CHAPTER 5: INSPECTION OF INERT GAS SYSTEMS

A. INTRODUCTION

1. Background

Fire and explosion are among the greatest threats to the mariner; a tankship carrying crude oil, refined petroleum, or chemicals is an even greater threat. Fortunately, a properly designed, installed, operating, and maintained inert gas system (IGS) will completely prevent fire and explosion in an intact ship tank. Combustion is impossible without oxygen; if there is some way to keep the oxygen below about 8 percent, the ship will be free of danger from explosions in intact tanks. Typically, this is done by adding to the tank atmosphere a gas that has less oxygen (often 5 percent or less) than air, which has an oxygen concentration of 21 percent. Of course, when a tank is opened, as in a collision, oxygen can enter the tank regardless of the IGS. In the 1920's and 1930's, one American petroleum company suffered several tankship fires and decided to inert the cargo tanks of its ships. Reportedly, its vessels have not had any intact cargo tank fires since that time. Since the late 1970's, inerting has been required for most U.S. and foreign tankships. As of 1 June 1983, inert gas (IG) systems are required aboard all U.S. crude oil carriers over 20,000 deadweight tons (DWT) and all U.S. product carriers over 40,000 DWT. While in U.S. waters, foreign tankships of the same size must have IG systems in operation. For the purpose of the IGS regulations, integrated tug-barge (ITB) combinations that operate only in a combined mode are subject to the tankship rules for IG systems.

> **NOTE:** In addition, for chemical tankers and gas carriers the applicability of alternate inerting requirements as allowed by SOLAS Regulation II-2/55.5 were adopted in 1985 through the International Maritime Organization (IMO) Assembly Resolution.

2. References

There are several good references in addition to 46 CFR 32.53 and Regulation 62 of SOLAS 1974/78. Commandant's International Technical Series (CITS) Volume VII (USCG CITS-80-1-1), "Regulations and Guidelines for Inert Gas Systems," contains the SOLAS requirements, the IMO Guidelines For Inert Gas Systems, and the National Academy of Sciences National Materials Advisory Board Study on Material Aspects of Inert Gas Systems.

3. Federal Initiatives

In the mid-1970's, a series of tankship accidents led to the International Conference on Tanker Safety and Pollution Prevention (TSPP) of 1978 and the passage of the Port and Tanker Safety Act of 1978 (PTSA). A major result of these initiatives is that most U.S. and foreign tank vessels are required to have IG systems in operation while they are in U.S. waters. The Coast Guard's IGS regulations are contained in 46 CFR 32.53 (Inert Gas Systems); international rules are contained in Chapter II-2, Regulation 62 (Inert Gas Systems) of the International Convention for the Safety of Life at Sea (SOLAS), 1974. The first set of amendments to SOLAS 74 were adopted and came into force on 1 September 1984; under them, a ship must satisfy applicable requirements to receive a SOLAS Safety Certificate. The second set of amendments to SOLAS 74 come into effect on 1 July 1986; they have only a minor effect on the IGS requirements. The Coast Guard is developing changes to 46 CFR 32.53 to bring U.S. requirements into line with both sets of amendments to SOLAS.

B. SYSTEM CONCEPTS

1. Reasons for Inerting Systems

The "fire triangle" provides the basis to consider fire prevention techniques on tankships. It would not be practical to remove the fuel, which in this regard is the vapor generated by the cargo. Unless the cargo is Grade E and carried at a temperature at least 5C below its flash point (in which case there are no inert gas requirements), the cargo is volatile enough to produce a flammable vapor-air mixture above the fuel. After the cargo is offloaded, unless the tank is gas-freed and cleaned of all residue and clingage on its surfaces, a flammable atmosphere can be expected. If all ignition sources could be eliminated, so would all chances for a fire. However, conditions such as lightning and electrostatic fields generated during tank washing and heavy seas in partially ballasted tanks will always be present as ignition sources. Hence, there is really no practical alternative to inerting cargo tanks.

2. Means of Inerting Cargo Tanks

Introduction

a. Introduction. There are several ways to inert a tank. The simplest would be to add a pure nonflammable gas, such as nitrogen or carbon dioxide, to the tank atmosphere. Unfortunately, these pure gases tend to be expensive, the costs of their storage aboard ship tend to be high, and re-supply in some ports is difficult. Thus, most "inerted" ships use the gases from a fuel burner, from the ship's propulsion equipment (flue gas), or from a unit dedicated to producing inerting gas (an inert gas generator (IGG)). The following general description of an IGS includes components that may vary, depending upon the manufacturer.

Use of Combustion Gases

b. Use of Combustion Gases. Use of combustion gases as the inerting medium proves advantageous due to its availability as needed and much lower cost, if sufficient fuel and properly adjusted and operated equipment is provided. Its disadvantage is that the raw combustion gases are impure and must be treated before use in the cargo tanks. This is especially important for product carriers, in which cargo purity is critical and some cargoes may react with impurities in the inert gases. Each IGS has several components intended to remove these impurities. For example, sulfur in the fuel appears in the inert gas in the form of sulfur oxides, sulfurous acid, and sulfuric acid. If not removed, they will attack the metal of the tank and gradually destroy it. Passing the inert gas through a water-filled device called a scrubber removes most of these acids (see paragraph MSM II-C5.C.2 below).

Gas Distribution

c. Gas Distribution. When the inert gas is clean, cool, and water-free, it is pressurized and sent to the various cargo tanks. The distribution system contains backflow prevention devices, control valves, alarms, and automatic shutdowns. These alert personnel to a malfunction and, when necessary, shut down the system before a dangerous condition is developed in the tanks. Such conditions involve the oxygen concentration, the temperature and pressure of the inert gas, the water flow to and water level within the scrubber, and the backflow prevention devices (water seals). Because IG systems are complex and subject to malfunction, it is important for ships' crews to inspect and maintain them in good working order. The Coast Guard's inspections verify that they are properly maintained and operable.

3. Operation of the System

Introduction

a. Introduction. The purpose of an IG system is to keep the oxygen content of the vapor space below the level needed for combustion. For crude carriers, the oxygen content of the inert gas delivered to the cargo tanks should be no more than 5 percent, to ensure that there is not enough oxygen in the tank to support combustion.

NOTE: This figure may be lower for certain chemicals carried in product carriers.

