Economic Commission for Europe

Inland Transport Committee

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Working Party on the Transport of Dangerous Goods

Joint Meeting of Experts on the Regulations annexed to the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) (ADN Safety Committee)

Twenty-fourth session
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Item 4 (e) of the provisional agenda
Implementation of ADN:
Matters related to classification societies

Rules on the carriage of liquefied natural gas (LNG)

Transmitted by Bureau Veritas

At the 23rd session of the ADN Safety Committee, the Classification Societies were asked to submit their Rules for the Transport of LNG (see ECE/TRANS/WP.15/AC.2/48, para. 53).

The current version of the Bureau Veritas Rules for Transport of LNG can be found at the following link:

http://www.veristar.com/content/static/veristarinfo/images/5150.13.RSS_PartD_Ch08-12_2013-01.pdf

and attcahed below :

Part D
Service Notations

Chapter 9
LIQUEFIED GAS CARRIERS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Ships complying with the requirements of this Chapter are eligible for the assignment of the service notation **liquefied gas carrier**, in accordance with Pt A, Ch 1, Sec 2, [4.4.5].

1.1.2 Ships which are intended for the carriage of liquefied gases are to comply with the requirements of the latest version of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), as amended.

1.1.3 These Rules and the IGC Code refer to ships carrying products which are listed in the table in Chapter 19 of the IGC Code and in Ch 9, Sec 19.

1.1.4 These Rules and the IGC Code include requirements for the carriage of cargo in containment systems incorporating integral, membrane or independent tank types as detailed in Chapter 4 of the IGC Code and in Ch 9, Sec 4.

1.1.5 In general, this Chapter applies to cargo containment and handling systems and to the interfaces between these systems and the remainder of the ship, which is to comply with the applicable requirements of Part B and Part C.

1.2 IGC Code requirements and the Society's Rules

1.2.1 General

a) For ships having the service notation **liquefied gas carrier**, the IGC Code requirements are to be considered as rule requirements, unless otherwise specified, and with the exception indicated in [1.2.2].

b) The rule requirements of this Chapter include:

- additional requirements to the IGC Code,
- Society's interpretations of the IGC Code.

c) The requirements of this Chapter are cross referenced to the applicable Chapters, Sections or paragraphs of the IGC Code, as appropriate, under the wording "IGC CODE REFERENCE".

1.2.2 IGC Code requirements not within the scope of classification

The following requirements of the IGC Code are not within the scope of classification:

- Chapter 1, Section1.4 - Equivalents
- Chapter 1, Section 1.5 - Surveys and certification
- Chapter 18 - Operating requirements.

These requirements are applied by the Society when acting on behalf of the flag Administration, within the scope of delegation (see [1.2.6]).

1.2.3 Carriage of products not listed in the Code

The requirements of the IGC Code and the additional requirements of this Chapter are also applicable to new products, which may be considered to come within the scope of these Rules, but are not at present listed in the table in Chapter 19 of the IGC Code.

1.2.4 Particularly hazardous products

For the carriage in bulk of products which are not listed in the table in Chapter 19 of the IGC Code, presenting more severe hazards than those covered by the IGC Code, the Society reserves the right to establish requirements and/or conditions additional to those contained in these Rules.

1.2.5 Equivalences

As far as the requirements for classification are concerned, the following wording in the IGC Code is to be given the meanings indicated in Tab 1.

Table 1 : Equivalences

IGC Code word	Meaning for classification only
Administration	Society
IGC Code or Gas Code	Part D, Chapter 9 of the Rules
Recognised Standard	Rules
should be	is to be or are to be (as applicable)

1.2.6 Certificate of fitness

a) The responsibility for interpretation of the IGC Code requirements for the purpose of issuing an International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk lies with the Administration of the state whose flag the ship is entitled to fly.

b) Whenever the Society is authorised by an Administration to issue on its behalf the "Certificate of Fitness for the Carriage of Liquefied Gases in Bulk", or where the Society is authorised to carry out investigations and surveys on behalf of an Administration on the basis of which the "Certificate of Fitness for the Carriage of Liquefied Gases in Bulk" will be issued by the Administra-

tion, or where the Society is requested to certify compliance with the IGC Code, the full compliance with the requirements of the IGC Code, including the operative requirements mentioned in [1.2.2], is to be granted by the Society.

2 Additional requirements

2.1 Emergency towing arrangement

2.1.1 Emergency towing arrangements are to be fitted on liquefied gas tankers of 20.000 dwt and above in accordance with Pt B, Ch 10, Sec 4, [4].

2.2 Steering gear

2.2.1 Additional requirements for steering gear of liquefied gas carriers of 10.000 dwt and above are given in Ch 7, Sec 4, [7].

3 Documentation to be submitted

3.1

3.1.1 Tab 2 lists the plans, information, analysis, etc. which are to be submitted in addition to the information required in the other Parts of the Rules for the parts of the ship not affected by the cargo, as applicable.

4 Cargo equipment trials

4.1 Scope

4.1.1 Trials in working conditions

All the equipment to which this Chapter is applicable is to be tested in actual working conditions.

4.1.2 Trials to be carried out when the ship is loaded

Those trials which may only be carried out when the ship is loaded are to be held at the first loading of the ship.

For LNG carriers, the extent of the examinations that are to be conducted before and after the first loaded voyage is given in [4.2.4].

4.2 Extent of the tests

4.2.1 Cargo equipment testing procedure

The cargo equipment testing procedure is to be submitted to the Society for review.

4.2.2 Ships with mechanical refrigeration units

Ships fitted with a mechanical refrigeration unit are to be subjected to an initial testing procedure in order to check the suitability of the plant in respect of the applicable requirements. The recording of the data of the reliquefaction system, such as working duration and ambient conditions, may be carried out during the first loaded voyage.

