LNG Fuel Systems:
Certification & Approval

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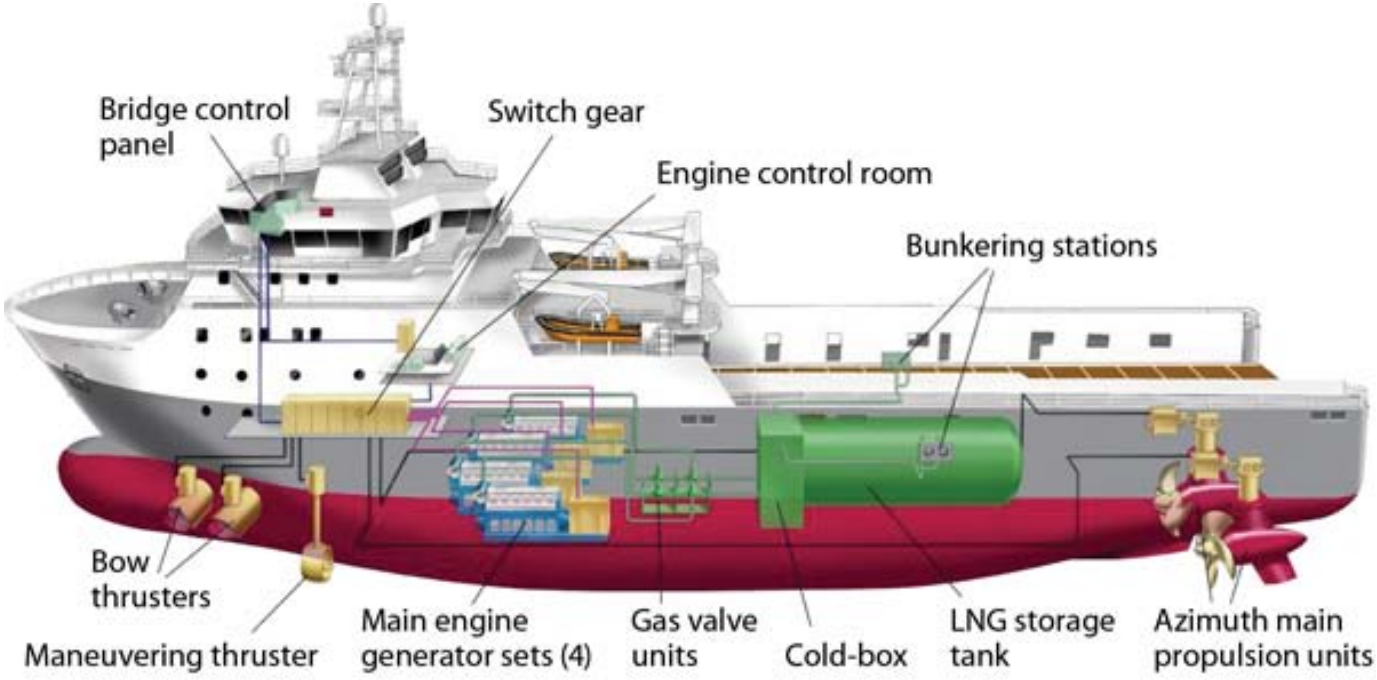
Cleveland
24 February 2012

Outline

- Drivers for fuel switch
- Regulatory framework
- Key design issues and ABS Guide
- Further considerations



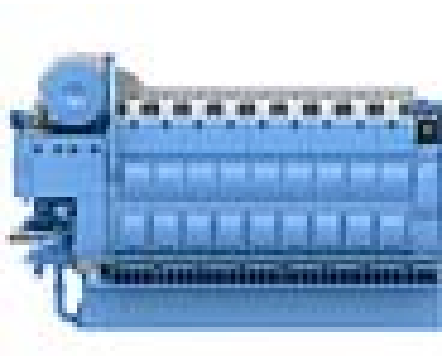
Why LNG as Fuel?

- Governing factors for selection of future fuel and power plants
  - MARPOL 0.1% sulfur fuel in ECA (from 1 Jan 2015)
  - MARPOL Tier III level NOx emission (from 1 Jan 2016)
  - EPA Tier 3 and Tier 4 (2014 and 2016)
  - Lowest possible EEDI (new MARPOL energy efficiency requirement)
  - Life cycle operating costs
- Options
  - HFO power plants with SOx scrubber
  - LNG fueled propulsion and auxiliary systems
  - Distillate fuel

Background & Key Drivers

- In recent years, dual fuel engine technology has been introduced to the marine market, primarily through medium-speed engine applications to LNG carriers
- Spark ignition gas engines have also been installed on a number of ferry and patrol craft vessels primarily operating in Norway
- No SOx emission
- Otto cycle DF and single fuel gas engines meet IMO Tier III NOx
- 24% NOx reduction for direct injection slow speed

Mitsubishi GS16R-MPTK, Source: Diesel Power

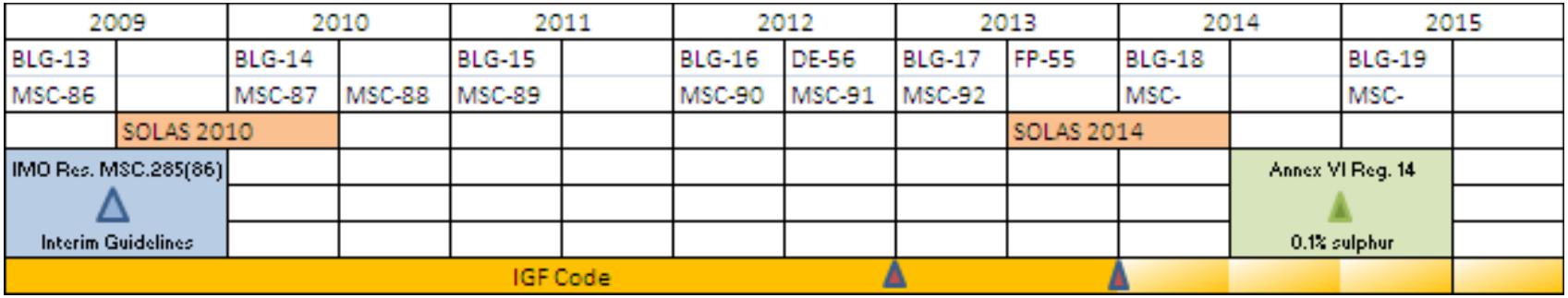


Rolls Royce Bergen C26:33, Source: Rolls Royce

Wartsila 50DF, Source: Wartsila

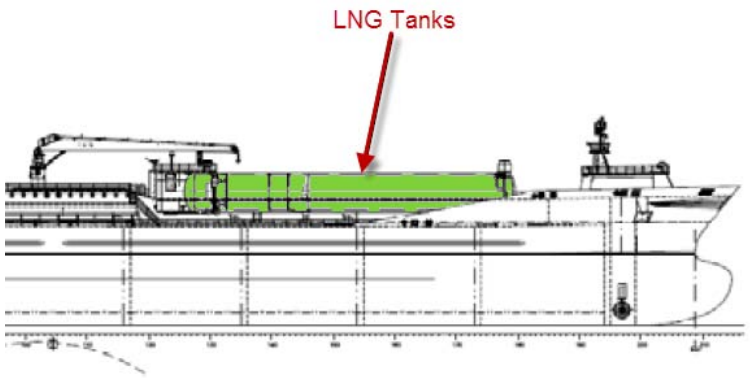
Regulatory Framework

- IMO Resolution MSC.285(86) – Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships – adopted 1 June 2009 – voluntary
- IMO International Code for Safety for Ships using Gases or Other Low Flashpoint Fuels (IGF Code) – originally scheduled for completion in 2012, BLG 15 in Feb 2011 extended that to 2014
- Needs to be mandated by SOLAS
- Needs to be reviewed by other IMO bodies, DE, FP, SLF, STW



