

**STANDARD
FOR
INERT GAS SYSTEMS**

SEPTEMBER, 1984

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STANDARD FOR INERT GAS SYSTEMS

Foreword

This Standard supplements the requirements of Schedule VII, Fire Protection, Detection and Extinguishing Equipment Regulations; it takes into account the arduous operating conditions of inert gas systems and the need to maintain them to a satisfactory level. The Standard will assist in determining appropriate design and constructional parameters and in formulating suitable operational procedures for installation of inert gas systems in ships.

1. This Standard may be cited as the Standard for Inert Gas Systems.

PART I

INTERPRETATION AND APPLICATION

Interpretation

2. In this Standard,

“inert gas” means a gas or a mixture of gases, such as flue gas, containing insufficient oxygen to support the combustion of hydrocarbons;

“inert condition” means a condition in which the oxygen content throughout the atmosphere of a tank has been reduced to 8 per cent or less by volume through addition of inert gas;

“inert gas plant” means all equipment specially fitted to supply, cool, clean, pressurize, monitor and control delivery of inert gas to cargo tank systems;

“inert gas distribution system” means all piping, valves and associated fittings to distribute inert gas from the inert gas plant to cargo tanks, to vent gases to atmosphere and to protect tanks against excessive pressure or vacuum;

“inert gas system” means an inert gas plant and inert gas distribution system, together with means for preventing backflow of cargo gases to the machinery spaces, fixed and portable measuring instruments and control devices;

“inerting” means the introduction of inert gas into a tank with the object of attaining the inert condition;

“gas freeing” means the introduction of fresh air into a tank, with the object of removing toxic, flammable and inert gases and increasing the oxygen content to 21 per cent by volume.

“purging” means the introduction of inert gas into a tank already in the inert condition, with the object of:

- (a) further reducing the existing oxygen content and/or

- (b) reducing the existing hydrocarbon gas content to a level below which combustion cannot be supported if air is subsequently introduced into the tank.

“topping-up” means the introduction of inert gas into a tank that is already in the inert condition, with the object of raising the tank pressure to prevent any ingress of air.

Application

- 3. (1) This Standard has advisory status and it is intended to cover the design and operation of:
 - (a) inert gas systems that are required on new tankers by section 49, Fire Protection, Detection and Extinguishing Equipment Regulations and in accordance with Schedule VII, Fire Protection, Detection and Extinguishing Equipment Regulations;
 - (b) inert gas systems that are required on existing tankers by section 49, Fire Protection, Detection and Extinguishing Equipment Regulations and in accordance with section 21, Schedule VII, Fire Protection, Detection and Extinguishing Equipment Regulations;
 - (c) inert gas systems that are fitted but not required to comply with the requirements of section 49 of the Fire Protection, Detection and Extinguishing Equipment Regulations.
- (2) For existing inert gas systems, however, the Standard is directed primarily at operational procedures and is not intended to be interpreted as requiring modifications to existing equipment other than those required on ships to which section 21, Schedule VII of the Fire Protection, Detection and Extinguishing Equipment Regulations, applies.
- (3) The content of this Standard is based on current general practice used in the design and operation of inert gas systems using flue gas from the uptake of the ship’s main or auxiliary boilers and installed on crude oil tankers and combination carriers.
- (4) The Standard does not exclude other sources of inert gas, such as systems incorporating independent inert gas generators, other designs, material or operational procedures; all such divergences should be carefully assessed to ensure that they achieve the objectives of this Standard.

PART II

PRINCIPLES

General

4. With an inert gas system, a tank is protected from exploding by introducing inert gas into it to keep the oxygen content low and to reduce to safe proportions the hydrocarbon gas concentration of its atmosphere.

Flammable Limits

5.
 - (1) A mixture of hydrocarbon gas and air cannot ignite, unless its composition lies within a range of gas-in-air concentrations known as the flammable range.
 - (2) The lower limit of the range, known as the "lower flammable limit", is any hydrocarbon concentration below which there is insufficient hydrocarbon gas to support combustion.
 - (3) The upper limit of the range, known as the "upper flammable limit", is any hydrocarbon concentration above which air is insufficient to support combustion.
 - (4) The flammable limits vary somewhat for different pure hydrocarbon gases and for the gas mixtures derived from different petroleum liquids; in practice, however, the lower and upper flammable limits of oil cargoes carried in tankers can be taken, for general purposes, to be 1 per cent and 10 per cent hydrocarbon by volume, respectively.

Effect of Inert Gas on Flammability

6.
 - (1) When an inert gas is added to a hydrocarbon gas/air mixture, the result is an increase in the lower flammable limit concentration and a decrease in the upper flammable limit concentration. Figure 1 illustrates these effects which should be regarded only as a guide to the principles involved.

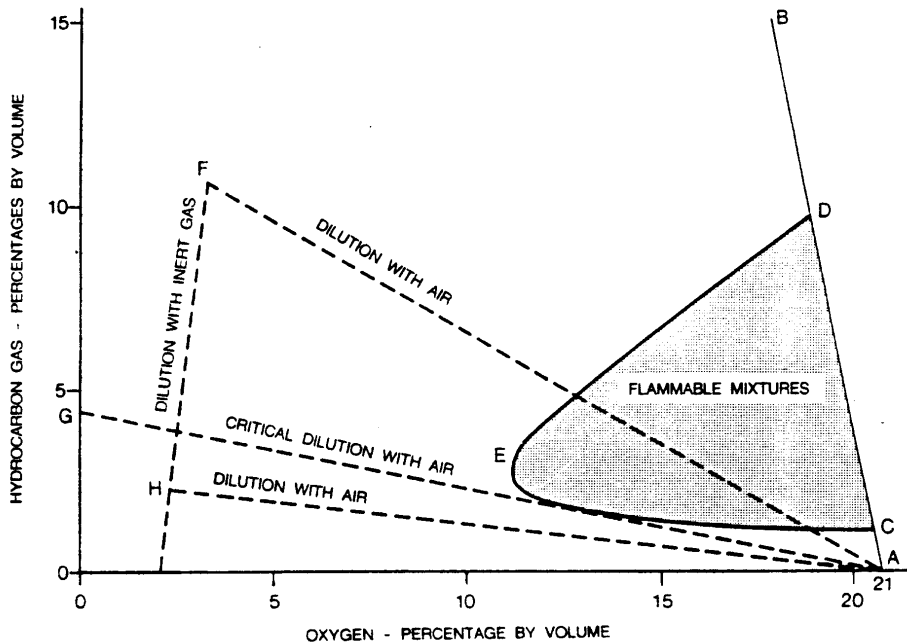


FIGURE 1 Hydrocarbon gas/air/inert gas mixtures effect on flammability

- (2) Any point on the diagram represents a hydrocarbon gas/air/inert gas mixture, specified in terms of its hydrocarbon and oxygen content.
- (3) Hydrocarbon/air mixtures, without inert gas, lie on the line AB, the slope of which shows the reduction in oxygen content as the hydrocarbon content increases.
- (4) Points to the left of AB represent mixtures whose oxygen content is further reduced by the addition of inert gas.
- (5) As indicated in Figure 1, as inert gas is added to hydrocarbon/air mixtures, the flammable range progressively decreases, until the oxygen content reaches a level generally taken to be about 11 per cent by volume, at which no mixture can burn.
- (6) The figure of 8 per cent by volume, specified in this Standard for a safely inerted gas mixture, allows some margin beyond this value.

- (7) The lower and upper flammability limit mixtures for hydrocarbon gas in air are represented by points C and D.
- (8) As the inert gas content increases, the flammable limit mixtures change; lines CE and DE indicate this, finally converging at point E.
- (9) Only those mixtures represented by points in the shaded area within the loop CED are capable of burning.
- (10) Changes of composition, due to the addition of either air or inert gas, are represented by movements along straight lines; these lines are directed either towards point A (pure air), or towards a point on the oxygen content axis corresponding to the composition of the added inert gas; such lines are shown for the gas mixture represented by point F.
- (11) When an inert mixture, such as that represented by point F, is diluted by air, its composition moves along line FA and enters the shaded area of flammable mixtures; this means that all inert mixtures in the region above line GA (critical dilution line) pass through a flammable condition as they are mixed with air (for example, during a gas-freeing operation); those below line GA, such as that represented by point H, do not become flammable on dilution.
- (12) It will be noted that dilution with additional inert gas, i.e. purging, makes it possible to move from a mixture, such as that represented by F, to one such as that represented by H, by dilution with additional inert gas, i.e. purging.

Sources

7. Possible sources of inert gas on tankers including combination carriers are:
 - (a) the uptake from the ship's main or auxiliary boilers;
 - (b) an independent inert gas generator, or
 - (c) a gas turbine plant equipped with an afterburner.

Quality

8. Good combustion control in ships' boilers is necessary to achieve an oxygen content of 5 per cent by volume; to obtain this quality, it may be necessary to use automatic control.

Methods of Gas Replacement

9. (1) Three operations involve replacement of gas in cargo tanks, namely:
- (a) inerting;
 - (b) purging;
 - (c) gas-freeing.
- (2) In each of these replacement operations, one of two processes can predominate -
- (a) dilution, which is a mixing process (see subsections 9(3), (4) and (5));
 - (b) displacement, which is a layering process (see subsection 9(6)).

These two processes have a marked effect on the method of monitoring the tank atmosphere and the interpretation of the results; Figures 3 and 5 show that the gas replacement process actually taking place within the tank must be understood to correctly interpret the reading shown on the appropriate gas sampling instrument.

- (3) The dilution theory assumes that the incoming gas mixes with the original gases to form a homogeneous mixture throughout the tank; the result is that the concentration of the original gas decreases exponentially.
- (4) In practice, the actual rate of gas replacement depends upon the volume flow of the incoming gas, its entry velocity and the dimensions of the tank.
- (5) For complete gas replacement, it is important that the entry velocity of the incoming gas be high enough for the jet to reach the bottom of the tank; it is therefore important to confirm the ability of every installation using this principle to achieve the required degree of gas replacement throughout the tank.

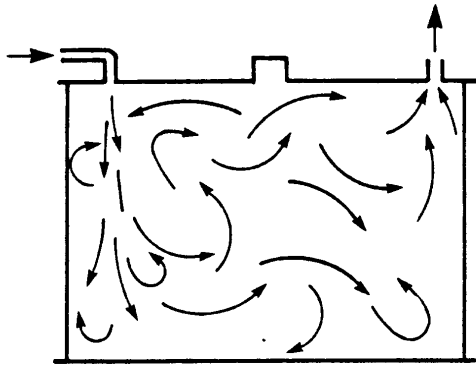


FIGURE 2

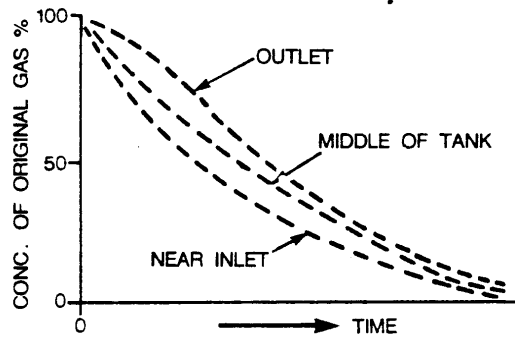


FIGURE 3

Dilution process of gas in cargo tanks

Figure 2 shows an inlet and outlet configuration of the dilution process and illustrates the turbulent nature of the gas flow within the tank.

Figure 3 shows typical curves of gas concentration against time for three different sampling positions.

- (6) Ideal replacement happens when a stable horizontal interface exists between the lighter gas entering at the top of the tank and the heavier gas being displaced from the bottom of the tank through some suitable piping arrangement; this method requires a relatively low entry velocity of gas and, in practice, more than one volume change is necessary; it is therefore important to achieve the required degree of gas replacement throughout the tank.

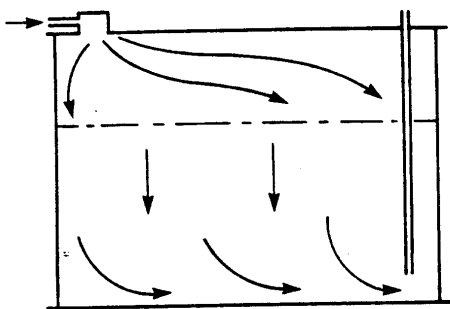


FIGURE 4

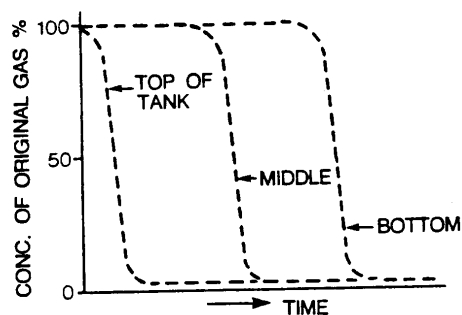


FIGURE 5

Displacement process of gas in cargo tanks

Figure 4 shows an inlet and outlet configuration for the displacement process, and indicates the interface between the incoming and outgoing gases.