Operation

b. Operation. 46 CFR 32.53 identifies which product/crude oil tankships must be equipped with an IGS. (See MSM II-C5.B.4 for discussion of "Inerting Requirements for Chemical Tankers and Gas Carriers.") For inerting purposes, oil cargoes are those cargoes identified as pollution category I in 46 CFR Table 30.25-1. Note: These cargoes may be different from what is considered to be oil for the application of Oil Pollution Act of 1990 requirements.) Questions have arisen concerning when an installed IGS must be operated, especially when a tanker is carrying a cargo that is not otherwise required to be inerted. While the requirements are clear, questions have arisen concerning when an installed IGS must be operated, especially when a tanker is carrying a cargo that is not otherwise required to be inerted. Normally, confusion arises concerning existing crude/product carriers between 20-40,000 DWT and vessels carrying only Grade E liquid cargoes. Generally, vessels required to have an installed IGS must maintain an inert atmosphere in the tanks whenever they are not gas free. However, when an IGS equipped tanker is carrying a cargo that is not required to be inerted and the tank, piping and venting conditions are functionally equivalent to a non-IGS tanker, the system may be secured at the operator's option. Table 15-1 summarizes the tanker categories that are required to have an installed IGS and the conditions whereby the

system may be secured. On tankers that are required to maintain an inert tank atmosphere,

it is not necessary for the IGS to be operated continuously. Once a tank is inerted and the tank openings closed and sealed, inert gas will leak out of the tank at such a small rate that the IGS may need to be operated only intermittently to maintain the inert tank atmosphere.

Requirements During Transfer and Tank Cleaning Operations

c. Requirements During Transfer and Tank Cleaning Operations. Offloading cargo is one of the few conditions under which the IGS must be in continuous operation. As the cargo is pumped out, inert gas must be introduced at an equal or greater volume rate, with excess inert gas flow vented to the atmosphere; if this is not done, air will enter the tank. Loading usually requires no additional inert gas if the tank is already inerted; the incoming cargo will displace the inert gas in the tank, which is then vented. Similarly, tank cleaning with fixed washing machines should not let inert gas escape. Cleaning with portable machines, if done with proper temporary seals around the machines, should release only a small amount of inert gas (requiring the IGS to operate for a short period to replace the gas that escapes). To gas-free an empty, clean tank, the IGS can be used to purge the tank free of hazardous vapors. Before loading a flammable cargo into a gas-free tank, the tank should be filled with an inert gas.

4. Inerting Requirements for Chemical Tankers and Gas Carriers

In considering the application of IGS requirements to chemical tankers, it was argued that this type of tanker should be given special consideration. This is primarily because both the inert gas from shipboard IGS and impurities in the inert gas can contaminate chemical cargoes. For example, the carbon dioxide produced as an inerting agent can drive certain cargoes off specification. Additionally, there are other chemical cargoes that are shipped with inhibitors that react with the oxygen in the tank to prevent the cargo from undergoing unwanted reactions. Therefore, the displacement of oxygen through inerting by any means (bottled nitrogen, inert gas generator, flue gas systems, etc.) can cause breakdown of inhibitors used to prevent these reactions.

Since the implementation of the 1993 Amendments to SOLAS '74, Regulation II-2/55.5 has allowed for substitute inerting requirements to be applied to chemical tankers and gas carriers in lieu of the requirements in Regulation II-2/60. These substitute requirements are contained in Res. A.473(XII), adopted on 19 November 1981. They apply to chemical tankers and gas carriers carrying petroleum products only.

The inert gas applicability requirements set out in Regulation II-2/55.5 are further modified by Res. A.566(14). In addition to the substitute requirements of Res. A.473(XII), Res. A.567(14). Adopter on 20 November 1985. This extends the applicability of substitute inerting requirements to the carriage of all flammable cargoes on board chemical tankers and gas carriers. Res. A.566(14) also prescribes the conditions under which no inerting is required.

Implementation

a. Implementation. Res. A. 566(14) applies only to chemical tankers and gas carriers, which would otherwise be subject to the IGS requirements of 46 CFR, 32.53 and SOLAS Regulation II-2/60 for tankers carrying crude oil and petroleum products. These include all "new" chemical tankers and gas carriers of 20,000 deadweight tons or more, as well as, those "existing" vessels of 40,000 deadweight tons or more, but less than 40,000 deadweight tons if fitted with tank washing machines having an individual throughput of greater than 60 cubic meters per hour. The dates distinguishing "new" from "existing" for the purpose of applying IGS requirements are contained in 46 USC 3701 and the 1978 protocol to SOLAS '74. For easy reference, those dates are included in this circular as Note 2 of enclosure (1).

Verify Vessel Type (e.g., Gas, Chemical Petroleum, Crude)

b. After establishing that the IGS requirements for tankers carrying crude oil and petroleum products would otherwise apply, it must be confirmed that the ship in question is a chemical tanker or gas carrier. As evidence a vessel meets the applicable definition, it must be in possession of a valid Certificate of Inspection (COI) (U.S. flag) or IMO Certificate of Fitness (foreign flag) endorsed for the carriage of at least one cargo appearing in the Tables/Chapters specified in the definition. For example, a U.S. flag tanker in possession of a valid COI, endorsed for the carriage of any cargo listed in Table 1 of 46 CFR 153, is considered to be a chemical tanker.

Identification of Cargo IG Need

c. Next, each flammable cargo to be carried must be considered individually to determine the inerting requirements applicable to the tank in which the cargo is being carried. The flammable cargoes should be divided into the following three categories:

- Crude oil;
- Petroleum products; and
- "Other than crude oil or petroleum products."

NOTE: Flammable cargoes "other than crude oil or petroleum products" are those listed in Table 1 of 46 CFR 153, Chapters VI or VII of the BCH Code, or Chapters 17 or 18 of the IBC Code. The cargoes listed in Table 1 of 46 CFR 153 closely parallel those listed in Chapter VI of the BCH Code and Chapter 17 of the IBC Code. There is no listing in U.S. regulations parallel to Chapter VII and 18 are identical); however, many of those cargoes are listed in 46 CFR 30.25-1.

d. For chemical tankers and gas carriers carrying flammable cargoes "other than crude oil or petroleum products, " there are no inerting requirements provided the vessel was constructed before 1 July 1986. If the vessel was constructed on or after 1 July 1986, no inerting is required provided the following conditions are met:

- The individual tank(s) involved do not have a capacity exceeding 3000 m3;
- The individual nozzle capacities of the tank washing machines do not exceed 17.5 m3/hr; and
- The total throughput for all the machines in use in a tank does not exceed 110 m3/hr.

For all chemical tankers carrying flammable crude oil or petroleum products, the IGS requirements of Res. A. 567(14) apply. If a chemical tanker was constructed before 1 July 1986, the IGS requirements of Res. A.473(XII) may be substituted for those in Res. A.567(14). The same requirements as included in this paragraph for chemical tankers or an equivalent should be applied to gas carriers when carrying flammable crude oil or petroleum products.

There may be instances when a flammable cargo which is not crude oil or a petroleum product also is not listed in 46 CFR 153, the BCH Code, or the IBC Code. This is most likely to occur when a new chemical is marketed and first transported. In situations such as this or any other time there is uncertainty regarding the inerting requirements for a particular cargo carried on board a chemical tanker or gas carrier, Commandant (G-MOC, 202-267-1464) should be consulted.

