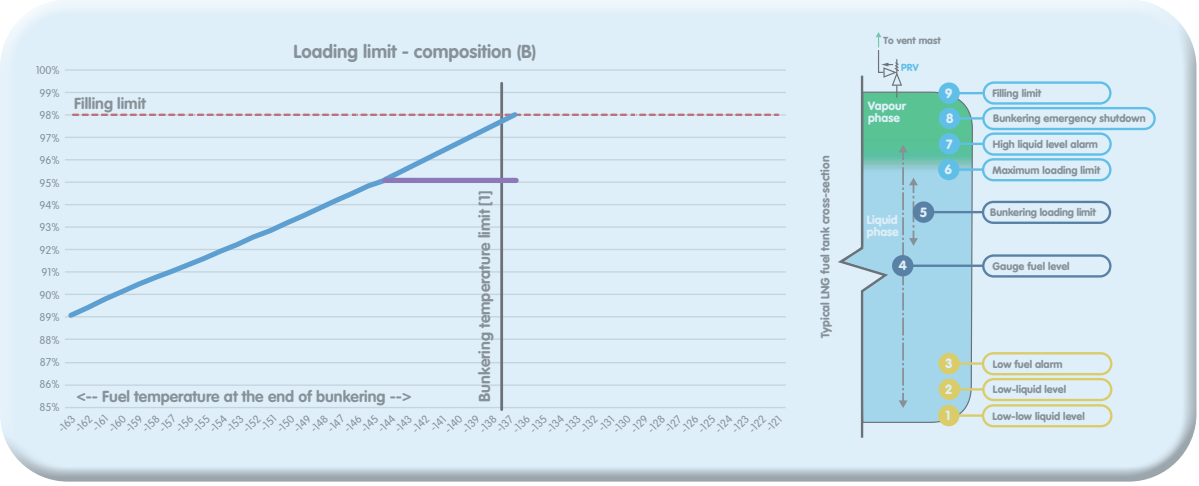
TGN17-01
version 1.0

LNG as a marine fuel

LNG Fuel Tanks – Loading/Filling Limits and Level Instrumentation: Considerations and Recommendations



sgmf
the society for gas as a marine fuel

technical guidance note

TGN17-01
version 1.0

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The Society for Gas as a Marine Fuel

The Society for Gas as a Marine Fuel (SGMF) is a non-governmental organisation (NGO) established to promote safety and good practice in the use of natural gas as a marine fuel. The Society supports the wider use of gas as marine fuel by developing technical guidelines that encourage safe and responsible operations. More information on the Society is available at: **https://sgmf.info**

Disclaimer

The advice in these guidelines is based on current good industry practice and available information. It is intended solely for guidance and use at the owner's/operator's own risk. No responsibility is accepted by SGMF – nor by any person, company or organisation related to SGMF – for any consequences resulting directly or indirectly from compliance with, or adoption of, any of the recommendations or guidance.

Notes:

1. This document provides only recommendations. They are not intended to constitute a detailed technical specification and apply only to the use of liquefied natural gas (LNG) on gas-fuelled vessels. It is the responsibility of the owner/operator:
   a. to develop appropriate operational guidance for a specific gas-fuelled vessel, bunkering facility and their equipment and systems, based on the builder's and manufacturer's instructions and these recommendations
   b. to ensure that any design specification meets the actual operational conditions to which the gas-fuelled vessel will be subjected over its asset lifetime
2. The recommendations and considerations in the ***Lessons learned*** sections represent only the collective experience of SGMF's membership on common issues and challenges that may arise during the use of LNG as a marine fuel:
   a. They are not intended to constitute a technical specification or to provide specific safety recommendations.
   b. Their application is left to the skilled design team and operator, who should evaluate which ones are applicable to their asset and, if so, under which circumstances.

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Reader key

Clarifications and qualifications

Codes/standards references

Case studies/examples/lessons learned

Foreword

As the use of LNG increases and becomes more established as a fuel, organisations will increasingly strive to make improvements in areas which not only provide safety benefits but also operational and performance improvements. From start to finish, SGMF Working Group 17 has made every effort to provide guidance which is useful in operating gas fuel ships.

