piping systems. In order to pass the test, the detonation arresters must stop a series of detonations and not fail mechanically. After successfully passing the required testing, the detonation arrester manufacturer receives a letter from the U.S. Coast Guard accepting the detonation arrester for use in marine emission control applications.

**A** detonation arrester forces the vapors to flow through small-diameter elongated channels or through a tortuous path, depending on the manufacturer. In either case, the device subjects the detonation to a large area of metal that acts as a heat sink. The heat sink absorbs energy from the combustion reaction and quenches the flame. Once the flame is quenched, there is no longer an ignition source, and the burning process is stopped.

Because of the design of a detonation arrester, it is easily plugged by foreign matter such as rust, wax, paint chips, or weld slag. Detonation arresters normally are installed with pressure indicators or differential pressure indicators to allow for monitoring pressure across the detonation arrester. If pressure drop increases, it causes problems with any blowers installed in the vapor collection system. Also, blockage could result in increasing pressures inside the vessels being loaded.

Detonation arresters must be maintained periodically to ensure proper operation. Care must be taken to make sure the internal element is handled carefully. Damage to the element causes the arrester to fail if exposed to a detonation. When inspected, the element must be checked for crimping, scoring, or other damage.

Detonation arresters come in two categories based on their ability to withstand continuous burning on the face of the flame arrester. If a detonation arrester withstands continuous burning at the face of the arrester without heating up to the point ignition occurs on the opposite face of the arrester, it is labeled a Type I detonation arrester. If the detonation arrester does not withstand continuous burning, it is labeled a Type II detonation arrester.

Either type of arrester may be used in marine emission control applications; however, a Type II arrester must be outfitted with a temperature sensor at either face. This temperature sensor automatically closes the remotely operated vapor block valve located at the dock if a flame is detected by either sensor.

A detonation is identified by a loud noise in the piping. If a detonation occurs, the loading process must be stopped immediately. After stopping the loading, all detonation arresters must be inspected for damage. Any damage to the arrester could prevent it from stopping detonations. If the unit is damaged, it must be removed from service and either repaired or replaced before loading is allowed to proceed again. Repair of detonation arresters must be done by qualified personnel.

Detonation arresters typically are located at the dock near the point where the vapor hose is attached. Others may be located at a point that isolates the dock from vapor recovery units, at combustion systems, and at vapor balance storage tanks. In some applications, detonation arresters are located on each side of a blower.

### 3.2.5.2.1.2 Shore PIC Responsibilities

a. If a detonation occurs or is thought to have occurred, the shore **PIC** must stop the loading operation immediately and secure the system until the cause is determined and corrected.

b. After stopping the loading, the shore PIC must internally check all detonation arresters in the system for damage.
c. If any arresters show damage, the shore PIC must replace or repair the arrester. Repairs must be made by qualified personnel.
d. If a high-temperature shutdown occurs at a detonation arrester, the shore PIC must stop the loading immediately.
e. After stopping the loading for a high temperature at the detonation arrester, the shore PIC must internally check the affected detonation arrester for damage.
f. If the affected detonation arrester shows damage, the shore PIC must replace or repair the detonation arrester. Repairs must be made by qualified personnel.
g. The shore PIC must monitor the inlet and outlet pressure of each detonation arrester or the differential pressure across the arrester. If pressure drop increases beyond the system pressure drop design limits without the flow rate increasing, the detonation arrester must be inspected for plugging. If plugging has occurred, the arrester must be cleaned before being placed into service again.

### 3.2.5.2.2 Eliminating Ignition Sources

#### 3.2.5.2.2.1 General

The U.S. Coast Guard regulations also protect vapor collection systems from burning inside the piping header by eliminating or isolating ignition sources.

Process systems such as vapor recovery units, combustion systems, refrigeration systems, or absorption systems are always isolated by at least a detonation arrester or detonation stopping valve. In the case of combustion systems, liquid seals that force the vapors to bubble through water are also installed to further isolate the piping.

Items such as vent stacks and vapor balance storage tanks are isolated by detonation arresters or detonation stopping valves.

In addition, blowers used to move vapors are required to be constructed of spark resistant materials. Also, blowers operating in systems that do not dilute, inert, or enrich the vapors being moved must be isolated by a detonation arrester or detonation arresting valve at the inlet and outlet.

Any external heat source that could increase the piping temperature to 177°C (350°F) must be separated or isolated from the vapor collection header.

Analyzers must also be designed so they do not provide a source of ignition to the system. Zirconium-oxide and thermomagnetic-type analyzers are prohibited.

Some systems handle crude oils containing sulfur. These sulfur-bearing compounds react with rust in the piping system to create pyrophoric iron sulfide. Pyrophoric iron sulfide reacts very quickly when exposed to air so that any small amounts generated are eliminated in an exothermic reaction. However, if a system handles sulfur-bearing compounds in inert atmospheres, enough oxygen may not be available to react with the iron sulfide. The pyrophoric iron sulfide formation continues to increase as long as oxygen is not available and forms deposits in the piping. If a large pyrophoric iron sulfide deposit is exposed to oxygen, it oxidizes to iron oxide with a large heat release. If the oxygen is carried as part of a combustible mixture, the pyrophoric iron sulfide can ignite the vapor. Inerted systems that handle sulfur-bearing compounds must have a means of controlling the potential hazard from iron sulfide formation.

One method of controlling pyrophoric iron sulfide buildup in piping is to purge the piping of any hydrocarbon after each loading. This purge must be done with an inert material such as nitrogen. After purging, the line is gas-freed with air to oxidize any iron sulfide to iron oxide. If the line is not purged of hydrocarbon before the air purge, the hydrocarbon may be ignited. A carefully designed written procedure should be developed to implement this technique.

#### 3.2.5.2.2.2 Shore PIC Responsibilities

a. The shore PIC must become familiar with potential ignition sources for the vapors being collected. The shore PIC must make sure any measures taken to isolate heat sources remain in place and are operational.
b. The shore PIC must monitor liquid seals associated with combustion systems to make sure the correct amount of water is maintained in the seal. If the water level drops, the liquid seal must be refilled with water or a water/glycol mixture in cold weather. An alarm with an automatic shutdown for low seal level must be provided with any liquid seal. The alarm must be maintained routinely and mechanically tested at least yearly.
c. If the system processes sulfur-bearing compounds in an inert atmosphere, the shore PIC must follow a procedure to prevent iron sulfide buildup.

## 3.2.6 MISCONNECTION OF HOSES AND LOADING ARMS

### 3.2.6.1 General

The shore PIC has to be concerned with different types of hoses for vapor and for liquid. There is a possibility of connecting the vapor hose to the liquid loading line and the liquid hose to the vapor collection line. Three problems occur if hoses are misconnected, as follows:

a. The liquid is loaded through the vapor header, which does not have drops into the bottom of the vessel. The liquid free-falls into the tank, creating a static electricity buildup.
b. The vapor is drawn off the bottom of the vessel tanks through the drop lines. The liquid in the tank covers the vapor line and creates a pressure drop, or liquids may be sucked into the vapor collection header.
c. The vapor hoses are not rated for the operating pressure of the liquid hoses. The weight of the liquids in the vapor hose may cause a rupture and subsequent spill.

The U.S. Coast Guard regulations require the following safety measures to prevent the misconnection of hoses:

a. Each vapor connection on the shore and on the vessel is color coded with a band 3.3 feet (1.0 meter) long painted red and yellow. The yellow band has the words "VAPOR" stenciled in black letters 2 inches (5.08 centimeters) tall (see Figure 2).
b. Each vapor hose has the same red and yellow color coding and markings as the vapor connections.
c. The shore vapor connection and the vessel vapor connection each have a metal lug [½ inch (1.27 centimeters) diameter and protruding 1 inch (2.54 centimeters)] welded at the top of the flange (see Figure 3).
d. Each flange connection of the vapor hose has a hole drilled between the bolt holes [⅝ inch (1.59 centimeters) diameter] that matches the metal lug on the vapor connections.

#### 3.2.6.2 Shore PIC Responsibilities

a. The shore PIC must identify the vapor connections on the vessel by the red and yellow color coding.
b. If the vessel is providing the vapor collection hose, the shore PIC must be sure the vessel is attached at the proper connection. The shore PIC must then attach the vapor hose to the shore facility vapor connection.
c. If the shore facility is providing the vapor collection hose, the shore PIC must be sure the hose is attached to the proper connection on the vessel.
d. The shore PIC must only connect hoses to the vapor collection system that are properly color coded and labeled as vapor collection hoses.
e. The shore PIC must be sure the vapor hose has been tested to one and one-half times the operating pressure within the past year.
f. The shore PIC must be sure the vapor hose is handled properly. Hoses must not be twisted or kinked during hookup.
g. As the vessel rises or falls with loading or tides, the shore PIC must make appropriate adjustments to the hose.

## 3.3 General Operating Concerns

### 3.3.1 VESSEL AND SHORE CARGO CONNECTIONS

#### 3.3.1.1 General

The U.S. Coast Guard marine emission control regulations do not change existing regulations applying to the liquid systems. There are some general responsibilities the shore PIC must remember.

#### 3.3.1.2 Shore PIC Responsibilities

a. The shore PIC must make sure all flange faces, gaskets, and seals are clean and in good condition. The shore PIC must replace any components that are damaged or are no longer usable.
b. Each terminal manifold flange must have a removable blind flange. Before removing the flange, the shore PIC must make sure the section between the flange and the last valve does not contain product under pressure.
c. The shore PIC must make sure any reducers used to make connections to either the shore or vessel connection are made of steel. If materials other than steel are used, special care may be required to avoid stress damage from hanging hoses.

### 3.3.2 CARGO HOSES

#### 3.3.2.1 General

The U.S. Coast Guard marine emission control regulations do not change the regulations applying to the cargo hoses. The shore PIC must remember some general responsibilities.

#### 3.3.2.2 Shore PIC Responsibilities

a. The shore PIC must make sure hoses are in good condition. Any hoses that appear to be defective must be rejected and replaced. Note that the vessel PIC also has the authority to reject a hose.
b. The shore PIC must be sure the cargo hose has been tested to the manufacturer's specifications within the past year.
c. The shore PIC must make sure the hose is handled properly. Hoses must not be twisted or kinked during hookup.
d. The shore PIC must provide adequate hose support to prevent excessive weight on the connection flanges.
e. As the vessel rises or falls with loading or tides, the shore PIC must make appropriate adjustments to the hose.

### 3.3.3 CARGO LOADING ARMS

#### 3.3.3.1 General

The U.S. Coast Guard marine emission control regulations do not change the regulations applying to the cargo arms. The shore PIC must remember some general responsibilities.

#### 3.3.3.2 Shore PIC Responsibilities

a. The shore PIC must thoroughly understand the operating envelope limits for the loading arm. Movement outside these limits creates undue stress on the connection flanges and the arm. The shore PIC must make sure the loading arm stays within its limits at all times during the loading.
b. Before moving the loading arm for connection to the vessel, the shore PIC must make sure the arm is liquid-free.
c. The shore PIC must make sure any external weight, such as ice, is removed before attempting to attach the arm to the vessel.
d. The shore PIC must make sure any mechanical couplers are smooth and free of rust in order to achieve a tight seal.

e. Where winds are excessive, wind loads apply strain to the manifold connections. The shore PIC must monitor wind speed and direction to make sure they stay within design guidelines. If winds exceed design loads, the arm must be uncoupled.

f. The shore PIC must make sure the vessel moorings are monitored during the loading and tended as necessary to prevent movement outside the operating envelope of the loading arm.

g. The shore PIC must make sure any drift alarms are activated.

h. The shore PIC must make sure the arm is free to move with the motion of the vessel. Any hydraulic or mechanical locks must be disengaged.

i. The shore PIC must make sure excessive vibration is not created in the loading arm due to liquid flow rates or external forces.

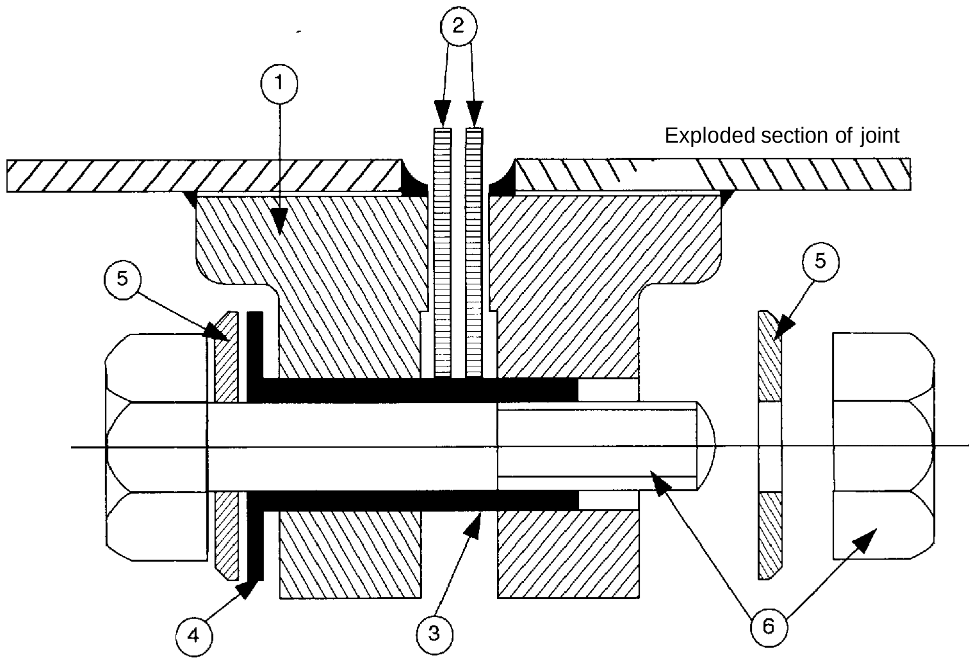
### 3.3.4 VESSEL AND SHORE INSULATING AND GROUNDING

#### 3.3.4.1 General

The shore PIC must follow shore facility procedures to protect against arcing due to static buildup. In addition, the U.S. Coast Guard regulations require that an insulating flange kit is installed at the shore facility vapor connection (see Figure 4). (For additional information, see API Recommended Practice 2003 or the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT), Chapters 7.4 and 19.)