Table 2 : Documents to be submitted

No	A/I	Documents
1	I	List of products to be carried, including maximum vapour pressure, maximum liquid temperature and other important design conditions
2	I	General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks
3	A	Gas-dangerous zones plan
4	A	Location of void spaces and accesses to dangerous zones
5	A	Air locks between safe and dangerous zones
6	A	Ventilation duct arrangement in gas-dangerous spaces and adjacent zones
7	A	Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, etc.
8	A	Calculation of the hull temperature in all the design cargo conditions
9	A	Distribution of quality and steel grades in relation to the contemplated actual temperature obtained by the calculation in item 8
10	A	Hull stress analysis
11	A	Hull ship motion analysis, where a direct analysis is preferred to the methods indicated in Ch 9, Sec 4
12	A	Intact and damage stability calculations
13	A	Scantlings, material and arrangement of the cargo containment system, including the secondary barrier, if any.
14	A	Stress analysis of the cargo tanks, including fatigue analysis and crack propagation analysis for type "B" tanks. This analysis may be integrated with that indicated in item 10
Note 1: A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

No	A/I	Documents
15	I	Calculation of the thermal insulation suitability, including boil-off rate and refrigeration plant capability, if any, cooling down and temperature gradients during loading and unloading operations
16	A	Details of insulation
17	A	Details of ladders, fittings and towers in tanks and relative stress analysis, if any
18	A	Details of tank domes and deck sealings
19	A	Plans and calculations of safety relief valves
20	A	Details of cargo handling and vapour system, including arrangements and details of piping and fitting
21	A	Details of cargo pumps and cargo compressors
22	A	Details of process pressure vessels and relative valving arrangement
23	A	Bilge and ballast system in cargo area
24	A	Gas freeing system in cargo tanks including inert gas system
25	A	Interbarrier space drainage, inerting and pressurisation systems
26	A	Ventilation system in cargo area
27	A	Hull structure heating system, if any
28	A	Refrigeration and reliquefaction plant system diagram, if any
29	A	Details of electrical equipment installed in cargo area, including the list of certified safe equipment and apparatus and electrical bonding of cargo tanks and piping
30	A	Schematic electrical wiring diagram in cargo area
31	A	Gas detection system
32	A	Cargo tank instrumentation, including cargo and hull temperature monitoring system
33	A	Emergency shutdown system
34	A	Jettison system, if any
35	A	Details of fire-extinguishing appliances and systems in cargo area
36	A	Loading and unloading operation description, including cargo tank filling limits
37	A	Cargo tank testing and inspection procedures
38	A	Programme of gas trials
39	I	When applicable, P & A manual
40		For machinery using gas as fuel
	I	a) General arrangement plan of the machinery plant
	I	b) Description of the entire plant
	A	c) Gas piping plans for the machinery plant
	A	d) Complete list of the safety, gas detection and warning equipment
	A	e) Drawings of the boilers
	I	f) Detailed drawings of the gas inlet and fuel inlet equipment
	I	g) Gas characteristics
	A	h) General arrangement plan of the gas treatment plant, including gas compressors, prime movers and gas preheaters
	A	i) Drawings of the gas storage tanks
	A	j) Drawings of the gas compressors and preheaters

Note 1: A = to be submitted for approval in four copies
I = to be submitted for information in duplicate

4.2.3 Use of cargo as fuel

The arrangements for using cargo as fuel are to be subjected to a special testing procedure.

4.2.4 First loaded voyage of ships carrying liquefied natural gases (LNG) in bulk

a) The following examinations are to be conducted at the first full loading of the ship:

1) Priority to be given to latter stages of loading (approximately last 6 hours).

2) Review cargo logs and alarm reports.

3) Witness satisfactory operation of the following:

- gas detection system
- cargo control and monitoring systems such as level gauging equipment, temperature sensors, pressure gauges, cargo pumps and compressors, proper control of cargo heat exchangers, if operating, etc.
- nitrogen generating plant or inert gas generator, if operating
- nitrogen pressure control system for insulation, interbarrier, and annular spaces, as applicable
- cofferdam heating system, if in operation
- reliquefaction plant, if fitted
- equipment fitted for the burning of cargo vapors such as boilers, engines, gas combustion units, etc., if operating.

4) Examination of on-deck cargo piping systems including expansion and supporting arrangements.

5) Witness topping off process for cargo tanks including high level alarms activated during normal loading.

6) Advise Master to carry out cold spot examination of the hull and external insulation during transit voyage to unloading port.

b) The following examinations are to be conducted at the first unloading of the ship:

1) Priority to be giving to the commencement of unloading (approximatively first 4-6 hours).

2) Witness emergency shutdown system testing prior to commencement of unlaoding.

3) Review cargo logs and alarm reports.

4) Witness satisfactory operation of the following:

- gas detection system
- cargo control and monitoring systems such as level gauging equipment, temperature sensors, pressure gauges, cargo pumps and compressors, proper control of cargo heat exchangers, if operating, etc.
- nitrogen generating plant or inert gas generator, if operating
- nitrogen pressure control system for insulation, interbarrier, and annular spaces, as applicable
- on membrane vessels, verify that the readings of the cofferdam and inner hull temperature sensors are not below the allowable temperature for the selected grade of steel. Review previous readings
- cofferdam heating system, if in operation
- reliquefaction plant and review of records from previous voyage
- equipment fitted for the burning of cargo vapors such as boilers, engines, gas combustion units, etc., if operating.

5) Examination of on-deck cargo piping systems including expansion and supporting arrangements.

6) Obtain written statement from the Master that the cold spot examination was carried out during the transit voyage and found satisfactory. Where possible, the Surveyor should examine selected spaces.

5 Additional service feature RV

5.1 Application

5.1.1 The additional service feature **RV** is assigned, in accordance with Pt A, Ch 1, Sec 2, [4.4.5], to liquefied gas carriers fitted with an installation for revaporisation of the LNG before delivery and complying with the requirements of the present Article.

5.2 Documentation to be submitted

5.2.1 Plans and documents to be submitted for approval

The following plans and documents are to be submitted to the Society for approval:

- piping and instrumentation diagram
- hazardous areas
- details of pumps and gas process vessels
- ventilation systems
- fire protection systems
- gas detection systems.

5.2.2 Plans and documents to be submitted for information

The following plans and documents are to be submitted to the Society for information:

- operation description including emergency shutdown system
- Hazard Identification (HAZID) / Hazard Operability Study (HAZOP)
- sloshing study of:
  - containment system
  - pump mast
  - pump tower supports,

  at all filling levels during operation.

