OIL COMPANIES INTERNATIONAL MARINE FORUM

INERT GAS SYSTEMS

DRY TYPE DECK WATER SEALS

Prevention of Inert Gas/Hydrocarbon Backflow

The OCIMF mission is to be recognised internationally as the foremost authority on the safe and environmentally responsible operation of oil tankers and terminals.

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INTRODUCTION

This document investigates the function of the inert gas system dry type deck water seal and its ability to protect the gas safe spaces of a ship.

There have been incidents, including one on an OCIMF member's ship, involving backflow of hydrocarbon vapours into the gas-safe spaces. It is apparent, therefore, that given certain modes of failure of equipment, such backflow, although rare, can occur.

This paper presents the current requirements for the Inert Gas System (IGS) non-return devices, examines the operation of dry type deck water seals, identifies possible modes of seal failure and proposes modifications to the hardware aimed at reducing the chances of hydrocarbon vapour backflow in the system.

REQUIREMENTS FOR IGS NON-RETURN DEVICES

SOLAS Chapter 11-2, Regulation 62, provides the requirements for the non-return devices installed in the inert gas main of a typical system.

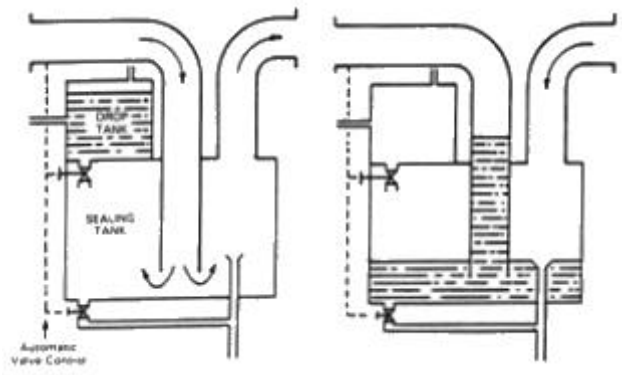
Regulation 62 requires that the inert gas system is equipped with two non-return devices, one of which shall be a water seal, to prevent the return of hydrocarbon vapour to the gas-safe spaces.

In addition, Regulation 62 requires that the arrangement of the deck seal shall be such that it will prevent the backflow of hydrocarbon vapours and will ensure the proper functioning of the seal under operating conditions.

The IMO "Guidelines for Inert Gas Systems", Sections 3.6 and 3.7, indicate the design considerations, and provide details on the function, of various types of deck water seals.

DRY TYPE DECK WATER SEAL FUNCTIONS

The dry type deck water seal has an upper reservoir (drop tank) and a lower reservoir (sealing tank). The flow of water from the drop tank to the sealing tank and from the sealing tank to the overboard discharge is controlled automatically via level sensors and other control equipment.



Gas Flow Towards Cargo Tanks **Back Pressure in Cargo Tanks**

The above figure indicates a typical dry type deck water seal with upper and lower reservoirs. The upper reservoir is filled with water at all times and supplies water to the lower reservoir. The lower reservoir is empty during system operation (gas flowing to tanks) and filled with water when the inert gas blower is shut down, either because of normal stopping or because of automatic system shutdown activated by off-design conditions. The filling and drainage of the upper and lower reservoirs is triggered automatically by the sensing of levels in the sealing tank and drop tanks, by the on/off status of the blowers or by the gas-to-tank push button switch.

The upper and lower reservoirs are usually equipped with float-type level sensors.

The IMO Guidelines indicate that the deck seal lower reservoir will be filled with water when the cargo tank pressure exceeds the blower discharge pressure. However, there appears to have been little action by administrations to ensure that this detail of the Guidelines is followed by, for example, requiring devices to sense the pressure differential between the inert gas main and the pressure at the blower discharge.

The IMO Guidelines indicate that the inert gas pressure control system should be designed to automatically prevent any backflow of gas in the event of:

(a) System failure of inert gas blower, scrubber pump, etc.

or,

(b) When the system operates correctly but the deck water seal and the non-return valve have failed and the pressure of the gas in the tanks exceeds the blower discharge pressure.

The requirement in (a) is accomplished by the gas regulating valve which closes automatically upon system shutdown. When the system is shut down, additional safety against backflow is provided by the requirement (for systems built on or after June 1, 1981) of venting to the atmosphere the portion of the inert gas main between the deck main isolating valve and the gas regulating valve.

The requirement in (b) is accomplished by the gas pressure regulating valve on the basis of a desired setting when the valve is on automatic control mode. If the pressure in the tanks reaches the pressure setting, the regulating valve closes and the blower re-circulation valve opens, or inert gas is vented to atmosphere. Pressure control considerations and prevention of overheating of the blower may dictate that both of these valves are only partially open when the system is in the middle flow range.

OCCURRENCE OF BACKFLOW ON DRY TYPE DECK WATER SEALS

The effectiveness of dry type deck water seals, as protective devices against backflow, is limited due to the requirement of an external signal, such as that triggered by the on/off status of the blowers, to initiate and maintain the sealing function. Therefore, the deck seal can malfunction and allow backflow of hydrocarbon vapours.

The dry type deck water seal may not conform with parts of the IMO Guidelines because the deck seal control signal, provided to actuate the filling of the lower sealing chamber, does not come from a device which senses the pressure differential between the blower discharge pressure and the tank pressure. Thus, it is possible that, during periods of the cargo discharge operation, the tank pressure may be higher than the blower discharge pressure and backflow can occur if the mechanical non-return valve is defective. Therefore, when dry type deck water seals are utilised, there is effectively only one protective non-return device during operation, the non-return valve, as opposed to the **two** non-return devices required by the SOLAS Regulations.