#### 3.3.4.2 Shore PIC Responsibilities

a. The shore PIC must make sure liquid and vapor cargo hoses and cargo arms are fitted with an insulating flange to ensure electrical discontinuity between the vessel and shore (see note).




| Item | Material | Description |
|---|---|---|
| 1 | Steel | Flange can be screw-on, slip-on, or weld-neck type (in accordance with ANSI B 16.5) |
| 2 | Klingerite | Joint rings 1/16 inch thick |
| 3 | Tufnol | Bolt insulating sleeves (Crow grade) |
| 4 | Tufnol | Bolt washer 1/8 inch thick (Crow grade) |
| 5 | Steel | Plain round washer B.S. |
| 6 | Steel | B.S.W. bright bolts and nuts |

Note: B.S. = British Standard; B.S.W. = British Standard Whitworth.

Source: *International Safety Guide for Oil Tankers and Terminals.*

Figure 4—Insulating Flange Joint

b. The shore PIC must make sure the insulating flanges or nonconducting hose is not short-circuited by contact with pipe supports or other metallic objects.
c. The shore PIC must periodically inspect and test the insulated flange to make sure it has not become electrically continuous. A measured value of not less than 1,000 ohms must be maintained.
d. The shore PIC must periodically inspect and test all cargo hoses to make sure they remain electrically continuous.

Note: API Recommended Practice 2003 and the *International Safety Guide for Oil Tankers and Terminals* strongly recommends vessel-to-shore grounding cables not be used. These grounds are considered ineffective as safety devices and may even be dangerous. These devices may be a shore facility preference, or, in some instances, they may be required by local regulations. If a grounding cable must be used, there must be a switch of a type suitable for use in a Class 1, Division 1, hazardous area in series with the grounding cable at the dock facility. The following precautions must be followed:

a. The shore PIC must inspect the grounding cable to make sure it is mechanically sound and electrically continuous.
b. The shore PIC must make sure the switch referenced above is turned to the "off' position before the grounding cable is connected or disconnected.
c. The shore PIC must attach the grounding cable before the cargo and vapor hoses are connected and must remove the grounding cable only after the hoses have been disconnected.
d. The shore PIC must turn the switch referenced above to the "on" position only after the cable has been firmly fixed in place.

### 3.3.5 STATIC ELECTRICITY

#### 3.3.5.1 General

Some products are known accumulators of static electricity. It is necessary practice to follow guidelines that minimize the chances of static discharges when loading these products. (See API Recommended Practice 2003 and the *International Safety Guide for Oil Tankers and Terminals* (TSGOTT), Chapters 7.4 and 19 for additional information.)

#### 3.3.5.2 Shore PIC Responsibilities

a. The shore PIC and the vessel PIC must determine the initial fill rate for the vessel being loaded and the amount of initial fill required before the loading rate is increased. To determine the initial fill rate, follow the steps in subitems 1–3 below. During the initial loading, the shore PIC must not load the vessel faster than its initially agreed-upon till rate as provided by the vessel PIC during the pretransfer conference. The maximum design load rate is initiated once all splashing and surface turbulence has been eliminated and the load pipes in the compartments are covered.

1. During the initial stages of loading into all individual vessel compartments, the liquid flow rate in the tank's branch line must not exceed a linear velocity of 3.3 feet per second (1.0 meter per second).
2. The initial fill rate is then derived by knowing the size of the drop line into the vessel's tanks and the number of tanks that are to be filled at the start of the loading.
3. Use Table 1 to determine the initial fill rate for various sizes of liquid drop lines, as follows:

Example 1: If a vessel is to fill one compartment during the initial fill period and the liquid drop line size is 8 inches, determine the initial fill rate. Reading from Table 1, the initial fill rate is 511 gpm or 730 bph.

Example 2: If a vessel is to fill three compartments during the initial fill period and the liquid drop line sizes are 6 inches, determine the initial fill rate. Reading from Table 1, the initial fill rate for a 6 inch line is 295 gpm or 421 bph. For three tanks the initial fill rate is as follows:

$$295 \text{ gpm} \times 3 = 885 \text{ gpm}$$
or
$$67 \text{ m}^3/\text{hr} \times 3 = 201 \text{ m}^3/\text{hr}$$
or
$$421 \text{ bph} \times 3 = 1{,}263 \text{ bph}$$

b. During loading and for 30 minutes after the completion of the loading, the shore PIC must make sure no metallic dipping, ullaging, or sampling equipment is introduced into a noninerted tank. These items must not be allowed to remain in the tank during loading. Nonconducting equipment with no metal parts may be used, in general, at any time (see note).
c. The shore PIC must make sure that any metallic dipping, ullaging, or sampling equipment is firmly grounded to the vessel structure before introduction into the tank.

Note: Permanently fitted metal float level gauges do not present a static electricity hazard provided the metal float has electrical continuity to the structure of the vessel.

### 3.3.6 VESSEL FILLING RATE

#### 3.3.6.1 General

The vapor piping on the vessel and the vapor piping and components on the shore are all designed for an expected maximum loading rate. The vessel design rate and the shore design rate most likely do not match, since they were developed independently. If the maximum loading rates are exceeded, the increase in flow develops a greater back pressure

Table I — Initial Fill Rate for Liquid Drop Lines

| Nominal Pipe Diameter (in inches) | Initial Fill Rate gpm | $m^3/hr$ | bph |
|---|---|---|---|
| 6 | 295 | 67 | 421 |
| 8 | 511 | 116 | 730 |
| 10 | 806 | 183 | 1151 |
| 12 | 1156 | 262 | 1651 |

Note: gpm = gallons per minute; $m^3/hr$ = cubic meters per hour: bph = barrels per hour.

than the systems are designed for. This increased back pressure must be sensed by the pressure monitoring systems in the vapor collection system. If the pressure monitoring systems fail or are isolated, loading too rapidly could overpressure the vessel and cause structural failure.

#### 3.3.6.2 Shore PIC Responsibilities

a. The shore PIC must know the maximum design loading rate for the shore vapor collection system.
b. During the pretransfer conference, the shore PIC must determine the initial, maximum, and topping-off vessel transfer rates.
c. During the loading of the vessel, the maximum fill rate must be the lesser of the vessel design rate and the shore design rate. It is the shore PIC's responsibility to set and maintain this tlow rate.

### 3.3.7 SYSTEM EMERGENCY SHUTDOWNS AND ALARMS: WHAT SHOULD BE DONE?

#### 3.3.7.1 General

There are many reasons a marine emission control system experiences a shutdown or an alarm condition. A shutdown both provides an audible and visual signal and automatically stops the operation of the system, whereas an alarm is generally only an audible and visual signal. Some systems have unique shutdowns and alarms that are not required by the U.S. Coast Guard but make operation safer for the particular site's operation. In general, some simple guidelines must be followed for any shutdown or alarm condition.

#### 3.3.7.2 Shore PIC Responsibilities

a. If an automatic shutdown occurs, the shore PIC should stop the flow of liquid to the vessel within 30 seconds. This prevents potential overpressurization since the vapor collection system must close in 30 seconds.
b. When an automatic shutdown or alarm occurs, the shore PIC must immediately determine the cause from a first-out annunciator, a computer control screen, or other means as provided by the system.
c. If an automatic shutdown occurs, the shore PIC must notify the vessel PIC of the cause, and a decision must be made either to close the manual isolation valves on the vessel or to restart the system. For specific problems, the shore PIC must refer to his design manual for recommended operational practices.
d. If an alarm condition occurs, the shore PIC must notify the vessel PIC of the problem and take the appropriate steps to take the unit out of the alarm condition. For example, a high-pressure alarm could be alleviated, in some instances, by lowering the flow rate to the vessel. For specific problems, the shore PIC must refer to his design manual for recommended operational practices.
e. If the shutdown occurs from a high temperature at the detonation arresters, the shore PIC must stop the loading and inspect the detonation arrester internals before proceeding. The cause of the high temperature should also be determined and corrected.
f. If the shore PIC believes a detonation has occurred in the piping, he must stop the loading and inspect the detonation arrester internals before proceeding. The cause of the detonation should also be determined and corrected.
g. The shore PIC must be familiar with all shutdown and alarm signals from the control panel and should be familiar with precautionary measures associated with each shutdown or alarm signal.

### 3.3.8 ROUTINE SYSTEM MONITORING

#### 3.3.8.1 General

Each operating system most likely is slightly different from all others. However, the U.S. Coast Guard regulations require certain items be included in each design. These items are included to enhance the operation and safety of the system. Also, there are general operational guideliqes, which are always good practice, that are associated with specific types of equipment, such as blowers. The items in 3.3.8.2 below represent control parameters that must be monitored routinely.

#### 3.3.8.2 Shore PIC Responsibilities

a. The shore PIC must monitor the following pressure drops (see note) through the system:
   1. lnlet and outlet pressure at each detonation arrester. This indicates if plugging is occurring.
   2. lnlet and outlet pressure of each blower. This indicates such things as bearing problems, loose drive belts, and leaking seals.
   3. Inlet pressure to the marine emission control system. This provides an indication of the vessel pressure.
b. The shore PIC must monitor the following liquid levels (see note) through the system:
   1. Each liquid condensate knockout drum. This indicates liquid accumulation.
   2. Each liquid seal associated with a combustion system to make sure the seal level is adequate for protection from flashback.
c. The shore PIC must monitor the following temperatures (see note) throughout the system:
   1. Heat exchanger inlet and outlet temperatures. This indicates loss of cooling medium or fouling of the exchanger.
   2. Combustion system temperatures. Low temperatures do not always provide good destruction of the vapors being collected.

Note: For units used for recovery or combustion of the recovered vapors, refer to specific operating manuals to determine additional pressure drop, liquid level, or temperature monitoring required.

d. The shore PIC must monitor the hydrocarbon or oxygen concentration for systems that inert, enrich, or dilute. The shore PIC must know the alarm points and shutdown points for each analyzer. By monitoring, the shore PIC prevents alarms or shutdowns from occurring by taking appropriate actions as called for in the system operating manual.
e. Many systems include heat tracing as a means of reducing or eliminating condensation. The shore PIC must be familiar with the method required for determining the status of the system heat tracing.

### 3.3.9 PRETRANSFER CONFERENCE

#### 3.3.9.1 General

The vessel PIC and the shore PIC must hold a pretransfer conference before the transfer of any product is started. During the pretransfer conference, the following topics must be discussed:

a. The identity of the product to be transferred.
b. The sequence of transfer operations.
c. The initial, maximum, and topping-off transfer rates.
d. The name, title, and location of each person participating in the transfer operation.
e. Details of the transferring and receiving systems.
f. Critical stages of the transfer operation.
g. Federal, state, and local rules that apply to the transfer of the product.
h. Emergency procedures.
i. Discharge containment procedures.
j. Discharge reporting procedures.
k. Watch or shift arrangement.
l. Transfer shutdown procedures.

In addition to the above topics, the following must be performed and reviewed for completion:

a. The electrical insulating flange fitted between the vapor hose and the shore flange connection must be checked to ensure it is in place and in good condition.
b. The pressure relief set point and the vacuum relief set point for the vessel must be discussed, and the high- and low-pressure alarm set points must be calculated for the vapor collection system.
c. The vessel's Certificate of Inspection must be reviewed to make sure the vessel is endorsed for connection to a vapor collection system.
d. If the vessel is to load benzene vapors, the vessel must have a certificate of leak tightness aboard dated within the last year. If the certificate is not available, the vessel is either loaded under vacuum, or the facility conducts a leak check of the vessel during the final 20 percent of the loading. If leaks are detected, the vessel must not be loaded again until it provides a certificate of leak tightness or an endorsement that the modifications to make the vessel leak tight cannot be made until the vessel is placed in dry dock.
e. The cargo condition of the vessel must be determined as either inerted or noninerted.