5.3 General

5.3.1 The revaporisation plant is subject to special examination by the Society, based on the studies mentioned in [5.2.2].

5.3.2 This plant is to comply with the applicable requirements of this Chapter and the applicable requirements of IGC Code.

6 Additional service feature STL-SPM

6.1 General

6.1.1 Application

a) The additional service feature **STL-SPM** is assigned, in accordance with Pt A, Ch 1, Sec 2, [4.4.5], to liquefied gas carriers used as regaseification terminal, fitted forward with equipment for not permament mooring, or for connection to single buoy, and complying with the requirements of the present Article.

b) The buoy and the mooring system may be not included within classification. In case the buoy and the mooring are covered by class, the Rules for the Classification of Offshore Loading and Offloading Buoys (NR494) are applicable to the buoy and the **POSA** additional class notation may be assigned to the mooring system.

6.1.2 Scope

The following items are covered by the additional service feature **STL-SPM**:

- ship structure, in way of the mooring or the single buoy
- hatch cover
- cylinders
- swivel
- piping and risers
- stoppers
- winch
- interface between equipments and ship structure
- ventilation
- handling equipment (HPU and control system)
- drainage of compartment
- fire and gas detection system
- fire extinction system
- emergency escape.

6.1.3 Applicable rules

a) The items listed in [6.1.2] are to comply with the applicable requirements of IGC code.

b) Components of the equipments used for mooring at single point are to comply with the applicable requirements of Pt B, Ch 10, Sec 4 for **ETA** (Emergency Towing Arrangement) and Pt E, Ch 10, Sec 4, for **SPM** (Single Point Mooring).

c) The swivel is to be classed according to Section 6 of the Rules for the Classification of Offshore Loading and Offloading Buoys (NR 494).

d) The lifting appliances are to meet the applicable requirements of the Rules for the Classification and Certification of Lifting Appliances of Ships and Offshore Units (NR184-ALM notation).

e) The risers are to be specially considered.

6.2 Documentation to be submitted

6.2.1 Plans and documents to be submitted for approval

In addition to the documents listed in Pt B, Ch 1, Sec 3, the following plans and documents are to be submitted to the Society for approval:

- ship structure drawings, in way of the mooring or the single buoy
- local reinforcements of ship structure below equipments
- ventilation plan
- emergency escape
- drawings of equipments
- fire and gas detection, wiring and arrangement diagram
- cable list
- STL, auxilliary and bridge system
- lighting installation, wiring and arrangement diagram
- electrical starter circuit diagram
- architecture diagram of control and safety system
- control and wiring diagram of:
  - hydraulic system for buoy locking devices
  - winches
- fire extinction
- drainage system.

6.2.2 Plans and documents to be submitted for information

The following documents are to be submitted to the Society for information:

- DLOC (design load operating conditions)
- structural calculation
- fatigue calculation
- model test results
- explosion calculation
- CCTV diagram
- operation procedure of system.

6.3 Structural design

6.3.1 Design loads

a) Model tests in mooring conditions are generally to be carried out to determine the loads.

b) For the ship structure, calculations based on test results or mooring and hydrodynamic calculations are to be submitted and subject to special examination by the Society.

6.3.2 Scantlings

The deck structure supporting accessories is to be reinforced on basis of loads given by the designer.

6.4 Mechanical installation

6.4.1 When hydraulic installation is used, it is to be in compliance with the applicable requirements of Pt C, Ch 1, Sec 10, [14] of the Rules.

6.4.2 The hydraulic cylinders are considered as pressure vessels; the scantlings of the shells and the ends are to be in compliance with the applicable requirements of Pt C, Ch 1, Sec 3 of the Rules.

6.4.3 Securing devices are to be simple to operate and easily accessible.

6.4.4 Securing devices are to be equipped with mechanical locking arrangement (self locking or separate arrangement), or to be of the gravity type. Where hydraulic securing devices are applied, they have to remain locked in the event of loss of the hydraulic fluid.

6.4.5 The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

6.4.6 The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in closed position.

6.5 Electrical and automation installation

6.5.1 Unless otherwise specified, the requirements in Part C, Chapter 2 and Part C, Chapter 3 are applicable to the system fitted in STL.

6.5.2 The STL room is to be considered as hazardous area. Electrical equipments are to be avoided in this area. When electrical equipments are fitted, they are to be of a safe type IIA T3 and considered as Zone 1.

6.5.3 The STL system is to be considered as a primary essential service.

6.5.4 The electrical equipments located in flooded space are to be IP 68 for the appropriate depth.

6.5.5 The electrical equipments located in non flooded space are to be IP 67.

6.5.6 Local control of systems is always to be available.

SECTION 2 SHIP SURVIVAL CAPABILITIES AND LOCATION OF CARGO TANKS

1 Freeboard and intact stability

1.1 Intact stability

1.1.1 General

IGC CODE REFERENCE: Ch 2, 2.2.2

The stability of the ship for the loading conditions in Pt B, Ch 3, App 2, [1.2.8] is to be in compliance with the requirements in Pt B, Ch 3, Sec 2.

1.1.2 Free surface effect of liquids

IGC CODE REFERENCE: Ch 2, 2.2.3

The free surface effect is to be calculated in accordance with Pt B, Ch 3, Sec 2, [4].

1.1.3 Information to be supplied

IGC CODE REFERENCE: Ch 2, 2.2.5

The Master of the ship is to be supplied with a Loading Manual as specified in Pt B, Ch 11, Sec 2, [3] and a Trim and Stability booklet as specified in Pt B, Ch 3, App 2.

2 Conditions of loading

2.1 Additional loading conditions

2.1.1

IGC CODE REFERENCE: Ch 2, 2.4

Loading conditions other than those in the Loading Manual and the Trim and Stability booklet are to be previously submitted to the Society. Alternatively, such cases may be examined by the Master or a delegated officer when a loading instrument approved in accordance with the requirements in Pt B, Ch 11, Sec 2, [4] is installed on board.