TABLE C5-1: INSTALLATION & OPERATION REQUIREMENTS FOR INERT GAS SYSTEM (IGS)[1,2]

VESSEL TYPE	INSTALLATION REQUIRED?	OPERATION REQUIRED?
Crude Oil Tankships		
Existing ships[3,4] All cargo grades	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
New ships All cargo grades	Yes for ships	Yes for ships
Product Tankships		
Existing ships[3] Grades A-D	Yes for ships 40,000 DWT & over	Yes for ships
40,000 DWT & over Grade E5 Design limited	No	No
Operationally limited: No volatile residues from previous voyages[6,7,9]	Yes for ships 40,000 DWT & over	No
Volatile residues from previous voyages	Yes for ships 40,000 DWT & over	Yes for ships 40,000 DWT & over
Any grade with high capacity washing machines (exceeding 60 cubic meters/hour)	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
New ships		
Grades A-D	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
Grade E5		
Design limited	No	No
Operationally limited:		
No volatile residues from previous voyages[6,7,9]	Yes for ships 20,000 DWT & over	No
Volatile residues from previous voyages	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
Crude Oil/Product Tankships[8]: Existing ships[3,4]		
Grades A-E crude oil	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
Grades A-D product[6,7]	Yes for ships 20,000 DWT & over	Yes for ships 40,000 DWT & over
Grade E5 product		
Design limited	No	No
Operationally limited:		
No volatile residues from previous voyages[6,7,9]	Yes for ships 20,000 DWT & over	No
Volatile residues from previous voyages	Yes for ships 20,000 DWT & over	Yes for ships 40,000 DWT & over
Any grade with high capacity washing machines (exceeding 60 cubic meters/hour)	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over

TABLE C5-1: INSTALLATION AND OPERATION REQUIREMENTS FOR INERT GAST SYSTEM (IGS)[1,2] — CONTINUED

VESSEL TYPE	INSTALLATION REQUIRED?	OPERATION REQUIRED?
Crude Oil/Product Tankships[8]: New ships		
Grades A-E crude oil	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
Grades A-D product	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over
Grade E5 product		
Design limited	N/A	N/A
Operationally limited:		
No volatile residues from previous voyages[6,7,9]	Yes for ships 20,000 DWT & over	No
Volatile residues from previous voyages	Yes for ships 20,000 DWT & over	Yes for ships 20,000 DWT & over

NOTES:

1. This Table is based on the requirements of 46 CFR 32.53.
2. The requirements for U.S. flag ships (operating worldwide) and foreign flag ships (operating in U.S. ports) are the same except as noted in footnote 8.
3. "New" and "Existing" tankers are defined in 46 U.S.C. 3701 (Contract date after June 1, 1979; in the absence of a contract date, keel laying date after January 1, 1980; delivery after June 1, 1982.).
4. The U.S. and SOLAS regulations provide for inert gas exemptions for existing crude and crude/product carriers in the range 20,000 to 40,000 DWT. However, the U.S. has not granted any exemptions to date for either U.S. or foreign flag tankships, and U.S. does not recognize inert gas exemptions granted by foreign Administrations.
5. This entry applies to a Grade E cargo that is carried at a temperature lower than 5 degrees C below its closed cup flashpoint. If it is heated to within 5 degrees C of its closed cup flashpoint, it is treated as if it were a Grade A - D cargo for the purposes of the IGS system. Differentiation is made between tankers that are limited to carriage of grade E cargoes by design and those that are capable of carrying more volatile cargoes but are only engaged in Grade E trade (i.e., operationally limited). The intent is to ensure that tankers that are operationally limited to Grade E cargoes are functionally equivalent to tankers that are limited by design to Grade E. See Notes 6,7 & 9.
6. Note that where an inert gas system is installed but not operated, the inert gas main stop valve must be closed and the inert gas blowers and inert gas generator, if any, secured.
7. In some venting system designs, when the IGS is not operating, the inert gas main can serve as a path for fire and explosion to travel from one tank to another. Therefore if the tank venting system incorporates the inert gas main and the tanks cannot be isolated from the inert gas main without risking over or under pressurizing the tanks, the inert gas system must operate at all times.
8. Foreign flag crude/product tankships from 20,000 to 40,000 DWT that have received inert gas exemptions from their Administration and that do not have inert gas systems installed may not carry crude oil in U.S. ports. However, they may carry product in U.S. ports.
9. A tank is considered to be free of volatile residues from previous cargoes when it has been cleaned and gas freed (safe for hot work) prior to loading the Grade E cargo. If the vessel shifts from the carriage of Grade D or higher cargoes to the carriage of Grade E cargoes without gas freeing, the first Grade E cargo must be treated as though it contained volatile residues. Subsequent Grade E cargoes need not be inerted provided the requirements of footnote 5 are met.

4. Problems of Reactive Products

Potentially, there is one significant problem introduced by the IGS systems: creation of pyrophoric iron sulfide. This solid chemical is formed at a very slow rate (building up over a period of months or years) by the reaction of the iron in the cargo tank surface with the sulfur compounds in the cargo. Iron sulfides react spontaneously and very rapidly with oxygen in the air, giving off heat. In an uninerted tank, this is not a problem. Each time that the tank is emptied (usually every few weeks), the iron sulfides react with the oxygen before much of a deposit has formed; thus, there is no opportunity for a buildup. If the tank is inerted, however, the tank surfaces may not be exposed to air for as long as 2 or more years and the iron sulfide may build up. When suddenly exposed to air, it will react, give off heat, and ignite any flammable vapors present. Although the International Maritime Organization (IMO) is examining this problem, no definitive solution has been found. A tankship should not be offloaded with an inoperative IGS because the process results in large amounts of oxygen entering the tank. In such cases, an external source of inerting gas should be used as a substitute for the inoperative system.

5. Basic Inspection Consider-ations

IG systems are complex, and the marine inspector should invest the time to learn what an IGS is, how it is designed, and how it can fail. Adding to this complexity is the fact that there are numerous IGS designs in use today. These involve different methods of producing inert gases, various ways to clean the gases themselves, and a vast number of combinations of types and arrangements of valves and piping. The inert gas is either treated flue gas from the ship's boilers or combustion gases from a separate, dedicated IGG. The major difference between flue gases and products of an IGG is that the sulfur oxide, sulfurous acid, and sulfuric acid concentrations are considerably lower when a low sulfur fuel is burned in the IGG. Otherwise, the principles of unable to support combustion operation, components, and general design are similar. Prior to inspecting an installed IGS, the inspector must become familiar with the particular system he or she will inspect, including a review of the manufacturer's instruction manual and the ship's operation and maintenance manual. The latter must provide specific outline plans, instructions, and safety precautions for the particular vessel.

SAFETY NOTE: Above all, the inspector must be careful: if an IGS has made a tank atmosphere, it will not support life, either. A person who enters an inerted space without adequate breathing apparatus will die within a few minutes.