#### 3.3.9.2 Shore PIC Responsibilities

a. The shore PIC must have available for review the material safety data sheets on the product being loaded.
b. The sequence of transfer operations now includes any steps required to accommodate the vapor collection system. Since vacuums are now implied on vessels by some systems, the shore PIC should assist the vessel PIC in determining the correct time to open the manual vapor block valves on the vessel.
c. The shore PIC must know the transfer rate for the shore facility. The facility transfer rate is compared to the vessel trancfer rate. Whichever is less sets the transfer rate during loading of the vessel.
d. The shore PIC must go over the details of the transfer operation and any critical stages. Such items as what to do during shutdown conditions, high-level or overfill alarms, and other details of the system must be discussed to ensure the vessel PIC and the shore PIC know how to respond properly.
e. The shore PIC must be familiar with shutdown procedures, including any modifications resulting from the use of the vapor collection system. Purging of hoses and mandatory wait periods for static reduction or other purposes must be followed.
f. The shore PIC must determine the initial fill rate based on the size of the liquid drops into the vessel tanks and the number of tanks to be filled initially. The length of time for the initial fill rate must also be determined.
g. The pressure relief and vacuum relief set points for the vessel must be verified by the shore PIC. The high- and low-pressure alarm set points must be calculated, and the required alarm pressures compared to the set points of the high- and low-pressure alarm sensors. If the calculated alarm points are less than the set points of the instruments, the instruments must be recalibrated and tested.
h. Vessels with vapor collection headers are not necessarily endorsed by the U.S. Coast Guard for connection to vapor collection systems. The shore PIC must review the vessel's Certificate of Inspection to ensure it is specifically endorsed for vapor recovery.
i. The shore PIC must make certain the vessel is certified as leak tight by one of the following means:
   1. The vessel is loaded under vacuum.
   2. The vessel has a certificate of leak tightness.
   3. The vessel is tested by dock personnel for leaks during the final 20 percent of the loading. If leaks are detected, the vessel cannot be loaded again until it is certified or proves modifications cannot be made until the vessel is placed in dry dock.

j. The shore PIC and vessel PIC must witness sampling of the vessel's cargo tanks, if it is inerted, to confirm that oxygen levels are below the required level of 8 percent by volume. The concentration must be measured twice, at a point 3.3 feet (1.0 meter) below the tank top and at a point equal to one-half the ullage in each inert cargo tank and in each area of a tank formed by partial bulkheads.

## 3.4 Before the Loading Begins

The regulations require that several preliminary tests and visual inspection of the system be conducted before the loading of the vessel and collection of vapors. Basically, the U.S. Coast Guard requires that all system components are working and are maintained on a routine basis.

When checking components, actual mechanical proof that the system is working is required. For example, pressure sensors must have a pressure imposed on them equal to the required set point, and the resulting alarms must be monitored. The generation of a false signal representing a sensor output does not prove the sensor works. Valves must be witnessed as operational, and alarm horns and beacons must be verified as working.

The following items must be checked within the 24 hours prior to loading the vessel. If the checkouts are completed for a vessel that is delayed beyond the 24 hours, the checkouts must be repeated.

a. Each high-pressure sensor must be set as required based on the vessel's pressure relief valve setting. The pressure sensor must have an equivalent pressure applied to it and must create an audible and visual alarm signal at the alarm set point.

b. Each low-pressure sensor must be set as required, based on the vessel's vacuum relief valve setting. The pressure sensor must have an equivalent vacuum applied to it and must create an audible and visual alarm signal at the alarm set point.

c. Each high high-pressure sensor must be set at 2.0 pounds per square inch gauge, or a lower value. The pressure sensor must have an equivalent pressure applied to it and, at the alarm set point, must create an audible and visual alarm signal and close the remotely operated vapor shutoff valve.

d. Each low low-pressure sensor must be set at –1.0 pounds per square inch gauge vacuum, or a higher value. The pressure sensor must have an equivalent vacuum applied to it and, at the alarm set point, must create an audible and visual alarm signal and close the remotely operated vapor shutoff valve.

e. Oxygen or hydrocarbon analyzers must be calibrated. The analyzer output must be checked to make sure the high-oxygen or low-hydrocarbon alarm creates an audible and visual alarm signal. The high high-oxygen or low low-hydrocarbon alarm must create an audible and visual alarm signal and close the remotely operated vapor shutoff valve.

f. The vapor processor must have a false shutdown generated. This must create an audible and visual alarm signal and close the remotely operated vapor shutoff valve.

g. If the system has a blower, it must be started and then forced to shut down. This must create an audible and visual alarm signal and close the remotely operated vapor shutoff valve.

h. Any flame screens associated with relief valves must be inspected to ensure they have not plugged.

i. If the system is equipped with automatic liquid block valves, they must be checked to make sure they close during a shutdown condition.

j. If the system uses enriching and a backflow differential pressure sensor to sense reverse flow to the vessel, the sensor must be checked. The differential pressure sensor must have pressure applied to it equivalent to its trip point. At the alarm point, it must cause an audible and visual alarm and close the remotely operated cargo block valve.

The following items must be inspected or tested prior to the loading of a vessel:

a. Each manual valve in the vapor collection system must be checked to make sure it is in the proper position to allow cargo loading. This includes any small valves used to isolate pressure sensors, level sensors, level gauges, or other devices for either pretransfer checking or maintenance.

b. The vapor collection hose or arm must be checked to make sure it is properly and firmly connected to the vessel's vapor connection.

c. Each vapor recovery hose and liquid hose must be inspected for unrepaired loose covers, kinks, bulges, soft spots, or other defects that permit the discharge of vapor or product through the hose material. There must not be signs of external damage to the hose such as gouges, cuts, or slashes that penetrate the first layer of hose reinforcement.

d. The oxygen content of any inerted vessel must be checked and verified as below 8 percent by volume.

e. If the vessel has a shore overfill control system, it must be connected to the overfill control panel. Each individual tank level sensor must be checked to make sure it provides an overfill alarm and a high-level alarm (if provided, this is optional). The high-level alarm must generate an audible and visual alarm. The overfill alarm must generate an audible and visual alarm at the alarm set point and close the remotely operated vapor shutoff valve.

The following items must be checked at least once a year. More frequent checks are permitted and encouraged.

a. All knockout drums must be filled to simulate a high-level and high high-level condition. The high-level alarm must generate an audible and visual alarm signal. The high high-level alarm must generate an audible and visual alarm signal and shut down any blowers in the system.

b. Each alarm and shutdown associated with the vapor processor must be checked mechanically and electrically.

c. Each temperature sensor associated with a Type II detonation arrester must be removed from the line and have a temperature equivalent to its set point applied to it. The sensor must create an alarm at its set point. The alarm must generate an audible and visual alarm signal and close the remotely operated vapor shutoff valve.

At least once a year, the following components must be inspected:

a. All relief valves must be inspected. They must have their relieving set points checked and reset, if necessary. This must be done by imposing an actual pressure signal on the valve, either in place or by removing and testing it on a bench.
b. All detonation arresters and flame arresters must be removed. The internals must be checked for damage or plugging. If damage is found, the arrester must be repaired or replaced before returning it to service. Repairs must be made by authorized personnel.

# APPENDIX A—WHAT IS COMBUSTION?

Combustion is a process that can be depicted by a triangle with each side of the triangle representing a component required for combustion to occur. The sides of the triangle are as follows:

a. A fuel source, such as gasoline.
b. An oxygen source, such as air.
c. An ignition source, such as a spark or a match.

The triangle is suitable for most combustion sources, such as the open flame on a gas stove. In a gas stove, natural gas or propane serves as the fuel. The air that exists naturally around the stove provides the source of oxygen; and a match, or in modern versions an electronically generated spark, serves as the ignition source to start the combustion process. The stove continues to bum after the match or electronic spark is removed because the flame generates enough heat to provide its own ignition source once started.

If the natural gas or propane is turned off, one leg of the triangle, fuel, is removed, and the fire goes out. Suppose that you want to stop the fire, but the source of fuel is not removed. One way to do this is to remove the source of oxygen. This is typically the method by which fire extinguishers work. By pouring carbon dioxide ($CO_2$) from a typical $CO_2$ extinguisher onto a fire, the air that provides oxygen is removed from the fire. This removes one leg of the triangle, oxygen, and again the result is the fire goes out.

With combustion that occurs inside closed systems, such as piping, an additional criteria plays a large part in determining whether combustion occurs or is sustained. This criteria is referred to as the upper and lower flammability limits of the fuel source being burned. Each fuel source, such as gasoline, benzene, natural gas, or propane, has a range of fuel and oxygen limits that sustain combustion. Since enclosed piping systems have no means of drawing in additional air as an oxygen source, the air must exist in the pipe within the correct range before combustion can occur. This range is commonly referred to as the upper flammability limit (UFL) and the lower flammability limit (LFL), or sometimes the upper explosive limit (UEL) and lower explosive limit (LEL).

These limits are normally stated in percentage of the fuel source mixed in air, instead of oxygen. For example, methane, the major component of natural gas, has an LFL of 5 percent and a UFL of 15 percent. This means if methane is mixed in air so that the percentage of methane is between 5 percent and 15 percent, the mixture bums. If the methane concentration is less than 5 percent, there is not enough fuel in the mixture to sustain combustion; or if the methane concentration is greater than 15 percent, there is not enough oxygen to sustain combustion. Other combustibles will have varying upper and lower flammability limits.

For combustion to occur inside a piping system, such as a vapor collection header in a marine vapor control system, four things must occur. There must be a fuel source, oxygen, an ignition source, and the proper mixture of fuel and oxygen. If any of these conditions are not present, combustion cannot occur.

Upper and lower flammability limits provide another means of eliminating combustion. If a mixture of fuel and air is in the combustible range, one of the following two additions can change the mixture of fuel and oxygen and take it out of the range where combustion occurs:

a. Adding more air to the system, which is referred to as diluting, reduces the percentage of fuel in the mixture. If enough air is added, a mixture is created that has a percentage of fuel below the LFL. When this occurs, the mixture is no longer combustible even if an ignition source is introduced.

b. Adding more fuel to the system, which is referred to as enriching, creates a mixture that has more fuel than required for the UFL. When this occurs, combustion is no longer sustained.

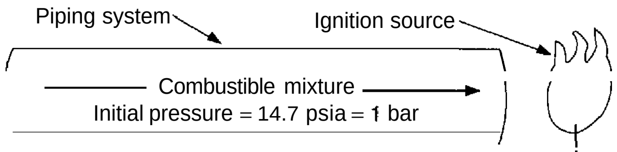
A final means of preventing combustion is called inerting. In this method, an inert gas, such as nitrogen, carbon dioxide, or combustion off-gases, is introduced into a stream that otherwise is combustible. The addition of inerts acts as an energy sponge. These noncombustible materials must also be heated if combustion temperatures are to occur. By adding enough inerts, the fuel in the stream does not provide enough heat to create combustion as well as heat all the inerts present. Therefore, combustion cannot proceed.

# APPENDIX B—DETONATIONS IN PIPING

## B.l General

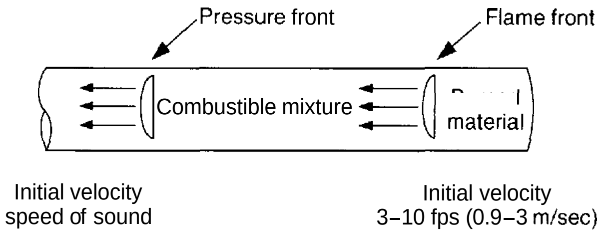
When combustion occurs inside a closed piping system such as a marine emission control system collection header, several different stages of burning or combustion may exist.

As discussed in Appendix A, combustion occurs in an enclosed system when several things take place. First, there must be a fuel source in the piping. Second, this fuel must be mixed with a correct amount of air to provide a combustible mixture. Third, the mixture of fuel and air must be exposed to an ignition source that creates enough heat to initiate burning. Once ignition has occurred and if the fuel provides sufficient heat, the burning process continues without a continuous ignition source, provided the mixture remains within its flammable region. Wherever these conditions are present in the pipe, burning occurs; wherever they are not present, burning cannot occur.



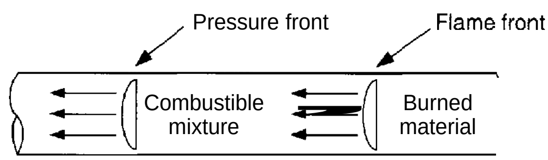

**Stage 1: Combustible mixture.**

If all conditions are met and the mixture ignites, it burns from the point of ignition through the combustible mixture. As this is occurring, the flame moves through the combustible mixture, but the combustible mixture itself does not necessarily move also. The flame moving through the combustible mixture is called a flame front. The flame front begins moving at what is referred to as its flame speed. The initial flame speed generally is in the range of 3 to 10 feet per second (0.9 to 3.0 meters per second). At this time, the burning is normally referred to as a deflagration.