Figure 5 shows typical curves of gas concentration against time for three different sampling levels.

General Policy of Cargo Tank Atmosphere Control

10. (1) The cargo tanks in tankers fitted with an inert gas system should be kept in a non-flammable condition at all times (see Figure 1) and to meet this requirement shall comply with subsections (2) through (5).
- (2) Tanks should be kept in the inert condition at all times except when entry is required.
- (3) The oxygen content should be kept at 8 per cent or less by volume with a positive gas pressure in all the cargo tanks.
- (4) The atmosphere within the tank should make the transition from the inert condition to the gas-free condition without passing through the flammable condition; in practice, this means that, before any tank is gas freed, it should be purged with inert gas until the hydrocarbon content of the tank atmosphere is below the critical dilution line (see Figure 1) .
- (5) When a ship is in a gas-free condition prior to arrival at a loading port, tanks should be inerted before loading.
- (6) To maintain cargo tanks in a non-flammable condition, the inert gas plant will be required to:
 - (a) inert empty cargo tanks (see section 30);
 - (b) be operated during cargo discharge, deballasting and tank cleaning (see sections 31, 34, 35, 37 and 38);
 - (c) purge tanks prior to gas freeing (see section 39);
 - (d) top-up pressure in the cargo tanks when necessary, during other stages of the voyage (see sections 33 and 37).

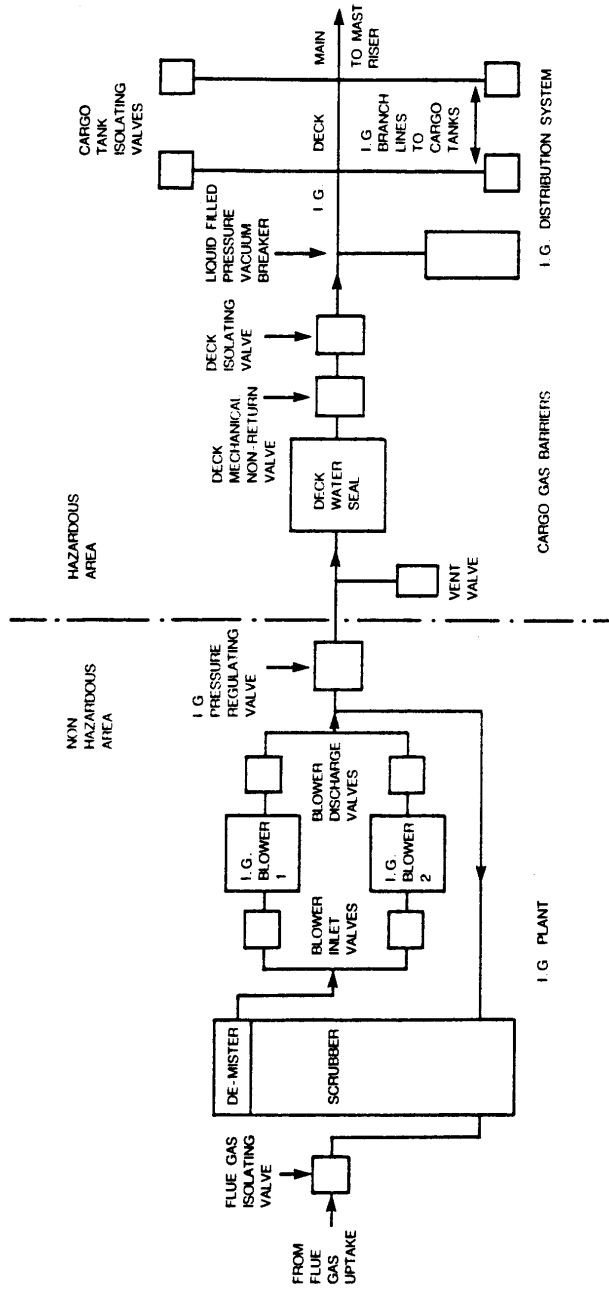


Figure 6 A typical arrangement for an inert gas system

PART III

FUNCTION AND DESIGN CONSIDERATIONS

11. This section addresses itself to inert flue gas systems; the design of systems other than inert flue gas systems should take into account, whenever applicable, the general principles outlined in this section.

Description of an Inert Flue Gas System

12. (1) A typical arrangement for an inert flue gas system is shown in Figure 6.
- (2) Flue gas isolating valves are located at the boiler uptake points, through which pass hot, dirty gases to the scrubber and demister; here the gas is cooled and cleaned before being piped to blowers, which deliver the gas through the deck water seal, the non-return valve and the deck isolating valve to the cargo tanks.
- (3) A gas pressure regulating valve is fitted downstream of the blowers to regulate the flow of gases to the cargo tank.
- (4) A liquid-filled pressure vacuum breaker is fitted to prevent excessive pressure or vacuum from causing structural damage to cargo tanks.
- (5) A vent is fitted between the deck isolating/non-return valve and the gas pressure regulating valve to vent any leakage when the plant is shut down.
- (6) For delivering inert gas to the cargo tanks during cargo discharge, de-ballasting, tank cleaning, and for topping up the pressure of gas in the tank during other phases of the voyage, an inert gas deck main runs forward from the deck isolating valve for the length of the cargo deck; from this inert gas main, inert gas branch lines lead to the top of each cargo tank.

Function of Inert Gas Scrubber

13. (1) The scrubber cools the flue gas and removes most of the sulphur dioxide and particulate soot; all three actions are achieved by direct contact between the flue gas and large quantities of sea water.

- (2) Before entering the bottom of the scrubbing tower, the gas is cooled by either passing through a water spray, or bubbling through a water seal; such a seal may also serve as the additional safety device to prevent any leakage of gas from the boiler uptake when the scrubber is opened up for inspection or maintenance.
- (3) In the scrubbing tower itself the gas moves upwards through downward flowing water; for maximum contact between gas and water, several layers made up of one or more of the following arrangements may be fitted:
 - (a) spray nozzles;
 - (b) trays of "packed" stones or plastic chippings;
 - (c) perforated "impingement" plates;
 - (d) venturi nozzles and slots.
- (4) At the top of the scrubbing tower or downstream of it, water droplets are removed by one or more demisters which may be polypropylene mattresses or cyclone dryers; designs of individual manufacturers vary considerably.

Design Considerations for Inert Gas Scrubber

14. (1) The scrubber should be of a design related to the type of tanker cargoes and combustion control equipment of the inert gas supply source; it should be capable of dealing with the quantity of inert gas required by Schedule VII, at the designed pressure differential of the system.
- (2) The performance of the scrubber at full gas flow should be such as to remove solids effectively and at least 90 per cent of sulphur dioxide; in product carriers, more stringent requirements may be needed for product quality.
- (3) The internal parts of the scrubber should be constructed of corrosion resistant materials because of the corrosive effect of the gas; alternatively, the internal parts may be lined with rubber, glass fibre epoxy resin or other equivalent material, in which case the flue gases may require cooling before they are introduced into the lined sections of the scrubber.
- (4) Adequate openings and sight glasses should be provided in the shell for inspection, cleaning and observational purposes; the sight glasses should be reinforced to withstand impact and be heat resistant; this condition may be achieved by double glazing.

- (5) The design should be such that, under normal conditions of trim and list, the scrubber efficiency will not fall more than 3 per cent, nor will the temperature rise at the gas outlet exceed the desired gas outlet temperature by more than 3 degrees Celsius.
- (6) The location of the scrubber above the load waterline should be such that the drainage of the effluent is not impaired when the ship is fully loaded.

Function of Inert Gas Blowers

- 15. (1) Blowers deliver the scrubbed flue gas to the cargo tanks; at least two blowers are required, which together shall be capable of delivering inert gas to the cargo tanks at a rate of at least 125 per cent of the maximum rate of discharge capacity of the ship, expressed as a volume.
- (2) In practice, installations vary from those that have one large blower and one small blower, whose combined total capacity complies with subsection (1), to those in which each blower can meet this requirement.
- (3) The advantage claimed for the former in subsection (2), is that it is convenient to use a small capacity blower when topping up the gas pressure in the cargo tanks at sea.
- (4) The advantage claimed for the latter in subsection (2), is that, if either blower is defective the other one is capable of maintaining a positive gas pressure in the cargo tanks without extending the duration of the cargo discharge.

Design Considerations for Inert Gas Blowers

- 16. (1) The blower casing should be constructed of corrosion-resistant material or of mild steel (but then its internal surfaces should be stove-coated, or lined with rubber or glass fibre epoxy resin or other equivalent material to protect it from the corrosive effect of the gas).
- (2) The impellers should be manufactured of a corrosion-resistant material; aluminum, bronze impellers should be stress relieved after welding; all impellers should be tested by overspeeding to 20 per cent above the design running speed of the electric motor, or 10 per cent above the speed at which the overspeed trip of the turbine would operate, whichever is applicable.

- (3) Substantial drains, fitted with adequate water seals, should be provided in the casing to prevent damage by an accumulation of water; the drains should be in accordance with the provisions of subsection 27(4).
- (4) Means, such as fresh water washing, should be provided to remove the build-up of deposits that would cause vibration during blower operation.
- (5) The casing should be adequately ribbed to prevent panting and should be so designed and arranged as to facilitate the removal of the rotor without disturbing major parts of the inlet and outlet gas connections.
- (6) Sufficient openings in the casing should be provided to permit inspection.
- (7) Where separate shafts are provided for the prime mover and the blower, a flexible coupling between these shafts should be provided.
- (8) When roller or ball bearings are used, due regard should be paid to the problem of brinelling and the method of lubrication; the choice of type of lubrication, i.e. oil or grease, should have regard to the diameter and rotational speed of the shaft; if sleeve bearings are fitted then resilient mountings are not recommended.
- (9) The blower pressure/volume characteristics should be matched to the maximum system requirements; the characteristics should be such that, in the event of the discharge of any combination of cargo tanks at the discharge rate indicated in subsection 5(13), a minimum pressure of 200 millimetres water gauge is maintained in any cargo tank after allowance is made for pressure losses due to:
 - (a) the scrubber tower and demister;
 - (b) the piping conveying the hot gas to the scrubbing tower;
 - (c) the distribution piping downstream of the scrubber;
 - (d) the deck water seal;
 - (e) the length and diameter of the inert gas distribution system.

- (10) When both blowers are not of equal capacity, the pressure-volume characteristics and inlet and outlet piping should be so matched that, if both blowers can be run in parallel, they are able to develop their designed outputs; the arrangements should be such as to prevent the blower on load from motoring the blower that is stopped or has tripped out.
- (11) If the prime mover is an electric motor, then it should be of sufficient power to ensure that it will not overload under any possible operating conditions of the blower; the overload power requirement should be based on the blower inlet conditions of -5 degrees Celsius at -400 millimetres water gauge and outlet conditions of 0 degrees Celsius and atmospheric pressure; arrangements should be provided, if necessary, to maintain the windings in a dry condition during the inoperative period.

Function of Non-Return Devices

17. The deck water seal and mechanical non-return valve together provide the means of automatically preventing the backflow of cargo gases from the cargo tanks to the machinery spaces, or other safe area in which the inert gas plant is located.

Deck Water Seal

18. (1) The deck water seal is the principal barrier; a water seal is fitted that permits inert gas to be delivered to the deck main but prevents any backflow of cargo gas, even when the inert gas plant is shut down; it is vital that a supply of water is maintained to the seal at all times, particularly when the inert gas plant is shut down; in addition, drains should lead directly overboard and not pass through the machinery spaces; one of three principal types of design may be adopted.

Wet type

- (2) This is the simplest type of water seal; when the inert gas plant is operating, the gas bubbles through the water from the submerged inert gas inlet pipe, but if the tank pressure exceeds the pressure in the inert gas inlet line, the water is pressed up into this inlet pipe, thus preventing backflow; the drawback to this type of water seal is that water droplets may be carried over with the inert gas, which, although not impairing the quality of the inert gas, could increase corrosion; a demister should, therefore, be fitted in the gas outlet from the water seal to reduce any carry-over; Figure 7 shows an example of this type.

