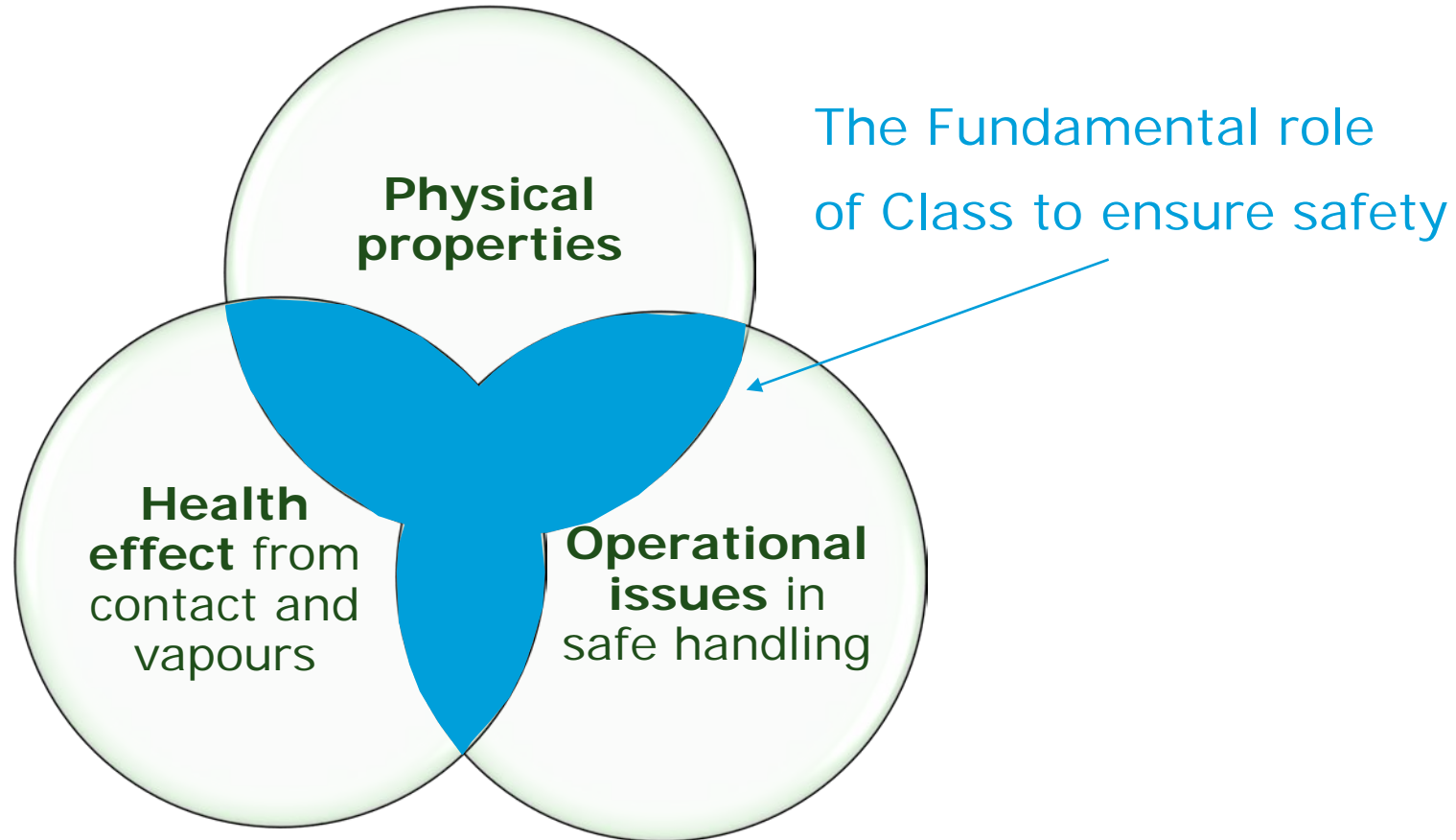


LNG Bunkering and the risks involved in operations using LNG as fuels

May 2018



How to handle LNG mainly driven by:



Physical Properties of LNG

According IGC Code

- Flammability,

Flashpoint of methane is -175°C

Flammable limits are 5-16% by volume

Volumetric expansion (during phase transition liquid to gas)

