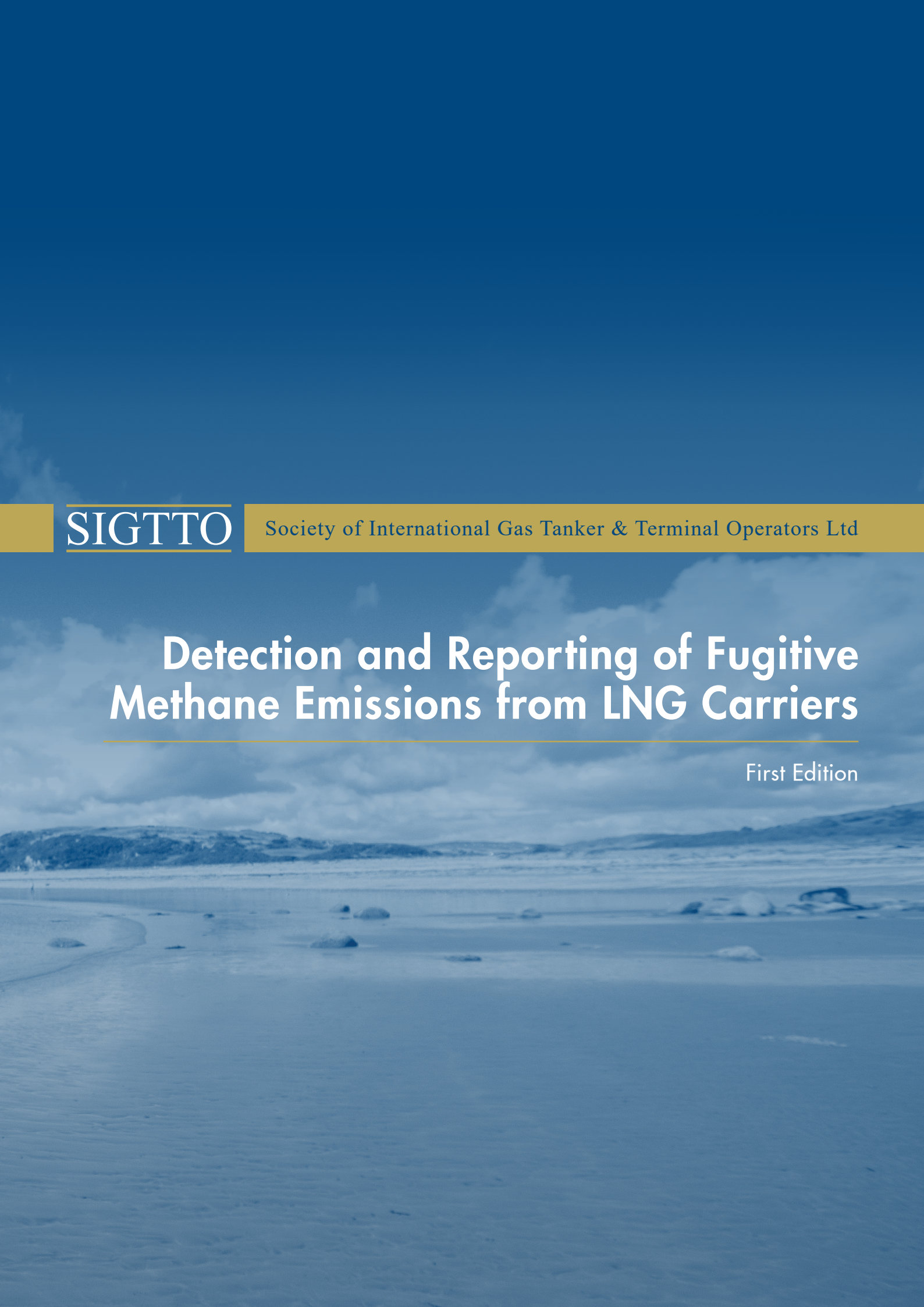
SIGTTO

Society of International Gas Tanker & Terminal Operators Ltd

Detection and Reporting of Fugitive Methane Emissions from LNG Carriers

First Edition



Detection and Reporting of Fugitive Methane Emissions from LNG Carriers

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The Society of International Gas Tanker and Terminal Operators (SIGTTO) *is a non-profit making organisation dedicated to protect and promote the mutual interests of its members in matters related to the safe and reliable operation of gas tankers and terminals within a sound environment. The Society was founded in 1979 and was granted consultative status at the International Maritime Organization in November 1983.*