The concept of LNG tank filling and loading limits are nothing new, having been implemented in the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) for LNG cargoes on LNG carriers for decades.

Whilst the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) specifies the two methods by which these limits are established or calculated for LNG fuel tanks, it is clear that for some vessels in operation and under construction, a number of different interpretations have been applied to date. These vary according to the tank type, shipyard or classification society involved in the projects.

These differing interpretations have seen some vessels applying a lower loading limit, limiting the amount of LNG which could be carried. Whilst safety was not impacted, allowing less LNG to be carried will have an impact on the vessels' autonomy and in service operations.

This Technical Guidance Note (TGN) takes feedback from SGMF members' projects to date and through construction discussion with designers and classification societies has established the background to these inconsistencies. It provides practical and clear guidance with a view to limiting inconsistent application in the future.

The combined body of knowledge from the working group members including tank manufacturers, system designers and operators has provided excellent and usable operational feedback and lessons learned.

This has allowed the production of clear and concise guidance to help designers and operators set consistent loading limits for LNG fuel tanks. It has also enabled the inclusion of operational specific guidance which will aid owners with setting the practical loading limits for bunkering operations.

Operational and in service feedback has been critical in developing this guidance and accordingly I would like to thank the open manner in which all members of the group were willing to share information.

Stuart Carpenter
Carnival Corporation
LNG Project Director and Working Group Chair

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Abbreviations

The following abbreviations are used in this document:

BDN – Bunker delivery note

BOG – Boil-off gas

ESD – Emergency shutdown

FL – Filling limit

GFV – Gas-fuelled vessel

IACS – International Association of Classification Societies

IGF Code – International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels

IMO – International Maritime Organization

LL – Loading limit

LNG – Liquefied natural gas

LOPA – Layer of protection analysis

MARVS – Maximum allowable relief valve setting

MAWP – Maximum allowable working pressure

NA – Not applicable

Definitions

The following definitions are used throughout this document:

Boil-off gas (BOG)
The vapour created when liquefied gas evaporates.

Bunkering facility
Any technology or system designed to be used to transfer/bunker liquefied gas as fuel to a gas-fuelled vessel. It usually consists of a bunker vessel, road tanker or terminal.

Bunkering loading limit
The loading limit calculated and agreed between the bunkering facility and the gas-fuelled vessel before each bunkering operation and based on the actual LNG volume commercially planned to be transferred, and the temperature and composition of the fuel at the receiving tank.

Calibrated tank volume
The actual measured usable 'as-built' internal volume including the tank domes at ambient conditions.

The calibration is carried out by the manufacturer or an independent certification organisation with a defined procedure and accuracy. The actual usable internal volume at cryogenic operating conditions is calculated by means of the (tank's) shrinkage factor.

Competent authority
In this document, the general term 'competent authority' describes an organisation with jurisdiction over the location, operation and/or assets involved.

The competent authority can have a legal, operational and location-specific interest over the operation and related activities. It can have a statutory function and may enforce requirements, rules and standards.

Different organisations, or more than one organisation, may act as a competent authority, depending on the activity being undertaken.

Emergency shutdown (ESD) (Bunkering)
The bunkering emergency shutdown is the event, signal or process initiated in an emergency to shut down the bunkering operation.

The process is divided into two consecutive stages: ESD-1 and ESD-2.

- The first stage, ESD-1, is intended to stop the flow in a controlled manner. The initiation of an ESD-1 process does not imply that an ESD-2 process will be initiated soon after.
- The second stage ESD-2 process is primarily intended to protect the bunkering transfer system, equipment and ship's manifold should the vessel drift out of a predetermined operating envelope. The ESD-2 release is usually initiated by the bunkering facility either automatically or manually.

Filling limit (FL)
Represents the maximum allowed filling level of the tank in terms of volume, normally expressed as a percentage of the total tank net volume.

Note
The filling limit is defined by the IGF Code § 2.2.16 as:
"the maximum liquid volume in a fuel tank relative to the total tank volume when the liquid fuel has reached the reference temperature".

Fuel
In the context of the recommendations in this document, 'fuel' means natural gas in its liquid or gaseous state.