3 Location of cargo tanks

3.1 Deck cargo tanks

3.1.1

IGC CODE REFERENCE: Ch 2, 2.6.1

Deck cargo tanks are to be located not less than 760 mm inboard from the side shell.

4 Flooding assumptions

4.1 Pipes, ducts and trunks in damaged zones

4.1.1 Strength of internal structures

IGC CODE REFERENCE: Ch 2, 2.7.7

Tunnels, ducts, pipes, doors, bulkheads and decks which might form watertight boundaries of intact spaces in the case of assumed conventional damage are to have minimum strength adequate to withstand the pressure height corresponding to the deepest equilibrium waterline in damaged conditions.

5 Standard of damage

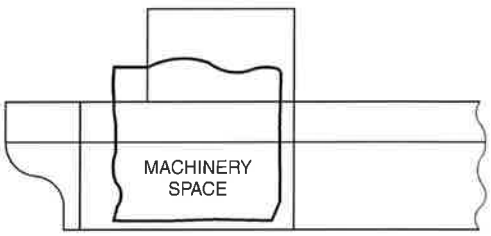
5.1 Longitudinal extent of damage to superstructure

5.1.1

IGC CODE REFERENCE: Ch 2, 2.8

The longitudinal extent of damage to the superstructure (see also IGC Code 2.7.8) in the case of side damage to a machinery space aft, as per IGC Code 2.8.1, is to be the same as the longitudinal extent of the side damage to the machinery space (see Fig 1).

Figure 1 : Longitudinal extension of superstructure damage



6 Survival requirements

6.1 General

6.1.1

IGC CODE REFERENCE: Ch 2, 2.9

Ships are to be capable of surviving the assumed damage specified in IGC Code 2.5.1 and 2.5.2 to the standard provided in IGC Code 2.8.1 and for the loading conditions in Pt B, Ch 3, App 2, [1.2.8] in a condition of stable equilibrium and such as to satisfy the criteria in IGC Code 2.9.

6.2 Intermediate stages of flooding

6.2.1

IGC CODE REFERENCE: Ch 2, 2.9.1.3

The criteria applied to the residual stability during intermediate stages of flooding are to be those relevant to the final stage of flooding as specified in IGC Code 2.9.2. However, small deviations from these criteria may be accepted by the Society on a case-by-case basis.

6.3 Definition of range of positive stability

6.3.1

IGC CODE REFERENCE: Ch 2, 2.9.2

The 20° range may be measured from any angle commencing between the position of equilibrium and the angle of 25° (or 30° if no deck immersion occurs) (see Fig 2).

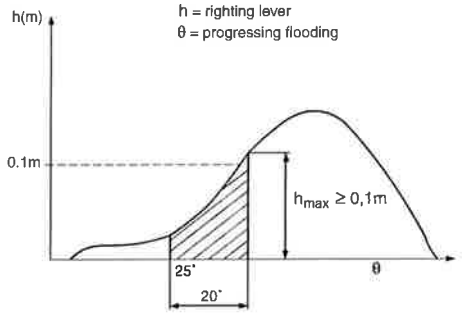
6.4 Type 3G ships less than 125 m in length

6.4.1

IGC CODE REFERENCE: Ch 2, 2.8.1.6

The flooding of the machinery space, if located aft on a type 3G ship less than 125 m in length, is to comply as far as practicable with the criteria in IGC Code 2.9. Relaxation of parts of these requirements may be accepted on a case-by-case basis.

Figure 2 : Range of positive stability



SECTION 3 SHIP ARRANGEMENT

1 Segregation of the cargo area

1.1 Segregation of hold spaces

1.1.1 Bow thruster location

IGC CODE REFERENCE: Ch 3, 3.1.1

Bow thrusters are allowed to be fitted forward of the hold spaces.

1.2 Cargo containment systems not requiring secondary barriers

1.2.1 Separation between cargo spaces

IGC CODE REFERENCE: Ch 3, 3.1.2

Hold spaces may be separated from each other by single bulkheads. Where cofferdams are used instead of single bulkheads, they may be used as ballast tanks subject to special approval by the Society.

1.3 Cargo containment systems requiring secondary barriers

1.3.1 Separation between cargo spaces

IGC CODE REFERENCE: Ch 3, 3.1.3

The requirement in [1.2.1] is applicable.

2 Accommodation, service and machinery spaces and control stations

2.1 General

2.1.1 Accommodation

IGC CODE REFERENCE: Ch 3, 3.2.1

Some acceptable and unacceptable arrangements of accommodation spaces, with respect to cargo tanks, are shown in Fig 1.

2.1.2 Precautions against hazardous vapours

IGC CODE REFERENCE: Ch 3, 3.2.2

Compliance with the relevant requirements of the IGC Code, in particular with 3.2.4, 3.8, 8.2.10 and 12.1.6, as applicable, also ensures compliance with the requirements in IGC Code 3.2.2, relevant to precautions against hazardous vapours.

2.1.3 Spaces located forward of the cargo area

IGC CODE REFERENCE: Ch 3, 3.2.4

Entrances and openings to service spaces located forward of the cargo area may not face such area.

2.1.4 Air outlets

IGC CODE REFERENCE: Ch 3, 3.2.4

The requirements in IGC Code 3.2.4, relevant to air intakes, are also intended to be applicable to air outlets. This interpretation also applies to the requirements in IGC Code 3.2.2, 3.8.4 and 8.2.10.