C. TYPICAL SYSTEM COMPONENTS FROM THE GAS SOURCE TO THE TANK

1. Boiler Uptake Valves (Flue Gas Isolating Valves, IGG Isolating Valves)

These valves are located near the main boiler uptake to isolate the IGS scrubber from the boiler uptake. Alternatively, if a dedicated IGG is used, this valve will be located near the IGG; it is closed when the IGS system is not operating. Associated with each boiler uptake valve is a steam soot-blowing system. A spectacle blank is also fitted between the boiler uptake valve and the IGS scrubber to ensure complete isolation of the IGS plant and cargo. This is very important to ensure that inert gas is not introduced into the system during maintenance.

2. IGS Scrubber (Scrubber Tower, Absorption Tower, and Gas Washer)

The raw inert gases are hot and contain soot, sulfur oxides, sulfurous acid, and sulfuric acid; all of these can be harmful to the cargo and the cargo tanks. The scrubber cools the gases and removes the contaminants by bubbling the gases through large quantities of seawater (there must be two sources of water for the scrubber). The gases are then sprayed with additional quantities of water, or rise through a packed bed of ceramic forms, plastic shapes, or metal trays through which seawater falls, increasing the efficiency of the water in cleaning the inert gas. The warm, acidic, dirty seawater is then piped overboard. If the scrubber is provided with a heater to prevent the water from freezing, an automatic control system is installed to prevent its overheating. The scrubber also acts as an automatic safety device by preventing a backflow of gas to the boiler uptake or the IGG (see Figure C5-1).

3. Demister Units

The gas from the scrubber has significant amounts of moisture, both from the burning process and from bubbling through the seawater in the scrubber. The demister is located close to the scrubber to remove entrained water from the IGS gas stream. If this water is not removed, it increases the corrosion rate in the system's piping, valves, and cargo tanks. Water may also contaminate the cargo. The demister may consist of "pads" or "mattresses" of woven polypropylene or fiberglass, or centrifuge separation (cyclone dryers). There are many designs, which vary considerably.

4. IGS Blowers (Fan Units)

Two or more independent blowers are located near the demister to draw the inert gas through the scrubber and the demister and deliver it to the IGS distribution system at the required pressure. Since the greatest need for inert gas is during offloading, the blower capacity is set at 125 percent of the maximum rated capacity of the cargo pumps. This provides a margin of safety to ensure that no air enters the cargo tanks. This capacity may be provided by two blowers of equal size, or by one large and one small blower. Separate inlet and discharge valves are fitted to each blower unit. On most plants, the valves are hand-operated, but on some the discharge valves are combined with the main and auxiliary pressure regulating valves.

5. Pressure Regulating Valve (Gas Regulating Valve, IGS Control Valve, Main Valve)

The pressure-regulating valve is used to adjust the pressure between the IGS and the cargo tanks. An overpressurized cargo tank can rupture if the pressure in the IGS value is too high. It is also important to prevent backflow from the cargo tanks, which could lead to inert or cargo gases entering the machinery spaces. A fire or explosion could occur if cargo gases mix with air and enter the boilers, the engines, or the IGG. The pressure-regulating valve is installed to regulate the flow of inert gas to the IGS deck main, maintain the IGS pressure, and prevent gas backflow when the IGS malfunctions or is shut down. The value position may be controlled either manually or automatically. For automatic control, the IGS pressure is used to set the valve in a pneumatic, hydraulic, or electric feedback control to maintain a constant pressure regardless of the rate cargo discharge.

NOTE: Electrical equipment in a hazardous location must be suitable, i.e., explosion-proof, intrinsically safe, or purged and pressurized.

6. Deck Water Seal

Introduction

a. Usually located on the main deck, the deck water seal is the primary safeguard to automatically prevent a reverse flow of cargo gas from a tank to the boilers, the engines, or the IGG. The deck water seal offers a positive break in the system by means of a water trap. This permits inert gas to be delivered to the main deck while preventing gas backflow, even when the IGS is shut down. The regulations require two independent water supplies for the deck water seal. When the IGS is operating, the scrubber pump supply is used; the second supply, normally the salt water service pump, is used when the IGS is not operating. Each pump must be capable of operation at all times. The deck water seal is provided with a heater to prevent the water from freezing and an automatic control system that prevents overheating of the seal. Although not required, a demister is usually fitted to remove entrained water. There is always a water layer through which the inert gas bubbles (see Figures C5-2 through C5-4).

Type Requirements

b. There are three general types of deck water seals: wet, dry, and semidry.

(1) The wet seal is described in Figure C5-2. It is deemed the most reliable and is the only type generally approved for use on U.S. vessels.

(2) The semidry seal operates dry after the IG flow displaces the water. Venturi action returns the water when a gas block is needed as described in Figure C5-3. This type of seal as been approved for U.S. vessels on a case-by-case basis, if the unit is quick-acting, has no moving parts, and has no sensors that are subject to failure.

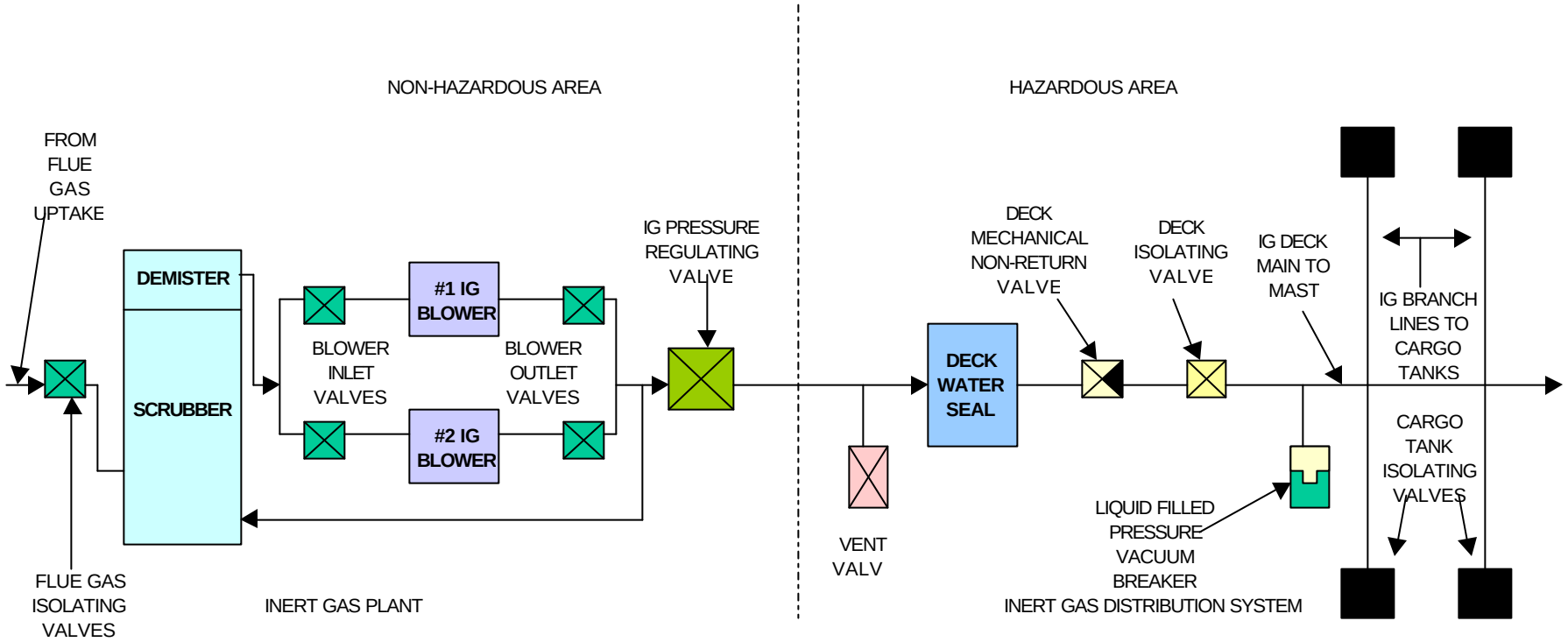
(3) The dry seal operates normally dry and is filled with water when the IG plant is shut down or when tank pressure exceeds the IG pressure. This system requires more operating parts, reacts slower and is not deemed as reliable as the wet type. Dry seals are not approved for use on U.S. vessels. See Figure C5-4 for a more complete description.