Gas-fuelled vessel (GFV)
An IGF-compliant vessel using gas as marine fuel.

Liquid
In this document, 'liquid' is fuel (natural gas) in the liquid phase.

LNG bunkering
The process of re-fuelling an LNG-powered vessel from a bunkering facility.

Loading limit (LL)
Represents the maximum volume of liquid, usually expressed as a percentage of the tank net volume, which can be loaded.

Note
The **loading limit** is defined by the IGF Code § 2.2.27 as:
"the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded".

Person-in-charge (PIC)
The individual responsible for managing the bunkering operation on behalf of either the bunkering facility or the gas-fuelled vessel. One PIC might act as the person-in-overall-advisory-control (POAC).

Receiver
In this document, 'receiver' is a general term used to refer to one or more organisations with ownership, operational and/or legal interests in a gas-fuelled vessel. The receiver may be the vessel owner(s), charterer or operator.

Reference temperature

Note
The **reference temperature** is defined by the IGF Code § 2.2.36 as:
"the temperature corresponding to the vapour pressure of the fuel in a fuel tank at the set pressure of the pressure relief valves (PRVs)".

Rich (gas)
In gas combustion terms, a gas which, although mostly methane, contains appreciable amounts of heavier hydrocarbons. Also known as 'heavy'.

Supplier
The 'supplier' is the fuel owner or organisations mandated by them for the operation or development of a bunkering activity.

Tank gross volume
The internal volume as per the tank's design specification including the tank domes calculated at ambient conditions (see figure 1.1).

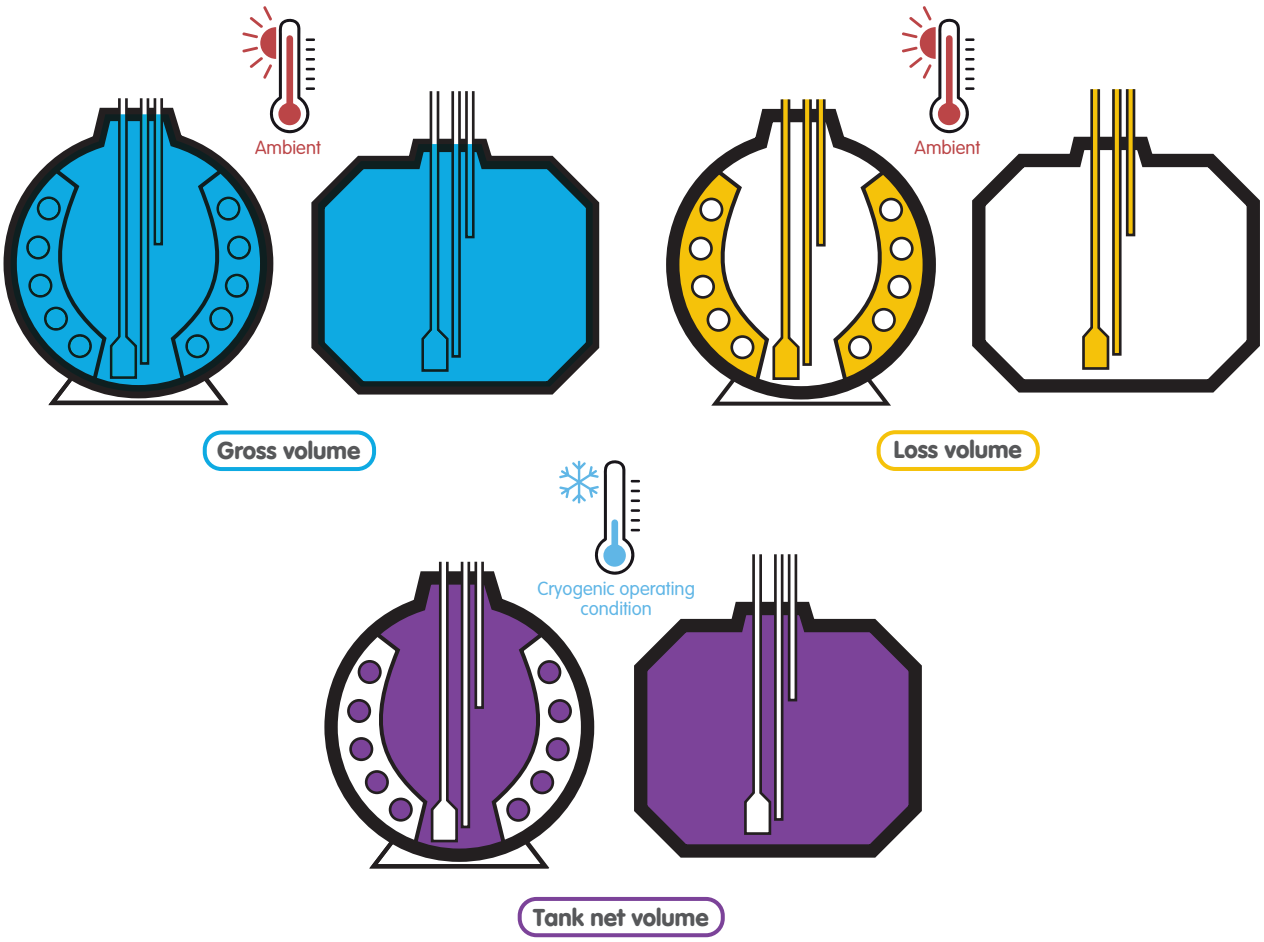
Tank internal loss volume
The volume, calculated at ambient conditions, of any internal structures and equipment which are submerged in the tank (e.g. piping, pump(s), etc.) (see figure 1.1).