- Storage
- Transportation
- Handling conditions
- High pressure

Methane/LNG

Appearance	Colourless	SYNONYMS	Carburized hydrogen
Odour	Very faint, nearly odourless	Firedamp	Hydrogen bicaride
UN Number	1972/1971	Liquefied natural gas	LNG
MFAG Table	620	Marg-gas	Methyl hydride
		MTH	

The Main Hazard
FLAMMABLE

EMERGENCY PROCEDURES

Fire	STOP GAS SUPPLY. Do not extinguish flame until gas or liquid supply has been shut off, to avoid possibility of explosive re-ignition. Extinguish with dry powder, halon or carbon dioxide. Cool tanks and surrounding areas with water spray.
Liquid in eye	DO NOT DELAY. Flood eye gently with clean fresh water. Force eye open if necessary. Do not rub affected area. Continue washing for at least 15 minutes. Obtain medical advice or assistance as soon as possible.
Liquid on skin	DO NOT DELAY. Remove contaminated clothing. Flood affected area with water. Handle patient gently. Do not rub affected area. Immerse frost-bitten area in warm water until thawed. Obtain medical advice or assistance as soon as possible.
Vapour inhaled	REMOVE VICTIM TO FRESH AIR. Remove contaminated clothing. If breathing has stopped or is weak or irregular, give mouth to mouth/face resuscitation or oxygen, as necessary. Obtain medical advice or assistance as soon as possible.
Spillage	STOP THE FLOW. Avoid contact with liquid or vapour. Extinguish sources of ignition. Flood with large amounts of water to disperse the spill, and to prevent brittle fracture. Inform port authorities or coastguard of spill.

Health Data	TLV 1000 ppm <small>(skin contact)</small>	Odour threshold 200 ppm
Effect of liquid	ON EYES Tissue damage due to frost-bite. ON SKIN Tissue damage due to frost-bite. BY SKIN ABSORPTION Not absorbed through skin. BY INGESTION Not pertinent. No hazard in normal industrial use.	Personal protection Protective clothing covering all parts of the body, gloves, boots, goggles or face shield, all insulated against cold temperature attack.
Effect of vapour	ON EYES No hazard in normal industrial use. May be tissue damage due to frost-bite. ON SKIN No hazard in normal industrial use. May be tissue damage due to frost-bite.	WHEN INHALED Acute effect Vapour has narcotic effect. Because of very rapid evaporation rate, there is possibility of total air replacement and danger of asphyxiation. Chronic effect No chronic effect known.

IGC TANKER SAFETY GUIDE (LIQUEFIED GAS) DATA SHEET 125

Methane/LNG

Fire and Explosion Data

Flashpoint -175°C approx.	Explosion Hazards Vapour can form a flammable mixture with air which, if ignited, may release explosive force causing structural damage.
Auto-ignition Temperature 595°C.	
Flammable Limits 5-16% by volume.	

Chemical Data

Formula CH ₄	Chemical Family Hydrocarbon
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Reactivity Data

Water, fresh or salt No dangerous reaction; may freeze to form ice or hydrates.	Other liquids or gases Dangerous reaction possible with chlorine.
Air No reaction.	

Physical Data

Boiling Point at Atmospheric Pressure -161°C.	Coefficient of Cubic Expansion 0.0026 per °C at -165°C.	Enthalpy (KJ/Kg) Liquid -29.3 at -165°C 285.5 at -100°C Vapour 545.1 at -165°C 588.3 at -100°C.
Vapour Pressure Bar (A) See graph in Figure A1.2.	Freezing Point -182°C.	Latent Heat of Vaporisation (KJ/Kg) See graph in Figure A1.2.
Specific Gravity See graph in Figure A1.2.	Relative Vapour Density (KJ/Kg) 0.55.	Electrostatic Generation
	Molecular Weight 16.04Kg/kmole.	

Conditions of Carriage

Normal Carriage Condition Fully refrigerated.	Control of Vapour within Cargo Tank Fully inerted with zero oxygen content.	Vapour Detection Flammable.
Ship Type ZG.	Independent Tank required No.	Gauging Closed or indirect.