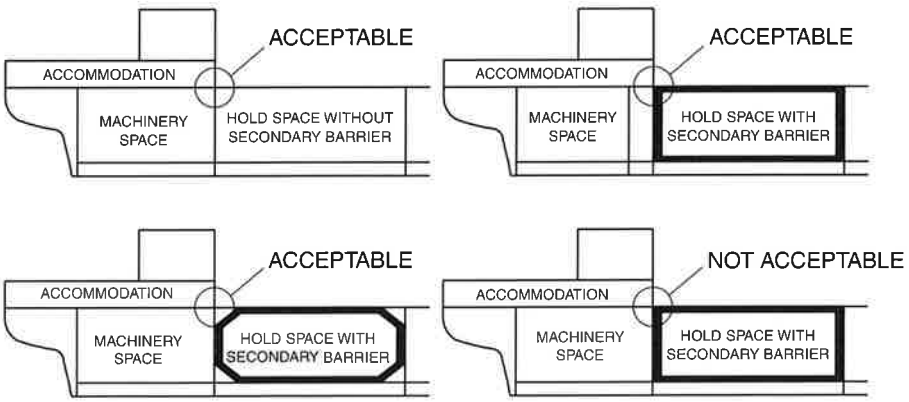
2.1.5 Doors facing cargo area

IGC CODE REFERENCE: Ch 3, 3.2.4

Doors facing the cargo area or located in prohibited zones in the sides are to be restricted to stores for cargo-related and safety equipment, cargo control stations as well as decontamination showers and eye wash.

Where such doors are permitted, the space may not give access to other spaces covered in IGC Code 3.2.4 and the common boundaries with these spaces are to be insulated with A60 class bulkheads.

Figure 1 : Acceptability of common corners between hold spaces and other spaces



2.1.6 Exemptions, ventilation openings and type of closures

IGC CODE REFERENCE: Ch 3, 3.2.6

The requirement for fitting air intakes and openings with closing devices operable from inside the space in ships intended to carry toxic products is to apply to spaces which are used for the ship's radio and main navigating equipment, cabins, mess rooms, toilets, hospitals, galleys, etc., but does not apply to spaces not normally manned such as deck stores, forecastle stores, engine room casings, steering gear compartments and workshops. The requirement does not apply to cargo control rooms located within the cargo area.

When internal closing is required, this is to include both ventilation intakes and outlets.

The closing devices are to give a reasonable degree of gas-tightness. Ordinary steel fire-flaps without gaskets/seals are normally not considered satisfactory.

2.1.7 Openings for removal of machinery

IGC CODE REFERENCE: Ch 3, 3.2.6

Bolted plates of A60 class for removal of machinery may be accepted on bulkheads facing cargo areas, provided sign-boards are fitted to warn that these plates may only be opened when the ship is in gas-free condition.

3 Cargo pump rooms and cargo compressor rooms

3.1 Location of cargo pump rooms and cargo compressor rooms

3.1.1 Single failure concept

IGC CODE REFERENCE: Ch 3, 3.3

When cargo pump rooms and compressor rooms are permitted to be fitted at the after end of the aftermost hold space, the bulkhead which separates the cargo pump rooms or compressor rooms from accommodation and service spaces, control stations and machinery spaces of category A is to be so located as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead. The same condition is also to be satisfied when cargo pump rooms and compressor rooms fitted within the cargo area have a bulkhead in common with accommodation and service spaces, control stations and machinery spaces of category A.

3.1.2 Electrical equipment in cargo pump rooms and cargo compressor rooms

IGC CODE REFERENCE: Ch 3, 3.3

Cargo pump rooms and/or cargo compressor rooms of ships carrying flammable gases may not contain electrical equipment, except as provided for in Chapter 10 of the IGC Code, or other ignition sources such as internal combustion engines or steam engines with operating temperature which could cause ignition or explosion of mixtures of such gases, if any, with air.

4 Access to spaces in the cargo area

4.1 Cargo tank clearances

4.1.1 General

IGC CODE REFERENCE: Ch 3, 3.5

Designated passageways below and above cargo tanks are to have at least the cross-sections as specified in IGC Code 3.5.3.1.

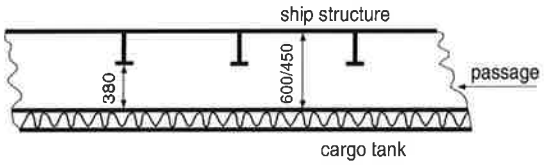
4.1.2 Passage through cargo tanks

IGC CODE REFERENCE: Ch 3, 3.5

For the purpose of the requirements in IGC Code 3.5.1 and 3.5.2, the following applies:

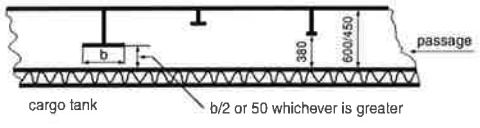
a) Where the Surveyor needs to pass between the flat or curved surface to be inspected and structural elements such as deck beams, stiffeners, frames, girders etc., the distance between that surface and the free edge of the structural elements is to be at least 380 mm. The distance between the surface to be inspected and the surface to which the above structural elements are fitted, e.g. deck, bulkhead or shell, is to be at least 450 mm in the case of a curved tank surface (e.g. type C-tank) or 600 mm in case of a flat tank surface (e.g. type A-tank) (see Fig 2).

Figure 2 : Minimum passage over cargo tanks



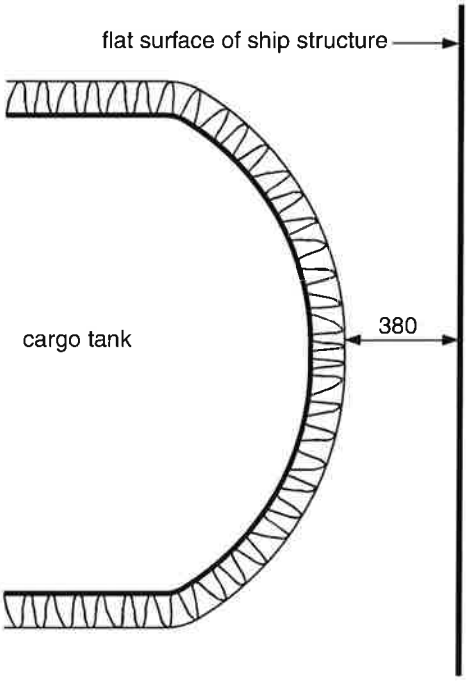
b) Where the Surveyor does not need to pass between the surface to be inspected and any part of the structure, for visibility reasons the distance between the free edge of that structural element and the surface to be inspected is to be at least 50 mm or half the breadth of the structure's face plate, whichever is the greater (see Fig 3).