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1 Introduction and Scope

1.1 Introduction

SIGTTO continues to actively encourage continuous improvement to reduce the environmental impact of liquefied gas shipping. This document is part of a series of documents specific to environmental protection matters which are aligned with, and support, the International Maritime Organization's (IMO's) environmental goals[1] on the reduction of greenhouse gas (GHG) emissions.

Methane is a GHG and it is vital that robust systems are in place to minimise the environmental impact of the transportation of LNG.[2] The main purpose of this document is to recommend that a structured system is set up to identify, detect, measure and quantify fugitive emissions[3] of methane from LNG carriers.

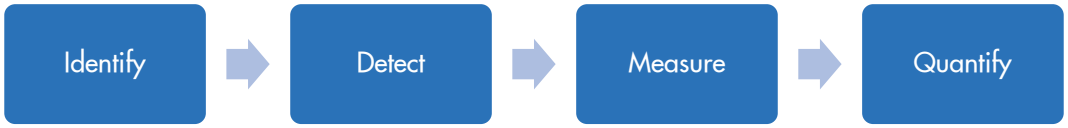

Figure 1: Process to reduce methane emissions

This is an important primary step that may also support a more comprehensive leak detection and repair system (LDAR) that is intended to reduce emissions through maintenance and design improvements. The United States Environmental Protection Agency (EPA)[4] and Methane Guiding Principles[5] are examples of organisations that have published useful information on this topic.

This document is intended to align with the existing principles in the oil and gas process industry. Adopting a consistent approach is expected to be helpful to the industry and facilitate the sharing of experience to collectively work towards minimising the impact of fugitive emissions on the environment.

[1] IMO – Resolution MEPC.304(72) – Initial IMO Strategy on Reduction of GHG Emissions from Ships

[2] Liquefied natural gas, the main constituent of which is methane

[3] Fugitive emissions are defined as emissions to the atmosphere caused by loss of tightness of an item that is designed to be tight

[4] United States Environmental Protection Agency – Leak Detection and Repair: A Best Practices Guide

[5] Methane Guiding Principles – Reducing Methane Emissions: Best Practice Guide. Identification, Detection, Measurement and Quantification

1.2 Scope

This document is applicable to LNG carriers and includes ships that are used for storage or regasification purposes. The guidance in this document only covers fugitive methane emissions. It does not consider other GHGs or methane released due to emergency, design or operational reasons.

The level of technical detail in this document assumes that the reader is familiar with the operation of an LNG carrier. Not all concepts are simplified or explained at an introductory level.

2

Identify

2 Identify

2.1 LNG Carrier Design

LNG carriers are carefully designed to minimise the leakage of methane as it is a flammable gas. Reducing the presence of flammable gas and eliminating ignition sources are critical to ensuring the safety of the ship. From a safety perspective, current systems and procedures are effective in ensuring that leaks are kept to a minimum.

Measurement of leaks, from a safety perspective, is normally in *percentage volume* of the flammable range of the gas. From an environmental perspective, effective leak detection needs to be carried out at much lower levels and the unit of measurement is usually in *parts per million* (ppm). This requires a more precise approach than that used for safety purposes.

Fugitive leaks are generally leaks from equipment from either imperfections or routine wear in joints such as flange gaskets, screwed connections, valve stem packing and poorly seated valves. Examples of areas that should be considered as potential sources of fugitive leaks are shown in Figure 2.