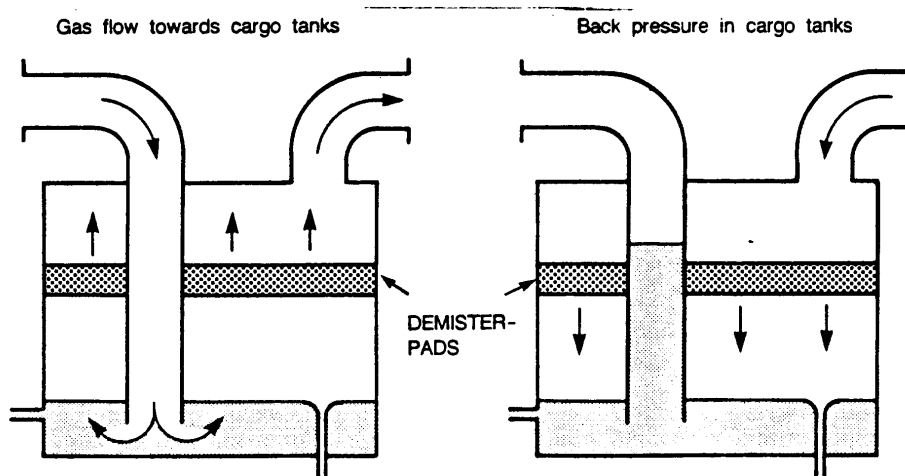


Figure 7 Deck water seal - wet type

Semi-dry type

- (3) Instead of bubbling through the water trap, the inert gas flow draws the sealing water into a separate holding chamber by venturi action, thus avoiding or at least reducing the amount of water being carried over; otherwise this seal is functionally the same as the wet type; Figure 8 shows an example of this type.

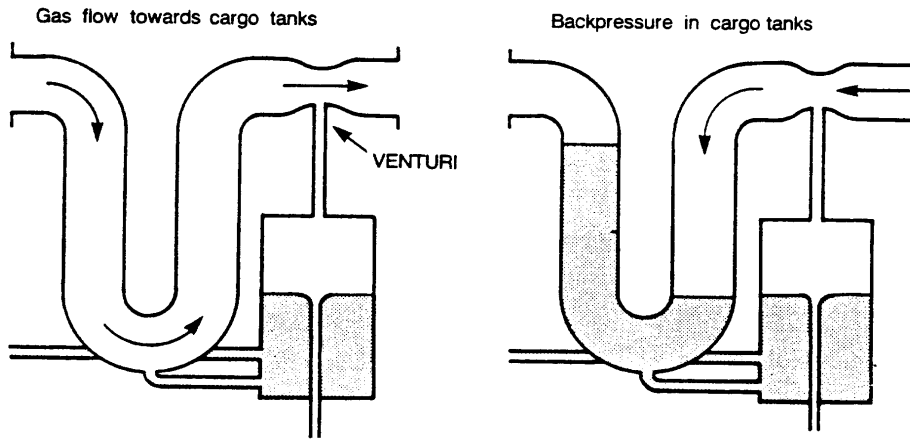


Figure 8 Deck water seal - semi dry type

Dry type

- (4) In this type, the water is drained when the inert gas plant is in operation (gas flowing to the tanks), and filled with water when the inert gas plant is either shut down or the tank pressure exceeds the inert gas blower discharge pressure; filling and drainage are performed by automatically operated valves controlled by the levels of the water seal and drop tanks and by the operation of the blowers; the advantage of this type is that it prevents water carry-over; the drawback could be the risk of failure of the automatically controlled valves that may render the water seal ineffective; Figure 9 shows an example of this type.

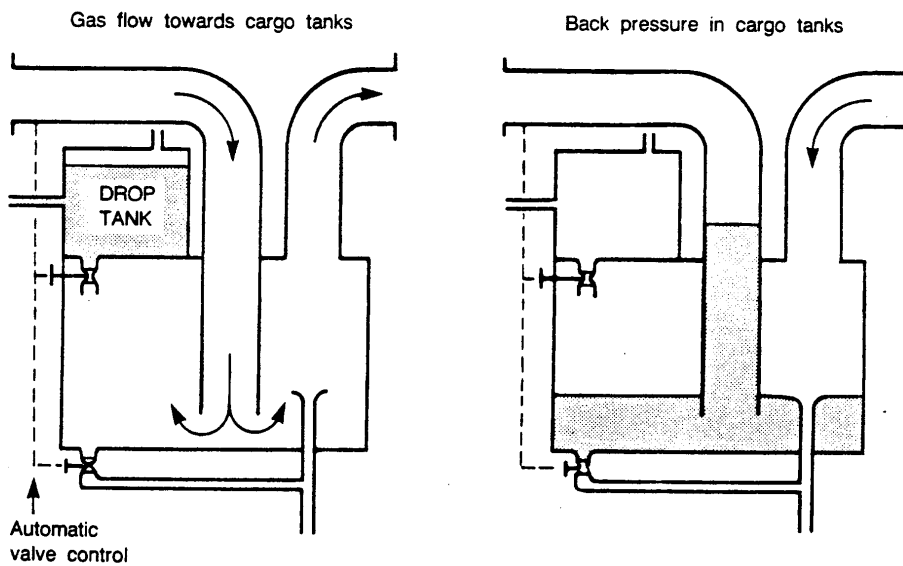


Figure 9 Deck water seal - dry type

Deck Mechanical Non-return Valve and Deck Isolating Valve

- (5) As a further precaution against any backflow of gas from the cargo tanks and any backflow of liquid that may enter the inert gas main if the cargo tanks are overfilled, a mechanical non-return valve, or equivalent is required; this should be fitted forward of the deck water seal and should operate automatically at all times.
- (6) The valve should be provided with a positive means of closure or, alternatively, a separate deck isolating valve fitted forward of the non-return valve, so that the inert gas deck main may be isolated from the non-return devices; the separate isolating valve has the advantage of facilitating maintenance work on the non-return valve.

Inert Gas Vent Valve

- (7) The valve should be opened when the inert gas plant is shut down to prevent leakage past the non-return devices from building up any pressure in the inert gas line between the gas pressure regulating valve and these non-return devices.

Design Considerations for Non-return Devices

19. (1) The material used in the construction of the non-return devices should be resistant to fire and to corrosive attack from acids formed by the gas; alternatively, low carbon steel protected by a rubber lining or coated with glass fibre epoxy resin or equivalent material may be used; particular attention should be paid to the gas inlet pipe to the water seal.
- (2) The deck water seal should resist backflow of not less than the pressure setting of the pressure/vacuum breaking device on the inert gas distribution system; it should be so designed as to prevent the backflow of gases under any foreseeable operating conditions.
- (3) "Where the deck seals are of dry type or semi-dry type, it is to be arranged such that the automatic sealing, equivalent to a wet type is achieved in approximately 6 seconds.
- (4) A regulating flow of clean water through the deck seal reservoir should maintain the water in the deck seal.

- (5) Sight glasses and inspection openings should be provided on the deck seal to permit satisfactory observation of the water level during its operation and to facilitate a thorough survey; the sight glasses should be reinforced to withstand impact.
- (6) Any drains from the non-return devices should incorporate a water seal in accordance with subsection 27(7), and comply generally with section 28.

Inert Gas Distribution System

- 20. (1) The inert gas distribution system, together with the cargo tank venting system, where applicable, has to provide:
 - (a) means of delivering inert gas to the cargo tanks during discharge, de-ballasting and tank cleaning operations, and for topping up the pressure of gas in the tank;
 - (b) means of venting tank gases to atmosphere during cargo loading and ballasting;
 - (c) additional inlet or outlet points for inerting, purging and gas-freeing;
 - (d) means of isolating individual tanks from the inert gas main for gas-freeing (see paragraph 24(2)(d));
 - (e) means of protecting tanks from excessive pressure or vacuum.
- (2) A large variety of designs and operational procedures may be used to meet these interrelated requirements; section 21 considers some of the major design options and their more important operational consequences; Part V gives further advice on operational precautions.

Design Considerations for Valves and Pipework in Inert Gas Systems

- 21. (1) The flue gas uptake point should be such that the gas is not too hot for the scrubber or does not cause hard deposits on the flue gas isolating valves; it should not be so close to the uptake outlet that air can be drawn into the system; when boilers are fitted with rotary air heaters, the offtake point should be before the air heater inlet.

- (2) The materials used for flue gas isolating valves should take into account the temperature of gas at the offtake; cast iron is acceptable for temperatures below 220 degrees Celsius; valves exposed to a temperature exceeding 220 degrees Celsius should be made from a material not only compatible with the temperature, but also resistant to the corrosive effect of stagnant flue gases.
- (3) Flue gas isolating valves should be provided with facilities to keep the seatings clear of soot, unless the valve is designed to close with a seat cleaning action; flue gas isolating valves should also be provided with air sealing arrangements.
- (4) If expansion bellows are considered necessary, they should have a smooth internal sleeve and preferably be mounted so that the gas flows through them vertically; they should be constructed of material resistant to stagnant damp acidic soot.
- (5) The pipework between the flue gas isolating valve and the scrubber should be made from heavy gauge steel, resistant to corrosion and arranged without unnecessary bends and branches so as to prevent the accumulation of damp acidic soot.
- (6) The inlet piping to the scrubber should be so arranged as to permit positive isolation from the flue gases before the scrubber is gas freed for entry for maintenance purposes; this may be accomplished by the removal of a suitable length of pipe section and blanking, by spectacle flanges or by a water seal that would prevent any leakage of gas from the boiler when the flue gas isolating valve is shut and the scrubber is opened for inspection and maintenance; in the event that the drainage of the water seal is itself required for inspection purposes, then isolation should be achieved either by removal of the suitable lengths of pipe sections and blanking, or by the use of spectacle flanges.
- (7) The gas outlet piping from the scrubber to the blowers and recirculating lines should be made from steel suitably coated internally.
- (8) Suitable isolating arrangements should be incorporated in the inlet and outlet blower to permit safe overhaul and maintenance, while the inert gas system uses the other blower.

- (9) The gas regulating valve should be provided with means to indicate whether the valve is open or shut; where the valve is used to regulate the flow of inert gas, it should be controlled by the inert gas pressure sensed between the deck isolating valve and the cargo tanks.
- (10) Deck lines should be steel and so arranged as to be self draining; they should be firmly attached to the ship's structure, with suitable arrangements to take into account movement due to heavy weather, thermal expansion and flexing of the ship.
- (11) The diameter of the inert gas main, valves and branch pipes should take account of the system requirements detailed in subsection 16(9); to avoid excessive pressure drop, the inert gas velocity should not exceed 40 m/s in any section of the distribution system, when the inert gas system is operating at its maximum capacity; if the inert gas main is used for venting during loading, other factors may need to be taken into consideration as developed in the Hull Construction Regulations, for cargo tank venting systems.
- (12) All pressure and vacuum relief openings should be fitted with flame screens that have easy access for cleaning and renewal; the flame screens should be at the inlets and outlets of any relief device, and be sufficiently robust to withstand the pressure of gas generated at maximum loading and during ballasting operations, while presenting minimum resistance.

Gas Pressure Regulating Valves and Recirculating Arrangements

- 22. (1) Pressure control arrangements should be fitted to fulfill two functions:
 - (a) to prevent automatically any backflow of gas in the event either of a failure of the inert gas blower, scrubber pump, etc., or that the inert gas plant is operating correctly, but the deck water seal and mechanical non-return valve have failed, and the pressure of gas in the tank exceeds the blower discharge pressure, e.g. during simultaneous stripping and ballasting operations;
 - (b) to regulate the flow of inert gas to the inert gas deck main.

- (2) A typical arrangement, by which the flow of inert gas can be regulated, is described for systems with automatic pressure control and a gas recirculating line; these installations permit control of inert gas pressure in the deck main without the need to adjust the inert gas blower speed; gas not required in the cargo tanks is recirculated to the scrubber or vented to the atmosphere; gas pressure regulating valves are fitted in both the main and recirculating lines; one is controlled by a gas pressure transmitter and regulator, while the other may be controlled either in a similar manner or by a weight-operated valve; the pressure transmitter is sited downstream of the deck isolating valve; this enables maintenance of a positive pressure in the cargo tanks during discharge; it does not necessarily ensure, however, that the scrubber is not overloaded during inerting and purging operations.