Figure 3 : Minimum distance of structures from cargo tank to allow visual inspection



c) If for inspection of a curved surface the Surveyor needs to pass between that surface and another flat or curved surface, to which no structural elements are fitted, the distance between both surfaces is to be at least 380 mm (see Fig 4). Where the Surveyor does not need to pass between a curved surface and another surface, a smaller distance than 380 mm may be accepted taking into account the shape of the curved surface.

Figure 4 : Minimum passage between curved surfaces



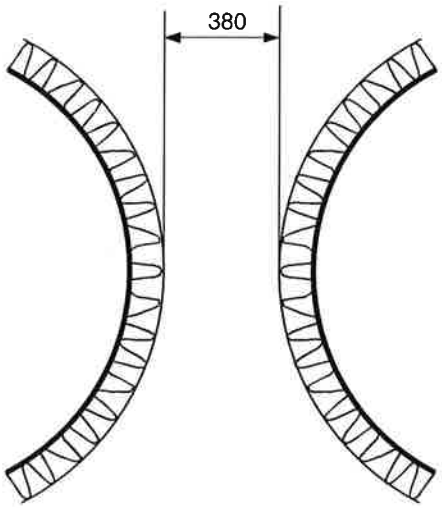


Figure 5 : Minimum passage between flat surfaces

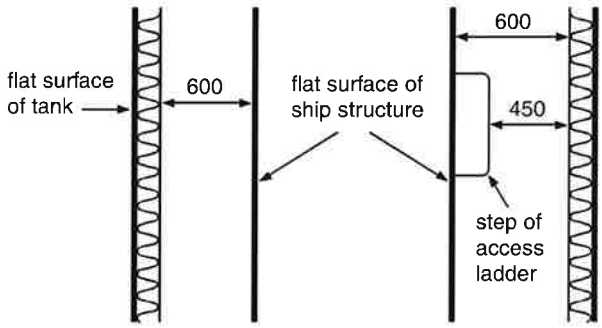


Figure 6 : Minimum distance of cargo tank sump and inner bottom

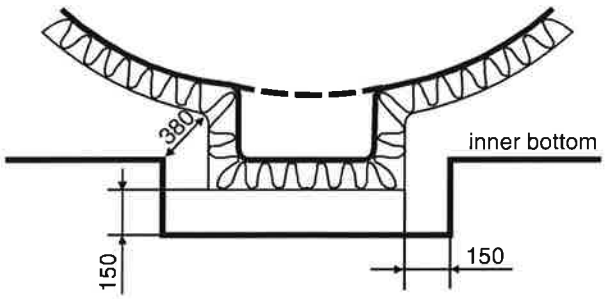
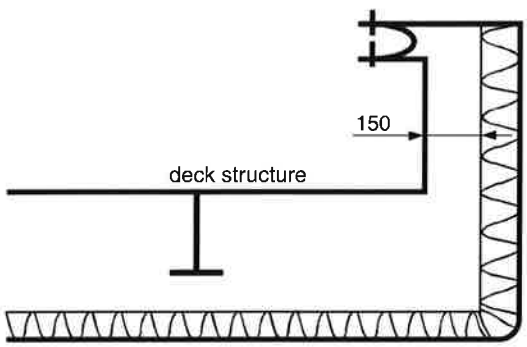


Figure 7 : Minimum distance between cargo dome and deck structures



d) If for inspection of an approximately flat surface the Surveyor needs to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted, the distance between those surfaces is to be at least 600 mm (see Fig 5).

e) The minimum distances between a cargo tank sump and adjacent double bottom structure in way of a suction well may not be less than that defined in Fig 6. If there is no suction well, the distance between the cargo tank sump and the inner bottom may not be less than 50 mm.

f) The distance between a cargo tank dome and deck structures may not be less than 150 mm (see Fig 7).

g) Where necessary for inspection, fixed or portable staging is to be installed. This staging may not impair the distances specified in IGC Code 3.5.3.

h) Where fixed or portable ventilation ducting is to be fitted in compliance with IGC Code 12.2, such ducting may not impair the distances specified in IGC Code 3.5.3.

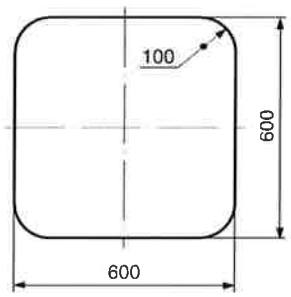
4.1.3 Passage through hatches and manholes

IGC CODE REFERENCE: Ch 3, 3.5

For the purpose of the requirements in IGC Code 3.5.3, the following applies:

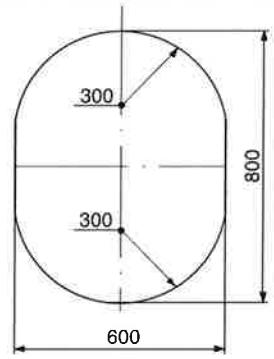
a) The term "minimum clear opening of not less than 600 x 600 mm" means that such openings may have corner radii up to a maximum of 100 mm (see Fig 8).

Figure 8 : Minimum horizontal hatch size



b) The term "minimum clear opening of not less than 600 x 800 mm" also includes an opening of the size specified in Fig 9.

Figure 9 : Minimum size of manholes



c) Circular access openings in type C cargo tanks are to have diameters of not less than 600 mm.

4.2 Cofferdams and pipe tunnels

4.2.1 Cofferdams

IGC CODE REFERENCE: Ch 3, 3.5

Where fitted, cofferdams are to have sufficient size for easy access to all their parts. The width of the cofferdams may not be less than 600 mm.

4.2.2 Pipe tunnels

IGC CODE REFERENCE: Ch 3, 3.5

Pipe tunnels are to have enough space to permit inspection of pipes. The pipes in pipe tunnels are to be installed as high as possible from the ship's bottom.

5 Air-locks

5.1 Arrangement

5.1.1

IGC CODE REFERENCE: Ch 3, 3.6.1

Air-locks are to be such as to provide easy passage and are to cover a deck area of not less than 1,5 m². Air-locks are to be kept unobstructed and may not be employed for other uses, such as storage.