Materials of Construction

Unsuitable Mild steel.	Suitable Stainless steel, aluminium, copper, 9% or 36% nickel steel.
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IGC TANKER SAFETY GUIDE (LIQUEFIED GAS) DATA SHEET 126

Notes and special requirements
1 Liquefied natural gas is a hydrocarbon mixture, mainly of methane but with small quantities of ethane, propane, butane and nitrogen. Always obtain shipper's advice, and refer to relevant data sheet for hazards of a specific mixture.

Health effect

- Tissue damage (frost-bite) at contact with liquid or cold vapours
- LNG vapours in concentrations exceeding 1000 ppm (0.1%) have narcotic effect
- Not often mentioned, but LNG in large concentrations is asphyxiant and due to its low boiling temperature may reach such concentrations relatively rapidly
- Luckily it does not have known chronic effects when inhaled



Managing LNG Bunkering through Ship to Ship



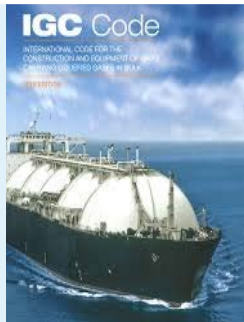
Ship to Ship



Managing LNG Bunkering through Ship to Ship



Bunkerina

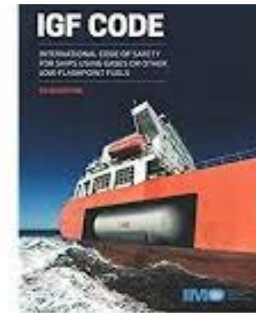


gas as a marine fuel

Bunkering of ships with Liquefied Natural Gas (LNG) competency and assessment guidelines

Training & Competence

version 2.0 PPO4-02



SIGTTO / GTC

- Classification:
- **Tanker for Liquefied Gas**
- Flag Administration

Ship to Ship

Experience and Qualification
Increase in LNG parcel lifts
Locations

SGMF

Classification:
Gas Fuelled ships
Flag Administration

What can go wrong during LNG Bunkering?



Potential failure of ship to ship **mooring lines** and ships break-away



Potential **leakages of QC/DC** or other flange and valves due to vessels relative motion



Excessive **surge pressures** in transfer lines with wrongly calibrated ESD systems (tougher closing time requirements for gas fuel transfer lines)



Danger of **overfilling of tanks** (ships and shore) due to necessity to do quick "turn-around" bunkering ships and refilling own tanks

Design and Construction

- General Safety Standards Outlined By IMO
- Classification Rules
- Industry Standards
- Guidelines

Operationally

- is in general lays beyond of the class scope and is subject to changes basis industry development
- Handling emergencies where it will be advisable to separate ships to minimise overall risk
- Provide better access of third party assistant (fire vessels, tugs, salvage vessels, etc.)

Mitigating Operational Risks through Risk Assessment

□ Assessment of the Location/Area

- Local regulations
- Exposure of transfer location
- Traffic density
- Dispersion trajectory of gas cloud in case of leak, etc.

□ Assessment of STS transfer itself

- Ships compatibility (LNG storage conditions, freeboard, location of connections, mooring system)
- Potential simultaneous operations SIMOPS

□ Developing of standard procedures for base cases



Challenges addressed and managed through Risk Assessment

Freeboard differences

SIMOPS

Manual Connection /
Disconnection

Ship Hazardous zones on
vessels

Person in charge and
responsibilities

Custody Transfer
Operations

Increase Boil off and
Vapour Management

Transfer connections
equipment

Operational envelope
(location, weather, etc.)