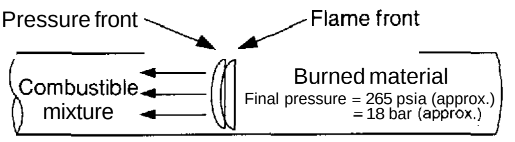

**Stage 2: Ignition occurs.**

As the burning is first initiated, a pressure wave is generated that leads the flame front through the combustible mixture. This pressure wave travels at the speed of sound in the combustible mixture and, therefore, initially moves faster than the flame front. Due to changes in density and flame geometry, the burning rate will begin to increase, and this in turn causes the flame front speed to increase. The increase in flame front speed generates additional pressure waves, which can come together to form a shock wave. If the process continues, the shock wave can increase in energy potential, until the shock wave can create localized explosions (combustion).




**Stage 3: Pressure front compresses combustible mixture; flame front speeds up.**

When the shock waves contain enough energy to create localized combustion, the deflagration becomes a detonation. At this point, the flame front will be moving at a much higher velocity than the pressure wave (shock wave). The early stage of a detonation is often known as overdriven detonation and is accompanied by a sharp increase in pressure. When the overdriven detonation catches up to the first pressure wave, stable detonation occurs and a constant velocity is reached.




**Stage 4: Flame front catches pressure front; detonation occurs.**

It is possible for the stable detonation to lose enough energy to return to a deflagration state and then to reinitiate an overdriven detonation and subsequently return to a stable detonation condition. This can occur repeatedly if conditions are appropriate. The pressures associated with detonations can vary but generally are not high enough to cause structural failure of piping systems. Even though some instances of piping failure have been documented, the pressure generally maximizes at approximately 18 times the initial pressure in the pipeline.

The speeds associated with detonation are extremely high. The time for a detonation to travel through 1,000 feet (304.8 meters) of pipe is approximately 0.17 seconds. This is quicker than a blink of the eye.

In order to provide systems that are as safe as possible, the U.S. Coast Guard requires detonation arresting devices be located at strategic points throughout all marine emission control systems. These devices can take one of the two different forms described in B.2 and B.3.

## 6.2 Detonation Arresters

Detonation arresters are large metallic devices located in the piping system. These devices force the flow of vapor and any detonation through small openings. The small openings increase the surface area to which the burning is exposed. The expanded surface area absorbs the heat generated by the combustion and, in effect, cools the flame below the point where combustion can continue. By removing the ignition source, the burning stops.

Detonation arresters are referred to as passive devices by the U.S. Coast Guard because they have no internal moving parts and do not need input from any external devices to operate properly.

## B.3 Detonation Arresting Valves

Detonation arresting valves have also been shown to be effective in stopping detonations. These valves use pressure sensors located along the piping to sense a detonation. The pressure sensors electronically tell the valve to seal off the piping system. The valves typically use a small explosive charge to open a pressure bottle that forces the valve to close very quickly. Often, the valves are accompanied by injection devices located on both sides of the valve. These injectors dump carbon dioxide, sodium bicarbonate, water, or some other flame suppressant into the piping system to further reduce the chance of detonation progressing beyond the point where the valve is located. These devices are referred to as active because they require external components to operate in order to stop the detonation.

# APPENDIX C—EXAMPLES OF VESSEL AND SHORE COMPONENTS

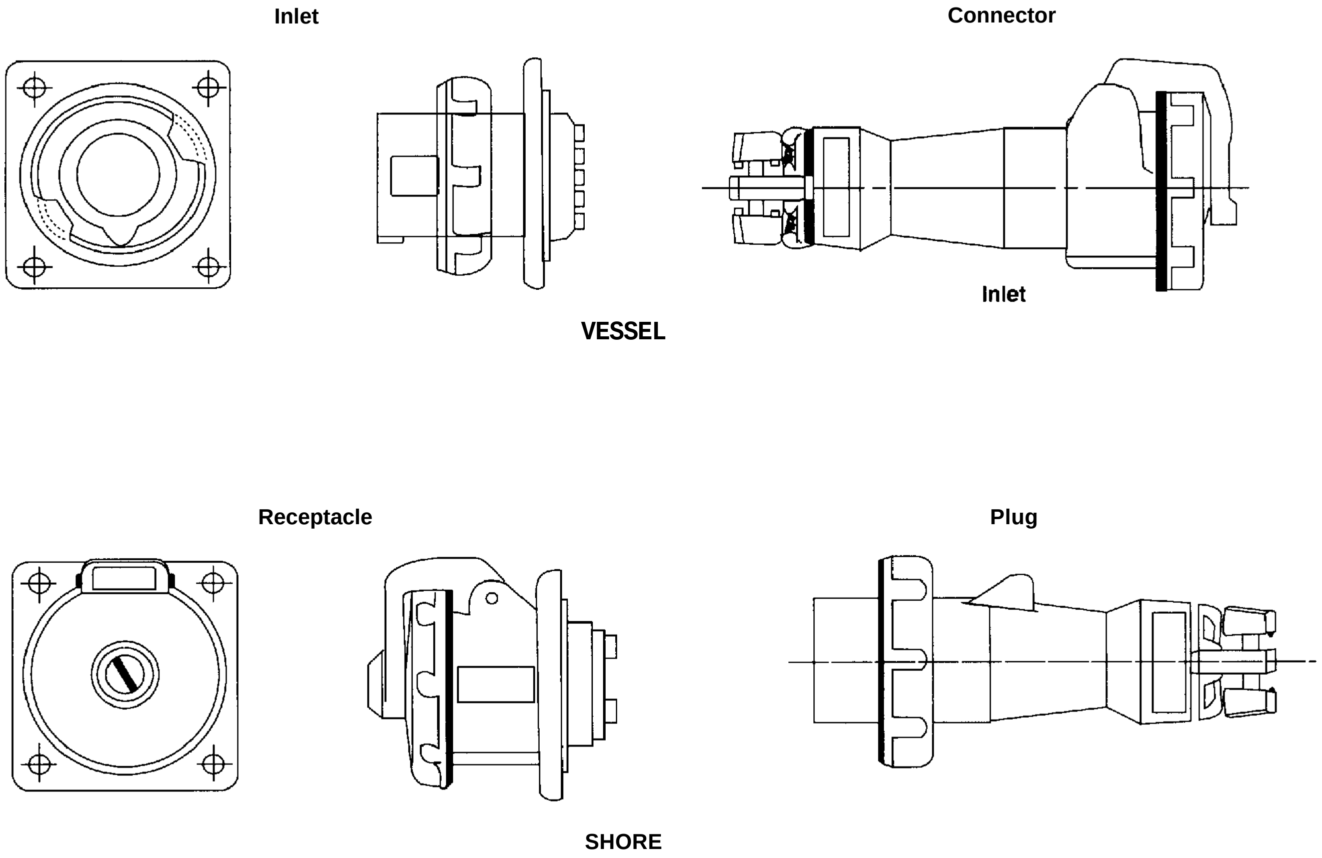
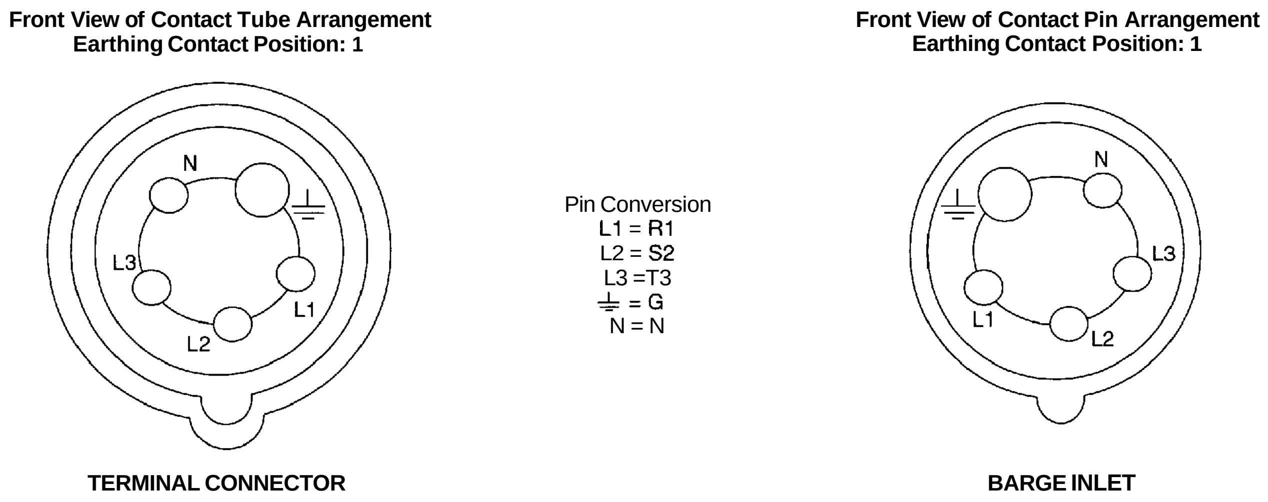



Figure C-1—High-Level or Overfill Alarm System Pin-and-Sleeve Device




Note: L1 and L2 are for overfill alarm and shutdown. L3 and N are for optional high-level alarm. ⏚ should be connected to the cable shield.

Figure C-2—Connector for an Intrinsically Safe Overfill System

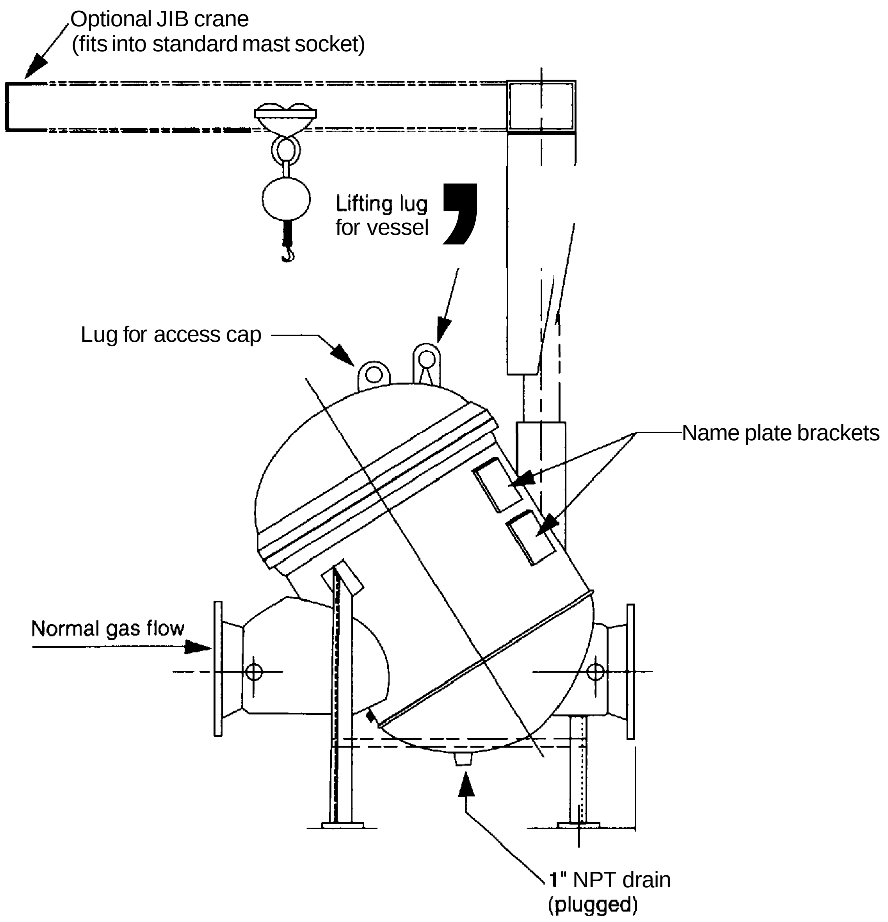
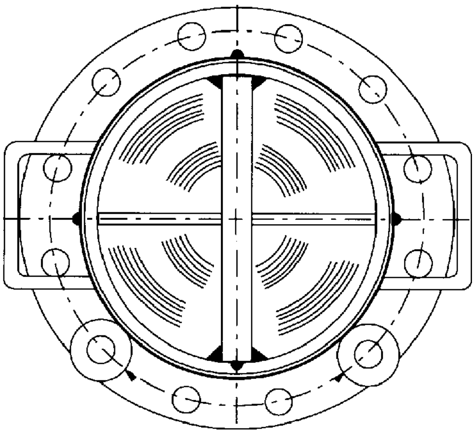
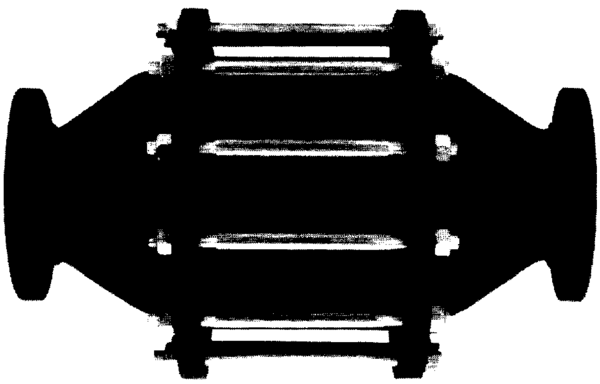