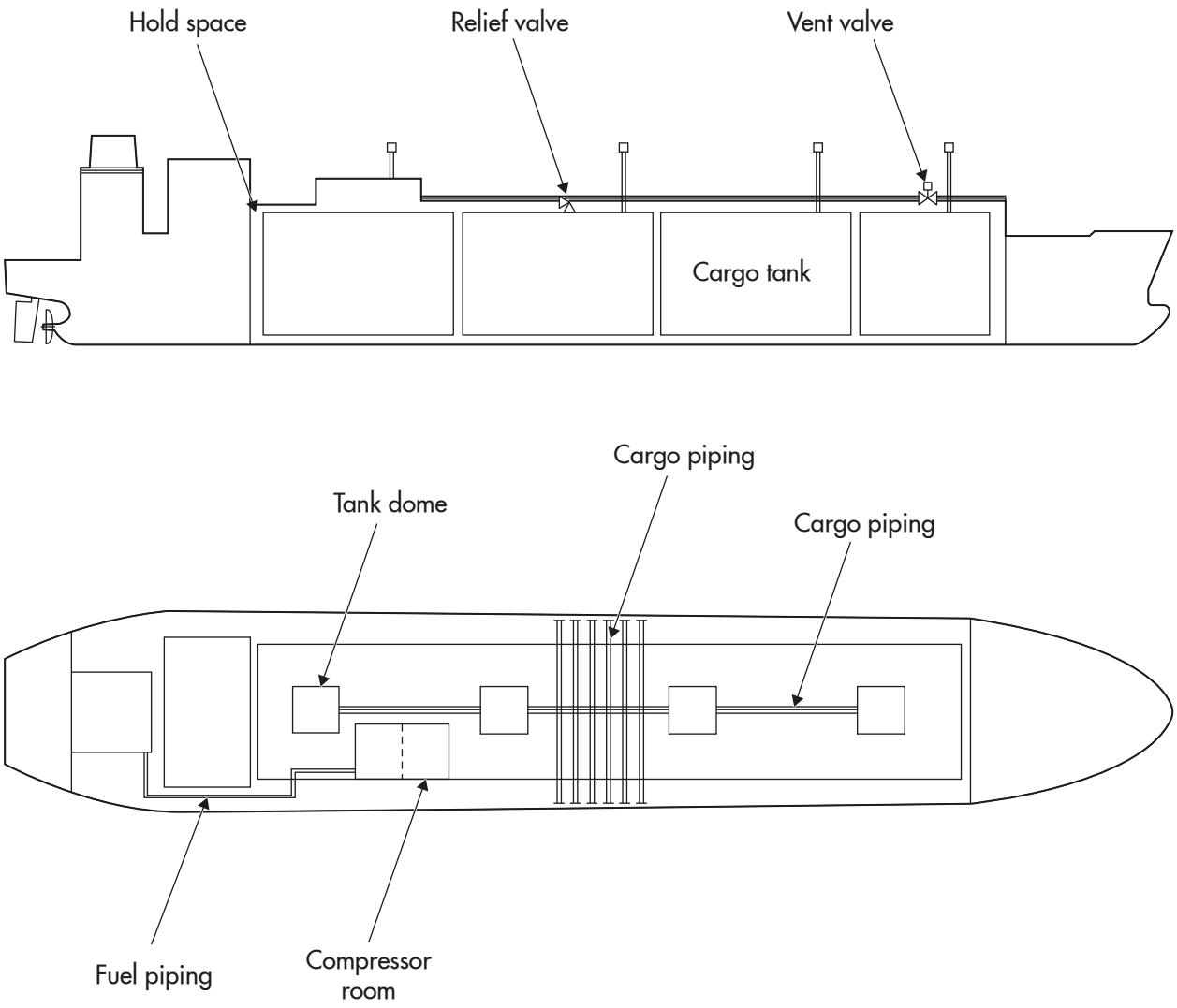

Figure 2: Areas to consider for sources of fugitive leaks

When a measured level of methane exceeds the prescribed limit it should be considered that a leak has been detected. When there is no prescribed limit, an appropriate limit should be determined by the owner and recorded in the ship's documentation. Multiple limits may need to be set depending on the equipment type. For example, valves and pumps may have different limits.