PPE and arrangements for
personnel protection

Different Tank Bunkering
Arrangements and
Pressure accumulation
systems

Safety Zones

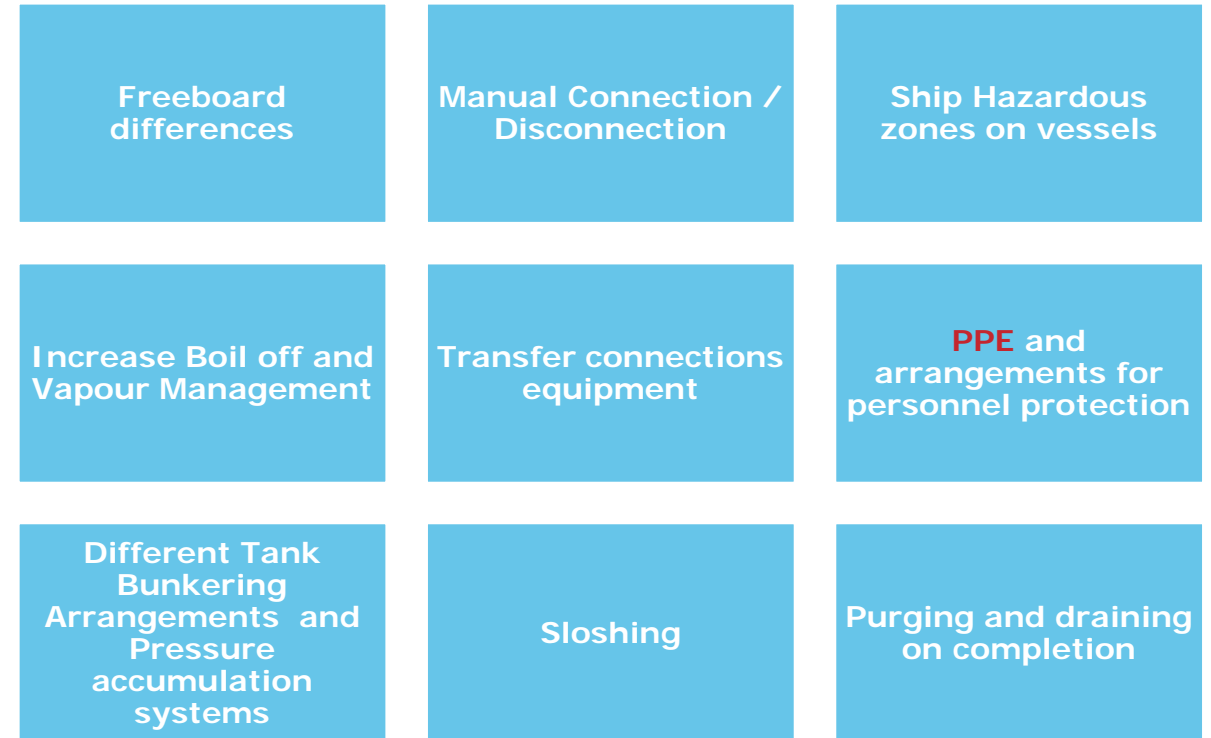
Sloshing

Purging and draining on
completion

Training and experience
differences

DNV GL Classification Rules for Gas Bunker Vessel

- New class notation for ships optimised for gas bunkering operations is introduced - **Gas Bunker**
- The rules for gas bunker vessels are developed by DNV section "LNG Cargo handling and Piping Systems" in the beginning of 2015
- First published in DNV Legacy Rules set (Pt.6 Ch.37) in 2015-07 edition
- Published in merged DNV-GL One Rule Set in October 2015 and entered in force from January 2016 (Pt.6 Ch.5 Sec.14 "Gas Bunker vessels – gas bunker")



DNV GL Classification Rules for Gas Bunker Vessel

Arrangement and system design

- Bunker manifold area
- Cargo tanks filling
- Bunker transfer arrangement
- Emergency release for bunker connection
- Bunker manifold
- Emergency Shut Down (ESD)
- Bunker hoses / Hose handling cranes / Rigid Arms
- Mooring equipment
- Inert gas system/nitrogen supply
- Fire Protection

Part 6 Chapter 5 Section 14

SECTION 14 GAS BUNKER VESSELS - GAS BUNKER

1 General

1.1 Introduction

1.1.1 Objective
The objective of this section is to outline requirements for carriers and barges intended for the transport of liquefied gas with dedicated gas fuel transfer equipment for supply of bunker for gas fuelled ships on regular basis

1.1.2 Scope
This section covers safety of the gas bunker vessel, its gas bunker related equipment and installations on-board. It outlines requirements for design, construction and required operational procedures with regard to connection and disconnection of transfer arrangements, bunker transfer and vapour return

1.1.3 Application
This section applies to the vessels with the ship type notation **Tanker for Liquefied Gas (Tanker for C)** built in compliance with Pt.5 Ch.7 and barges specifically intended for carriage of liquefied gas built in compliance with Pt.5 Ch.11
This section provides requirements for features that are relevant for a bunkering vessel due to its particular operations and which are not covered by Pt.5 Ch.7. Arrangement and equipment of vessels operating in restricted areas or vessels for inland waterways not in compliance with Pt.5 Ch.7 and Pt.5 Ch.11 will be assessed on a case to case basis

1.1.4 Class notation
A ship complying with relevant parts of this section may be given the additional class notation **Gas bunker**, with qualifiers as given in [1.1.5] below may be added to the notation.