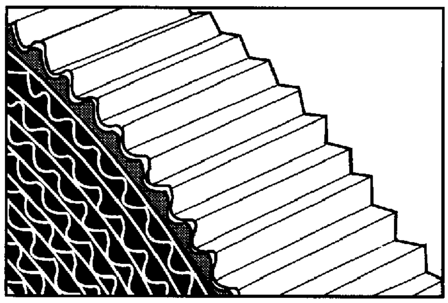

Figure C-3—Bidirectional Detonation Arrester



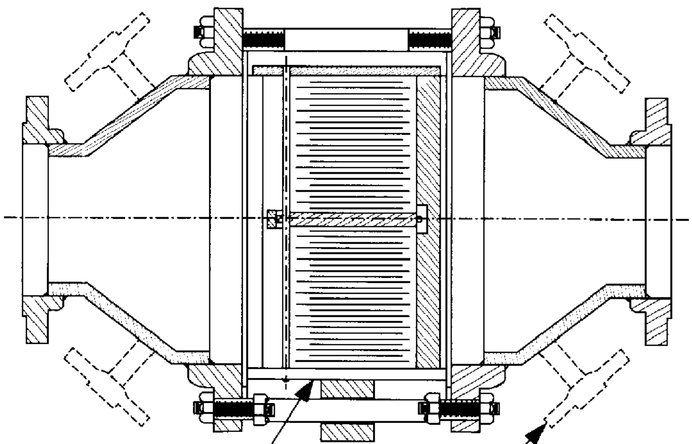
END VIEW SHOWING ARRESTER ELEMENT



PHOTOGRAPHIC SIDE VIEW



MAGNIFIED ILLUSTRATION OF CRIMPED METAL




SIDE VIEW

Figure C-4—Bidirectional Detonation Arrester: Crimped Ribbon Style

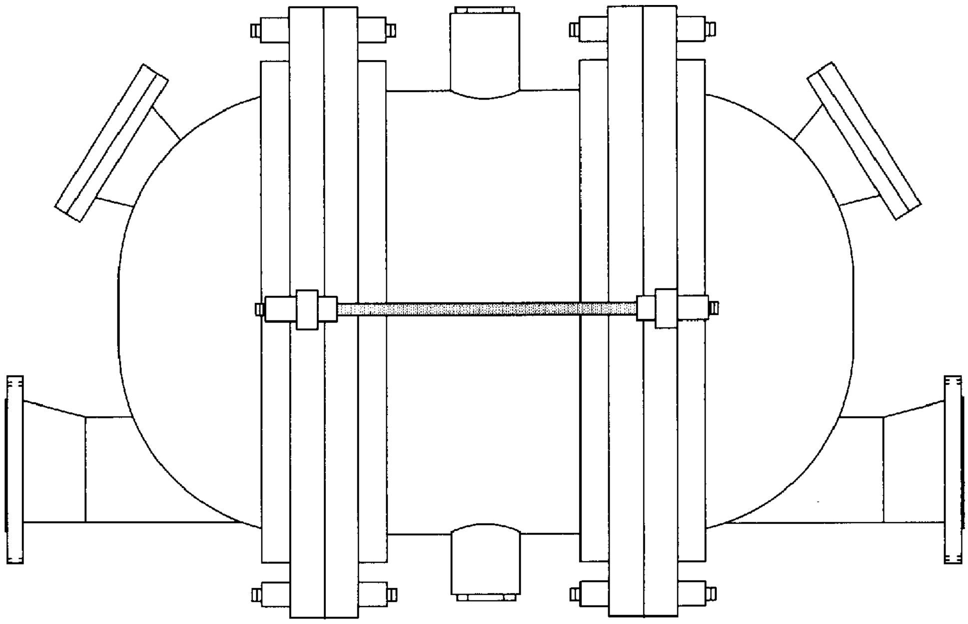


Figure C-5—Bidirectional Detonation Arrester: Packed Style

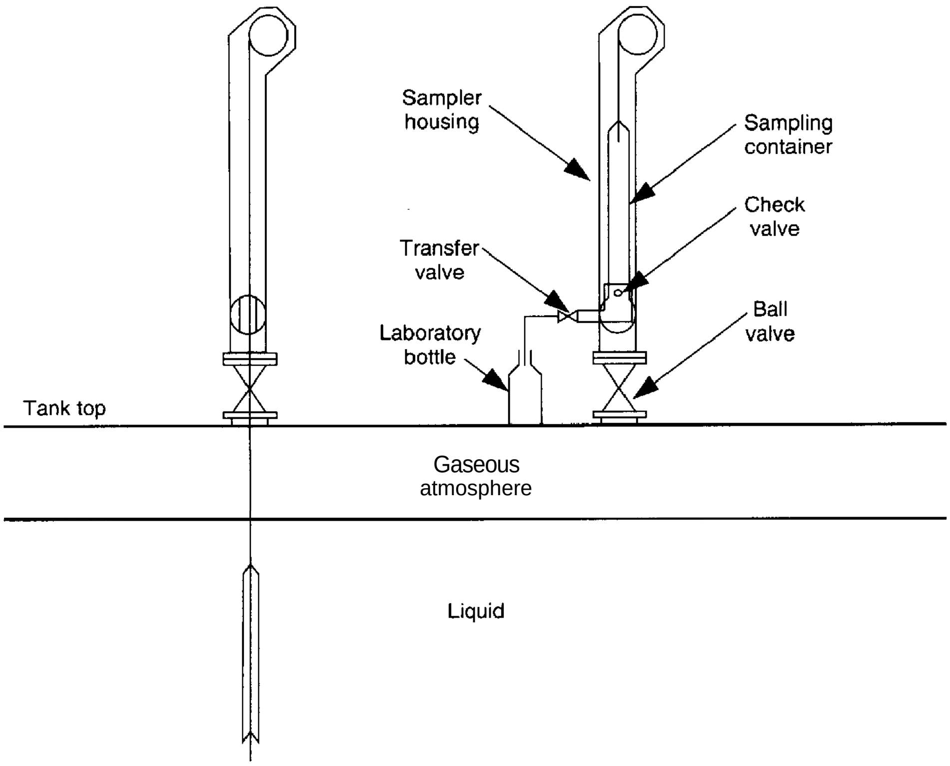



Figure C-6—Closed Sampling Device

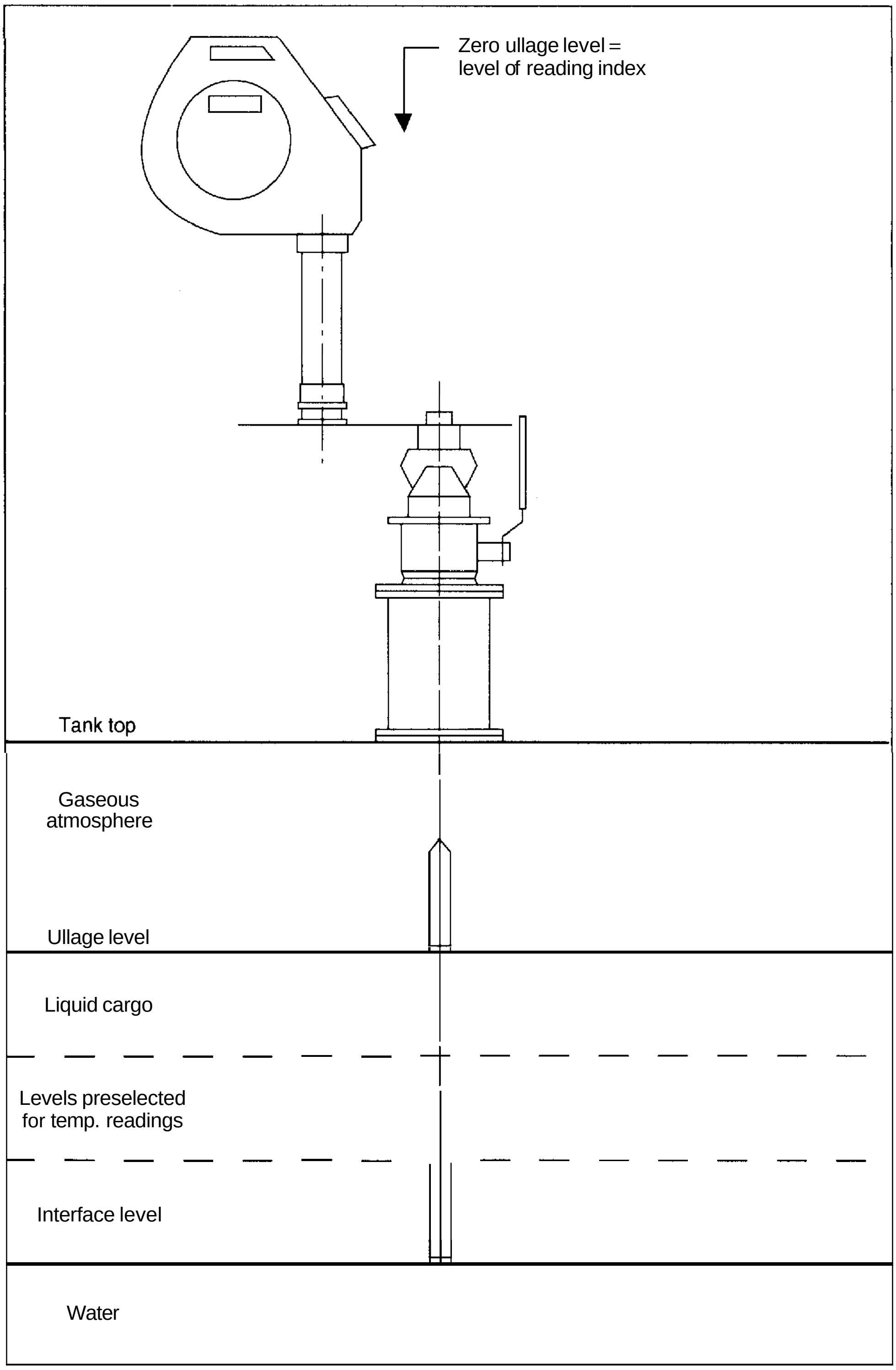



Figure C-7—Closed Gauging Device with Block Valve

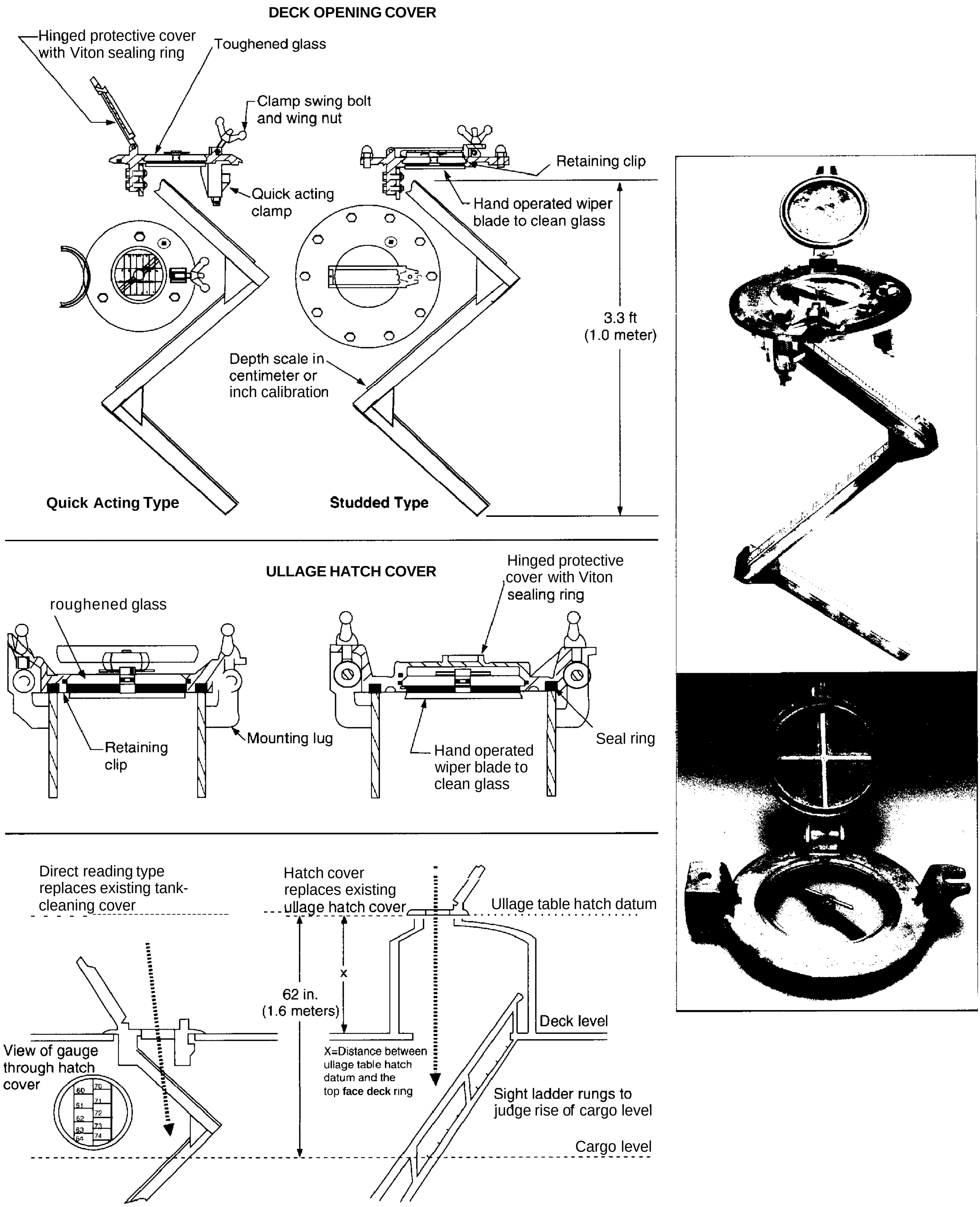
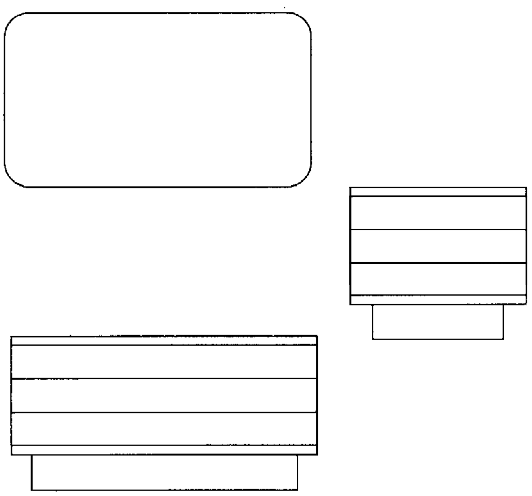
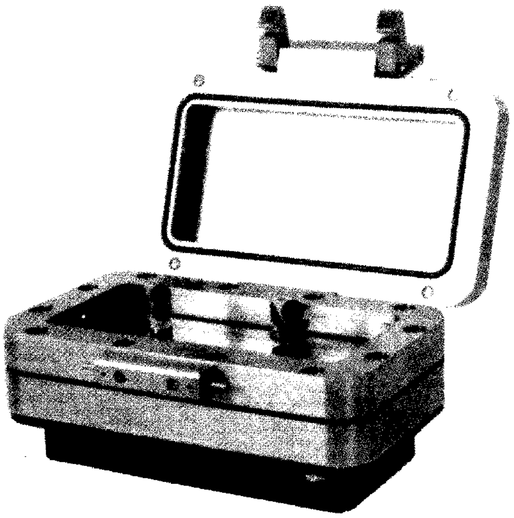
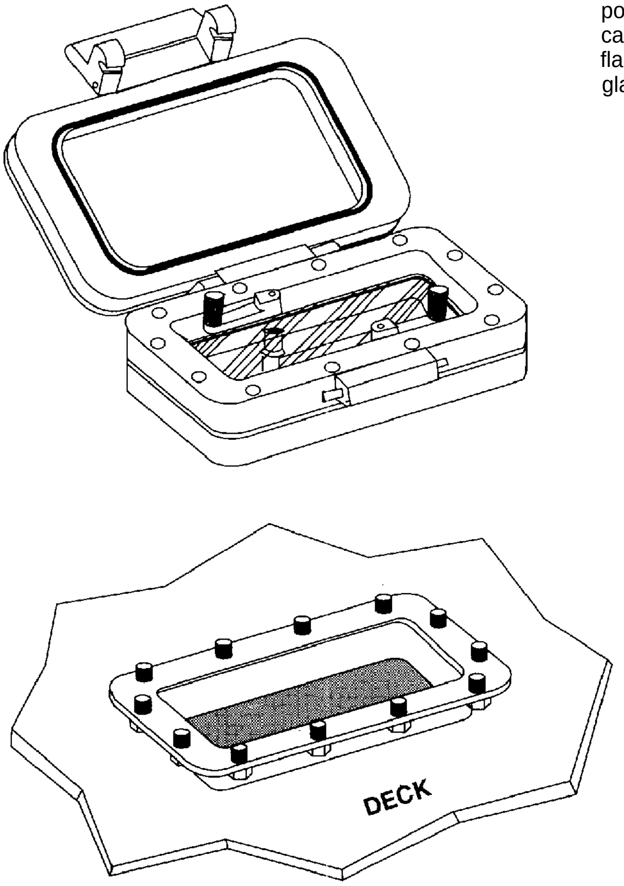



Figure C-8—Deck and Hatch Covers





59 sq. in. (381 sq. cm) of viewing area [34 sq. in. (219 sq. cm) of which is wiped]. Wiper blades can be readily changed and are standard Viton or EPDM "O" rings. 3/4 in. (1.9 cm) thick #7740 Pyrex ground and polished plate glass is stress relieved. All mounting hardware is 303 stainless steel except for the aluminum weather cover and the carbon steel deck mounting flange. Complies with USCG regulations on marine vapor control systems as a visual gauging device. Allows inspection of cargo without exposure to cargo vapors. The separate deck mounting flange simplifies shipyard installation and prevents damage to the sight glass.