All identified components within the areas to be considered for leaks should be physically tagged with their own unique identification number and a record kept of the tag numbers. It may be efficient to use the same tag numbers as are available in the ship's piping and instrumentation diagram (P&ID) for this purpose. This information should be recorded in the ship's fugitive emissions reduction documentation.

Consideration should be given to use of an electronic data management system for records, which could help with audits and improve efficiency if barcoding or similar equipment is used.

2.2 Areas to Consider

This section provides additional information on the various areas that should be surveyed for fugitive emissions, listed in Table 1.

Area group	Source of leak
Cargo tanks	Tank dome: access hatch, gas dome cover, penetrations for instrumentation and sampling, connections
	Hold space: tank integrity monitoring
Cargo and fuel piping	Pipe penetrations: instrumentation, sampling connections, pipe connections
	Flanges: gasket integrity
	Flexible connections: bellows, hoses
Cargo and fuel valves	Process valves: shaft seals, valve body assembly
	Relief valves: sealing faces, diaphragm, valve body assembly
	Vent valve: sealing faces, shaft seals, valve body assembly
Cargo equipment	Heat exchangers: end plate gaskets, assembly
	Compressors: seals, casing assembly, valves, crankcase
	Pumps on deck: shaft seals, casing assembly
Combustion equipment	Engine crankcase assembly, instrumentation, pipe connections

Table 1: Typical sources of potential fugitive methane emissions on LNG carriers

2.2.1 Cargo tanks

Fugitive leaks from cargo tanks can typically occur at access hatches, tank skirts and around penetrations into the tank dome. Cargo tank domes have penetrations for process piping and for instrumentation and sampling. Accordingly, there are several locations that should be checked for leaks, such as flanges, valve stems, screwed connections and end caps.

The tank containment should be checked for fugitive leaks on a regular basis. The cargo tank hold space atmosphere should also be sampled to check for leaks.

Special care should be taken to check for fugitive leaks from cargo tanks after maintenance, particularly after drydocking. Where hatches to cargo tanks have been opened for maintenance, it is essential to monitor them for leaks after cargo is loaded into the tank.

2.2.2 Cargo and fuel piping

Cargo and fuel piping is designed to minimise leaks, but there are necessary connections for process piping, instrumentation and sampling. Flanges and screwed connections are possible sources of fugitive emissions. Temperature probe pockets, liquid sensors and sampling connections are examples of items that should be checked.

Gaskets used to ensure tight connections may deteriorate over time and the connections may leak due to forces on the joint. These forces typically occur due to thermal cycling, mechanical stress or vibration. Large flange connections should be included during routine checking due to a correspondingly larger potential for leaks.

Flexible connections, including bellows and hoses, are not typically used if they will be constantly pressurised with vapour or liquid. If flexible connections are used, care should be taken to check for fugitive emissions that may occur from pin holes or material deterioration.

2.2.3 Cargo and fuel valves

Cargo and fuel valves should be checked for leaks that may occur from valve gland packing and valve body joints. Process valves that are subject to regular thermal cycles, vibration and routine wear and tear from operations may need to be checked more frequently. Some process valves may not be under constant liquid or vapour pressure and have only intermittent service, so the detection of leaks will need to be planned accordingly.

Relief valves, as shown in Figures 3 and 4, may be subject to continuous pressure or occasional pressure from cargo vapour or liquid. Understanding the construction of the valve is important for knowing where and at what interval to check. These valves may develop leaks at the sealing faces seat, the diaphragm and in the valve body.