1.1.5 Special features

1.1.5.1 A ship equipped for handling of excess vapour return from the receiving ship in compliance with [7.1.1] may have the qualifier **VR x** (vapour recovery with capacity x kW) added to the notation.

1.1.5.2 A ship equipped for enhanced positioning by means of controllable thrust vectors (fixed or direction controlled thrusters) in compliance with [7.1.2] may have qualifier **EPC** (enhanced positioning control) added to the class notation.

1.1.5.3 A ship equipped with enhanced transfer control system in compliance with [7.1.3] may have the qualifier **TC** added to the class notation.

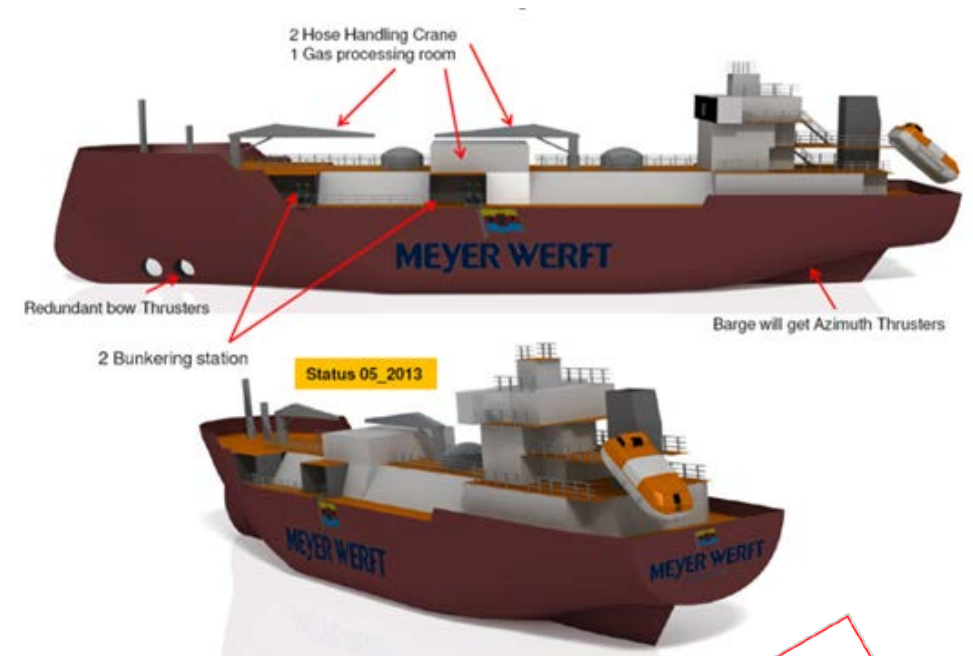
Guidance note:
An example of a class notation for a bunkering vessel with qualifiers for vapour return and for enhanced transfer control can be as follows: **1A Tanker for liquefied gas (-163°C, 500 kg/m³, 0.7 bar) Gas bunker (VR 500, TC)**.
---end-of-guidance-note---