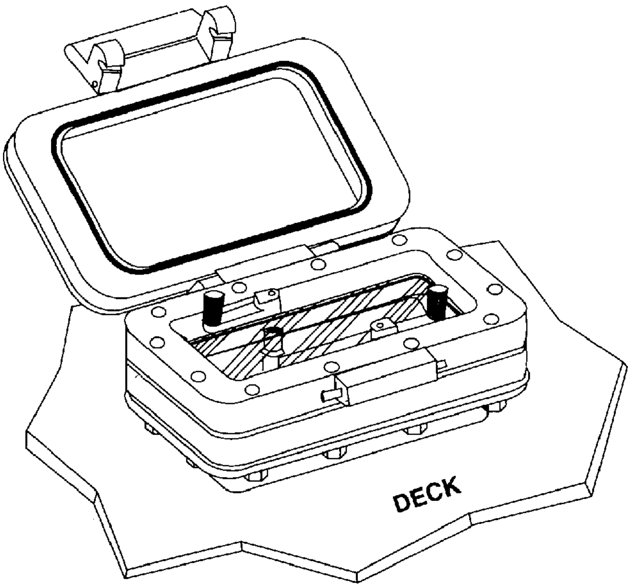
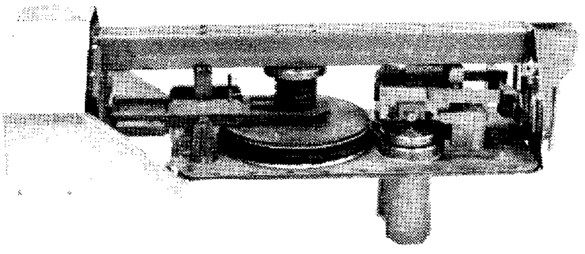
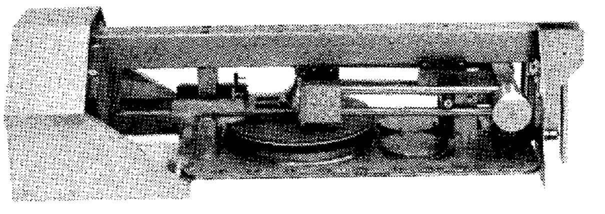




Figure C-9—Marine Sight Glass



**Type I**
**12**" Pilot Operated
Marine Spill Valve
Per **ASTM F-1271**

Vapor and liquid tight in normal operation due to 800-pound (363-kilogram) clamping force on the seal plate. In an overfill situation the valve automatically opens at rated set point opening pressure and flows at a rate equal to the loading rate of the compartment being protected. The valve automatically closes when loading stops, and tank pressure reduces to a safe level. It can be field tested for proper operation including checking the opening set point.



**Type II**
12" Weight Operated
Marine Spill Valve
Per ASTM **F-1271**

Vapor and liquid tightness is equal to the opening set point. In an overfill situation the valve automatically opens at rated set point opening pressure and flows at a rate equal to the loading rate of the compartment being protected. The valve automatically closes when loading stops, and tank pressure reduces to a safe level. It can be field tested for proper operation, including checking the opening set point.