(4) A double block-and-bleed arrangement is used on some foreign vessels in place of the water seal. This involves two closely spaced valves to stop the inert gas flow (the "double block") plus a means to release (or "bleed") any gas trapped between the valves. This automatic device is not permitted on U.S. ships as a substitute for the required water seal.

7. Deck Mechanical Non-Return Valve

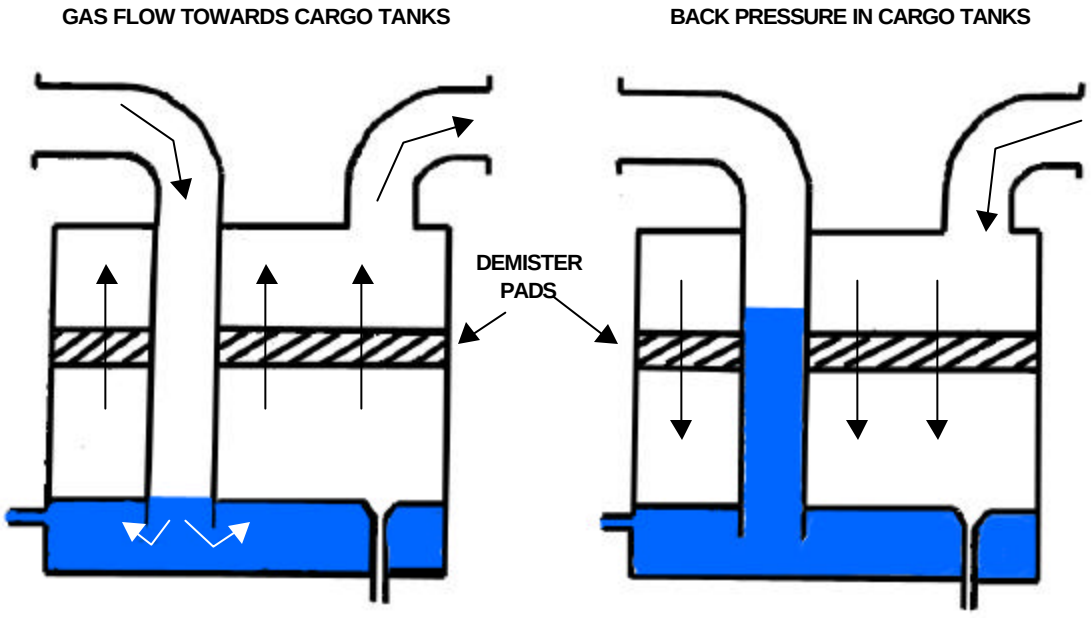
As an additional safeguard to prevent the backflow of gas from the cargo tanks, one or more mechanical non-return valves are installed on the cargo tank side and in series with the deck water seal.

FIGURE C5-2: TYPICAL IG SYSTEM COMPONENTS



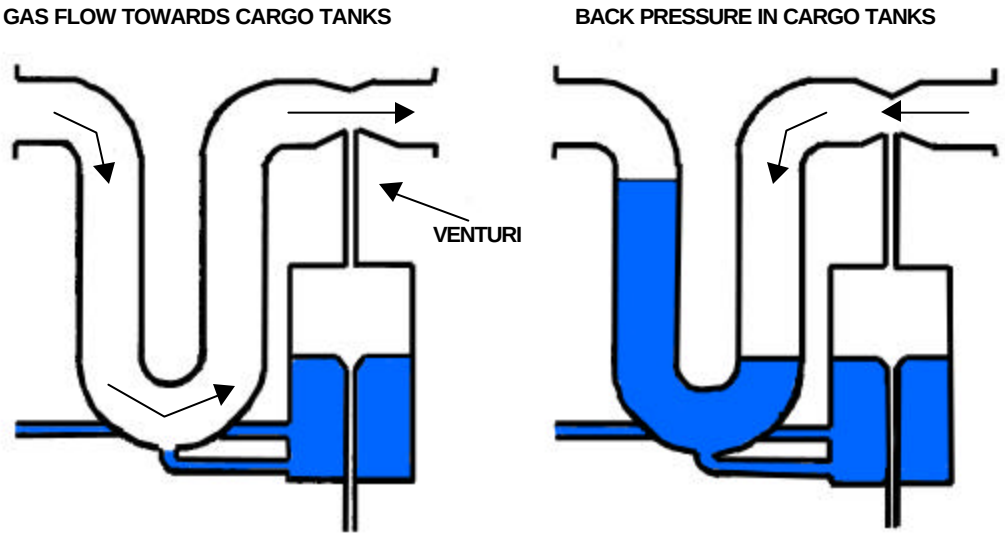
TYPICAL ARRANGEMENT FOR AN INERT GAS SYSTEM