1.1.6 Terms and definitions
Except where expressly provided otherwise, the following definitions apply to this section:

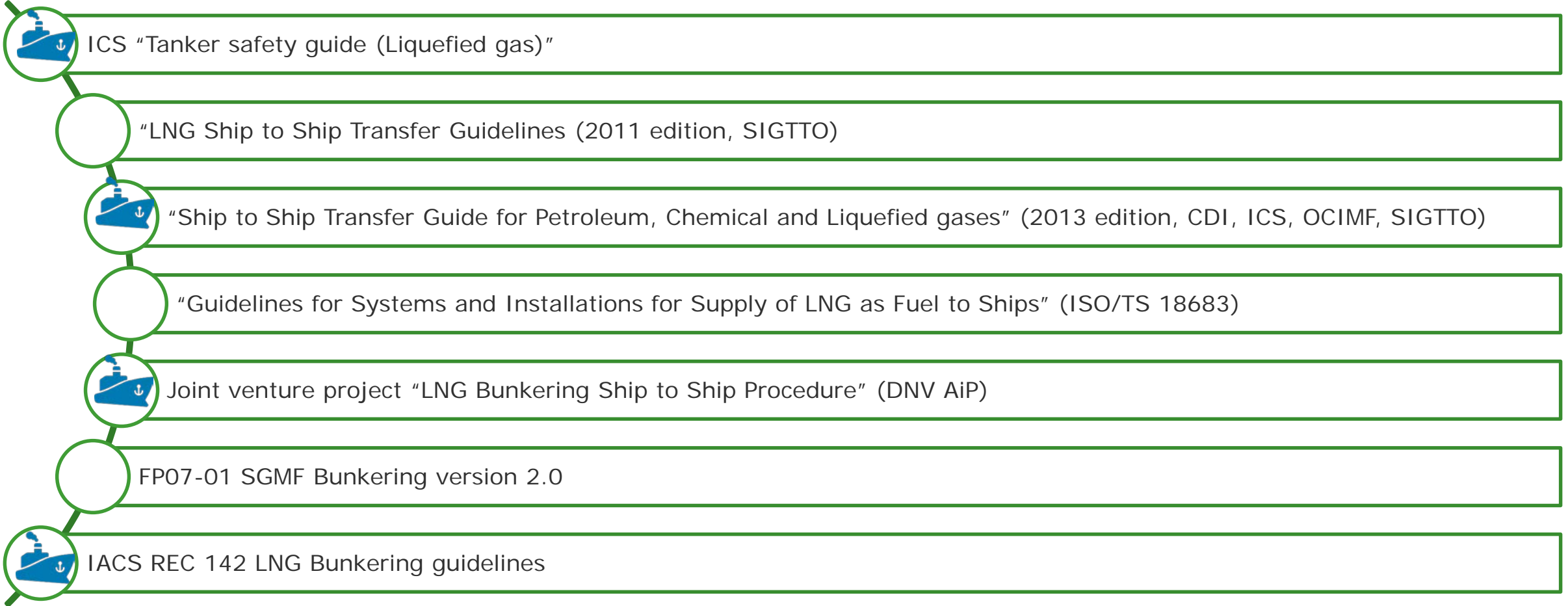
Rules for classification: Ships — DNVGL-RU-SHIP-Pt6Ch5, Edition January 2016 Page 184
Equipment and design features

Gas Bunker vessel notation – additional safety features

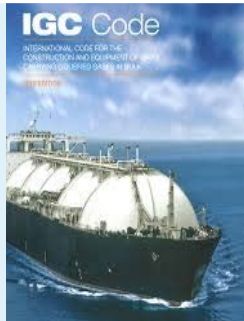
- Extended gas detection system coverage
- Arrangement of cross over stations
- Dry break away release systems for bunker transfer lines (ERS/ERC)
- Quick connect-quick disconnect coupling (QC/DC)
- Static electricity and galvanic currents hazard (isolating flange)
- Provisions for inerting of the transfer lines prior to disconnection
- Emergency un-mooring arrangement
- Fire safety (GCU, boilers, engine exhausts)
- Communication equipment and its operation in low power mode
- Increased capability to handle BOG generated onboard and on received vessel ("vapour recovery")
- Enhanced position control (for mooring and unmooring)
- Enhanced transfer control and automation of transfer



Existing Guidelines

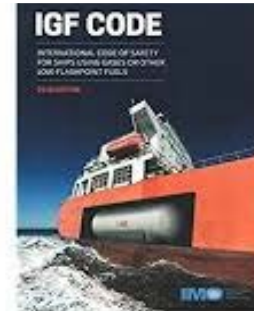


Managing LNG Bunkering through Ship to Ship



Bunkering

DNV·GL



SIGTTO

- Classification:
- **Tanker for Liquefied Gas**
- Flag Administration

SGMF, IACS

- DNV GL Classification:
- **Gas Bunker**

SGMF

- Classification:
- **Gas Fuelled ships**
 - Flag Administration

Thank you for your attention!

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