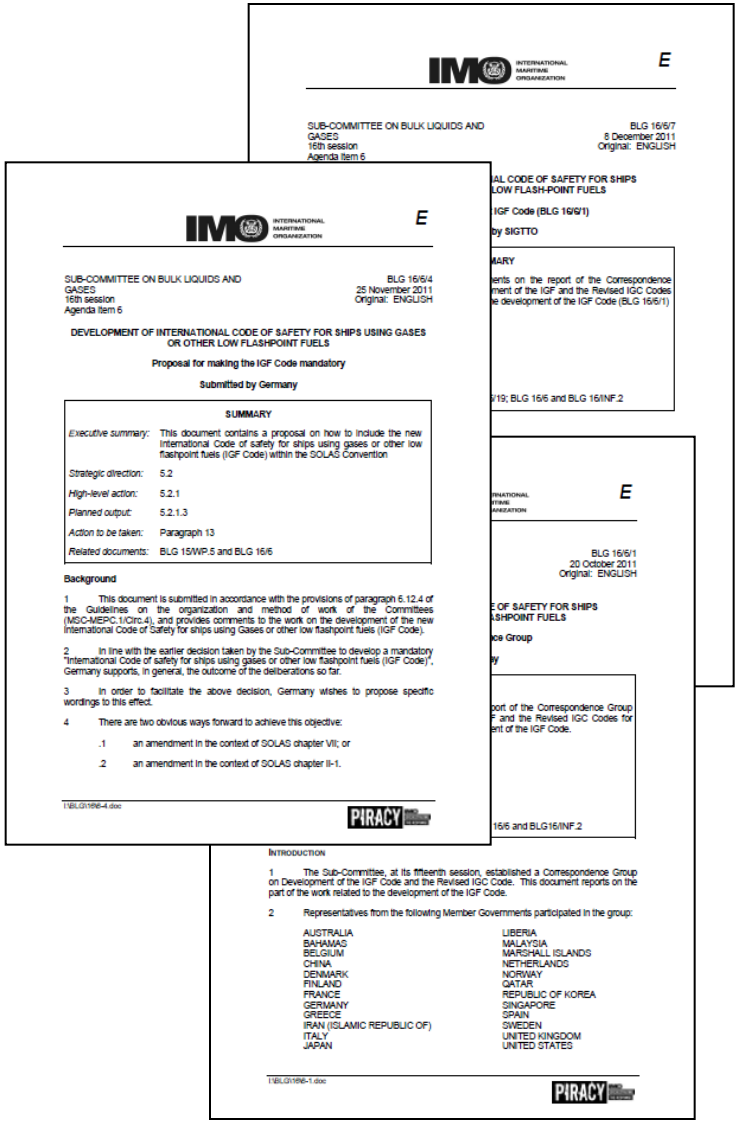
Regulatory Framework

- BLG 15 directed harmonization of IGC and IGF Codes, where possible
- Paper 16/6/4 from Germany indicates a preference to delete Chapter 16 of the IGC Code and to be replaced with the IGF Code
- Norway have submitted 16/7/2 on the IGC Code suggesting changes to the requirements for gas detection, ventilation and actions in DF machinery spaces
- Is the 2014 deadline possible?



Regulatory Framework

- BLG 16 at IMO 30 Jan – 3 Feb 2012
- SIGTTO submitted BLG 16/6/7 on IGF Code with following concerns
  - Location of bunker tanks
  - ESD protected machinery spaces
  - Use of gases/fuels other than methane
  - Bunkering
  - Training
- Germany has submitted 16/6/4 proposing to make IGF Code mandatory by amendment of SOLAS, including location of fuels with flashpoint less than 60°C



IMO E

SUB-COMMITTEE ON BULK LIQUIDS AND GASES
16th session
Agenda item 6

BLG 16/6/4
25 November 2011
Original: ENGLISH

DEVELOPMENT OF INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW FLASHPOINT FUELS

Proposal for making the IGF Code mandatory

Submitted by Germany

SUMMARY

Executive summary: This document contains a proposal on how to include the new International Code of safety for ships using gases or other low flashpoint fuels (IGF Code) within the SOLAS Convention

Strategic direction: 5.2

High-level action: 5.2.1

Planned output: 5.2.1.3

Action to be taken: Paragraph 13

Related documents: BLG 15/WP.5 and BLG 16/6

Background

1 This document is submitted in accordance with the provisions of paragraph 6.12.4 of the Guidelines on the organization and method of work of the Committees (MSC-MEPC.1/Circ.4), and provides comments to the work on the development of the new International Code of Safety for ships using Gases or other low flashpoint fuels (IGF Code).

2 In line with the earlier decision taken by the Sub-Committee to develop a mandatory "International Code of safety for ships using gases or other low flashpoint fuels (IGF Code)", Germany supports, in general, the outcome of the deliberations so far.

3 In order to facilitate the above decision, Germany wishes to propose specific wordings to this effect.

4 There are two obvious ways forward to achieve this objective:

.1 an amendment in the context of SOLAS chapter VII; or

.2 an amendment in the context of SOLAS chapter II-1.

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PIRACY

IMO E

SUB-COMMITTEE ON BULK LIQUIDS AND GASES
16th session
Agenda item 6

BLG 16/6/7
8 December 2011
Original: ENGLISH

IGF Code (BLG 16/6/1)

by SIGTTO

BLG 16/5/1
20 October 2011
Original: ENGLISH

INTRODUCTION

1 The Sub-Committee, at its fifteenth session, established a Correspondence Group on Development of the IGF Code and the Revised IGC Code. This document reports on the part of the work related to the development of the IGF Code.

2 Representatives from the following Member Governments participated in the group:

AUSTRALIA, BAHAMAS, BELGIUM, CHINA, DENMARK, FINLAND, FRANCE, GERMANY, GREECE, IRAN (ISLAMIC REPUBLIC OF), ITALY, JAPAN, LIBERIA, MALAYSIA, MARSHALL ISLANDS, NETHERLANDS, NORWAY, QATAR, REPUBLIC OF KOREA, SINGAPORE, SPAIN, SWEDEN, UNITED KINGDOM, UNITED STATES

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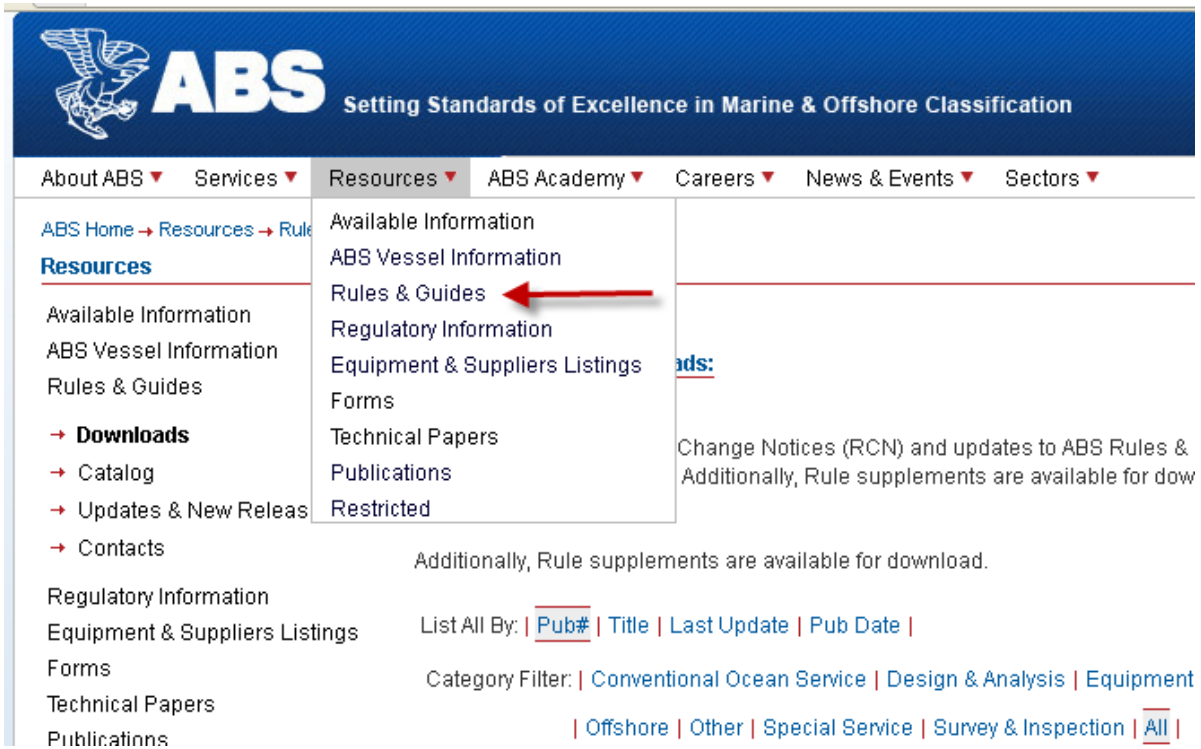
PIRACY