FIGURE C5-3: DECK WATER SEAL — WET TYPE



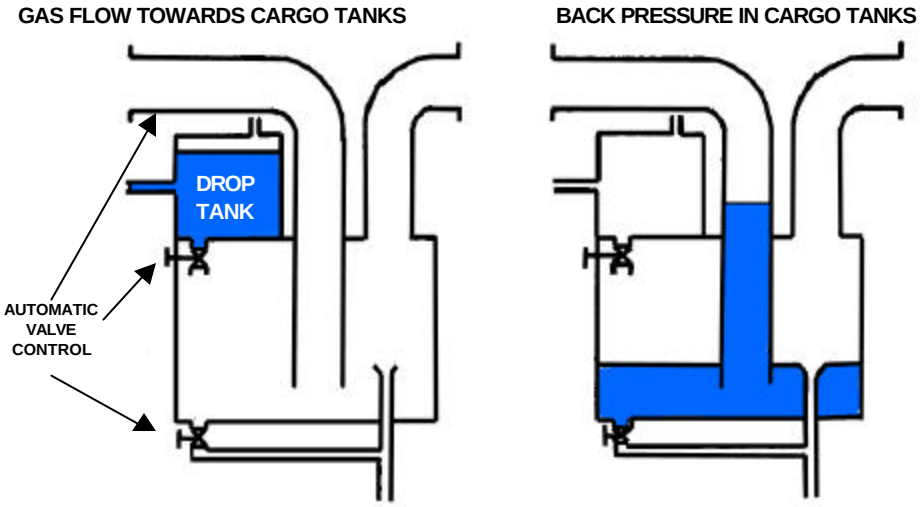
DECK WATER SEAL — WET TYPE

FIGURE C5-4: DECK WATER SEAL — SEMI-DRY TYPE



DECK WATER SEAL — SEMI-DRY TYPE

FIGURE 15-4: DECK WATER SEAL—DRY TYPE



DECK WATER SEAL — DRY TYPE

In the dry type seal, the water is drained from the seal when the IG plant is in operation (gas flowing to the tanks), and filled with water when the IG plant is either shut down, or the tank pressure exceeds the IG blower discharge pressure. Filling and drainage are performed by automatically operated valves controlled by the levels in the water seal and the drop tank, and by the operating state of the blowers. U.S. vessels must be equipped with seals that are completely passive in operation, so that failure of sensors, control systems, or moving parts cannot cause failure to establish a seal. Active seals, such as the dry seal shown above, are not acceptable.

8. Deck Isolating Valve (Main Isolating Valve)

This valve is used to isolate the inert gas plant from the deck distribution subsystem and the cargo tanks; it therefore constitutes the "first" barrier to any reverse flow of cargo tank gas when the IGS is started, tested, or secured. A second valve is necessary unless the deck mechanical non-return valve has a positive means of closure.

9. Deck Distribution System

This subsystem consists of a single inert gas main running the entire length of the cargo deck, starting at the deck isolating valve aft and ending at the vent valve forward. One or more pressure/vacuum devices are fitted to the inert gas main to prevent the cargo tanks from being over or under-pressurized. The inert gas main contains a means for receiving an outside source of inert gas when the IGS is not functioning. From the inert gas main, individual branch lines run to the cargo tanks. Stop valves or equivalent closures are fitted at each branch line, so that each cargo tank can be isolated from the inert gas system. If there is a connection between the inert gas main and the cargo piping system, there must be valves or similar closures to isolate the systems from one another.

10. Typical Gas Venting Arrangements

Venting System

a. Each tank vessel has a venting system that is capable of venting vapors displaced from the cargo tanks during loading and ballasting. There are also pressure/vacuum (P/V) valves to protect the cargo tanks from overpressure or vacuum resulting from thermal variation when the cargo tanks are isolated from the inert gas mains. Some of the possible arrangements are:

(1) A single common venting system, using the IGS deck main and branch lines from each tank and venting to the atmosphere through one or more mast risers or high-velocity vents. Precautions must be taken to prevent an arrangement by which tank vents can be blocked off;

(2) A common venting system, using a separate vent main and vent lines from each tank, with the system venting to the atmosphere through one or more mast risers or high-velocity vents; or

(3) Individual vents on each tank, using either standpipes (vent stacks) or high-velocity vents.

High Level Alarms

b. Tank high level alarms have been accepted in lieu of equal area venting required by 46 CFR 56.50-85(a)(7). However, precautions are necessary to prevent tank over pressurization during cargo or ballast loading. The oil transfer procedures, crude oil washing (COW), and equipment manual and ballasting instructions should include requirements for testing high level alarms and the proper positioning of valves for each type of operation.

11. System Documentation

Each tank vessel has an operating and maintenance manual. There are devices located downstream of the blowers to indicate the oxygen concentration, the IGS pressure and temperature, and means of automatically recording this information. The records of oxygen concentration and IGS pressure should remain aboard the vessel for at least 2 years.

D. GAS FLOW THROUGH THE IG SYSTEM

1. Introduction Inert gas is provided from the main or auxiliary propulsion uptake point or from the IGG, and flows through the flue gas isolating valve or IGG isolating valve, to the IGS scrubber. Before entering the bottom of the "scrubbing tower," the gas is cooled by bubbling through a water seal or by passing through a water spray (see Figure 15-5 for a diagram of a typical IGS arrangement).

2. Water Flow In the scrubbing tower itself, the gas moves upward through a supply of downward-flowing seawater. To maximize the contact between the gas and the water, several water layers created by one or more of the following arrangements may be used:

a. Spray nozzles;

b. Trays of "packed" stones or plastic shapes;

c. Perforated "impingement" plates; or

d. Venturi nozzles and slots. Seawater is supplied to the scrubber by an independent, continuously rated "scrubber pump." The saltwater service pump is normally piped into the system to provide a secondary or backup supply of seawater. The scrubber effluent ("wash" or "cooling water") is both warm and acidic, and special corrosion-resistant piping must be used to discharge it overboard. A vacuum breaker (U-bend) is necessary to prevent possible loss of water in the seal.

NOTE: The scrubber must have an adequate supply of salt water for the prescribed gas flow. A low saltwater level means that the scrubber will not work as designed or not at all.

Fresh water flushing facilities are provided so that all acidic solutions and all salt water may be removed from the scrubber when the IGS is shut down.

3. Refinement of the IG Mixture and Flow Control

At the top of the scrubbing tower, water droplets are removed from the inert gas mixture by one or more demisters. The operating blower draws the gas from the scrubber/demister unit under vacuum and delivers it to the inert gas distribution at the required pressure and volume. The total capacity of the blowers must be at least 125 percent of the maximum rated capacity of the cargo pumps. The blowers may be either steam turbine or electric powered. Steam inlet and return valves are manually operated, but both blowers can be controlled from the engine control room. To prevent the blowers from overheating when there is no demand for inert gas in the cargo tanks, and to allow gas concentration to be developed during startup, a recirculating line is fitted to return the blower discharge to the scrubber. Flow is controlled by recirculating or bypass valves, operated independently by gas flow demand, or in conjunction with the gas pressure regulating system.

4. Alternate Blower Arrange-ments

Some IGS blowers are used to gas free the cargo tanks in lieu of portable blowers or a separate fixed gas freeing blower system. In this arrangement, the installation is fitted to isolate the flue gas and substitute suction from the atmosphere. As with the scrubber, fresh water flushing facilities are fitted to remove acidic residues in the blower casings. The fresh air then passes through the pressure regulating valve, the deck isolating valve, the IGS main, and the individual branch lines into the cargo tanks.

E. INTERNAL INSPECTIONS OF IG SYSTEMS

1. Introduction

The marine inspector must appreciate the potential for introducing "dirty" or corrosive gas into the IGS by improper operating procedures or poor maintenance practices. This situation will create an environment for rapid system degradation or component failure. The following policy is not intended to be applied during routine testing of the IGS on either a U.S. or foreign tanker. Internal inspections are anticipated on U.S. tankers during biennial inspections for certification and drydockings. This cycle is considered a minimal requirement, as many manufacturer instruction manuals recommend that owners inspect various components of the IGS on an annual, semiannual, or weekly basis.