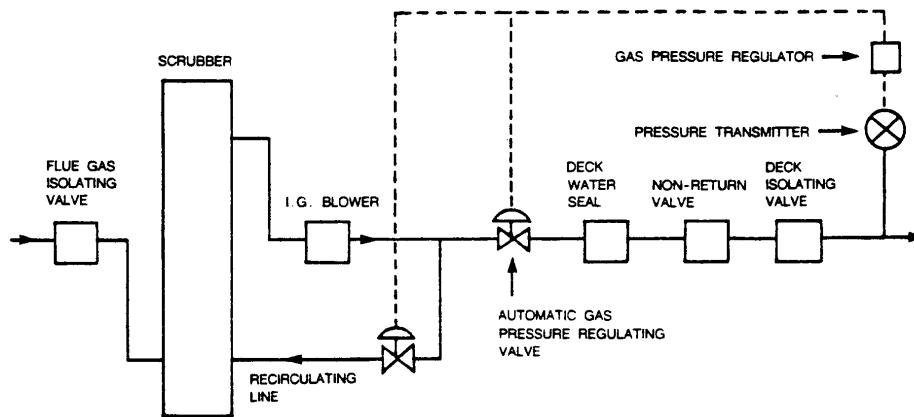


Figure 10 Typical automatic pressure control system

Alternative methods of regulating gas may be considered.

Arrangements for Inerting, Purging and Gas-freeing

23. (1) The principles of dilution and displacement have already been described in section 9; their application to specific installations depends on a variety of factors, including:
- (a) the results of laboratory tests;
 - (b) whether or not purging of hydrocarbon gas is required in every tank on every voyage; and

(c) the method of venting cargo tank vapours.

(2) Several arrangements are possible; one feature that should be common to all is the location of the inlet and outlet points such that efficient gas replacement can take place throughout the tank.

(3) There are three principal arrangements:

Arrangement	Inlet point	Outlet point	Principle
I	top	top	dilution
II	bottom	top	dilution
III	top	bottom	displacement or dilution

it will be noted that all three arrangements can be used for inerting, purging and gas-freeing and that a particular ship design may incorporate more than one arrangement.

Arrangement I

(4) In this, the simplest arrangement, gases are both introduced and vented from the top of the tank; gas replacement is by the dilution method; the incoming gas should always enter the tank in such a way as to achieve maximum penetration and thorough mixing throughout the tank; gases can be vented through a vent stack on each tank or through a common vent main. (see Figure 11)

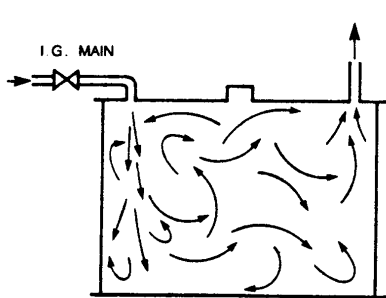


Figure 11 Dilution (I)

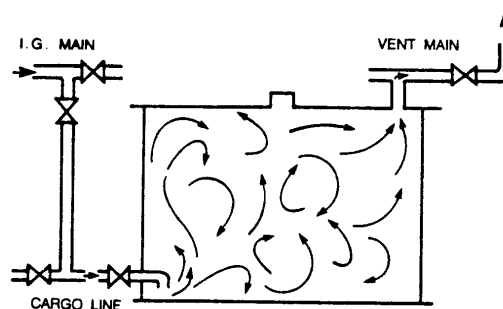


Figure 12 Dilution (II)

Inerting, purging and gas-freeing by dilution method

Arrangement II

- (5) Gas is introduced at the bottom of the tank and vented from the top; gas replacement is by the dilution method; this arrangement introduces the gas through a connection between the inert gas deck main (just forward of the mechanical non-return valve) and the bottom cargo lines (see figure 12); a special fixed gas-freeing fan may also be fitted; exhaust gas may be vented through individual vent stacks or, if valves are fitted to isolate each cargo tank from the inert gas main, through this main to the mast riser or high velocity vent.

Arrangement III

- (6) Gas is introduced at the top of the tank and discharged from the bottom; this arrangement permits the displacement method (see Figure 13), although the dilution method may predominate, if the density difference between the incoming and existing gases is small or the gas inlet velocity is high (see Figure 14); the inert gas inlet point is often led horizontally into a tank hatch to minimize turbulence at the interface; the outlet point is often a specially fitted purge pipe extending from within 1 metre of the bottom plating to 2 metres above deck level (to minimize the amount of vapour at deck level).

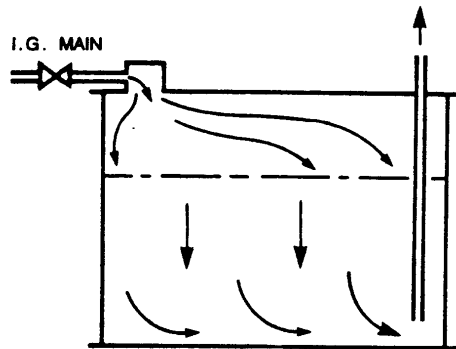


Figure 13 Displacement (III)

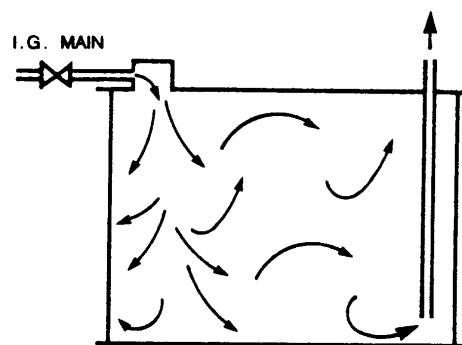


Figure 14 Dilution (III)

Inerting, purging and gas-freeing by displacement or dilution methods

Isolation of-Cargo Tanks from the Inert Gas Deck Main

14. (1) For gas-freeing and tank entry, some valve or blanking arrangement is always fitted to isolate individual cargo tanks from the inert gas deck main.
- (2) The following factors should be considered in choosing a suitable arrangement:
- (a) protection against gas leakage or incorrect operation during tank entry;
 - (b) ease and safety of use;
 - (c) facility to use the inert gas main for routine gas-freeing operations;
 - (d) facility to isolate tanks for short periods for the regulation of tank pressures and manual ullaging;
 - (e) protection against structural damage due to cargo pumping and ballasting operations, when a cargo tank is inadvertently isolated from the inert gas main.
- (3) In no case should the arrangement prevent the proper venting of the tank.
- (4) Figure 15 shows some examples of arrangements in use.

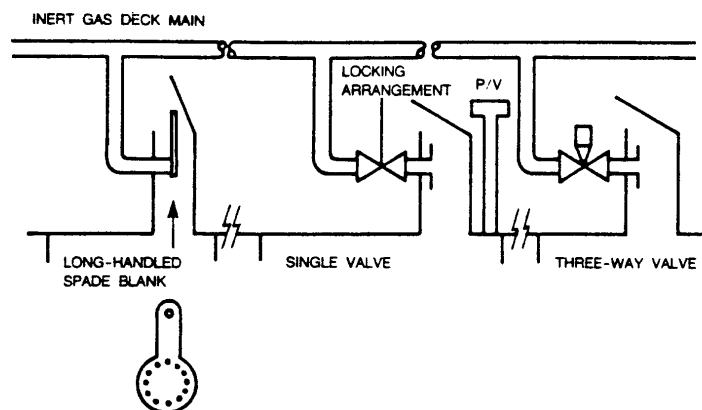


Figure 15 Examples of methods for isolating tanks from inert gas main

Liquid-filled Pressure-vacuum Breakers

25. (1) One liquid-filled pressure-vacuum breaker, or more, should be fitted, unless pressure-vacuum valves are fitted that have the capacity to prevent excessive pressure or vacuum.
- (2) These devices require little maintenance, but will operate at the required pressure only if they are filled to the correct level with liquid of the correct density; either a suitable oil or a freshwater/glycol mixture should be used to prevent freezing in cold weather; evaporation, ingress of seawater, condensation and corrosion should be taken into consideration and adequately compensated for; in heavy weather, the pressure surge, caused by the motion of liquid in the cargo tanks, may cause the liquid of the pressure-vacuum breaker to be blown out (see Figure 16).

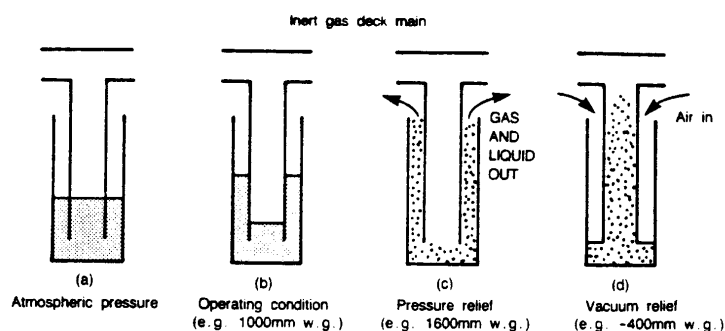


Figure 16 Principles of liquid filled pressure-vacuum breakers

- (3) The designer should ensure that the characteristics of the deck water seal, pressure-vacuum breakers and pressure-vacuum valves and the pressure settings of the high and low inert gas deck pressure alarms are compatible; it is also desirable to check that all pressure-vacuum devices are operating at their designed pressure settings.

Instrumentation and Alarms

26. (1) Certain fixed and portable instruments are required for the safe and effective operation of an inert gas system; all instruments should be graduated to a consistent system of units.
- (2) Clear instructions should be provided for operating, calibrating and testing all instruments and alarms; suitable calibration facilities should be provided.

- (3) All required instrumentation and alarm equipment should be designed to withstand supply voltage variation, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on board ships.
- (4) The arrangement of scrubber instrumentation and alarm should be as follows in subsections (5) through (10).
- (5) The water flow to the scrubber should be monitored either by a flow meter or by pressure gauges; an alarm should be initiated when the water flow drops below the designed flow requirements by a predetermined amount, and the inert gas blowers should be stopped automatically in the event of a further reduction in the flow; the precise setting of the alarm and shutdown limits should be related to individual scrubber designs and materials.
- (6) The water level in the scrubber shall be monitored by a high-water-level alarm; this alarm should be given when pre-determined limits are reached and the scrubber pump shut down when the level rises above set limits; these limits should be set having regard to the scrubber design and flooding of the scrubber inlet piping from the boiler uptakes.
- (7) The inert gas temperature at the discharge side of the gas blowers shall be monitored; an alarm should be given when the temperature reaches 65 degrees Celsius, with automatic shut down of the inert gas blowers if the temperature reaches 75 degrees Celsius.
- (8) If a pre-cooler at the scrubber inlet is necessary to protect coating materials in the scrubber, the arrangements for giving an alarm in subsection (7) should apply to the outlet temperature from the pre-cooler.
- (9) To monitor the scrubber efficiency, it is recommended that the cooler water inlet and outlet temperatures and the scrubber differential pressures be indicated.
- (10) All sensing probes, floats and sensors required to be in contact with the water and gas in the scrubber should be made from materials resistant to acidic attack.
- (11) For the deck water seal, an alarm should be given when the water level falls by a pre-determined amount, but before the seal is rendered ineffective; for certain types of deck water seals, such as the dry type, it may be necessary to suppress the water level alarm when inert gas is being supplied to the inert gas distribution system.

- (12) The pressure of the inert gas in the inert gas main shall be monitored; an alarm should be given when the pressure reaches the set limit; the set limit should take into account the design of cargo tanks, mechanical non-return valve and deck water seal.
- (13) The arrangement for oxygen analyser, recorder and indicating equipment should be as follows in subsections (14) through (22).
- (14) The sampling point for the oxygen analyser and recorder unit should be located in the pipework after the blowers and before the gas pressure regulating valve, at the chosen position, turbulent flow conditions should prevail at all outputs of the blowers; the sample point should be easily accessible and provided with suitable air or steam cleaning connections.
- (15) The sampling probe should incorporate a dust filter in accordance with the instrument manufacturer's advice; the probe and filter should be able to be withdrawn and cleaned or renewed as necessary.
- (16) The sensing pipe from the sampling probe to the oxygen analyser should be so arranged that any condensation in the sensing pipeline does not prevent the gas sample from reaching the oxygen analyser; joints in the pipeline should be kept to a minimum to prevent the ingress of air.
- (17) Any coolers required in the sensing pipes should be installed at the coldest point in the system; alternatively, in certain instances it may be prudent to heat the sensing pipes to prevent condensation.
- (18) The position of the analyser should be chosen so that it is protected from heat and adverse ambient conditions, but it should be placed as close as practicable to the sampling point to reduce to a minimum the time between the extraction of a sample and its analysis.
- (19) The recording unit and repeater indication should not be located in positions subject to heat and undue vibration.
- (20) The resistance of the connecting cables between the analyser and the recorder should be in accordance with the instrument manufacturers' instructions.
- (21) The oxygen analyser should have an accuracy of ± 1 per cent of the full-scale deflection of the indicator.