ABS Rules

- ABS Guide for Propulsion and Auxiliary Systems for Gas Fueled Ships
- Free download available – Pub #181
- Under Alternative Compliance Program (ACP), US flag ships are built to ABS Rules with USCG supplemental requirements



Guide for Propulsion & Auxiliary Systems for Gas Fueled Ships

- The ABS Guide is arranged with the following sections
  - Section 1 – General
  - Section 2 – Ship Arrangements and System Design
  - Section 3 – Gas Fuel Storage
  - Section 4 – Fuel Bunkering System
  - Section 5 – Fuel Gas Supply System
  - Section 6 – Re-liquefaction Unit
  - Section 7 – Gas Combustion Units/Thermal Oxidizers
  - Section 8 – Dual Fuel Diesel and Single Gas Fuel Engines
  - Section 9 – Dual Fuel Gas Turbine Propulsion System
  - Section 10 – Surveys After Construction and Maintenance of Class

Key Design Issues

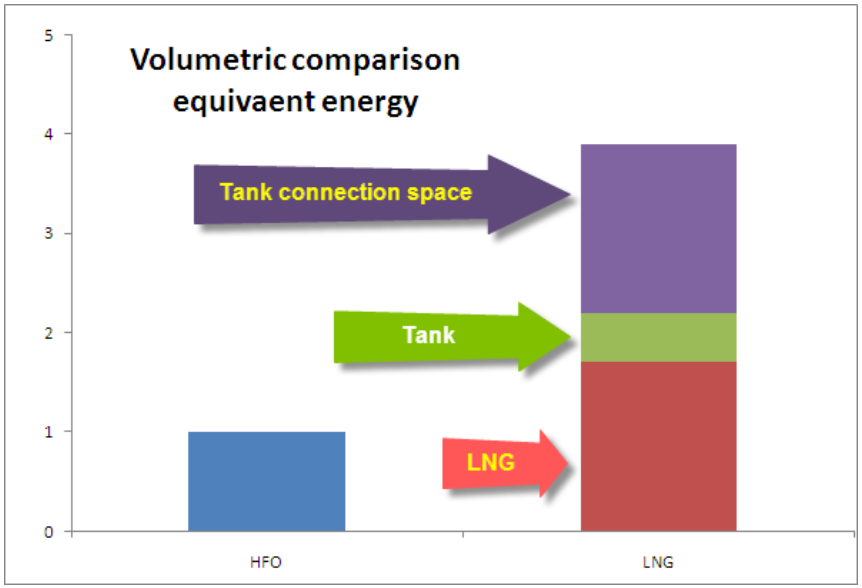
- LNG fuel tank capacity and type
- LNG fuel tank location
- Leak mitigation in tank hold space
- Fuel gas pipe arrangements
- Bunker station
- BOG management
- Continuity of power – fault tolerant design

Fuel Tank Capacity

Gross Calorific Values
- **HFO 41.2 MJ/Kg**
- **LNG 55.5 MJ/Kg**

and

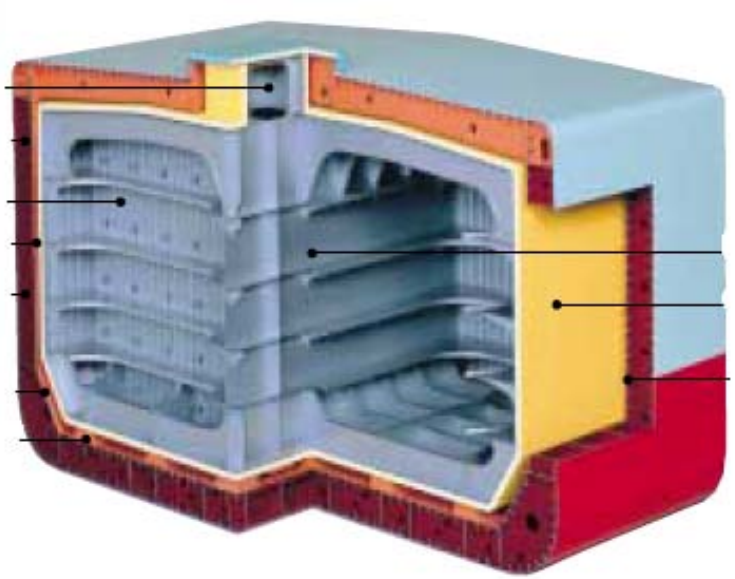
Density
- **HFO 991 Kg/m3**
- **LNG 464 Kg/m^3**



- For the same energy input, LNG need 1.6 times more storage volume (m^3)
- “Type C” tanks with access around tank, it could be 3 to 4 times
- Tank type is a function of required capacity