2. Specific Inspection Guidelines

Scrubber

a. Where feasible, all access plates and internal components such as demister pads and scrubber trays shall be removed. Soot and scale deposits shall be removed prior to the inspection. The following areas and internal components should be given close attention:

(1) Internal coatings should be completely intact. Check for signs of chipping or cracking, particularly around internal fastenings.

(2) Inspect gas inlet pipe in the scrubber water seal for corrosion and holes or leaking flanges, especially above the water level, that would allow gas to bypass the seal and render it ineffective.

(3) Closely inspect the internal area at the bottom of the scrubber for corrosion, especially in way of the effluent discharge line. Check the discharge line for clogging.

(4) Inspect float switches, temperature sensors, Venturi slots, impingement plates, packed trays, and demisters (as applicable) for damage, wastage, and corrosion.

(5) Ensure that the water heater (used to prevent water freezing) and its control system are in good condition.

(6) Inspect fresh and saltwater inlet piping for corrosion or wastage, and especially for holes or leaking flanges. Check spray nozzles for clogging and intact condition.

Valves

b. Boiler uptake (or IGG) valves, blower inlet and discharge valves, recirculating valves, pressure regulating valves, deck mechanical non-return valves, deck isolating valves, and IGS isolating valves shall be disassembled for inspection. Valve internals shall be inspected for cleanliness, and for signs of corrosion or erosion. Careful attention should be given to "butterfly" mechanisms to ensure free, smooth operation and proper seating. Check non-return valve seals. If accessible, either through inspection ports or disassembled components, the internal areas of the inert gas main and branch lines shall be checked for excessive scale buildup or soot deposits, which could result in a critical gas pressure drop between the IGS blowers and the cargo tanks.

Deck Water Seal

c. This shall be disassembled. Internal coatings shall be inspected for intactness; housing and heating coils, for corrosion; gas inlet pipes, for corrosion, holes, or leaking flanges (especially above the water level) that would permit gas to bypass the seal; and drain lines, for clogging or corrosion. The demister pads must be clean and free of soot and scale deposits. Check that the heater (used to prevent water freezing) and its control system are in good condition. Only the wet type of water seal is permitted; in this type there is always water present in the device and the inert gas flowing through the seal always bubbles through a layer of water. Semidry seals, in which water is not always present, are approved for U.S. vessels on a case-by-case basis. "Dry" water seals and the double block-and-bleed assemblies are not permitted aboard U.S. vessels.

Blowers

d. The inspection ports and access plates on all blowers shall be opened. Blower impellers, bearings, and casings shall be checked for corrosion or excessive buildup of deposits that may cause blade failure. If accessible, fresh water flushing spray nozzles shall be checked for intactness or clogging; the blower drain piping, for corrosion or clogging.

P/V Valves

e. P/V valves shall be disassembled and inspected for corrosion and the choking of flame screens from soot, oil entrainment, and rust. The forward pressure release valve shall be disassembled and the butterfly mechanism inspected for free, smooth operation and proper seating. If feasible, the liquid-filled, pressure/vacuum breaker shall be drained and inspected for sludge, sediment, or soot deposits that could render the component ineffective. High-velocity vent installations shall be inspected for internal deposits or corrosion that may reduce venting capacity or prevent tight closure.

Flue Gas Uptakes

f. If accessible, the flue gas uptake should be inspected for clogging from soot deposits when the boilers, engines, or IGG's are secured. On systems with IGG's, the combustion chamber shall be checked for soot, scale, or fuel deposits that could indicate improper combustion control or a distorted fuel spray pattern.

Calibration

g. Check the equipment used for the calibration of the fixed and portable gas concentration measurement devices.

F. OPERATIONAL INSPECTIONS

1. Introduction

The following tests shall be conducted on U.S. tankships during biennial and mid-period inspections and on foreign tankships, at each annual safety examination. On all vessels, these tests shall be conducted prior to allowing COW in a U.S. port. The scope of such tests must be sufficient to ensure that the IGS is operating within the manufacturer's design parameters and that the installed safeguards will operate as designed in the event of system malfunction. The marine inspector must review the manufacturer instruction manual and the vessel's operating and maintenance manual, and must be alert to conditions that must be simulated. In no case shall the inspector accept a manual that does not address specific safety precautions for the particular vessel.

2. Inspection Procedures

a. Externally inspect the condition of all piping and components, including scrubber, fans, valves, bellows expansion pieces, standpipes, and screens, for signs of corrosion and gas/effluent leakage.

b. Observe all IGS blowers in operation for proper operation and for excessive bearing noise or vibration. Ensure that the scrubber room ventilation system is operating.

c. Observe the operation of both the salt water scrubber pump and the pump used to provide an alternate salt water supply.

d. If the scrubber design uses a water seal, check for proper water level. Some foreign vessels are fitted with water sprays only, but U.S. vessels must have a wet type water seal.

e. Observe the deck water seal for automatic filling and check the water level with the local gauge, if possible. Check for the presence of water carryover (especially in the wet and semidry types) by opening the drain cocks on the IG main during operation. Check that the heater coil for cold weather operation is operational.

f. Check the operation of all remotely operated or automatically controlled valves, particularly the flue gas isolating valves. Check that there are functioning indicators showing whether the valves are open or shut.

g. If possible, check the level of the liquid in the pressure/vacuum breaker.

h. Check to ensure that all salt water supply pressure gauges, oxygen and gas pressure recorders, and temperature and pressure gauges are fully operational. The fixed inline oxygen analyzing equipment will be calibrated during the operation of the IGS. Observe a calibration check of the equipment by a qualified member of the ship's crew. Spot-check several recordings made since the last inspection during normal system operation for compliance with oxygen and pressure level requirements.

i. Examine the blower drives, the seawater pumps, valves, and strainers for the scrubber and the water seal; the piping connections at the scrubber; water seals; and the shell plating.

j. Observe that all portable instruments are properly calibrated and operating as required by the manufacturer instruction manual. These may include an oxygen analyzer, a combustion gas indicator, and a hydrocarbon gas indicator. Sample points should be provided for the use of portable instruments for monitoring cargo tank atmospheres.

k. If an IGG is used, examine the automatic combustion control system, the combustion chamber and its mountings, the forced draft fan, and both fuel oil service pumps.

3. Operational Tests

a. The operation of both audible and visual alarms should be observed in the cargo control room, the engine control room, and the pilothouse. The marine inspector shall consult the manufacturer instruction manual and the ship's operation and maintenance manual for guidance in establishing proper test procedures. Simulation may be necessary for some tests. However, simulation tests of the alarm panel shall not be accepted as evidence of satisfactory operation of the following alarm and safety shutdown systems:

(1) High oxygen content of gas in IGS main; alarms activated at an 8 percent concentration.

(2) Low gas pressure in IGS main downstream of all non-return devices; alarms activated at 100mm (4 inches) water gauge. An automatic shutdown of the cargo pumps may be fitted on some vessels. Also, high gas pressure in the IGS main downstream of all non-return devices.