- (22) Depending on the principle of measurement, fixed zero and/or span calibration arrangements should be provided in the vicinity of the oxygen analyser, and fitted with suitable connections for portable analysers.
- (23) A sampling point should be provided between the automatic gas pressure regulating valve and the deck water seal for use with portable instruments.
- (24) The inert gas pressure sensor and recorder should obtain the signal from a point in the inert gas main between the deck isolating/non-return valve and the cargo tanks.
- (25) When the pressure in the inert gas main forward of the non-return devices falls below 50 millimetres water gauge, means shall be provided to sound an alarm or to shut down the main cargo pumps automatically.
- (26) The alarms required by paragraph 19(1)(g), Schedule VII, should be given on the navigating bridge and in the machinery space.
- (27) Portable instruments shall be provided for measuring oxygen and flammable concentration; with regard to the hydrocarbon vapour meter, it should be borne in mind that meters working on the catalytic filament principle are unsuitable for measuring hydrocarbon concentration in oxygen deficient atmospheres; furthermore, meters using this principle cannot measure concentrations of hydrocarbon vapours above the lower flammable limit; it is, therefore, advisable to use meters that are not affected by oxygen deficiency, and which are capable of measuring hydrocarbon concentration in and above the flammable range; the catalytic filament meter is suitable for measuring below the lower flammable limit, provided sufficient oxygen is present.
- (28) All metal parts of portable instruments and sampling tubes that must be introduced into tanks should be securely earthed to the ship's structure while the instruments and sampling tubes are being used; these portable instruments should be intrinsically safe.
- (29) Sufficient tubing etc., should be provided to enable fully representative sampling of a cargo tank atmosphere.
- (30) Suitable openings should be provided in cargo tanks to enable fully representative samples to be taken from each tank; where tanks are subdivided by complete or partial wash bulkheads, additional openings should be provided for each such subdivision.

Effluent and Drain Piping

27. (1) The effluent piping from scrubbers and deck water seal drain pipes, where fitted, should be corrosion resistant, or made of carbon steel suitably protected internally against the corrosive nature of the fluid.
- (2) The scrubber effluent pipe and deck water seal drain pipe, where fitted, should not be led to a common drain pipe and the deck seal drain should be led clear of the engine room and any other gas-safe space.
- (3) The effluent lines should, as far as possible, be discharged below the water line under light ballast conditions, or suitable means should be provided to avoid run-off of the effluent along the ship's side plating in order to prevent accelerated corrosion/erosion of the plating.
- (4) Piping made in glass reinforced plastic of acceptable manufacture, and substantial thickness, which is pressure tested and adequately supported, may be acceptable for effluent piping from scrubbers under the conditions given in subsections (5) and (6).
- (5) The effluent lines should, as far as possible, be led through cofferdams or ballast tanks and accord with the load line regulations in force.
- (6) Where effluent lines are led through machinery spaces the arrangements should include:
- (a) a valve fitted to a stub piece at the shell and actuated both from inside and outside the machinery space; the valve should have a position indicator; the valve is to be closed at all times when the plant is not in operation as well as in the event of a fire in the machinery space; suitable instructions to this effect are to be given to the master;
 - (b) a flap type non-return valve;
 - (c) a short length of steel pipe, or spool piece, lined internally and fitted between the valve referred to in (a) above and the non-return valve referred to in (b) above; this is to be fitted with a 12.5 millimetre diameter flanged drain branch pipe and valve;
 - (d) a further spool piece fitted inboard of, and adjacent to, the non-return valve referred to in (b) above, similarly fitted with a drain;

(Note: the purpose of this arrangement is to enable the valves and non-return valves referred to in (a) and (b) above to be checked for tightness and to facilitate the removal of the non-return valve for examination and replacement.)

(e) means outside the machinery space for stopping the scrubber pump.

Figure 17 illustrates a suitable arrangement.

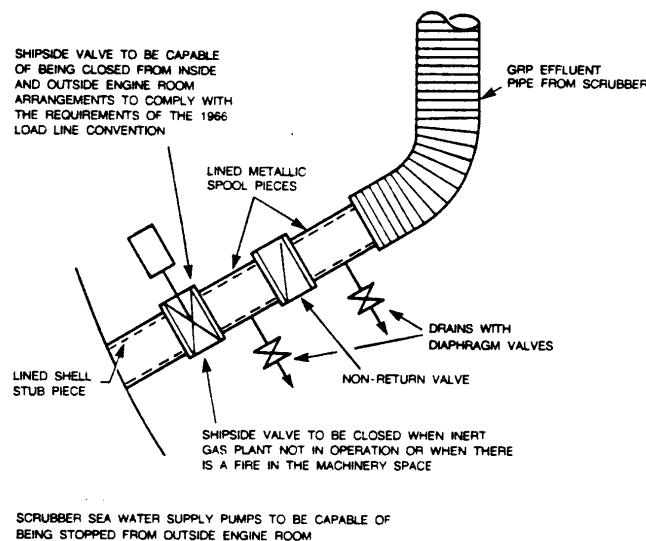


Figure 17 A suitable arrangement of effluent piping led through machinery spaces

- (7) Where effluent lines penetrate water-tight decks or bulkheads, the requirements of the Marine Machinery and Electrical Equipment Regulations, Standard IX shall apply.
- (8) A water seal in the shape of a 'U' bend, at least 2 m in depth, should be fitted at least 2 m below the equipment to be drained; means should be provided for draining the lowest point of the bend; in addition, the seal should be adequately vented to a point above the water level in the scrubber or deck water seal.
- (9) The diameter of the effluent and drain pipes should be adequate for the duties intended and the pipe run should be self-draining from the water seal referred to in subsection 27(8).

Seawater Service

28. (1) It is advisable that the main supply of water to the inert gas scrubber be from an independent pump; the alternative source of supply of water may be from another pump, such as the sanitary, fire, bilge and ballast pumps, provided that the quantity of water required by the inert gas scrubber is readily available, and the requirements of other essential services are not thereby impaired.
- (2) The requirement for two separate pumps capable of supplying water to the deck water seal can be met by any of the pumps referred to under alternative source of supply in subsection (1), subject to the same provisions as are recorded in that subsection.
- (3) The pumps supplying water to the scrubber and the deck water seal should provide the required throughput of water at light draught conditions; the quantity of water at all other draught conditions should not flood the scrubber or increase the gas flow resistance excessively.
- (4) Loops in the piping of the deck water seal to prevent the backflow of hydrocarbon vapour or inert gas should be positioned outside the machinery space and suitably protected against freezing, for example by steam tracing; with reference to the deck water seal arrangement, provisions should be made to prevent a pneumatically controlled system from freezing.
- (5) Vacuum breakers provided to prevent the water loops being emptied should vent to a position on the open deck.

PART IV

OPERATION OF INERT GAS PLANT

29. (1) Flue gas systems may differ in detail, but certain basic principles remain the same; these are:
- (a) starting up the inert gas plant;
 - (b) shutting down the inert gas plant;
 - (c) safety checks when the inert gas plant is shut down;

in all cases the manufacturer's detailed instructions should be followed.

Start-up procedures

- (2) Ensure boiler is producing flue gas with an oxygen content of 5 per cent by volume or less (for existing ships 8 per cent by volume or, wherever practicable, less).
- (3) Ensure that power is available for all control, alarm and automatic shutdown operations.
- (4) Ensure that the quantity of water required by the scrubber and deck water seal is being maintained satisfactorily by the pump selected for this duty.
- (5) Test operation of the alarm and shutdown features of the system dependent upon the throughput of water in the scrubber and deck seal.
- (6) Check that the gas-freeing fresh air inlet valves, where fitted, are shut and the blanks in position are secure.
- (7) Shut off the air to any air-sealing arrangements for the flue gas isolating valve.
- (8) Open the flue gas isolating valve.
- (9) Open the selected blower suction valve; ensure that the other blower suction and discharge valves are shut unless it is intended to use both blowers simultaneously.
- (10) Start the blower.

- (11) Test blower "failure" alarm.
- (12) Open the blower discharge valve.
- (13) Open the recirculating valve to enable plant to stabilize.
- (14) Open the flue gas regulating valve.
- (15) Check that oxygen content is 5 per cent by volume or less (for existing ships 8 per cent by volume or, wherever practicable, less); then close the vent to atmosphere between the gas pressure regulating valve and the deck isolating valve.

Note: Some oxygen analysers require as much as two hours to stabilize before accurate readings can be obtained.

The inert gas system is now ready to deliver gas to the cargo tanks.

Shutdown procedures

- (16) When all tank atmospheres have been checked for an oxygen level of not more than 8 per cent and the required in-tank pressure has been obtained, shut the deck isolating/non-return valve.
- (17) Open vent to atmosphere between the gas pressure regulating valve and the deck isolating/non-return valve.
- (18) Shut the gas pressure regulating valve.
- (19) Shut down the inert gas blower.
- (20) Close the blower suction and discharge valve; check that the drains are clear; open the water washing system on the blower while it is still rotating, with the power supply of the driving motor turned off, unless otherwise recommended by the manufacturer; shut down the water-washing plant after a suitable period.
- (21) Close the flue gas isolating valve and open the air sealing system.
- (22) Keep the water supply on the scrubber tower full, in accordance with the manufacturer's recommendation.

- (23) Ensure that the water supply to the deck water seal is running satisfactorily, that an adequate water seal is retained and that the alarm arrangements for it are in order.

Safety checks when inert gas plant is shut down.

- (24) Ascertain the water supply and water level in the deck seal at regular intervals, at least once per day depending on weather conditions.
- (25) Check the water level in water loops installed in pipework for gas, water or pressure transducers, to prevent the backflow of hydrocarbon gases into gas safe spaces.
- (26) In cold weather, ensure that the arrangements to prevent the freezing of sealing water in the deck seals, pressure vacuum breakers, etc. are in order.
- (27) Re-pressurize the inerted cargo tanks with inert gas before their pressure drops to 100 mm.

Possible failures of inert gas system,
and actions to be taken

- (28) High oxygen content may be caused or indicated by the following conditions:
- (a) poor combustion control at the boiler, especially under low load conditions;
 - (b) air drawn down the uptake when boiler gas output is less than the inert gas blower demand, especially under low load conditions;
 - (c) air leaks between the inert gas blower and the boiler uptake;
 - (d) faulty operation or calibration of the oxygen analyser;
 - (e) inert gas plant operating in the recirculation mode; or
 - (f) entry of air into the inert gas main through the pressure vacuum valves, mast risers etc. due to maloperation.
- (29) If the inert gas plant is delivering inert gas with an oxygen content of more than 5 per cent, the fault should be traced and repaired; however, that all cargo tank operations shall be suspended if the oxygen content exceeds 8 per cent, unless the quality of the gas improves.

- (30) Inability to maintain positive pressure during cargo discharge or deballasting operations may be caused by:
- (a) inadvertent closure of the inert gas valves;
 - (b) faulty operation of the automatic pressure control system;
 - (c) inadequate blower pressure; or
 - (d) a cargo discharge rate in excess of the blower output.
- (31) The cargo discharge or deballasting should be stopped or reduced, depending on whether or not the positive pressure in the tanks can be maintained while the fault is rectified.

PART V

APPLICATION TO CARGO TANK OPERATION

The inert gas system should be used during the full cycle of tanker operation as described in this section.