Fuel Tank Requirements: Meet IGC

- Independent tanks



“Type B” Tank

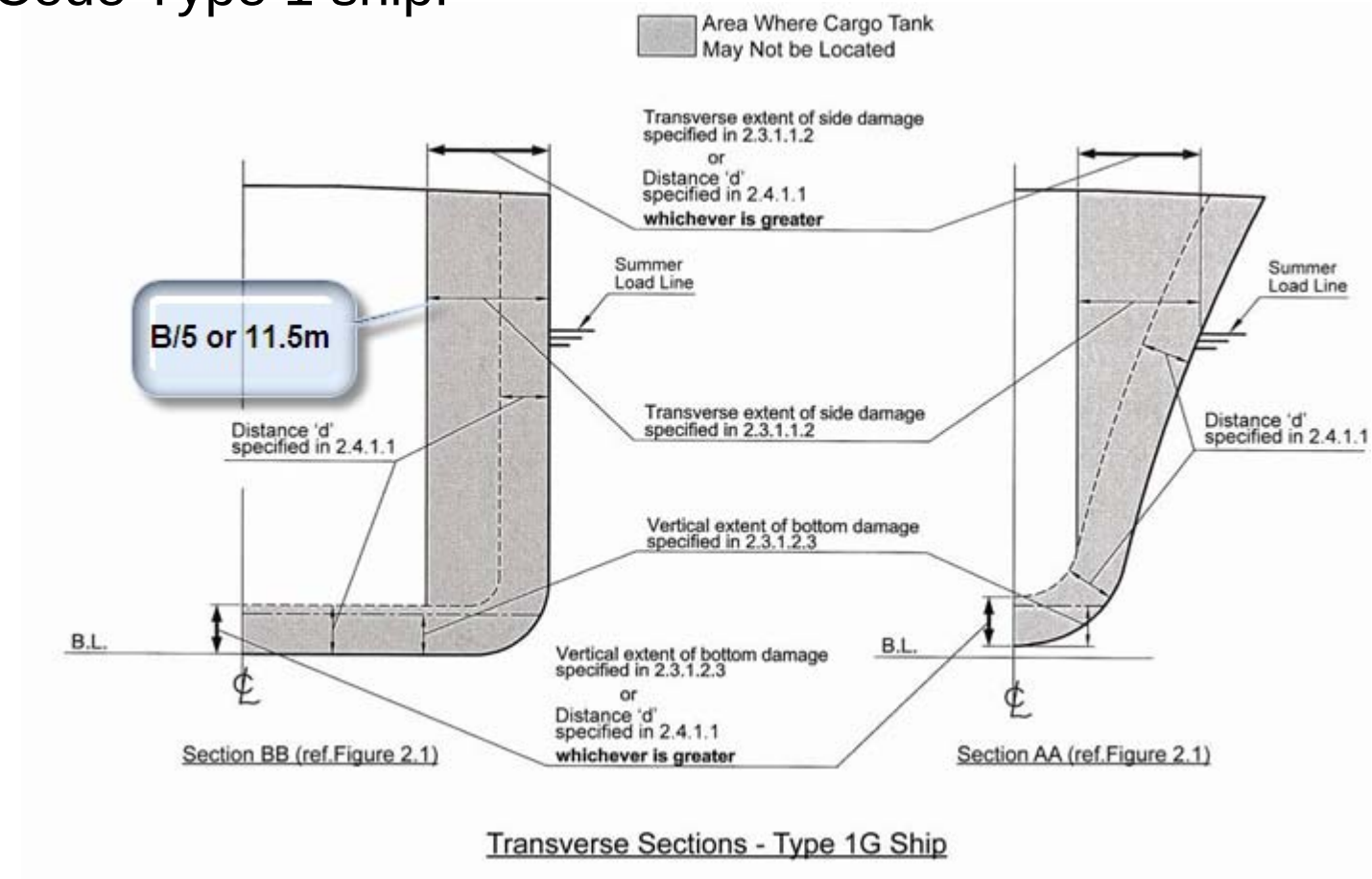
“Type C” Tank

Location of Tanks

- Risk of sustaining mechanical damages
- Risk of fire in adjacent space causing over pressure
- Risk of leaked flammable product causing fire and explosion
- Risk of leaked cryogenic fluid leading to loss of structural integrity

Fuel Tank Requirements: Type & Locations

- Normal fuel storage tank location B/5 from side shell as per IGC Code Type 1 ship:



Transverse Sections - Type 1G Ship

Fuel Tank Requirements: Type & Locations

- For ships other than passenger vessels the revised IGC Code tank location criteria may be applied

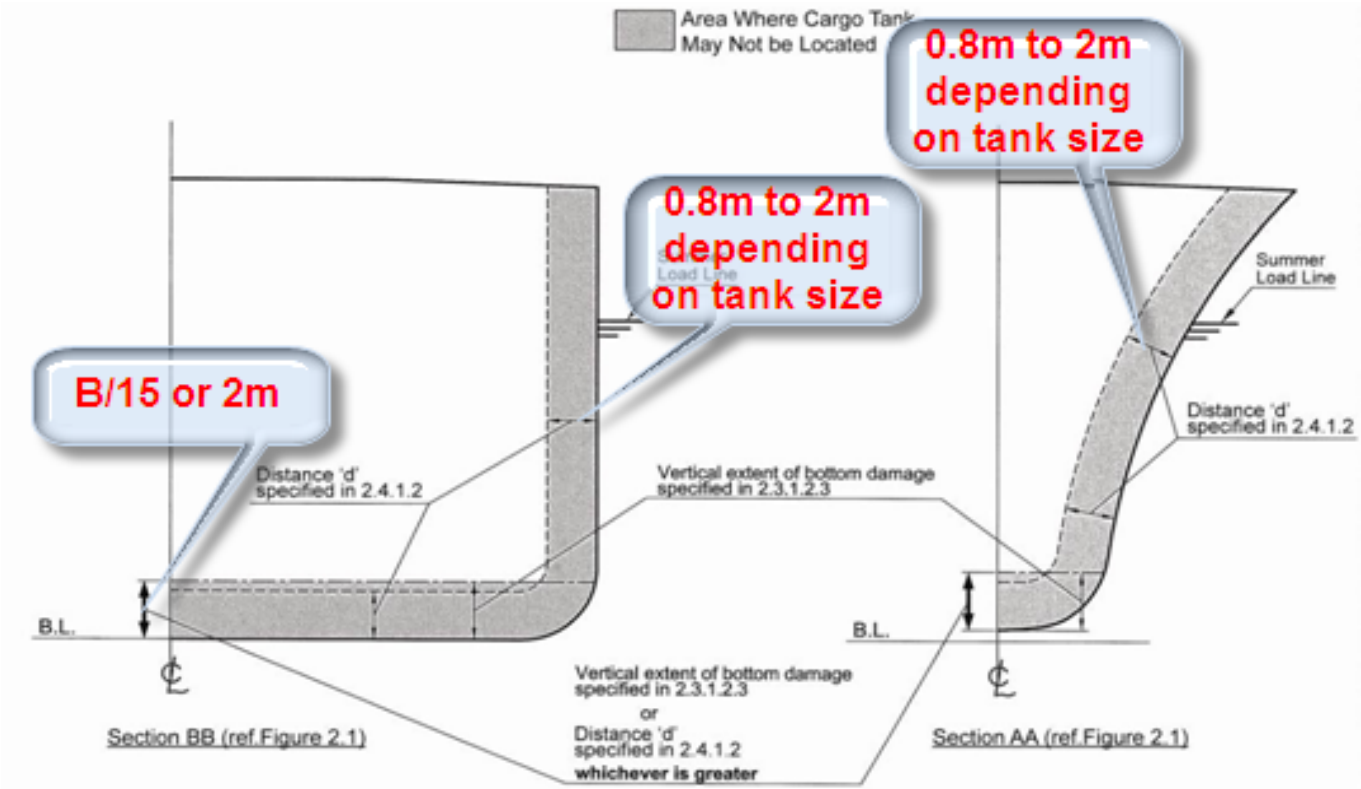
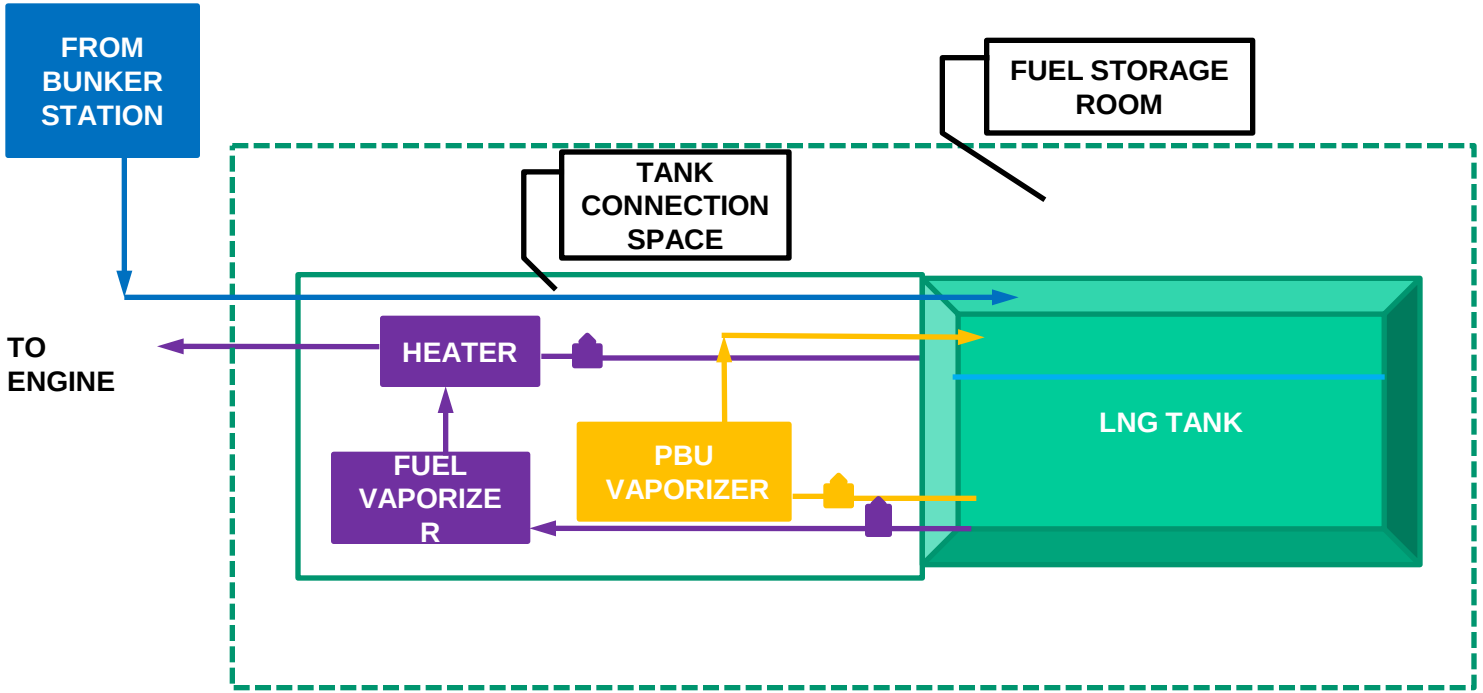