5.2 Alarm

5.2.1 Alarm signalling lamp

IGC CODE REFERENCE: Ch 3, 3.6.3

The alarm systems are to be of the intrinsically safe type. However, signalling lamps may be of a safe type authorised for the dangerous spaces in which they are installed.

5.3 Electrical equipment

5.3.1 Acceptable alternatives to differential pressure

IGC CODE REFERENCE: Ch 3, 3.6.4

The following means are considered acceptable alternatives to differential pressure sensing devices in spaces having a ventilation rate not less than 30 air changes per hour:

- monitoring of current or power in the electrical supply to the ventilation motors; or
- air flow sensors in the ventilation ducts.

In spaces where the ventilation rate is less than 30 air changes per hour and where one of the above alternatives is fitted, in addition to the alarms required in IGC Code 3.6.3, arrangements are to be made to de-energise electrical equipment which is not of the certified safe type if more than one air-lock door is moved from the closed position.

5.3.2 Compressors for boil-off system

IGC CODE REFERENCE: Ch 3, 3.6.4

Lack of overpressure or air flow is not to imply the stopping of motors driving compressors used for the boil-off system mentioned in IGC Code, Ch 16; therefore, such engines are to be of the certified safe type and the relevant control appliance is to be fitted in a non-gas-dangerous space.

The requirement above is not applicable if, during manoeuvring and operations in port, only fuel oil is used or when the automatic transfer from gas to fuel oil, as per IGC Code 16.5.4, operates also when such electric motors are stopped without causing the shut-off of the boiler.

5.4 Ventilation

5.4.1 Air changes

IGC CODE REFERENCE: Ch 3, 3.6.5

After any loss of the overpressure, the spaces protected by air-locks are to be ventilated for the time necessary to give at least 10 air changes prior to energising the non-safe type electrical installations.

6 Bilge, ballast and fuel oil arrangements

6.1 Drainage arrangement

6.1.1 Drainage of dry spaces in the cargo area

IGC CODE REFERENCE: Ch 3, 3.7

Dry spaces within the cargo area are to be fitted with a bilge or drain arrangement not connected to the machinery space.

Spaces not accessible at all times are to be fitted with sounding arrangements.

Spaces without a permanent ventilation system are to be fitted with a pressure/vacuum relief system or with air pipes.

6.2 Additional requirements relative to the bilge system

6.2.1 Operation of the bilge system in cargo and interbarrier spaces

IGC CODE REFERENCE: Ch 3, 3.7

Bilge arrangements for holds containing cargo tanks and for interbarrier spaces are to be operable from the weather deck.

6.2.2 Diameter of bilge main

The diameter of the bilge main may be smaller than the diameter specified in Pt C, Ch 1, Sec 10, [6.8.1], provided that this diameter is not less than twice the value given in Pt C, Ch 1, Sec 10, [6.8.3]. This reduction of diameter, however, is not applicable to the determination of the capacity of fire pumps according to Pt C, Ch 1, Sec 10, [6.7.4].

6.2.3 Means for leakage detection

IGC CODE REFERENCE: Ch 3, 3.7

With reference to the means to ascertain leakages in holds and/or in interbarrier spaces, the following requirements apply:

- the above-mentioned means is to be suitable to ascertain the presence of water:
  - in holds containing type C independent tanks
  - in holds and interbarrier spaces outside the secondary barrier
- the above-mentioned means is to be suitable to ascertain the presence of liquid cargo in the spaces adjacent to cargo tanks which are not type C independent tanks.

  Where the aforesaid spaces may be affected by water leakages from the adjacent ship structures, the means is also to be suitable to ascertain the presence of water.

  Where the above-mentioned means is constituted by electrical level switches, the relevant circuits are to be of the intrinsically safe type and signals are to be transduced to the wheelhouse and to the cargo control station, if fitted.

7 Bow or stern loading and unloading arrangements

7.1 Locations of stopping devices for cargo pumps and compressors

7.1.1

IGC CODE REFERENCE: Ch 3, 3.8.7

Devices to stop cargo pumps and cargo compressors and to close cargo valves are to be fitted in a position from which it is possible to keep under control the loading/unloading manifolds.

8 Hull outfitting

8.1 Equipment

8.1.1 Emergency towing arrangements

The specific requirements in Pt B, Ch 10, Sec 4, [4] for ships with the service notation **liquefied gas carrier** and not less than 20000 t deadweight are to be complied with.

SECTION 4 CARGO CONTAINMENT

Symbols

R_{eH} : Minimum yield stress, in N/mm², of the material, defined in Pt B, Ch 4, Sec 1, [2]

R_m : Minimum ultimate tensile strength, in N/mm², of the material

R_y : Minimum yield stress, in N/mm², of the material, to be taken equal to 235/k N/mm², unless otherwise specified

k : Material factor for steel, defined in Pt B, Ch 4, Sec 1, [2.3]

s : Spacing, in m, of ordinary stiffeners

ℓ : Span, in m, of ordinary stiffeners, measured between the supporting members, see Pt B, Ch 4, Sec 3, [3.2]

c_a : Aspect ratio of the plate panel, equal to:

$$c_a = 1,21\sqrt{1 + 0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell}$$

to be taken not greater than 1,0

c_r : Coefficient of curvature of the panel, equal to:

$c_r = 1 - 0,5\ s / r$

to be taken not less than 0,5

β_b, β_s : Coefficients defined in Pt B, Ch 7, Sec 2, [3.4.2].

1 Definitions

1.1 Design pressure in harbour conditions

1.1.1

IGC CODE REFERENCE: Ch 4, 4.2.6.4

Where the vapour pressure in harbour conditions is greater than p_0, defined in IGC Ch 4, 4.2.6.4, this value is to be specified in the operating instructions for the ship's Master.

1.2 Design temperature

1.2.1 Use of cargo heater to raise the cargo temperature

IGC CODE REFERENCE: Ch 4, 4.2.7

Where a cargo heater, intended to raise the cargo temperature to a value permissible for cargo tanks, is envisaged, the following requirements are to be complied with:

- the piping and valves involved are to be suitable for the design loading temperature
- a thermometer is to be fitted at the heater outlet. It is to be set at the design temperature of the tanks and, when activated, it is to give a visual and audible alarm. This alarm is to be installed in the cargo control station or, when such a station is not foreseen, in the wheelhouse.
- The following note is to be written on the Certificate of Fitness: "The minimum permissible temperature in the cargo preheater is..... °C".