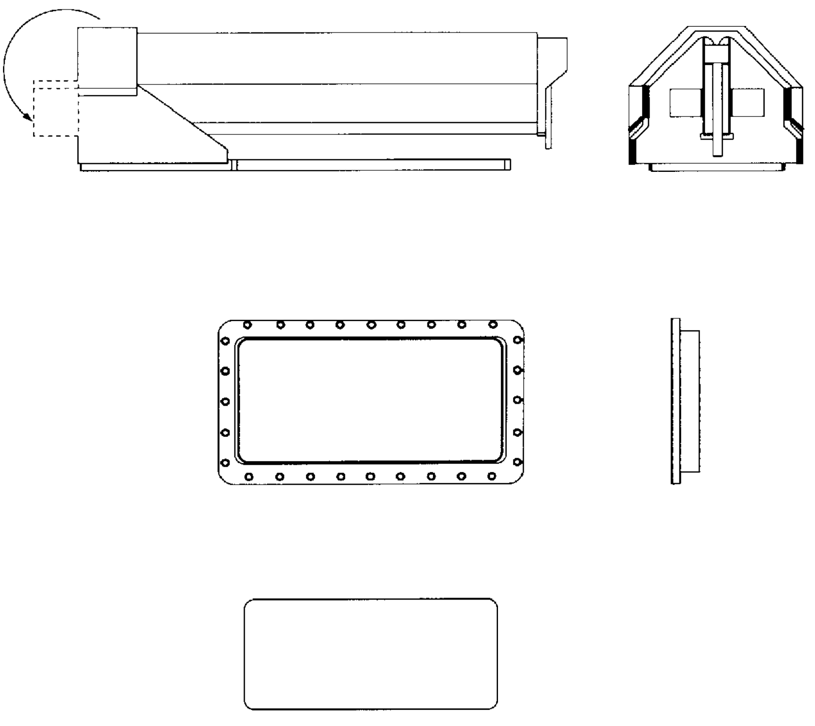


Figure C-10 — Marine Spill Valves

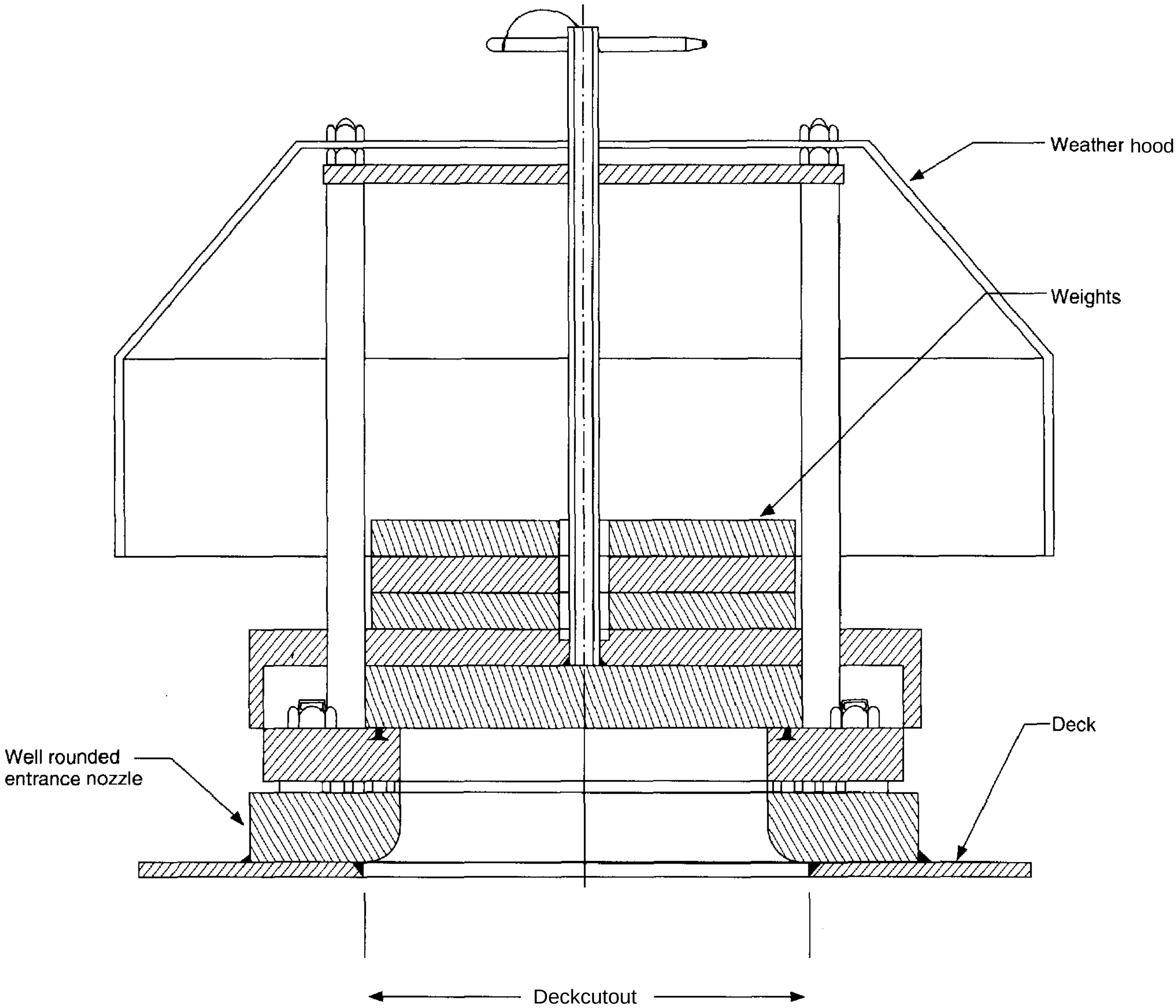
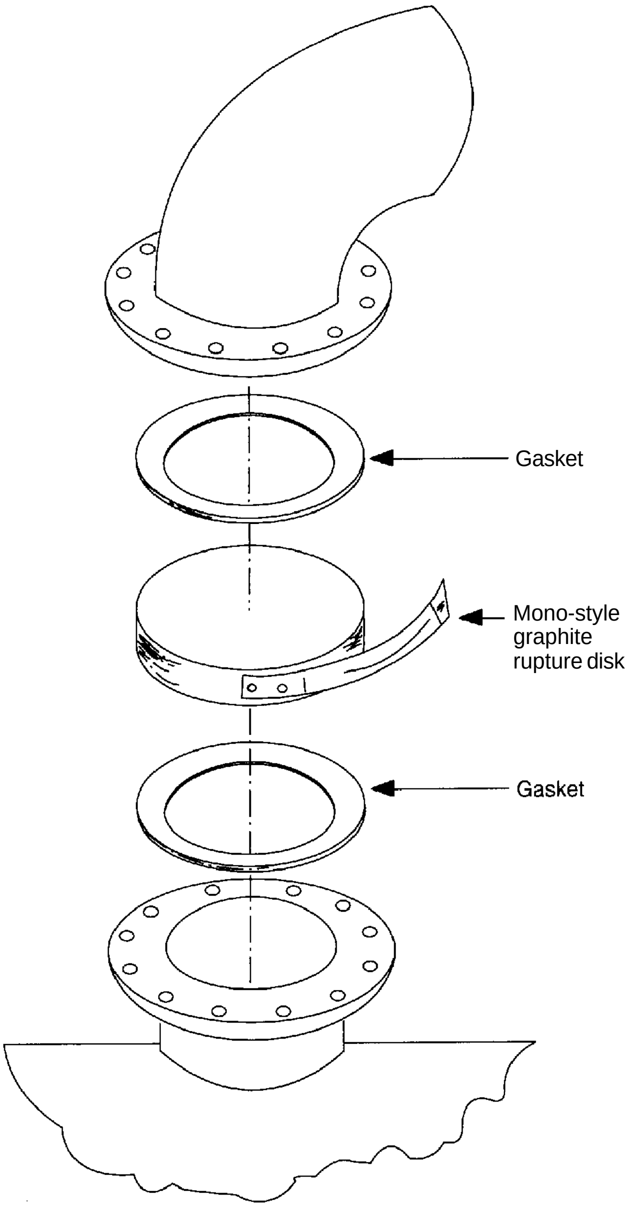



Figure C-11—Marine Spill Valve




C-12—Rupture **Disk**

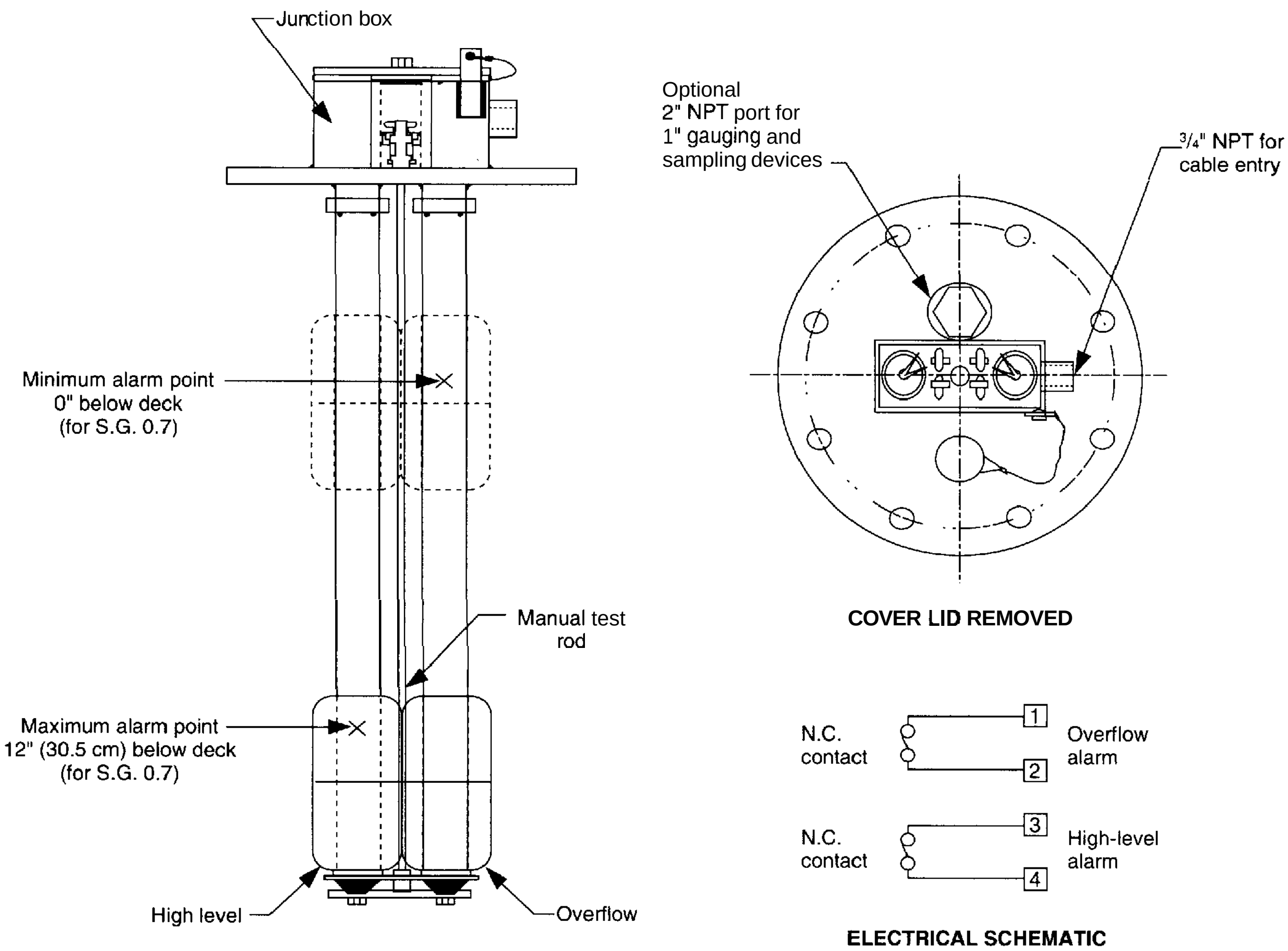
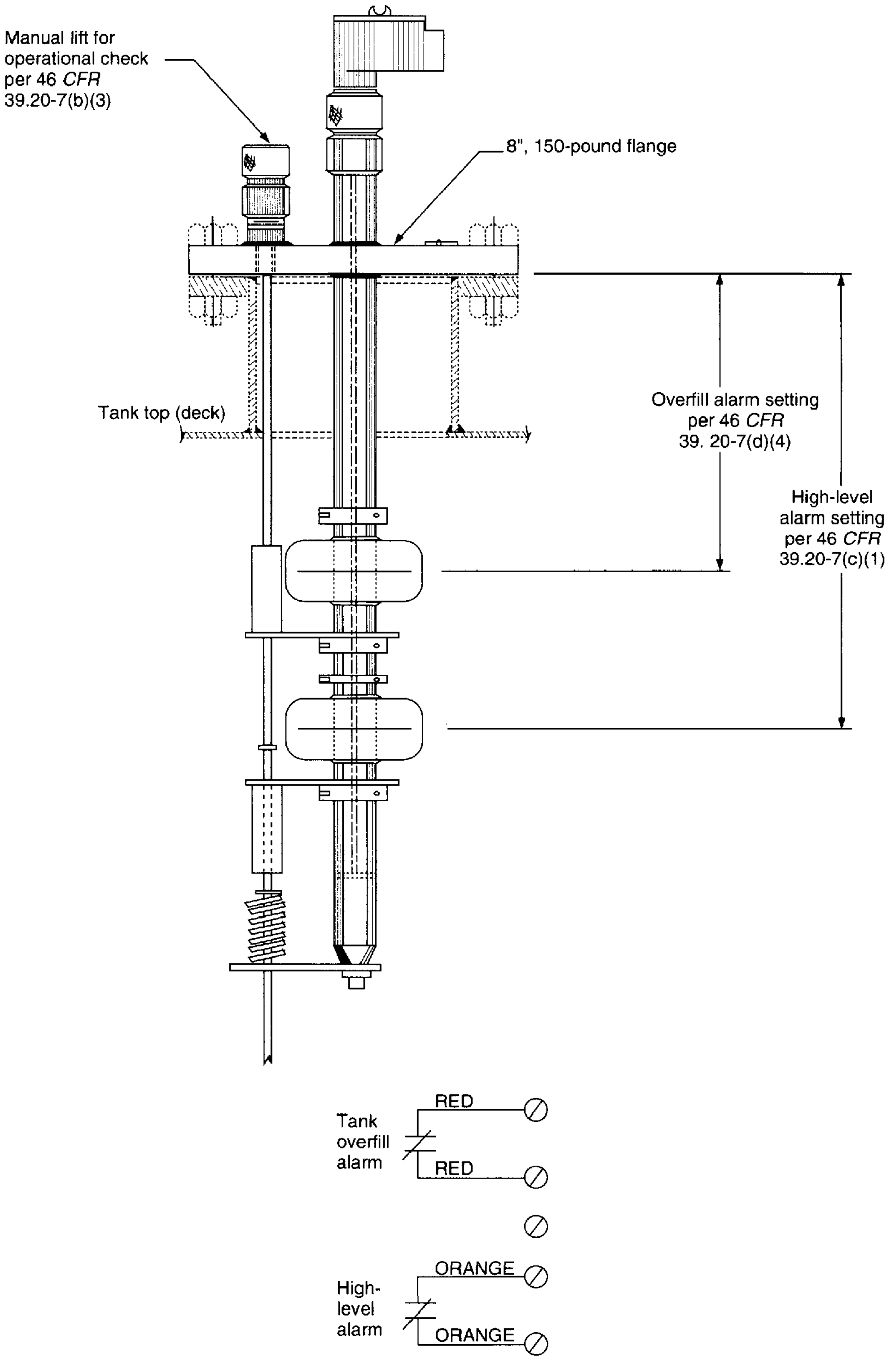



Figure C-I3A — Combination High-Level and Overfill Sensor




**WIRING** DIAGRAM

*Note: CFR = Code of Federal Regulations*

Figure C-I3B—Combination High-Level and Overfill Sensor (Continued)