Inerting of Tanks

30. (1) Tanks that have been cleaned and gas freed should be re-inerted according to manufacturers instructions, preferably during the ballast voyage, to allow the inert gas system to be fully tested prior to cargo handling; purge pipes/vents should be opened to atmosphere; when the oxygen concentration of the atmosphere in the tank has fallen below 8 per cent, the purge pipes/vents should be closed and the tank pressurized with inert gas.
- (2) During the re-inerting of a tank following a breakdown and repair of the inert gas system, non-gas-free and non-inerted tanks should be re-inerted in accordance with subsection (1); during inerting, no ullaging, dipping, sampling or other equipment should be inserted, unless it has been established that the tank is inert; this should be done by monitoring the efflux gas from the tank being inerted until the oxygen content is less than 8 per cent by volume; this procedure should continue for as long as determined by previous test records when inerting gas-free tanks to ensure that the efflux gas is fully representative of the atmosphere within the tank.
- (3) When all tanks have been inerted, they should be kept common with the inert gas main and maintained at a positive pressure in excess of 100 millimetres water gauge during the rest of the cycle of operation.

Discharge of Water Ballast

31. (1) Before discharge of cargo tank ballast is undertaken, the following conditions as given in subsection (2) through (7) should be checked:
- (2) All cargo tanks are connected to the inert gas system and all isolating valves in the deck inert gas pipework are locked open.
- (3) All other cargo tank openings are shut.
- (4) All valves isolating the mast risers from the inert gas system are shut.

- (5) The arrangements required by the Fire Protection, Detection and Extinguishing Equipment Regulations, subsection 13(d) and paragraph 13(d)(i), Schedule VII, are used to isolate the cargo main from the inert gas main.
- (6) The inert gas plant is producing gas of an acceptable quality.
- (7) The deck isolating valve is open.
- (8) During the deballasting operation, the oxygen content of the inert gas and its pressure in the inert gas main should be continuously recorded.

Loading

32. When cargo is being loaded, the deck isolating valve should be closed and the inert gas plant may be shut down, unless other cargo tanks are being deballasted simultaneously in which case a close watch should be kept on the inert gas main pressure; all openings to the cargo tanks, except the connections to the mast risers or equivalent venting arrangements, should be kept closed to minimize flammable vapour on deck; before loading commences, the flame screens in the mast risers, or equivalent venting arrangements, should be inspected and any stop valves isolating the cargo tanks from the inert gas main locked in the open position.

Loaded Condition

33. (1) During the loaded passage, a positive pressure of inert gas of at least 100 mm water gauge should be maintained in the cargo tanks and topping up of the pressure may be necessary; when the inert gas pressure is being topped up in the cargo tanks, particular attention should be paid to obtaining an oxygen concentration of 5 per cent, or less, in the inert gas supply before the gas is introduced into the cargo tanks.
- (2) On motor tankers, the boiler loading may have to be increased to achieve the low oxygen concentration in the inert gas supply; it may also be necessary to restrict the output of the inert gas blowers to prevent air being drawn down the uptake during the topping up operation; if by these means inert gas of the quality defined in subsection (1) cannot be achieved, then inert gas from an alternate source of supply, such as an inert gas generator, might be used.

Cargo Transfer and Cargo Sampling

34. (1) Ullaging devices of the closed type should be used to avoid the opening of ullage ports.
- (2) However, it may be necessary to infrequently relieve the inert gas pressure in the cargo tanks on certain occasions to permit manual tank gauging or cargo sampling before or after cargo is transferred, but during this time, no cargo or ballasting operation is to be undertaken, and a minimum number of small tank openings are to be uncovered for as short a time as necessary to permit these measurements.
- (3) Manual gauging or cargo sampling may be performed during the following four periods:
- (a) at the loading port, prior to cargo loading;
 - (b) at the loading port, after cargo loading;
 - (c) at the discharge port, prior to cargo discharge; and
 - (d) at the discharge port, after cargo discharge.
- (4) The tanks should then be re-pressurized immediately after the measurements or cargo samples have been taken.
- (5) If the tank is opened prior to cargo transfer, cargo transfer should not be commenced until all the conditions have been checked and are in order; similarly, if the tank is opened after cargo transfer, normal ship operations should not be commenced until all the conditions have been checked and are in order.
- (6) During cargo transfer the oxygen content and pressure of the inert gas main should be continuously recorded.

Crude Oil Washing

35. (1) A crude oil washing system fitted in an oil tanker shall comply with the relevant requirements of the "Oil Pollution Prevention Regulations", Chapter 2 - Oil.

- (2) Before each tank is crude oil washed, the oxygen level shall be determined at a point 1 metre below the deck and at the middle region of the ullage space; neither of these determinations shall exceed 8 per cent by volume; where tanks have complete or partial wash bulkhead, the determination should be made at similar levels in each section of the tank; the oxygen content and pressure of the inert gas being delivered during the washing process should be continuously recorded.
- (3) If, during the crude oil washing,
- (a) the oxygen level of the inert gas being delivered exceeds 8 per cent by volume; or
 - (b) the pressure of the atmosphere in the tanks is no longer positive;
- then washing must be stopped until satisfactory conditions are restored; operators should also be guided by paragraph 29(5)(b).

Ballasting of Cargo Tanks

36. The conditions for ballasting of cargo tanks are the same as those for loading in section 32; when, however, simultaneous be kept on the inert gas main pressure.

Ballast Condition

37. (1) During a ballast voyage, tanks other than those required to be gas free for necessary tank entry should be kept inerted with the cargo tank atmosphere at a positive pressure of not less than 100 mm water gauge; the oxygen level should not exceed 8 per cent by volume especially during tank cleaning.
- (2) Before any inert gas is introduced into cargo tanks to maintain a positive pressure, it should be established that the inert gas contains not more than 5 per cent oxygen by volume.

Tank Cleaning

38. Cargo tanks should be washed in the inert condition and under a positive pressure; the procedures adopted for tank cleaning with water should follow those for crude oil washing in section 35.

Purging prior to Gas-freeing

39. When a tank is to be gas freed after washing, the concentration of hydrocarbon vapour should be reduced by purging the inerted cargo tank with inert gas; purge pipes/vents should be opened to atmosphere and inert gas introduced into the tank until the hydrocarbon vapour concentration measured in the efflux gas has been reduced to 2 per cent by volume, and until enough time, as determined by previous tests on cargo tanks, has elapsed to ensure that readings have stabilized and the efflux gas is representative of the atmosphere within the tank.

Gas-Freeing

40. (1) Gas-freeing of cargo tanks should only be carried out when tank entry is necessary (e.g. for essential repairs); it should not be started until it is established that a flammable atmosphere in the tank will not be created as a result; hydrocarbon gases should be purged from the tank (see section 39).
- (2) Gas-freeing may be affected by pneumatically, hydraulically or steam-driven portable blowers, or by fixed equipment; in either case, it is necessary to isolate the appropriate tanks to prevent the leakage of air into inerted tanks, or of inert gas into tanks that are being gas-freed.
- (3) Gas-freeing should continue until the entire tank has an oxygen content of 21 per cent by volume, and a reading is obtained on a combustible gas indicator of less than 1 per cent of lower flammable limit.

Tank Entry

41. (1) The entry of personnel to the cargo tank should be carried out only under the close supervision of a responsible ship's officer, in accordance with national rules and/or with the normal industrial practice laid down in the International Safety Guide for Oil Tankers and Terminals; the particular hazards encountered in tanks previously inerted and then gas-freed are outlined in 9.2.8, 9.3.3 and Chapter 10 of that Guide.
- (2) Practical precautions to meet these hazards include:
- (a) securing the inert gas branch line gas valves and/or blanks in position, or, if gas-freeing is being done with the inert gas blower, isolating the scrubber from the flue gases;
 - (b) closing of any drain lines entering the tank from the inert gas main;

- (c) securing relevant cargo line valves or controls in the closed position;
- (d) keeping the inert gas deck pressure in the remainder of the cargo tank system at a low positive pressure, such as 200 mm water gauge; this minimizes the possible leakage of inert or hydrocarbon gas from other tanks through any bulkhead cracks, cargo lines, valves, etc;
- (e) lowering clean sample lines deep into the lower regions of the tank in at least two locations; these locations should be away from both the inlet and outlet openings used for gas-freeing; after it has been ascertained that a true bottom sample is being obtained, the following readings are required
 - (i) 21 per cent on a portable oxygen analyser, and
 - (ii) less than 1 per cent of lower flammable limit on a combustible gas indicator;
- (f) using breathing apparatus whenever there is any doubt about the tank being gas free, e.g. in tanks where it is not possible to sample remote locations; (this practice should be continued until all areas, checked);
- (g) continuously ventilating and regularly sampling the tank atmosphere whenever personnel are in the tank;
- (h) carefully observing normal regulations for tank entry.

Re-inerting after Tank Entry

42. (1) Once all personnel have left the tank and the equipment has been removed, the inert gas branch line blank, if fitted, should be removed, the hatch lids closed and the gas pressure regulating valve re-opened and locked open to the inert gas main, where appropriate; this will avoid any risk of structural damage when liquids are subsequently handled.
- (2) As soon as a gas-free tank is reconnected to the inert gas main, it should be re-inerted (as described in section 30) to prevent transfer of air to other tanks.

PART VI

PRODUCT CARRIERS

The basic principles of inerting are exactly the same for a product carrier as for a crude oil tanker; however, there are differences in operation as outlined below.

43. One area of difference relates to the carriage of products having a flashpoint exceeding 60°C (closed cup test), as determined by an approved flashpoint apparatus.
- (1) Subsection 47(1), Fire Protection, Detection and Extinguishing Equipment Regulations, implies that section 49 and Schedule VII, Fire Protection, Detection and Extinguishing Equipment Regulations, do not apply to tankers carrying petroleum products having a flashpoint exceeding 60°C; in other words, product carriers may carry bitumens, lubricating oils, heavy fuel oils, high flashpoint jet fuels and some diesel fuels, gas oils and special boiling point liquids, without inert gas systems having to be fitted, or, if fitted, without tanks containing such cargoes as have to be kept in the inert condition.
 - (2) If cargoes with a flashpoint exceeding 60 degrees, whether heated or otherwise, are carried at temperatures near or above their flashpoint (some bitumen cut-backs and fuel oils), a flammable atmosphere can occur; when cargoes with a flashpoint exceeding 60°C are carried at a temperature higher than 5 degrees Celsius below their flashpoint they should be carried in an inerted condition.
 - (3) When a non-volatile cargo is carried in a tank that has not been previously gas freed, then that tank shall be maintained in an inert condition.

Product Contamination by Other Cargoes

44. Contamination of a product may affect its odour, acidity or flashpoint specifications, and may occur in several ways; the types of contamination relevant to ships with an inert gas main (or other gas line) inter-connecting all cargo tanks are:
- (1) Liquid contamination due to overfilling a tank.

- (2) Vapour contamination through the inert gas main; this is largely a problem of preventing vapour from low flashpoint cargoes, typically gasolines, from contaminating the various high flashpoint cargoes listed in subsection 43(1) plus aviation gasolines and most hydrocarbon solvents; this problem can overcome by
- (a) removing vapours of low flashpoint cargoes prior to loading; and
 - (b) preventing ingress of vapours from low flashpoint cargoes during loading and during the loaded voyage;

When hydrocarbon solvents are being carried where quality specifications are stringent, and where it is necessary to keep individual tanks positively isolated from the inert gas main after a cargo has been loaded, pressure sensors should be fitted for monitoring the pressure in each tank; when it is necessary to top up the relevant tanks, the inert gas main should first be purged of cargo vapour.

Contamination of Cargoes by Inert Gas

45. For a well-designed and operated flue gas system, experience suggests that petroleum cargoes traditionally carried on product tankers do not suffer contamination from the flue gas itself, as opposed to contamination from other cargoes; however, unacceptable contamination from the flue gas may be encountered if proper control is not exercised over fuel quality, efficiency of combustion, scrubbing and filtering; the more critical petrochemical cargoes on product carriers can be contaminated by flue gas.

Contamination of Cargoes by Water

46. All lubricating oils and jet fuels are acutely water critical; current practice requires full line draining and mopping up of any water in tanks before loading; water contamination may occur on inerted ships due to:
- (a) water carry-over from the scrubber and/or deck water seals due to inadequacies in design or maintenance of the various drying arrangements; and
 - (b) condensation of water from warm, fully saturated flue gas delivered to the tanks.

Additional Purging and Gas-freeing

47. Gas-freeing is required on non-inerted product carriers more frequently than on crude carriers, both because of the greater need for tank entry and inspection, especially in port, and for venting vapours of previous cargoes; any gas-free operation on inerted product carriers has to be preceded by a purging operation, but gas-freeing for purely quality reasons may be replaced by purging only; in addition purging may be required on the basis outlined in subsection 43(3) above.