(3) A low level water alarm, high level water alarm, or low flow pressure alarm fitted to the deck water seal to shut down the IGS blowers automatically.

(4) IGS blower high discharge temperature alarm that will automatically shut down the IGS blowers and the gas regulating valve; alarms activated at 150°F (65.6°C) or less for U.S. vessels and at temperatures indicated in approved operation manual for foreign vessels.

(5) High gas pressure of the inert gas supply forward of the non-return devices.

(6) IGS blower failure alarm and automatic shutdown of main or regulating valve.

(7) Power supply failure for the automatic control system gas regulating valve and the indicating devices showing the proper quantity and quality of the inert gas supply.

(8) Insufficient fuel oil supply to the IGG and the failure of the power supply to the IGG.

b. Conduct backflow pressure test of water seal and non-return valve.

c. Test interlocking of soot blowers. The IGS will automatically shut down if soot blowers are operated.

d. Test for automatic shutdown of the gas pressure regulating valve when the IGS blowers are secured.

e. Test the automatic combustion control features of the IGG (if used) in accordance with standard combustion test procedures for automatic auxiliary heating equipment (see 46 CFR 63).

f. Test IGS remote shutdown required by 46 CFR 111.103.9.

G. SAFETY PRECAUTIONS

1. Introduction

The purpose of an IGS is to establish positive pressure in a cargo tank with an atmosphere that will not support combustion. If an atmosphere will not support a fire, it will not support life. Clearly, such an inerted, pressurized atmosphere is highly dangerous, producing unconsciousness and death in a short period. The following guidance is intended to make inspectors aware of the fundamental steps that must be taken to ensure IGS safety.

2. References

In addition to this chapter of the Marine Safety Manual (MSM), the inspector should consult the following sources:

a. 46 CFR 32.53;

b. The American Bureau of Shipping (ABS) Rules for Building and Classing Steel Vessels, Appendix B, Regulation 10;

c. SOLAS 74/78, Chapter II-2, Part E, Regulation 62, and amendments;

d. The manufacturer instruction manual;

e. The vessel's operating and maintenance manual; and

f. Commandant's International Technical Series (CITS), Volume VII (USCG CITS-80-1-1), "Regulations and Guidelines for Inert Gas Systems."

3. Requirements for an Escort

The marine inspector must always have a ship's officer or port engineer trained in the operation of the IGS along as an escort. The ship's officer or the port engineer will oversee all required tests and inspections.

4. Personal Caution

Always stand well clear of any ullage opening when the cover is being removed, even though the cargo tank pressure has been lowered to a "safe" level. Wear protective goggles and clothing when conducting internal inspections of the system. Remember that the potentially corrosive nature of the dirt, scale, and soot associated with the internals of an IGS can irritate or damage your skin and eyes.

5. Requirements for Tank Entry

The marine inspector shall, under no circumstances, enter a cargo tank when the IGS is operating, or when the tank or the adjacent tanks have been inerted, unless the following steps are taken:

a. The cargo tank shall be certified "safe for workers" by a certified marine chemist.

b. Pressure on the remainder of the system shall be lowered to 200mm (8 inches) water gauge to minimize the possibility of IGS leakage into the "gas-free" cargo space.

c. The IGS branch line control valve to that tank shall be closed, with a person stationed at the ullage opening within clear view of the valve. This person should be wearing a self-contained, pressure-demand breathing apparatus, ready for immediate use, and should be provided with a rescue lifeline and a standby person positioned as noted above.

NOTE: If an isolation blank is fitted instead, it shall be wired closed with the label "Personnel in cargo tank."

d. Drain lines (if fitted) from the IGS main to that cargo tank shall be secured.

e. The relevant cargo line valve shall be closed.

f. The cargo tank shall be continually vented and regularly tested with the portable oxygen analyzer.

g. An approved self-contained, pressure-demand breathing apparatus shall be worn for immediate use if needed. It shall be equipped with a belt-mounted, calibrated oxygen/combustion gas indicator in continuous operation.

6. Ventilation Requirements

If the IGS is secured and the IGS blowers are being used to purge and ventilate the cargo tanks, the branch valve must be left opened. In this case, ensure that the spectacle blank or valve downstream of the boiler uptake valve is in place and that a person is stationed at that blank.

7. Branch Line Inspections

Never inspect the flue gas bellows or scrubber unless: all branch line spectacle blanks are in place (or branch line isolation valves are closed); the spectacle blank downstream of the boiler uptake valve is in place; isolation valves are closed; and the IGS has been purged and certified "safe for workers" by a marine chemist. If a boiler is operating, require a person to be stationed at the spectacle blank downstream of the boiler uptake valve.

8. Internal Inspections of Enclosed Spaces

When conducting internal inspections of pumprooms, cofferdams, permanent ballast tanks, and fuel oil tanks on tank vessels fitted with IGS, be aware that inert gas may have leaked into such tanks or compartments. While inspecting the tank or compartment, the inspector shall be equipped with an emergency escape breathing apparatus (EEBA) and a belt-mounted, calibrated oxygen/combustion gas indicator that is in continuous operation. Always test for sufficient (at least 19.5 percent) oxygen first, then test for vapors above 10 percent of the lower flammable limit.

> **NOTE:** A combustion gas indicator will not give an accurate indication of the percentage of hydrocarbon gas in an oxygen-deficient atmosphere. A hydrocarbon gas content meter must be used to determine whether hydrocarbon vapors are present in an inerted tank or compartment.

H. PRESSURIZATION OF IG SYSTEMS

1. General Requirements

The operational requirements in 46 CFR 32.53-5 require the master to ensure that the IGS is operated as necessary to maintain a positive pressure on the cargo tanks. This requires the tank to be sealed at all times except when the tank is either gas-free or carrying a cargo that cannot produce a flammable atmosphere. For certain cargoes, the cargo purity is of critical importance; thus, the cargo tanks must be gas-freed and entered prior to loading. In such instances, standard gas-freeing procedures must be followed.

2. During Periods of Cargo Access

The high costs of crude oil and petroleum products can require cargo level measurement and cargo sampling before and after loading, and before and after the cargo is transferred. When manual measurement or cargo sampling is being conducted, no cargo or ballasting operation shall be performed. The following requirements shall apply:

a. A minimal number of small tank openings may be uncovered for as short a time as necessary to perform measurement or sampling.

b. If tanks are thus opened prior to cargo transfer, the tanks shall be repressurized before beginning the transfer.

c. If tanks are thus opened after cargo transfer, the tanks shall then be repressurized before beginning another transfer or the vessel leaves port.

d. Neither cargo transfer nor movement of the vessel shall begin until all conditions have been checked and are in order.

e. During cargo transfer operations, the oxygen content and pressure of the inert gas in the IG main shall be continuously recorded.

f. These instructions shall be contained in the system operating manual required by 46 CFR 32.53-85.