Figure 2.3 - *Cargo tank location requirements*

Leak Mitigation: Tank Spaces

- Fuel gas conditioning and preparation to be undertaken in a space outside of the engine room
- For smaller vessels using “Type C” fuel storage tanks, this is typically undertaken in the ‘tank connection space’ or tank room



Hazardous Area Classification

- Hazardous areas IEC 60092-502

Table 1 – Spaces separated by one gastight boundary from the zones mentioned in the column

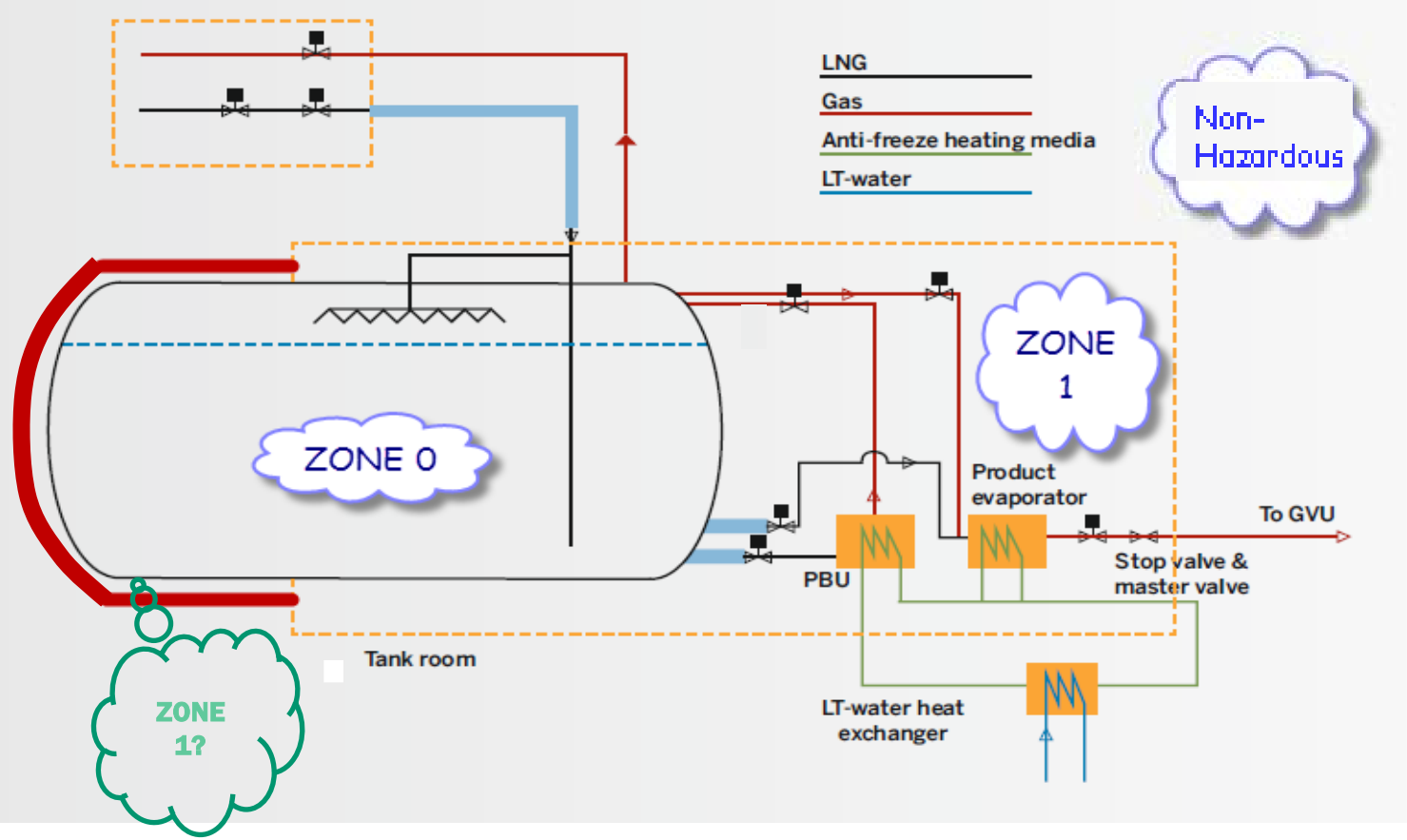
	With source of release [1]		Without source of release	
	With ventilation [2]	Without ventilation	With ventilation [2]	Without ventilation
Zone 0	Zone 1 for example cargo pump room (see annex A, clause A.1)	Zone 0 for example cofferdams with cargo pipe flanges (see annex A, clause A.4)	Zone 2 for example ballast pump rooms adjacent to cargo tanks (see annex A, clause A.7)	Zone 1 for example cofferdam, void space (see annex A, clause A.10)
Zone 1	zone 2 for example rooms with cargo pipe flanges, (see annex A, clause A.2)	zone 1 for example rooms with cargo pipe flanges (see annex A, clause A.5)	Non-hazardous areas (see annex A clause A.8)	Non-hazardous areas (see annex A, clause A.11)
Zone 2	Zone 2 for example rooms with cargo pipe flanges (see annex A, clause A.3)	Zone 1 for example rooms with cargo pipe flanges (see annex A, clause A.6)	Non-hazardous areas (see annex A, clause A.9)	Non-hazardous areas (see annex A, clause A.12)

[1] The following are examples of some sources of release:
– venting and other openings to cargo tanks, slop tanks and cargo piping;
– seals of cargo pumps, cargo compressors and process equipment;
– seals of valves and flanges and other connections and pipe fittings.