It should be recognized that:

- (1) There are increased risks of air leaking into inert tanks and of inert gas leaking into a tank being entered.
- (2) Purging is not a prerequisite of gas-freeing when the hydrocarbon gas content of a tank is below 2 per cent by volume.
- (3) The operation of gas-freeing for product purity, and where tank entry is not contemplated, does not require the atmosphere to have an oxygen content of 21 per cent by volume.

PART VII

COMBINATION CARRIERS

The basic principles of inerting are exactly the same for a combination carrier as for a tanker; however, differences in the design and operation of these vessels make necessary the relevant considerations outlined below.

Slack Holds

48. It is particularly important for combination carriers to have their holds inerted because, whenever a hold in an OBO carrier (which could extend the full breadth of the ship) is partially filled with clean or oily ballast, water agitation of this ballast can occur at small angles of roll, resulting in the generation of static electricity; the agitation, sometimes referred to as 'sloshing', can happen whenever the ullage above the liquid level of the hold is more than 10 per cent of the depth of the hold, measured from the underside of the deck (see Figure 18 for remedy condition).

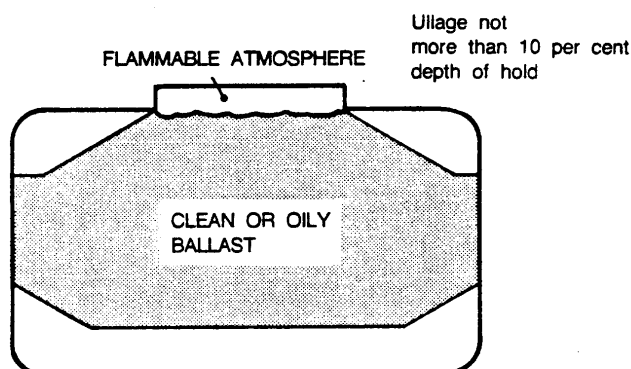


Figure 18 Cargo tank ullage effect on generation of static electricity

Leakage

49. To ensure that leakage of tank gas, particularly through the hatch centreline joints, is eliminated or minimized, it is essential that the hatch covers be inspected frequently to determine the state of their seals, their alignment, etc; when the hatch covers have been opened, particularly after the ship has been carrying a dry bulk cargo, the seals and trackways should be inspected and cleaned to remove any foreign matter.

Ballast and Void Spaces

50. The cargo holds of combination carriers are adjacent to ballast and void spaces; leakages may occur in pipelines or ducts in these spaces, or from a fracture in the boundary plating; oil, inert gas and hydrocarbon gas may leak into the ballast and void spaces; consequently gas pockets may form and cause difficulty with gas-freeing because of the considerable steelwork, acting as stiffening, that is characteristic of these spaces; personnel should be alerted to this hazard.

Inert Gas Distribution System

51. Due to the special construction of combination carriers, the vent line from the cargo hatchway coaming is situated very close to the level of the cargo surface; in many cases, the inert gas main line passing along the main deck may be below the oil level in the hold; during rough weather, oil or water may enter these lines, completely blocking the opening, and thus prevent an adequate supply of inert gas during either tank cleaning or discharge; vent lines should therefore have drains fitted at their lowest point, which should always be checked before any operation takes place within the cargo hold.

Application when Carrying Oil

52. When combination carriers are engaged exclusively in the carriage of oil, the inert gas system should be utilized in the manner described in Part (V).

Application when Carrying Cargoes Other than Oil

53. (1) A combination carrier transporting a cargo other than oil should be considered a tanker, unless the requirements in subsection 53(8) are complied with.
- (2) When cargoes other than oil are intended to be carried, it is essential that all holds/cargo tanks other than slop tanks referred to in subsection 53(6) and subsection 53(7) be emptied of oil and oil residues, cleaned and ventilated to such a degree that the tanks are completely gas free and internally inspected; the pumproom, cargo pumps, pipelines, duct keel and other void spaces are to be checked to ensure that they are free of oil and hydrocarbon gas.

- (3) Holds required to carry cargo other than oil should be isolated from the inert gas main and oil cargo pipeline by means of blanks; these blanks should remain in position at all times when cargoes other than oil are being handled or carried.
- (4) During the loading and discharging of solid cargoes, and throughout the intervening periods, all holds/cargo tanks [other than the slop tanks referred to in subsection 53(6) and subsection 53(7)], cargo pumphooms, cofferdams, duct keels and other adjacent void spaces should be kept in a gas-free condition and checked periodically at intervals of not more than two days to ensure that:
 - (a) no hydrocarbon gas has been generated or leaked from slop tanks referred to in subsection 53(6) and subsection 53(7); if concentrations of more than 20 per cent of the lower flammable limit are detected, the compartments concerned should be ventilated;
 - (b) no oxygen deficiency exists that could be attributable to leakage of inert gas from another compartment.
- (5) As an alternative to subsection 53(4), empty cargo tanks may be re-inerted in accordance with section 30, provided they are subsequently maintained in the inert condition and at a minimum pressure of 100 mm water gauge at all times, and provided that they are checked periodically, at intervals of not more than two days, to ensure that any generation of hydrocarbon gas does not exceed one per cent by volume; if such a concentration is detected, the compartments concerned should be purged in accordance with section 39.
- (6) Slops should be contained in a properly constituted slop tank and should be
 - (a) discharged ashore, and the slop tanks cleaned and ventilated to such a degree that they are completely gas free and then inerted; or
 - (b) retained on board for not more than one voyage when, unless the vessel reverts to carrying oil, the slop tank should be treated as in subsection 53(5).

If slops are retained on board for more than one voyage because reception facilities for oily residues are not available, the slop tank should be treated as in subsection 53(5) and, in addition, a report be forwarded to the Board.

- (7) Slop tanks that have not been discharged should comply not only with the requirements of subsection 53(6), but also with the Fire Protection, Detection and Extinguishing Equipment Regulations, subsection 11(3), Schedule VII; the latter requires that they be isolated from other tanks by blank flanges, which will remain in position at all times when cargoes other than oil are being carried, except as provided for in this Standard; reference is also made to subsection 53(3); on combination carriers where there are also empty cargo tanks that are not required to be isolated from the inert gas main, the arrangement for isolating the slop tanks from these tanks should be such as to:
- (a) prevent the passage of hydrocarbon gas from the slop tanks to the empty tanks; and
 - (b) facilitate monitoring of the pressure in slop tanks and in any empty cargo tanks, and, if necessary topping it up, if the latter are being kept in the inert condition as referred to in subsection 53(5)

Figure 19 shows suggested arrangement.

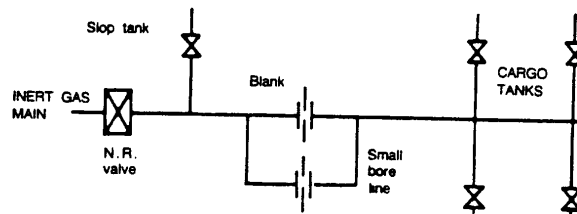


Figure 19 Inert gas by-pass arrangement for topping up cargo tanks

in addition, all cargo pipelines to or from the slop tanks should be blanked off.

- (8) Instead of complying with the requirements in subsections 53(2) to 53(7), a combination carrier may operate as a bulk carrier without having to use its inert gas system if either
- (a) it has never carried a cargo of oil; or

- (b) after its last cargo of oil, all its cargo tanks, including slop tanks, the pumproom, cargo pumps, pipelines, cofferdams, duct keel and other void spaces are emptied of oil and oil residues, cleaned and completely gas-freed, and the tanks and void spaces internally inspected to that effect; in addition, the monitoring required in subsection 53(4) should be continued until it has been established that generation of hydrocarbon gas has ceased.

PART VIII

EMERGENCY PROCEDURES

54. (1) In the event of total failure of the inert gas system to deliver the required quality and quantity of inert gas and maintain a positive pressure in the cargo and slop tanks, action must be taken immediately to prevent any air being drawn into the tank; all cargo tank operations should be stopped, the deck isolating valve closed, and the vent valve between it and the gas pressure regulating valve opened and immediate action taken to repair the inert gas system.
- (2) In the case of tankers engaged in the carriage of crude oil it is essential that the cargo tanks be maintained in the inerted condition to avoid the hazard of pyrophoric iron sulphide ignition; if it is assessed that the tanks cannot be maintained in an inerted condition before the inert gas system can be repaired, an external supply of inert gas should be connected to the system through the arrangements required by the Fire Protection, Detection and Extinguishing Equipment Regulations, as soon as practicable, to avoid air being drawn into the cargo tanks.
- (3) In the case of product carriers, if it is considered to be totally impracticable to effect a repair to enable the inert gas system to deliver the required quality and quantity of gas and maintain a positive pressure in the cargo tanks, cargo discharge and deballasting may only be resumed provided that either an external supply of inert gas is connected to the system through the arrangements required by the Fire Protection, Detection and Extinguishing Equipment Regulations, or the following precautions as given in subsections (4) through (8) are taken.
- (4) In the case of Safety Convention tankers built on or after 1 September 1984 or new tankers, the venting system is checked to ensure that approved devices to prevent the passage of flame into cargo tanks are fitted and that these devices are in a satisfactory condition.
- (5) In the case of Safety Convention tankers built before 1 September 1984 or existing Non Safety Convention tankers the flame screens are checked to ensure that they are in a satisfactory condition.
- (6) The valves on the vent mast risers are opened.
- (7) No free fall of water or slops is permitted.

- (8) No dipping, ullaging, sampling or other equipment should be introduced into the tank unless essential for the safety of the operation; if such equipment is necessary, it should be introduced only after at least 30 minutes have elapsed since the injection of inert gas ceased; all metal components of equipment to be introduced into the tank should be securely earthed; this restriction should be applied until a period of five hours has elapsed since injection of inert gas has ceased.
- (9) In the case of product carriers if it is essential to clean tanks following a failure of the inert gas system and inerted conditions as defined in the Fire Protection, Detection and Extinguishing Equipment Regulations cannot be maintained, tank cleaning should be carried out with an external supply of inert gas connected to the system; alternately, if an external supply of inert gas is not connected to the ship, the following precautions as given in subsections (10) through (19) should be taken, in addition to subsections (4) through (8).
- (10) Tank washing should be carried out only on one tank at a time.
- (11) The tank being washed should be isolated from other tanks and from any common venting system, or the inert gas main and maximum ventilation output should be concentrated on that tank both before and during the washing process; ventilation should provide, as far as possible, a free flow of air from one end of the tank to the other.
- (12) The tank bottom should be flushed with water and stripped; the piping system including cargo pumps, cross-overs and discharge lines should also be flushed with water.
- (13) Washing should not commence until tests have been made at various levels to establish that the vapour content in any part of the tank is below 10 per cent of the lower flammable limit.
- (14) Testing of the tank atmosphere should continue during the washing process; if the vapour level rises to within 50 per cent of the lower flammable limit, washing should be discontinued until the vapour level has fallen to 20 per cent of the lower flammable limit or less.

- (15) If washing machines with individual capacities exceeding 60 m³/hour are to be used, only one such machine shall be used at any one time on the ship; if portable machines are used, all hose connections should be made and bonding cables tested for continuity before the machines are introduced into the tank; bonding cables should not be disconnected until after the machines have been removed from the tank.
- (16) The tank should be kept drained during washing; if build-up of wash water occurs, washing should be stopped until the water has been cleared.
- (17) Only clean, cold sea water should be used; recirculating systems should not be used.
- (18) Chemical additives should not be used.
- (19) All deck openings should be kept closed during the washing process, except those necessary for washing and venting.
- (20) During cargo operations in port, more stringent regulations of the port authorities shall take precedence over any of the foregoing emergency procedures.
- (21) The attention of the ship's master should be drawn to Regulation 11(c), Chapter I, of the 1978 SOLAS Protocol in the event of the inert gas system becoming inoperative.

PART IX

MAINTENANCE AND TESTING

General

55. (1) As the safety arrangements are an integral part of the inert gas system, it is important for ship's staff to give special attention to them during any inspection.
- (2) Inspection routines for some of the main components are dealt with in this section.

Inert Gas Scrubber

56. (1) Inspection may be made through the manholes; checks should be made for corrosion attacks, fouling and damage to:
- (a) scrubber shell and bottom;
 - (b) cooling water pipes and spray nozzles (fouling);
 - (c) float switches and temperature sensors;
 - (d) other internal components such as trays, plates and demister filters.
- (2) Checks should be made for damage to non-metallic parts such as:
- (a) internal linings;
 - (b) demisters;
 - (c) packed beds.