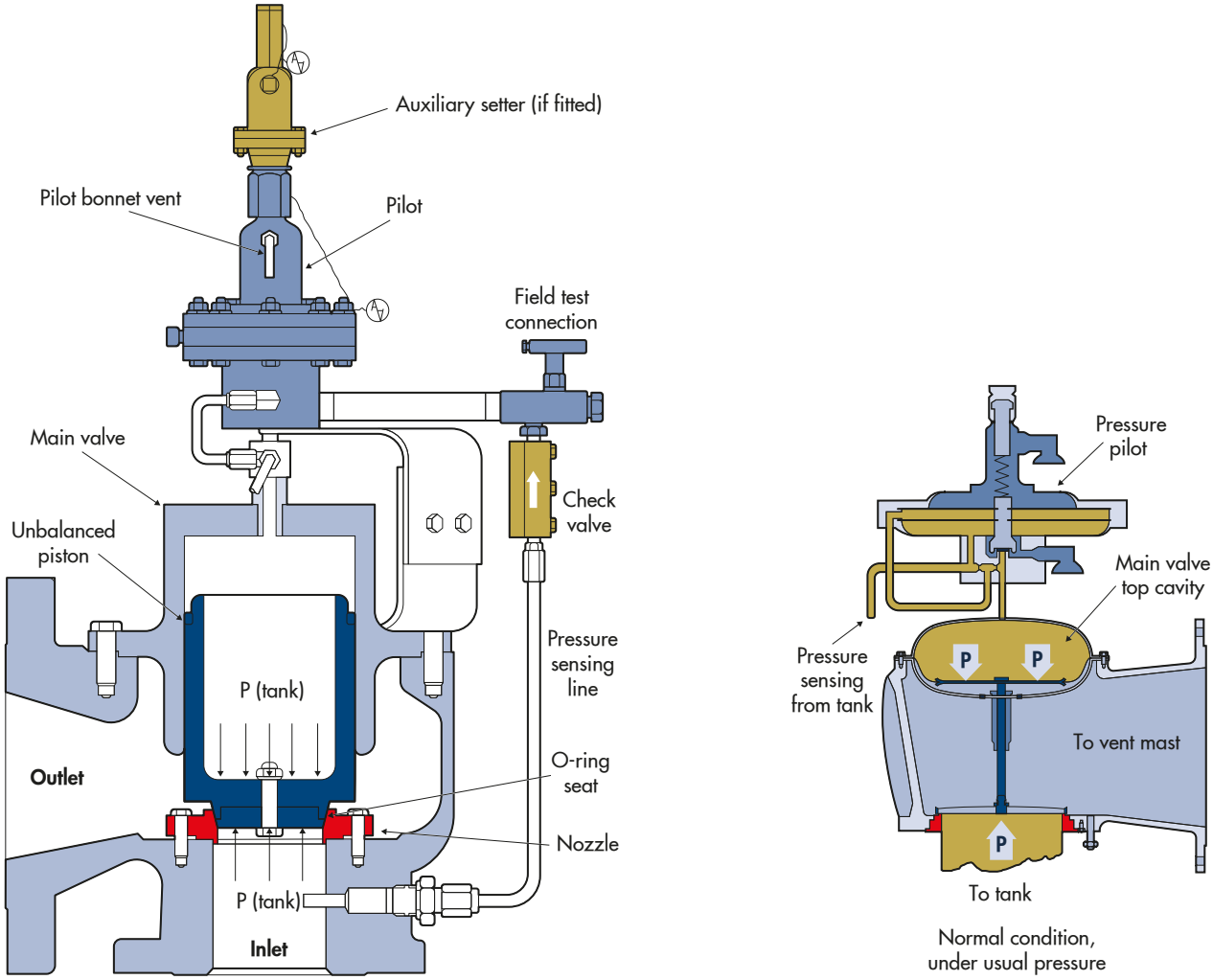

Figure 3: Pilot operated relief valves

For spring loaded relief valves, shown in Figure 4, leaks may occur from the valve disc seat.