Tank net volume
The tank's theoretical calculated internal net usable volume at cryogenic operating conditions. It is equal to the 'tank gross volume' minus the 'tank internal loss volume' times the 'tank's shrinkage factor' (see figure 1.1).

Tank's shrinkage factor
In the context of this publication, it refers to the multiple factors that account for the amount of volume 'loss' due to the contraction of the tank material when cooled down at cryogenic operating conditions.

Vapour
The gaseous phase of liquefied gas.

Figure 1.1: Tank volumes schematic



Purpose

The inherent properties of liquefied natural gas (LNG), in particular its cryogenic nature and behaviour, differ significantly from those of conventional marine fuels. This means that the quantity of fuel to be loaded into fuel tanks on gas-fuelled vessels will depend not only on the geometric size and capacity of the tank itself but also on the temperature and pressure of the LNG to be bunkered.

Statutory safety limits on filling and loading LNG fuel tanks are set out in codes and regulations, and the difference between the tanks' overall capacity and the maximum allowable quantity of fuel that may be bunkered is defined in the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) as the tank's **FILLING LIMIT** and **LOADING LIMIT.**

Within the gas-fuelled vessel industry, however, the interpretation of such requirements has been inconsistent, leading to questions about the overall safety approach. Furthermore, a lack of clear guidance on the impact of filling and loading limits during bunkering operations has been shown to have a negative impact on fuel tanks' volume utilisation.

This Technical Guidance Note (TGN) addresses the industry requirement for clarity on the applicability and interpretation of some of the statutory requirements for filling and loading limits of an LNG fuel tank. Its overall purpose is to provide not only guidance on statutory requirements on these limits to those directly involved in the bunkering operation or who may be engaged in monitoring and managing the fuel, but also to share industry good practice and lessons learned. These address operational requirements for the bunkering operation that go beyond the minimum statutory requirements so that it can take place safely, efficiently and in an environmentally responsible way.

The document aims to answer the most common questions about filling and loading limits and level instrumentation. Also included are lessons learned that promote industry good practice and form a basis for common understanding between the main stakeholders involved, specifically:

- ship owners
- ship operators
- LNG tank and fuel system designers, and
- the crew and personnel involved in the bunkering operation