In summary, systems with dry type deck water seals **which have a defective non-return valve** are shown to be vulnerable during operation to occurrence of backflow due to:

- Lack of a shutdown device at high cargo tank pressure (SOLAS requires only an alarm)
- The IG pressure regulating valve being set higher than the tank high pressure alarm setpoint
- Operating the IG pressure regulating valve in the manual mode.

PROPOSED MEASURES TO REDUCE RISK OF BACKFLOW

The risk of hydrocarbon gas backflow can be reduced by modifying operating procedures to reduce or eliminate the need to operate the system in the manual tank pressure control mode. Provision of additional controls will enhance the safety of the dry type deck water seals. However, the cost of the additional hardware should be compared to the cost of changing the deck water seal to a different type (wet or semi-dry). **The preferred solution would be to replace the dry deck water seal with another type.**

Several proposed modifications, primarily relating to system sensors and controls, are listed below for consideration by operators if they desire to retain the dry type deck water seal. Some of the devices proposed may be utilised with other types of seals, as required by SOLAS for systems installed after 1981 (i.e. provision of a bleed to atmosphere valve), or as dictated by individual operator's practices. It is recognised that the additional instrumentation will increase the system complexity and overall maintenance. This, indeed, should be considered when deciding whether to modify the existing controls or to replace the deck seal with a new type. In either case, additional instrumentation will be required, for example, to replace or augment the deck seal level sensors.

RECOMMENDED ADDITIONAL INSTRUMENTATION NECESSARY TO AUGMENT THE DRY TYPE SEALS

Note: Items a, b and e are considered as a minimum for safe operation. All other items will incrementally enhance system safety.

a) **Provision of Deck Main High Pressure Shutdown**

The proposed shutdown will reduce the risk of gas/hydrocarbon backflow by stopping the system when the deck main cargo tank pressure exceeds a predetermined level, e.g. 1400mm W.G. Currently SOLAS requires only the provision of a high pressure alarm. Some existing systems with dry type deck seals are equipped with a shutdown. Indication of high pressure shutdown condition should be provided in the Engine Control Room and the Cargo Control Room.

b) **Provision of a Differential Pressure Alarm Shut Down**

The device will sense the difference between the pressure in the line upstream of the pressure regulating valve and the pressure in the IG main. If the pressure of the IG main is equal or higher than the pressure upstream of the control valve, the system will shut down automatically, and close the gas regulating valve. Indication of this condition should be provided in the Engine Control Room and the Cargo Control Room.

Measuring points should be arranged to preclude bypass of hydrocarbons from the tanks into the engine room via the sensing lines by, for example, using secondary 3 to 15 psi loop signal in lieu of direct signal or by using other suitable electronic sensors. A timing mechanism, providing a few seconds delay, should be built into the starting sequence to permit the blower to start with zero differential pressure. During this time the pressure regulating valve will be kept closed automatically.

c) **Provision of a Bleed to Atmosphere Valve**

This valve and the associated bleed line should be installed between the deck seal and the pressure regulating valve. The valve should be power operated and fail safe (i.e. air to close/spring to open) and should be equipped with limit switches to provide an indication of the valve position in the Engine Control Room and the Cargo Control Room. The valve and vent line diameter should be about 100mm or greater.

Note: A means to vent the IG line is required to SOLAS for systems built on or after 1 June 1981. However, there is no requirement regarding the size of the valve. The 100mm diameter recommended above is greater than that usually provided with other type deck seals (50mm) in order to compensate for the reduced safety associated with the dry type seals, by allowing a larger quantity of gas to escape to the atmosphere in the event of backflow and reducing the possibility of building up the pressure in the IG line downstream of the IG pressure regulating valve.

d) **Provision of a Power Operated Deck Main Isolating Valve**

The valve should be fail safe (i.e. air to open/spring to close) and be equipped with open-closed limit switches to provide an indication of the valve position in the Engine Control Room and the Cargo Control Room. The valve must be arranged to close automatically upon system shutdowns, either normal, alarm, or emergency.

Note: This valve is required by SOLAS. The automatic operation is recommended to increase the safety of the system and prevent backflow when the system is shut down.

e) **Provision of a Deck Main Non-return Valve with Disc Position Indication**

The valve should be equipped with a direct mechanical indicator of the disc position and the means to check its operation manually. It is also recommended that a test valve be installed upstream of the non-return valve to enable periodic checks for leakage. This feature is recommended for all types of non-return valves.

If the system is equipped with a wafer type non-return valve, which usually does not have a position indicator and does not allow manual checking of the valve operation, it is recommended that the valve be changed with the type recommended above. As a minimum, consideration should be given to providing a spare valve onboard and introducing a schedule for frequent valve inspections and overhauls. Valve replacement is the preferred option.

f) **Provision of a Deck Seal S.W. Supply Low Pressure (or Flow) Alarm**

The alarm is required by SOLAS. However, some systems with dry type deck water seals have a low level alarm on the drop tank which is accepted by a number of administrations as being equivalent to the pressure alarm on the deck seal S.W. supply line. The pressure alarm on the S.W. supply is recommended to ensure that the dry type deck water seal has a supply of water available at all times.

g) **Provision of Ultrasonic Type Level Sensors**

As they require less maintenance, ultrasonic level sensors are recommended as direct replacements for existing float type sensors, if feasible, or as backup to the corresponding float type devices. Metallic floats may be perforated quickly by the action of seawater and such failure will prevent proper function of the deck water seal.

Ultrasonic type deck seal level sensors are not required by SOLAS, but are recommended as a reliable means to alert operators of possible malfunction of the deck water seal controls.

The above hardware will enhance the safety of operation of the dry type deck water seals. It is also recommended that **all types of deck water seals** be inspected regularly to ensure that there is no internal corrosion which can result in hydrocarbons bypassing the water seal and entering the gas-safe spaces.