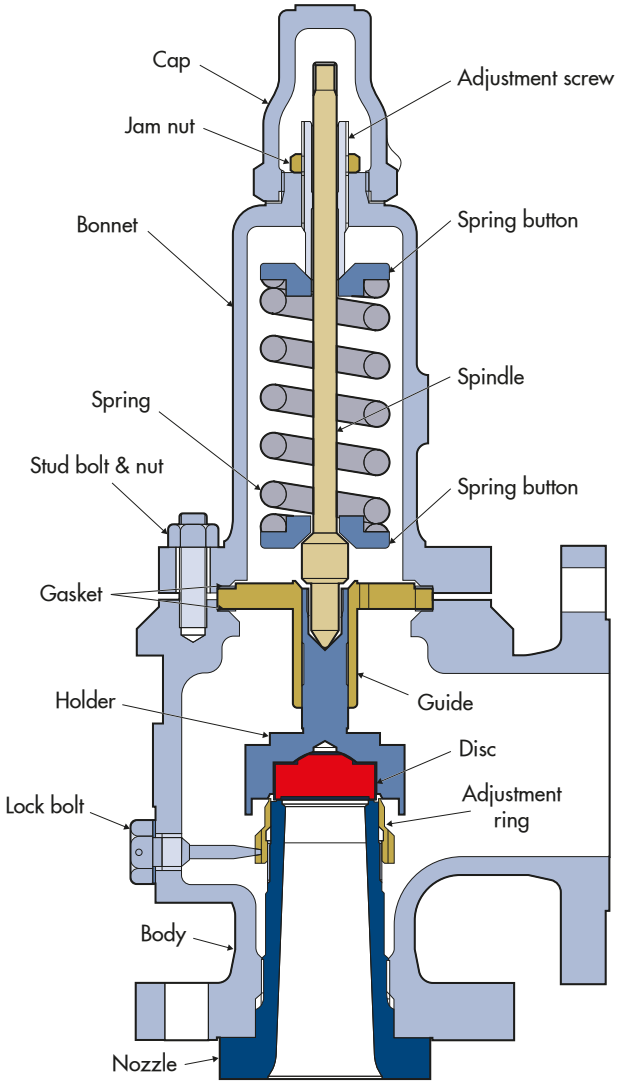

Figure 4: Spring loaded relief valve

Some ships may have automatic vent valves that are connected to the vapour system. These valves could be a source of fugitive emissions if the valve disc is not sealing properly.

2.2.4 Cargo equipment

Compressors and heat exchangers are possible sources of fugitive emissions. Any cargo pumps that are outside the cargo tank are also possible sources. Leaks may occur from shaft seals, casing, gaskets, penetrations for instrumentation and equipment valves.

There may be multiple sources of leaks for each equipment type and it is important to identify all the possible sources and record them individually with reference to the tag number of any relevant identified component. This will be helpful when creating a system that can effectively monitor for fugitive emissions.

2.2.5 Combustion equipment

Combustion equipment, such as the gas combustion unit (GCU), boilers and engines, receive cargo vapour via piping from the cargo tanks. The fuel gas system includes valves, piping and instrumentation that should be monitored for leaks and recorded in the ship's fugitive emissions reduction documentation.

As each item of equipment is unique, care should be taken to identify which areas of the equipment are exposed to cargo vapour and consequently may be a source of fugitive emissions. Identification should cover all parts of the system, including the engine cylinder head and engine crankcase. Operational emissions should not be considered as fugitive emissions.

3

Detect, Measure and Quantify

3 Detect, Measure and Quantify

3.1 Detect

Detection of methane emissions can be carried out by using various methods, the suitability of which may depend on whether the installation is fixed or mobile, and whether it is on land or at sea. Fixed assets include terminals on land or fixed offshore structures and mobile assets are, typically, ships.

Methods used on land, such as truck-mounted detection, and other methods for fixed assets, such as survey by drone, aircraft and satellite, may not be practical for a ship. Open-path detection and point sensors may be affected by atmospheric conditions and it could be challenging to install and obtain representative readings on a ship. This situation may improve with advancements in technology.

For LNG carriers, practical options include detection using point sensors on portable and fixed detection equipment. This type of method provides a high level of confidence in detection and it may be possible to measure the rate and quantify the leakage as well. For cargo containment, thermal imaging may also be used to detect leaks and then measure the rate to quantify the leakage. The appropriate frequency of detection depends on the system type and source of leak, and this frequency should be specified in the ship's fugitive emissions reduction documentation.