Inert Gas Blowers

57. (1) To a limited degree, internal visual inspection will reveal damage at an early stage; diagnostic monitoring systems greatly assist in maintaining the effectiveness of the equipment; an acceptable level of availability of blowers is ensured by fitting two equal blowers or, alternatively, supplying and retaining on board a spare impeller with a shaft for each blower; visual inspection through the available openings in the blower casing is adequate for this purpose.

- (2) An inspection of inert gas blowers should include:
- (a) internal inspection of the blower casing for soot deposits or signs of corrosive attack;
 - (b) examination of fixed or portable washing system;
 - (c) inspection of the functioning of the fresh water flushing arrangements, where fitted;
 - (d) inspection of the drain lines from the blower casing to ensure that they are clear and operative;
 - (e) observation of the blower under running conditions for signs of excessive vibration, indicating too large an imbalance.

Deck Water Seal

58. (1) This unit must be maintained in good condition as it performs an important function; corroded inlet pipes and damage to float controlled valves are not uncommon; the overboard drain line and connection are also possible sources of trouble.
- (2) An inspection of the deck water seal should include:
- (a) opening for internal inspection to check for:
 - (i) blockage of the venturi lines in semi-dry type water seals;
 - (ii) corrosion of inlet pipes and housing;
 - (iii) corrosion of heating coils;
 - (iv) corroded or sticking floats for water drain and supply valves and level monitoring.
 - (b) testing for function:
 - (i) automatic filling and draining (check with a local level gauge if possible);

- (ii) presence of water carry-over (open drain cocks on inert gas main line) during operation.

Non-return Valve

59. The non-return valve should be opened to check for corrosion and also the condition of the valve seat; the valve should be tested in operation.

Scrubber Effluent Line

60. The scrubber effluent line cannot normally be inspected internally except when the ship is in dry dock; the ship side stub piece, referred to in paragraph 27(3)(b), and the overboard discharge valve should be inspected at each dry-docking period.

Testing of Other Units and Alarms

61. (1) A method should be devised to test the functioning of all units and alarms; it may be necessary to simulate certain conditions to carry out an effective testing programme.
- (2) Such a programme should include checking:
- (a) all alarm and safety functions;
 - (b) the functioning of the flue gas isolating valves;
 - (c) the operation of all remotely or automatically controlled valves;
 - (d) the functioning of the water seal and non-return valve (with a backflow pressure test);
 - (e) the vibration level of the inert gas blowers;
 - (f) for leakages: deck lines in systems four years old or more should be examined for gas leakage;
 - (g) the interlocking of the soot blowers;
 - (h) oxygen-measuring equipment, both portable and fixed, for accuracy by means of both air and a suitable calibration gas.

Suggested Maintenance Programme

Component	Preventive maintenance	Maintenance interval
Flue gas isolating valves	Operating the valve	Before start-up and one week
	Cleaning with compressed or steam	Before operating valve
	Dismantling for inspection and cleaning	Boiler shutdown
Flue gas scrubber	Water flushing	After use
	Cleaning of demister	Three months
	Dismantling of level regulators and temperature probes for inspection	Six months
	Opening for full internal inspection	Dry docking
Overboard pipes and valve from flue gas scrubber	Flushing with scrubber water pump for about one hour	After use
	Dismantling of the valve for overhaul, inspection of pipeline and overboard end	Dry-docking/regular period
Blowers	Vibration checking	While running
	Flushing	After use
	Internal inspection through hatches	After flushing and six months
	Dismantling for full overhaul of bearings, shaft tightenings and other necessary work	Two years or more frequently if required/dry-docking
Deck water seal	Dismantling of level regulators/float valves for inspection	Six months
	Opening for total internal inspection	One year

Component	Preventive maintenance	Maintenance interval
	Overhaul of auto-valves	One year
Deck mechanical non-return valve	Moving and lubricating the valve if necessary	One week and before start
	Overhaul of auto-valves	One year/18 months
Pressure-vacuum valves	Operating and lubricating the valves	Six months
	Opening for full overhaul and inspection	One year
Deck isolating valve	Opening for overhaul	One year
Gas pressure regulating system	Removal of condensation instrument, air supply	Before start
	Opening of gas pressure regulating valves for overhaul.	As appropriate
Liquid filled pressure-vacuum breaker	Checking liquid level when system at atmospheric pressure	When opportunity permits and every six months

PART X

TRAINING

General

63. (1) An inert gas installation is an important feature of a tanker's safety system and training in its use is essential.
- (2) The requirements for training depend upon the policies of the shipping company concerned, as well as the Board; this Part is not intended to specify any particular training policy, but to set out a number of alternatives that can be adapted.

Personnel Requiring Training

64. (1) This section does not spell out in detail a syllabus for courses in the design, operation and maintenance of inert gas systems, but it is suggested that any syllabus should cover the same ground as that contained in this Standard.
- (2) Such practical training can only be given, however, if those in charge of, and responsible for, the vessel's safety and performance are themselves completely familiar with the type of installation fitted, and the hazards associated with its use; it is recommended that the training of both deck and engine room personnel is co-ordinated to ensure a common understanding of the procedures.
- (3) The vessel shall be equipped with the necessary manufacturers' manuals and instructions to give information about carrying out the various operations.

Location of Training

65. Training may take place aboard or ashore; if shore training in basic design and operation is given, personnel should be made familiar with the equipment on board ship.

Some training Methods

66. Currently three methods are used in training; companies may practice one, or a permutation of the following:
- (a) on board training by shipping company staff;

This may be carried out either by a senior member of the ship's company who has been made responsible for training, or by a specialist who joins the vessel for part of a voyage; films and other suitable audio-visual aids can enhance such a training programme; under these circumstances, it should be possible to deal with the theoretical as well as the practical aspects.

(b) specialist shore-based training

This can be undertaken by nautical colleges either in consultation with shipping companies or manufacturers; a one-week course should cover the subject adequately.

(c) shore-based training by shipping company staff

Training under this heading may occur either as part of a company cargo courser, or, for example, as part of a senior officer's seminar where appropriate time may be devoted to a discussion of inert gas and operating problems.

PART XI

INSTRUCTION MANUAL(S)

67. Instruction Manuals required to be provided on board should contain the following information and operational instructions.
- (1) A line drawing of the inert gas system should show the positions of the inert gas pipework from the boiler or gas generator uptakes to each cargo tank and slop tank; gas scrubber; scrubber cooling water pump and pipework up to the effluent discharge overboard; blowers including the suction and discharge valves; recirculation or other arrangements to stabilize the inert gas plant operation; fresh air inlets; automatic gas pressure regulating stop valve; deck water seal and water supply, heating and over-flow arrangements; deck non-return stop valve; water traps in any supply, vent, drain and sensing pipework; cargo tank isolation arrangement; purge pipes/vents; pressure/vacuum valves on tanks; pressure/vacuum breakers on the inert gas main; permanent recorders and instruments and the take-off points for their use; arrangements for using portable instruments, complete and partial wash bulkheads, mast risers, mast riser isolating valves; high velocity vents; manual and remote controls.
 - (2) A description of the system should be included and a listing of procedures for checking that each item of the equipment is working properly during the full cycle of tanker operation. This includes a listing of the parameters to be monitored, such as inert gas main pressure, oxygen concentration in the delivery main, oxygen concentration in the cargo tanks, temperature at the scrubber outlet and blower outlet, blower running current or power, scrubber pump running current or power, deck seal level during inert gas discharge to cargo tanks at maximum rate, deck seal level at nil discharge, etc. Established values for these parameters during acceptance trials should be included, where relevant.
 - (3) Detailed requirements should be given for conducting the operations described in Parts IV and V, particular to the installation of the ship, such as times to inert, purge and gas-free each tank, sequence and number of tanks to be inerted, purged and gas-freed, sequence and number of purge pipes/vents to be opened or closed during such operations, etc.
 - (4) Dangers of leakage of inert gas and hydrocarbon vapours and precautions to prevent such leakages should be described relating to the particular construction and equipment on board.

- (5) Dangers of cargo tank overpressure or underpressure during the various stages in the cycle of tanker operation, and the precautions to be taken to prevent such conditions, should also be described in detail relating to the particular construction or the equipment on board.

PART XII

SOME SAFETY CONSIDERATIONS WITH INERT GAS SYSTEMS

Backflow of Cargo Gases

68. (1) To prevent the return of cargo gases or cargo from the tanks to the machinery spaces and boiler uptake, it is essential that an effective barrier always be present between these two areas; in addition to a non-return valve, a water seal and vent valve should be fitted on the deck main; it is of prime importance that these devices be properly maintained and correctly operated at all times.
- (2) An additional water seal is sometimes fitted at the bottom of the scrubber (see also subsection 21(6)).

Health Hazards

Oxygen Deficiency

69. (1) Exposure to an atmosphere with a low concentration of oxygen does not necessarily produce any recognizable symptom before unconsciousness occurs; the onset of brain damage and death can follow within a few minutes; if oxygen deficiency is not sufficient to cause unconsciousness, the mind nevertheless is liable to become apathetic and complacent; even if the victim notices these symptoms and attempts to escape, the physical exertion will aggravate the weakness of both mind and body; it is therefore necessary to ventilate thoroughly to ensure that no pockets of oxygen-deficient atmosphere remain; a steady reading of 21 per cent oxygen is required for a worker to enter.

Toxicity of Hydrocarbon Vapours

- (2) Inert gas does not affect the toxicity of hydrocarbon gases and the problem of toxicity is no different from that on ships without an inert gas system; because of possible gas pockets, regeneration, etc. gas-freeing must continue until the entire compartment shows a zero reading, with a reliable combustible gas indicator or equivalent, or a 1 per cent reading of the lower flammable limit, should the instrument have a sensitivity scale on which a zero reading is not obtainable.

Toxicity of Flue Gas

- (3) The presence of toxic gases such as sulphur dioxide, carbon monoxide and oxides of nitrogen can be ascertained only by measurement; however, provided that the hydrocarbon gas content of an inerted tank exceeds 2 per cent by volume before gas-freeing is started, the dilution of the toxic components of flue gas during the subsequent gas freeing can be correlated with the readings of an approved combustible gas indicator or equivalent; if, by ventilating the compartment, a reading of 1 per cent of the lower flammable limit or less is obtained in conjunction with an oxygen reading of 21 per cent by volume, the toxic trace gases will be diluted to concentrations at which it will be safe to enter; alternatively, and irrespective of initial hydrocarbon gas content, ventilation should continue until a steady oxygen reading of 21 per cent by volume is obtained.

Tank Pressure

70. When an inerted cargo tank is maintained at a positive pressure, personnel should be advised of the practical hazards; such pressure must be adequately reduced before any tank-lids, ullage plugs or tank washing openings are opened.

Electrostatic Hazards

71. (1) Small particulate matter carried in flue gas can be electrostatically charged; the level of charge is usually small, but levels have been observed well above those encountered with water mists formed during tank washing.
- (2) Because cargo tanks are normally in an inerted condition, the possibility of electrostatic ignition has to be considered only if the oxygen content of the tank atmosphere rises as a result of an ingress of air, or if it is necessary to inert a tank that already has a flammable atmosphere (see section 30).

Repair of Inert Gas Plant

72. (1) Because inert gas is asphyxiating, great care must be exercised when work on the plant is undertaken; although the worker may be in the open air, inert gas leaking from the plant could render him unconscious very quickly; before any equipment is opened, therefore, the inert gas plant should be completely gas freed.

- (2) If any unit (e.g. the inert gas scrubber) is to be examined internally, the standard recommendations for entering enclosed spaces must be followed; blind flanges should be fitted where applicable, or the plant completely isolated.

Hazards from pyrophoric iron sulphide

73. (1) Bearing in mind the reduction of oxygen in ullage spaces compounded by the operation of inert gas systems, research has led to the conclusion that there is a significant risk of pyrophoric deposits forming in inerted tankers carrying sour crude oil; furthermore, that pyrophoric deposits can form with crude oils having a low hydrogen sulphide content and that no minimum safe level of hydrogen sulphide content can be identified; and, finally, that pyrophors which have formed during a loaded passage can persist during the subsequent ballast voyage.
- (2) Thus, while various factors (such as lack of sufficiently thick deposits of iron oxide) may inhibit pyrophor formation and while the correct operation of the inert gas plant will prevent the possibility of ignition, the degree of risk is judged to be sufficiently high to require the precautions in subsection 54(2) in case of inert gas system failure.