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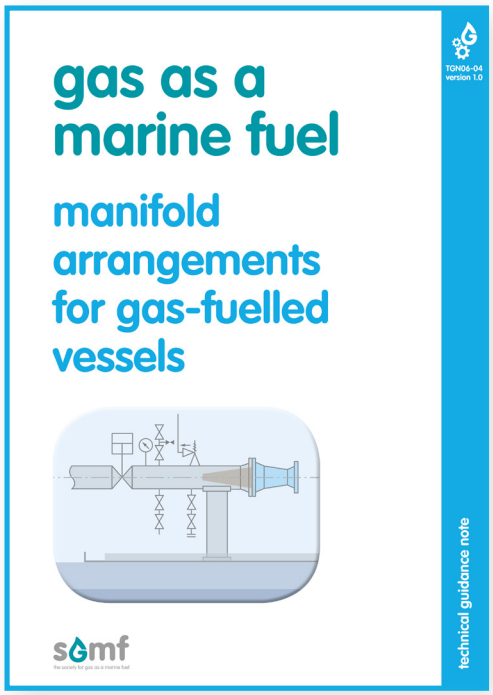

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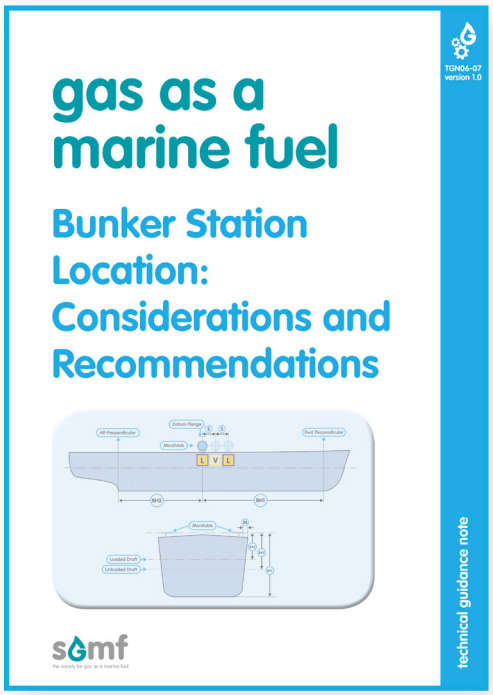

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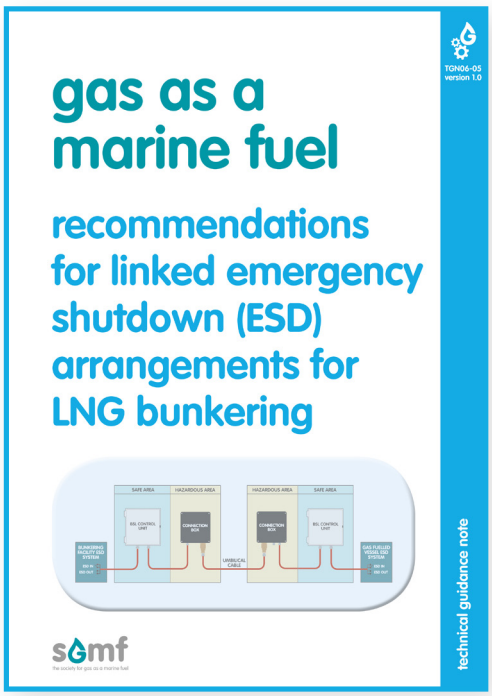

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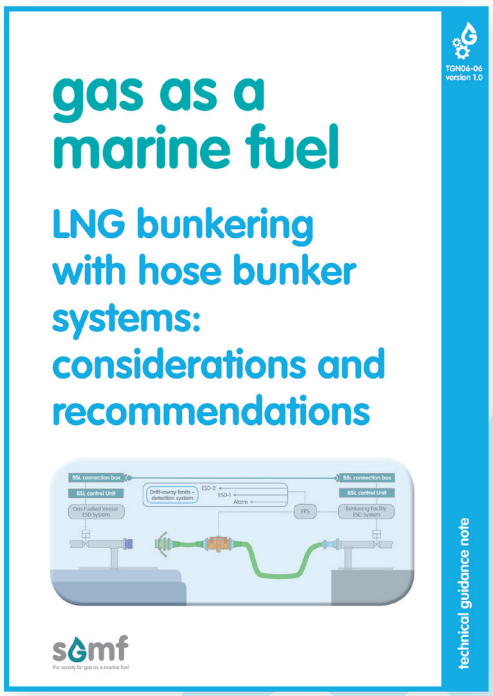

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