Useful information on detection methods is provided by organisations such as MARCOGAZ,[6] the National Association of Regulatory Utility Commissioners (NARUC)[7] and the Interstate Technology and Regulatory Council (ITRC).[8] There are links to additional information from other organisations in the Appendix of *Reducing Methane Emissions*.[9]

3.2 Measure

Measurement is carried out to enable detection or to determine the emission rate. Table 2 in *Reducing Methane Emissions* provides a comparison of various methods and some general advantages and disadvantages. For example, by using suitable sensors for individual sources, it is possible to use the indirect quantification methodology in BS EN 15446.[10]

The fugitive emission reduction plan should detail each aspect of the monitoring process, including the items to be monitored, frequency of monitoring and method of detection.

[6] marcogaz.org/knowledge-hub/#publications

[7] naruc.org

[8] itrcweb.org/home

[9] Methane Guiding Principles – Reducing Methane Emissions: Best Practice Guide. Identification, Detection, Measurement and Quantification

[10] BS EN 15446 – Fugitive and diffuse emissions of common concern to industry sectors – Measurement of fugitive emission of vapours generating from equipment and piping leaks

3.3 Quantify

Fugitive emissions need to be measured or calculated to quantify the emission rate. This will give the amount emitted over a period, which should be recorded and used to check the effectiveness of continuous improvement measures.

The process may be carried out automatically by the detection equipment used or may need to be modelled. Assessment of quantification methods has been carried out by organisations such as ITRC, MARCOGAZ and the US National Academies of Sciences, Engineering and Medicine (NASEM).[11]

[11] nationalacademies.org/about

4

Records, Audits and Reporting

4 Records, Audits and Reporting

The key recommendation of this document is that a structured system and methodology should be set up to identify, detect, measure, and quantify fugitive emissions. This system, along with a leak detection and repair (LDAR) programme, will help to reduce the environmental (GHG) impact of LNG transportation.

Proper record keeping, audits and a reporting regime are essential for making continuous improvement in reducing fugitive emissions.

4.1 Records

Records should be kept of the surveys carried out and the leaks found. The leaks should be tagged and recorded, preferably electronically. Details of any repairs made should also be noted.

The frequency of regular monitoring may be guided by planned maintenance routines. Significant events that affect the routine checks for leaks should be recorded. A few examples of these types of events include repairs, modifications, and major overhauls such as at drydocks.

Understanding the purpose of records will improve the categorisation and organisation of information, allowing for better analysis of the data. Records should enable the data to be analysed and compared across the company to enable continuous improvements and audits.

4.2 Audits

Improvements in methods, technology and lessons learnt from audits should be used to drive continuous improvement, which can enhance the effectiveness of measures to reduce fugitive emissions. The ship's fugitive emission reduction documentation should be periodically updated to reflect these improvements.

Regular audits should be carried out by the company to ensure the ship's fugitive emission reduction documentation is being followed and that records are reviewed for quality and accuracy. It is important that the system is checked to ensure it is capturing and recording all fugitive emissions. Audits should also check the documentation to ensure that lists, diagrams and tag numbers correctly represent the actual state.

4.3 Reporting

There should be a structured process for the company to receive periodic reports from the ship. The data should be gathered in a standard format that will enable analysis and comparison across ship types to identify any anomalies.

Companies should analyse information and maintain records internally. This can aid the development of industry best practice and sharing of lessons learnt to minimise the impact of fugitive emissions on the environment.

Annexes

Annex 1 – Glossary of Terms and Abbreviations

EPA Environmental Protection Agency (United States)

GCU Gas Combustion Unit

GHG Greenhouse Gas

IMO International Maritime Organization

ITRC Interstate Technology and Regulatory Council

LDAR Leak Detection and Repair

LNG Liquefied Natural Gas

NARUC National Association of Regulatory Utility Commissioners

NASEM National Academies of Sciences, Engineering and Medicine

P&ID Piping and Instrumentation Diagram

ppm Parts Per Million

Annex 2 – Reference List

- IMO – Resolution MEPC.304(72) – Initial IMO Strategy on Reduction of GHG Emissions from Ships
- United States Environmental Protection Agency – Leak Detection and Repair: A Best Practices Guide
- Methane Guiding Principles – Reducing Methane Emissions: Best Practice Guide. Identification, Detection, Measurement and Quantification
- marcogaz.org/knowledge-hub/#publications
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