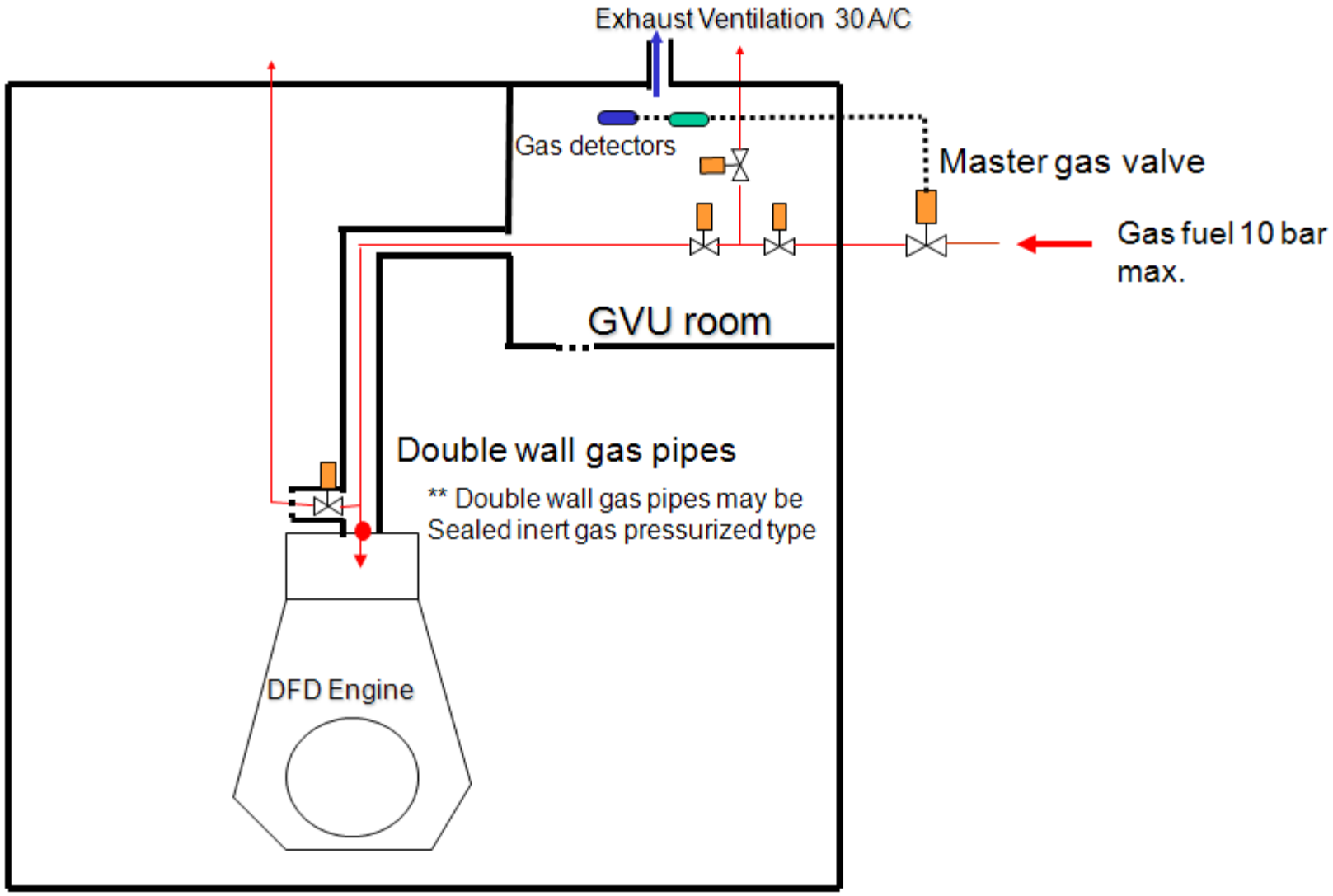
[2] Where the area classification of a space is dependent upon its ventilation, the arrangements shall be such that discontinuities in ventilation are not expected to occur for long periods and there is no accumulation of gas or vapour in the vicinity of any source of release, or where electrical equipment is installed.

Hazardous Area Classification

- Vacuum insulated “Type C” arrangements



Gas Safe Machinery Space



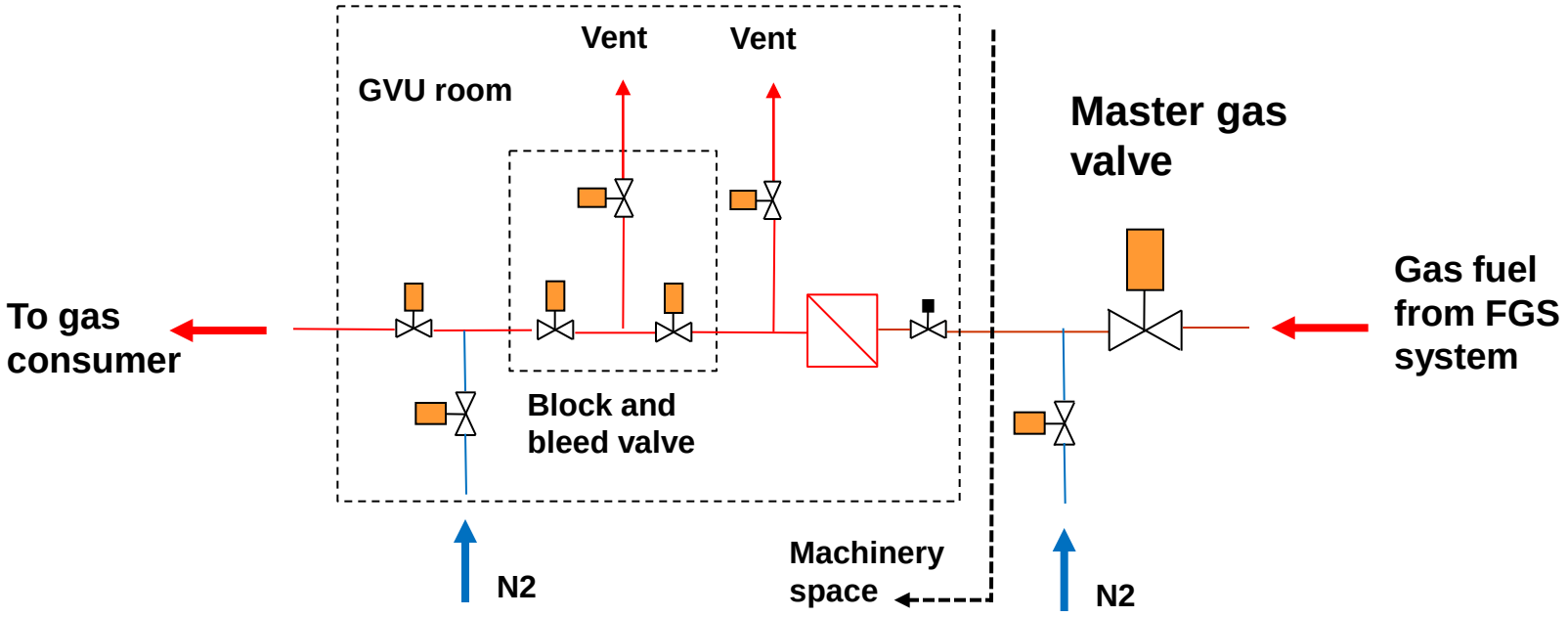
GVU Room Requirements

- ABS Gas Fueled Ships Guide GVU room requirements
  - 30 air changes/hour
  - 2 permanent continuous
  - Gas detectors with alarms
  - Electrical equipment should be certified as safe
  - Self-closing gastight door with alarm
  - Explosion mitigation
  - Access arranged in consideration of hazardous area ratings, generally by air lock