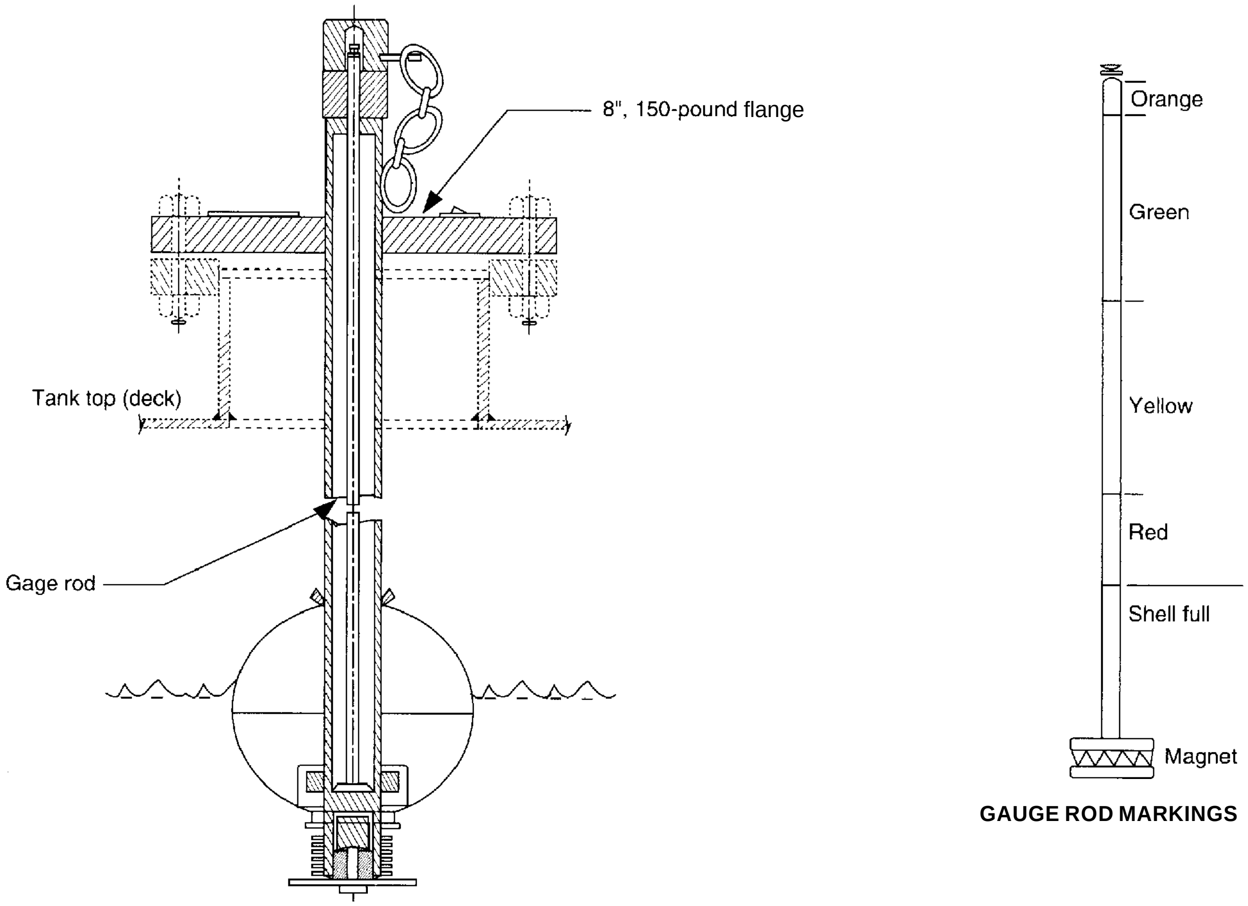



Figure C-I4A — Magnetically Coupled Dipstick

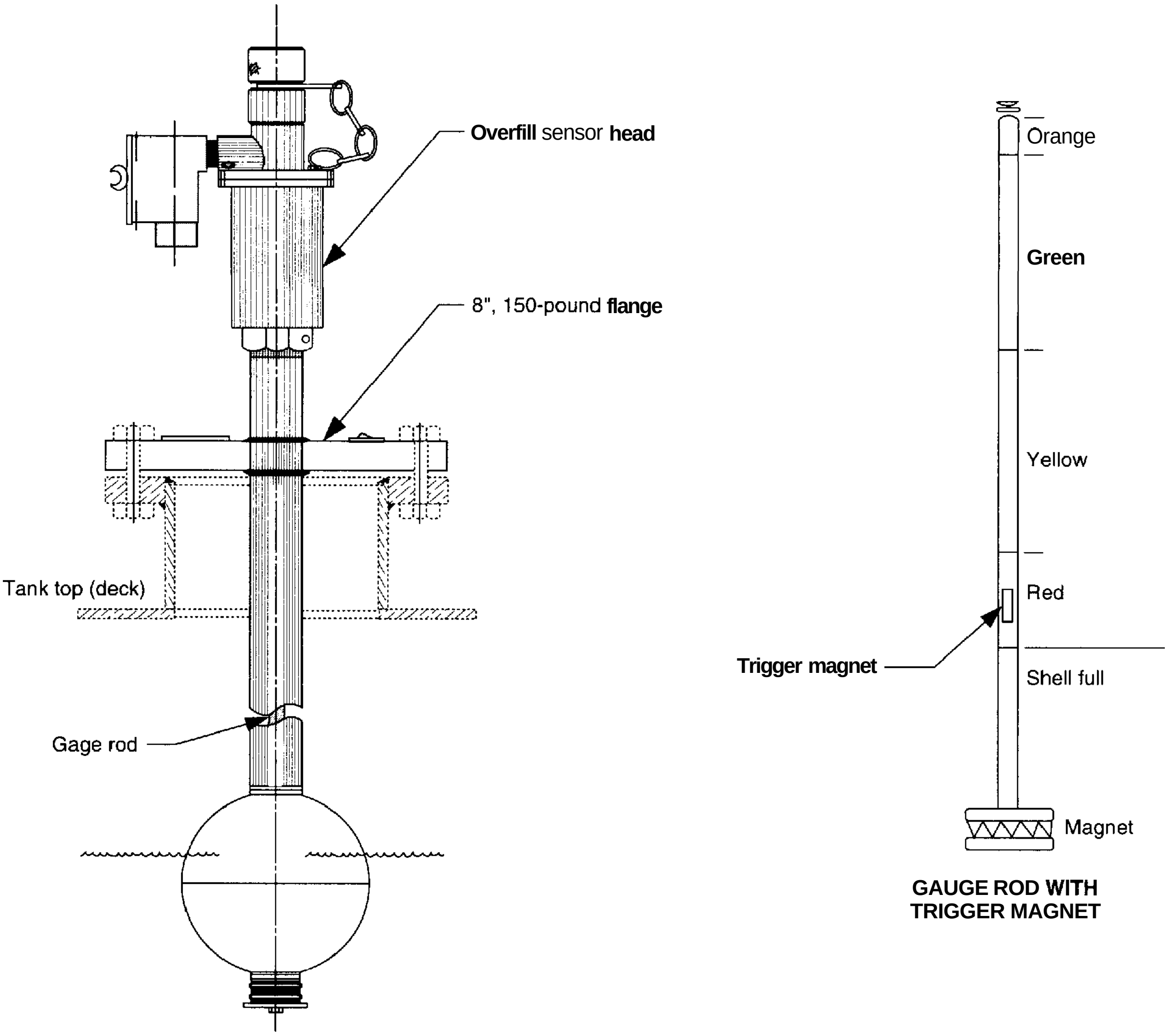



Figure C-15—Magnetically Coupled Dipstick with Overfill Sensor

# APPENDIX D—GLOSSARY

*Ballast operations* or *ballasting* is the procedure whereby liquid material is loaded into either segregated ballast tanks or cargo tanks to restrict the freeboard of a vessel. Ballasting may be necessary because of weather conditions or to keep the vessel within the envelope restrictions of the terminal metal loading arms or shore gangways.

*Detonation arresters* are passive devices, included as part of piping systems, that can stop a flame front or a detonation traveling through the piping. The following two types of detonation arresters are recognized:

a. Type I detonation arresters are suitable for applications where stationary flames may rest on the device.
b. Type II detonation arresters are suitable for applications where stationary flames are unlikely to rest on the device. These detonation arresters must include a method to prevent flame passage if a stationary flame should occur on the face of the device.

*Detonation arresting valves* are active devices, included as part of piping systems, that can stop a flame front or detonation traveling through the piping.

*Diluting* is the addition of air to a vapor stream to reduce the overall hydrocarbon concentration of the stream. For marine emission control systems, the diluting air is added to keep the vapor well below its lower flammability limit, thus decreasing the possibility of vapor ignition.

*Enriching* is the addition of hydrocarbons to a vapor stream to raise the overall hydrocarbon concentration of the stream. For marine emission control systems, the enriching hydrocarbon is added to keep the vapor well above its upper flammability limit, thus decreasing the possibility of vapor ignition.

*Facility vapor connection* means the point in a facility's vapor collection system where it connects to a vapor collection hose or to the base of a vapor collection arm.

*Flame arresters* are passive devices, included as part of piping systems, that can stop a flame front traveling through the piping. A flame arrester is not suitable for use as a detonation arrester. The following two types of flame arresters are recognized:

a. Type I flame arresters are acceptable for end-of-line applications.
b. Type II flame arresters are acceptable for in-line applications. These typically must be installed in piping arrangements that are specified by the flame arrester vendor and are not intended for use in all piping configurations.

*Inerted* means the oxygen content of the vapor space in a tank vessel's cargo tank is reduced to 8 percent by volume or less in accordance with the inert gas requirements of 46 *Code of Federal Regulations* Part *32.53* or 46 *Code of Federal Regulations* Part 153.500.

*Inerting* is the addition of an inert gas into a vapor stream. Typically, inert gases are nitrogen, carbon dioxide, or gases from an inert gas system. The inerting gas is generally added to the vapor stream to reduce the flammable range of the vapor. If enough inert gas is added to the vapor, the vapor will become noncombustible.

The *initialfill rate* is the maximum rate at which cargo may be transferred at the start of a vessel loading operation. Higher transfer rates at the beginning of vessel loading will result in splashing and turbulence that can generate buildup of static electricity. If static charge is allowed to increase without control, it can discharge with enough energy to ignite combustible vapors in the vessel compartment being loaded.

An *intrinsically safe* electrical system is designed so that any spark created by one of the system components will not create enough energy to ignite a combustible mixture.

*Lightering* or *lightering operation* means the transfer of a bulk liquid cargo from a tank vessel to a service vessel.

*Liquid knockout vessel* means a device that separates liquid from vapor.

*Maximum allowable transfer rate* means the maximum volumetric rate at which a vessel may receive cargo or ballast.

*Service vessel* means a vessel that transports hulk liquid cargo between a facility and another vessel.

*Topping-off* is the transfer of a bulk liquid cargo from a service vessel to another vessel in order to load the vessel to capacity.

A *U.S Coast Guard-accepted detonation arrester* is one that has successfully completed testing as outlined in Appendix A of **33** *Code of Federal Regulations* Part 154.800. and has received a letter from the U.S. Coast Guard stating it is accepted for use in marine emission control systems.

A *U.S. Coast Guard-acceptedflame arrester* is one that has successfully completed testing as outlined in Appendix B of 33 *Code of Federal Regulations* Part 154.800 and has received a letter from the U.S. Coast Guard stating it is accepted for use in marine emission control systems.

*Vapor* or *vapors* are gases that are below their critical temperature and pressure and can be condensed to liquids.

*Vapor balancing* is the transfer, via a vapor collection system, of vapor displaced by incoming cargo from a tank of a vessel receiving cargo into a tank of the vessel or facility delivering cargo.

A *vapor collection system* is an arrangement of piping and hoses used to collect vapor emitted from a vessel's cargo tanks and transport the vapor to a vapor processing unit.

*Vapor control system* means an arrangement of piping and equipment used to control vapor emissions collected from a vessel. The vapor control system includes the vapor collection system and the vapor processing unit.

*A vapor destruction unit* is a vapor processing unit that destroys cargo vapor by a means such as incineration.

*Vapor processing unit* refers to the components of a vapor control system that recovers, destroys, or disperses vapor collected from a vessel.

A *vapor recovery unit* is a vapor processing unit that recovers cargo vapor by a nondestructive means such as lean-oil absorption, carbon bed adsorption, or refrigeration.

*Vessel vapor connection* means the point in a vessel's fixed vapor collection system where it connects to a vapor collection hose or arm.

VOC is a volatile organic compound. Any liquid containing carbon atoms, except carbon dioxide ($CO_2$), methane ($CH_4$), and molecules containing halogen, is classified as a VOC. VOS, or volatile organic substance, usually has the same meaning as VOC.

# APPENDIX E—BRIEF OUTLINE OF NATIONAL EMISSION STANDARD FOR HAZARDOUS AIR POLLUTANTS (NESHAP) REQUIREMENTS FOR THE DOCK OPERATOR

The U.S. Environmental Protection Agency (EPA) and many state environmental agencies have begun limiting emissions caused by the loading of marine vessels. These agencies have determined that marine emissions have a significant impact on the health of personnel and on the environment.

Benzene is classified as a carcinogen, which means that exposure of personnel to benzene liquids or vapors results in increased incidents of cancer. To reduce the risk of cancer to personnel who must work with benzene, guidelines have been developed mandating safety procedures when working with this chemical.

On March 7, 1990, the EPA included loading of marine vessels carrying cargoes consisting of 70 percent or more benzene by volume under the safety guidelines for handling benzene. Facilities loading more than 343,425 gallons of products containing 70 percent or more benzene per year must reduce the emissions of benzene by 98 percent. In addition, marine facilities are required to load only vessels that are leak tight.

The EPA defines a leak-tight vessel as either of the following:

a. A vessel that has a certificate on board verifying that it has passed the required leak-tightness test within the past twelve months.
b. A vessel that is loaded under vacuum.

In addition, for a vessel that does not have a certificate of leak tightness, the EPA allows the loading of a vessel under positive pressure if the following conditions are met:

a. A leak test must be conducted on the vessel during the last 20 percent of the load. The leak test must be done as required by EPA Method 21 while the vessel is being loaded at its maximum loading rate (40 *Code of Federal Regulations* Part 60, Appendix A). If a 10,000 parts per million by volume leak is sensed, the vessel is considered to be leaking.
b. If a leak is detected, the leak must be documented to the vessel's owner or operator.
c. If a leak is detected, the vessel must not be loaded again under pressure until proof is provided to the dock operator in the form of a certificate of leak tightness dated within the past 12 months or an endorsement indicating that the modifications required to make the vessel leak tight must be done at a dry dock.

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