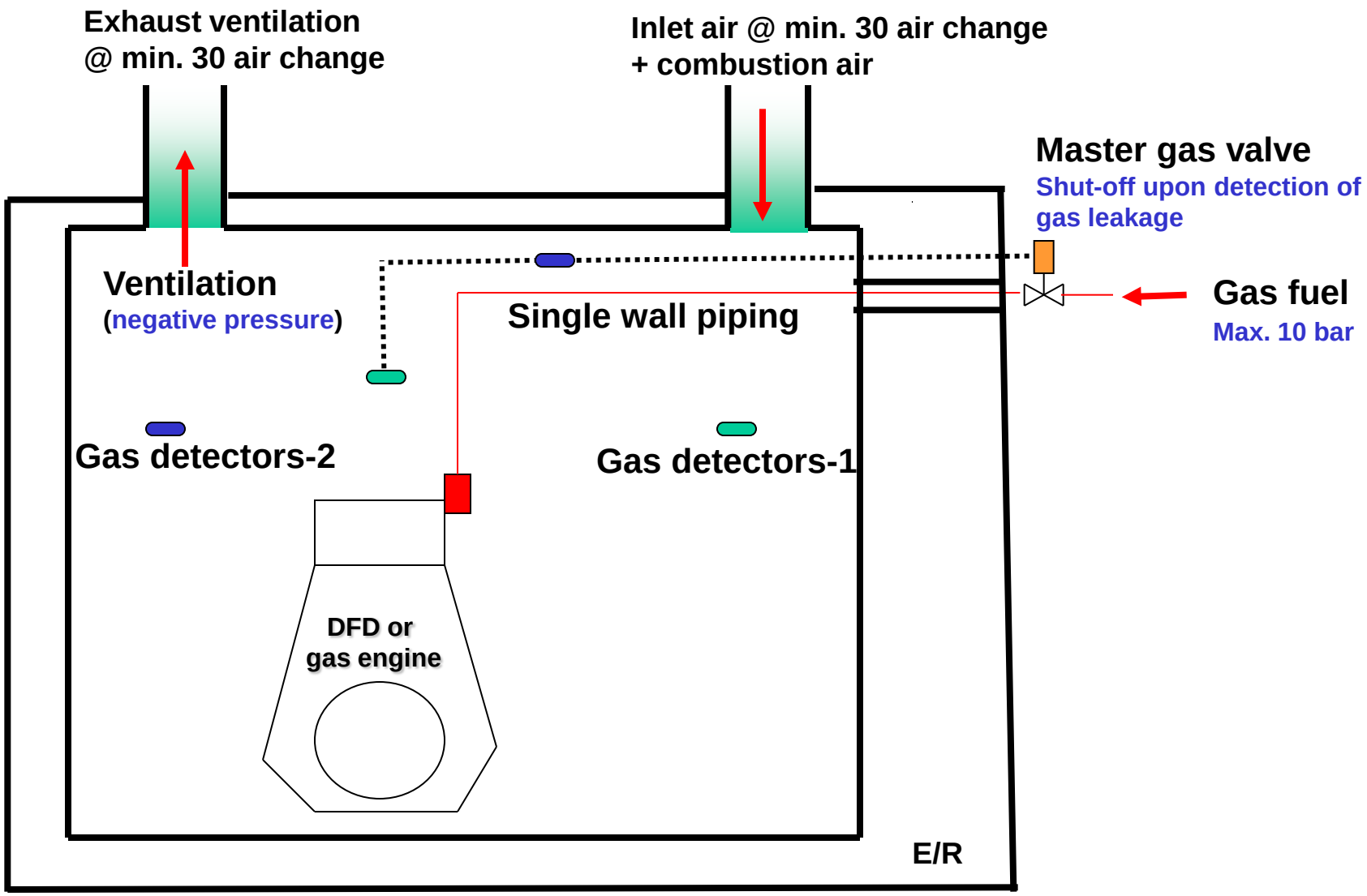
Source: Wartsila

Fuel Preparation & Supply

- Master gas valve to be located outside machinery space
- Block and bleed valve required for each consumer
- Venting and purging facility



Single Wall Piping: ESD Protected E/R

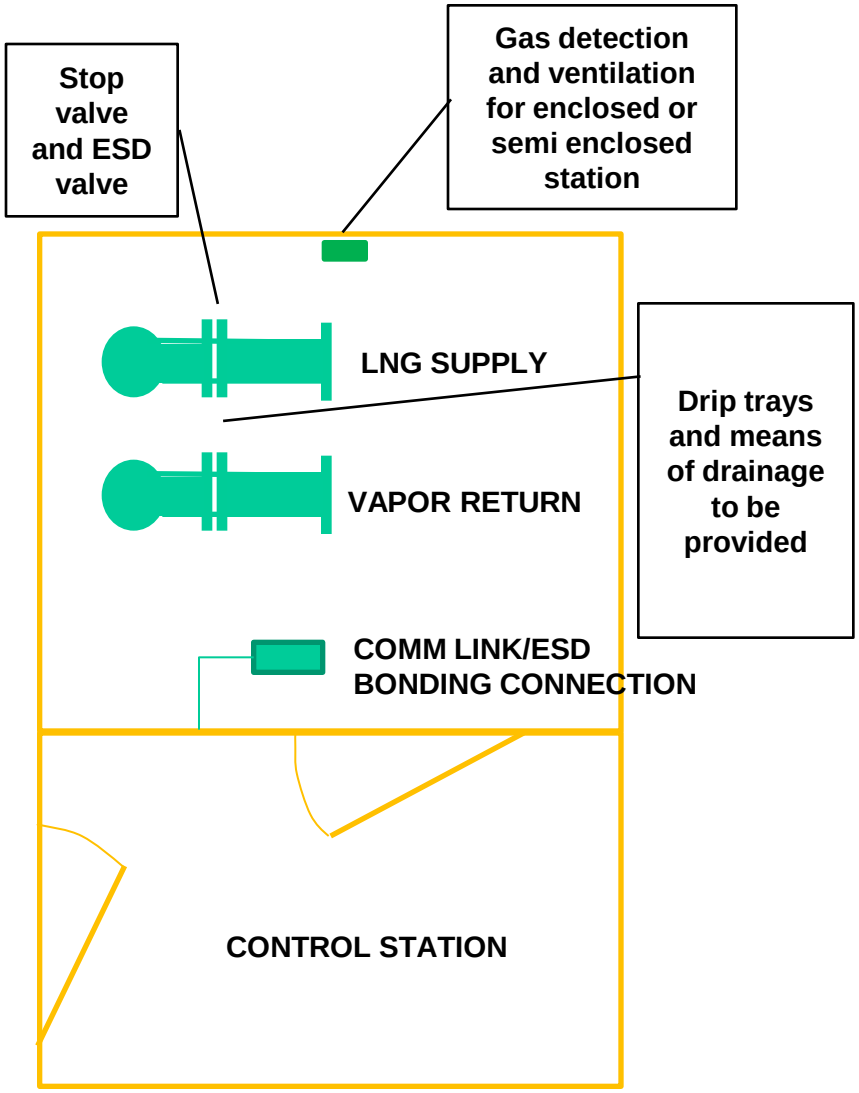


Single Wall Piping: ESD Protected E/R

- Low pressure gas systems (<10bar) only
- Two separate machinery spaces are to be provided
- Spaces to contain only engines and minimum necessary equipment
- Alarm upon gas detection at 20% LEL
- Upon gas detection (40% LEL), shut-off gas supply and shutdown the machinery
- Electrical equipment that needs to be operational is to be of Zone-0 certified safe type (Ex-ia only) IEC 92-502
- Ventilation fans redundancy (100% fan capability maintained)
- Access to the spaces through double self-closing doors, or single self-closing door with left-open alarm
- Two independent gas monitoring systems. Locations of gas detectors to be verified by smoke tests or gas dispersion analysis.

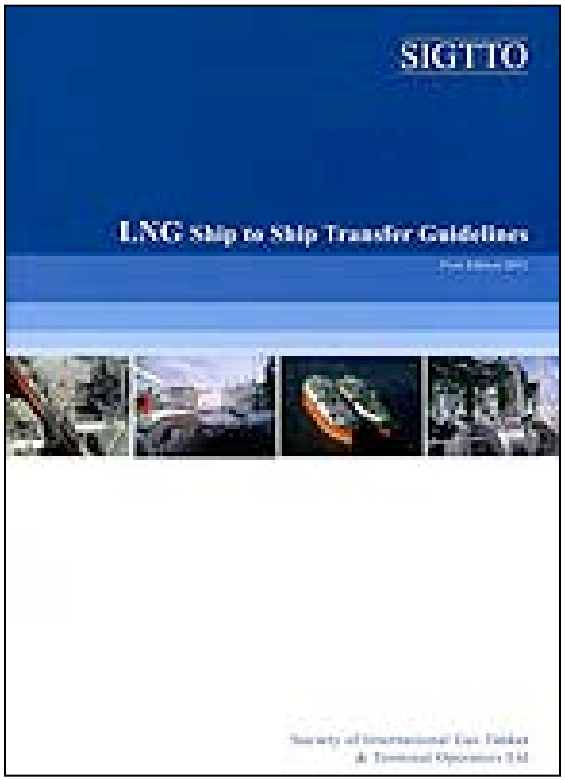
Bunker Station Requirements

- No gas is to be discharged to air during bunkering operations
- Key bunker station requirements
  - Sufficient natural ventilation
  - Physical separation and structural protection
  - Stainless steel drip trays
  - Class A-60 protection
  - Remote control and monitoring
  - Manual and remote ESD valves
  - Draining/purging/inerting provision
  - Ventilation and gas detection of bunkering lines



Bunker Station Requirements

- ABS Guide Section 4 “Fuel Bunkering System”
- The Guidelines for systems and installations for supply of LNG as fuel to ships is under development under ISO TC67 WG10
- Target is to “…standardize the interface between the ship and the fuel supply facilities, to ensure that a LNG fueled ship can refuel in any port with LNG fuel supply facilities…”
- SIGTTO has published Ship to Ship Transfer Guidelines



Ship Arrangements

- Gas fuel storage tanks can be located on deck or in enclosed spaces
- Requirements for tank connection spaces are given which are typically to be applied to smaller vessels with “Type C” LNG fuel tanks where the tank connection space incorporates vaporizers, valves, etc., forming part of the fuel gas supply system
- Engine block and bleed and regulating valves typically located in separate GVU room

Source: TGE

Safe Utilization or Disposal of NBO

- Means of pressure and temperature control must be available at all times even when in port or maneuvering
- System is required to safely handle all natural boil-off under upper ambient conditions
- Means may be
  - Refrigeration and re-liquefaction
  - Pressure accumulation
    - "…maintain tank pressure below MARVS and not to become liquid full for a period of 15 days…"
  - Burning gas for propulsion power and steam dump
  - Gas combustion unit

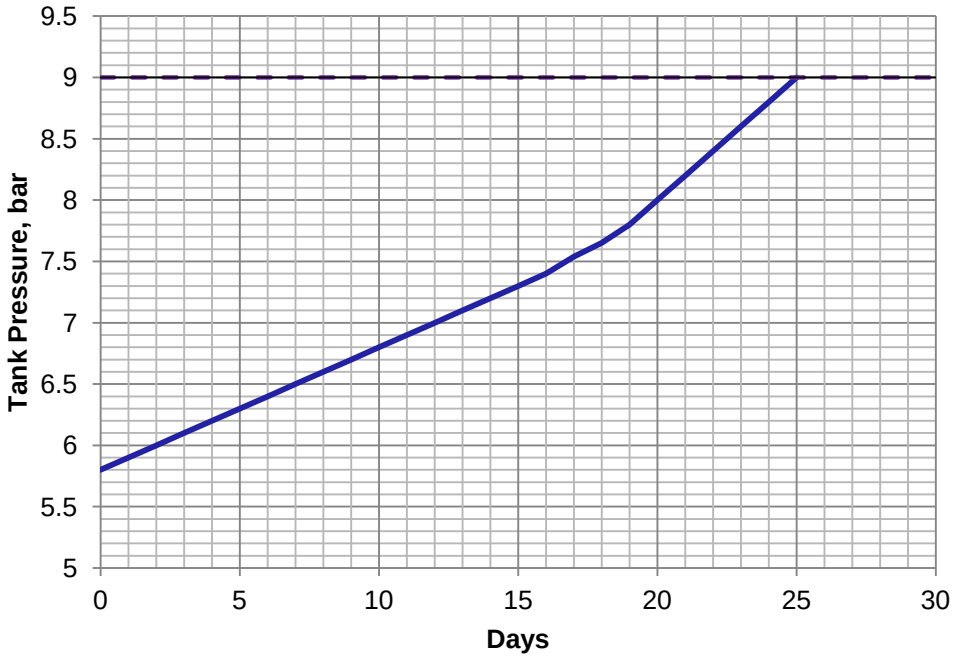


Table 2: Certification of Gas Fuel Storage Tanks & Gas Fuel Storage Rooms

TABLE 2
Certification of Gas Fuel Storage Tanks and Gas Fuel Storage Rooms

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable.

Code	*Explanation*
MD	*Manufacturer's Documentation* – Manufacturer should supply documentation as evidence that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.).
DR	*Design Review* – Design review required.
MT	*Material Testing* – Material testing is to be witnessed by the Surveyor.
MS	*Manufacture Survey* – Product is to be surveyed during fabrication stages by the Surveyor.
FS	*Final Survey* – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

Equipment	*MD*	*DR*	*MT*	*MS*	*FS*
LNG/CNG tanks		X	X	X	X
LNG pumps		X			X
Pump motors (rated at 100 kW and over)		X			X
Main tank valve and associated piping		X (1)	X	X	X
Pressure relief valves and associated piping		X (1)	X	X	X
Fuel gas piping system in tank connection space and gas fuel storage room, as applicable		X	X	X	X
Fuel gas piping ventilation system		X (1)			
Ventilation system and fire dampers in tank connection space and gas fuel storage room, as applicable		X			X
Hold space inert gas system		X			X
Gas storage pressure vessels (2)					
Tank monitoring system		X			X
Fire detection system		X			X
Fire extinguishing system		X			X
Gas detection system		X			X
Automatic shutdown system		X			X

Notes:

1 Design verification only.

2 See Appendix 1, Table 1 of this Guide.

Table 3: Certification of Fuel Gas Supply Systems

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Equipment [1]	*MD*	*DR*	*MT*	*MS*	*FS*
BOG compressors		X	X		X
LNG pumps		X	X		X
Pump and compressor motors (rated at 100 kW and over)		X			X
Condensers [2]		X	X		X
Vaporizers/Heaters [2]		X		X	X
Heat exchangers [2]		X		X	X
Cryogenic valves and associated piping		X[3]	X	X	X
Fuel gas supply piping		X	X	X	X
Fuel gas piping ventilation system		X[3]			
Pump room, compressor room, fuel preparation room ventilation system		X			X
Control system		X			X
Fire detection system		X			X
Fire extinguishing system		X			X
Gas detection systems		X			X
Automatic shutdown and safety system		X			X

Notes:

1 As applicable

2 See Appendix 1, Table 1 of this Guide.

3 Design verification only

Harvey Gulf/ Trinity Offshore/ Wartsila/ STX/ ABS

(4) 92m L x 19.5m B x 7m D, dual fuel PSVs

✠ A1 Offshore Support Vessel , FFV Class 1, ✠ AMS, ✠ ACCU GFS (Dual Fuel Diesel), NBLES, POT ✠ DPS-2, ENVIRO+, UWILD GP

Further Considerations

- Availability of LNG fueling terminals
- Sufficient storage space
- LNG tank under accommodation
- Crew training

Benefits of Choosing ABS

- Early design stage evaluations
- Joint development projects
- Advice on Regulatory issues
- Training courses for crews

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