2 Design loads

2.1 Internal pressure for type A, type B and type C independent tanks

2.1.1 General

IGC CODE REFERENCE: Ch 4, 4.3.2

The inertial internal liquid pressure is to be calculated considering the ship in the following mutually exclusive conditions:

- upright ship conditions (see [2.1.2])
- inclined ship conditions (see [2.1.3]).

2.1.2 Accelerations in upright ship conditions

In these conditions, the ship encounters waves which produce ship motions in the X-Z plane, i.e. surge, heave and pitch.

The dimensionless acceleration a_β is to be obtained, for an arbitrary direction β, in accordance with Fig 1, in which the wave longitudinal and vertical accelerations a_X and a_Z, respectively, are calculated from the formula in IGC Ch 4, 4.12.

2.1.3 Accelerations in inclined ship conditions

In these conditions, the ship encounters waves which produce ship motions in the X-Y and Y-Z planes, i.e. sway, heave, roll and yaw.

The dimensionless acceleration a_β is to be obtained, for an arbitrary direction β, in accordance with Fig 2, in which the wave transverse and vertical accelerations a_Y and a_Z, respectively, are calculated from the formula in IGC Ch 4, 4.12

2.1.4 Liquid heights and pressure

IGC CODE REFERENCE: Ch 4, 4.3.2.2

The liquid heights Z_β are to be calculated in accordance with Fig 3 at each calculation point of the tank.

At each calculation point, the maximum internal pressure $(P_{gd})_{max}$ is to be obtained for the β direction which gives the maximum value of P_{gd}, according to IGC Ch 4, 4.3.2.2 (see Fig 4).

Figure 1 : Dimensionless acceleration in upright ship condition

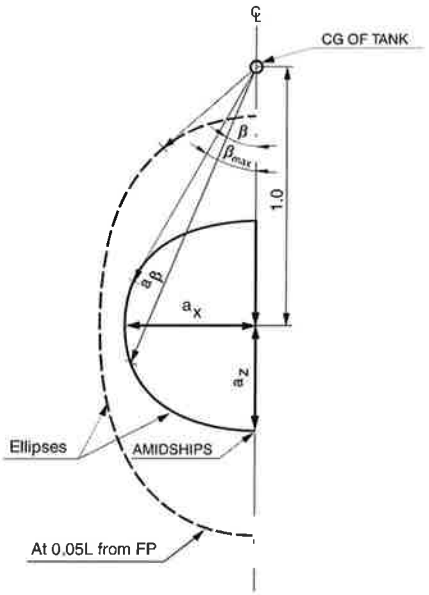


Figure 2 : Dimensionless acceleration in inclined ship condition

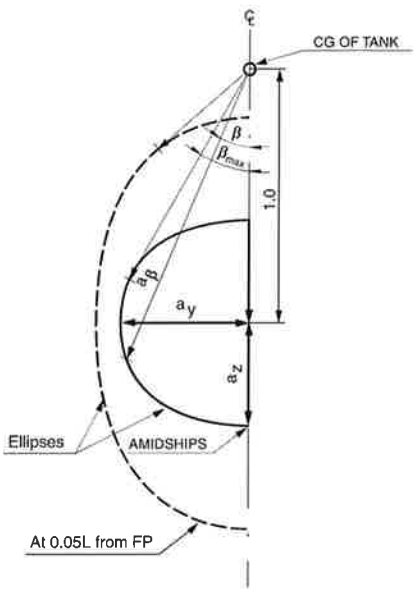


Figure 3 : Determination of liquid height Z_β for pressure points 1, 2 and 3

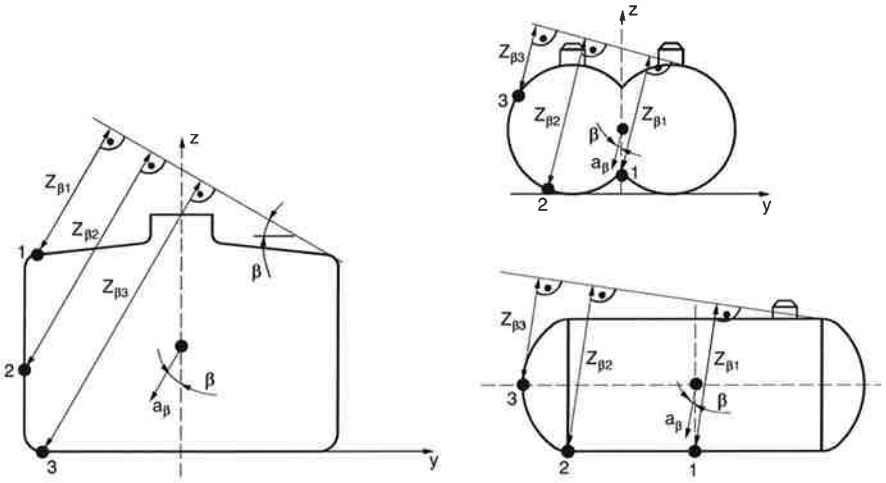
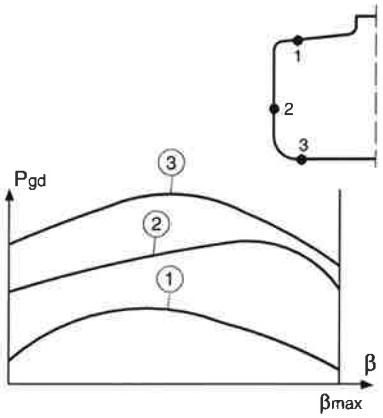


Figure 4 : Determination of internal pressure for pressure points 1, 2 and 3



2.1.5 Cargo mass density

IGC CODE REFERENCE : Ch 4, 4.3.2.2

Where the maximum mass density of the liquid carried is not given, the following values, in t/m³, are to be considered:

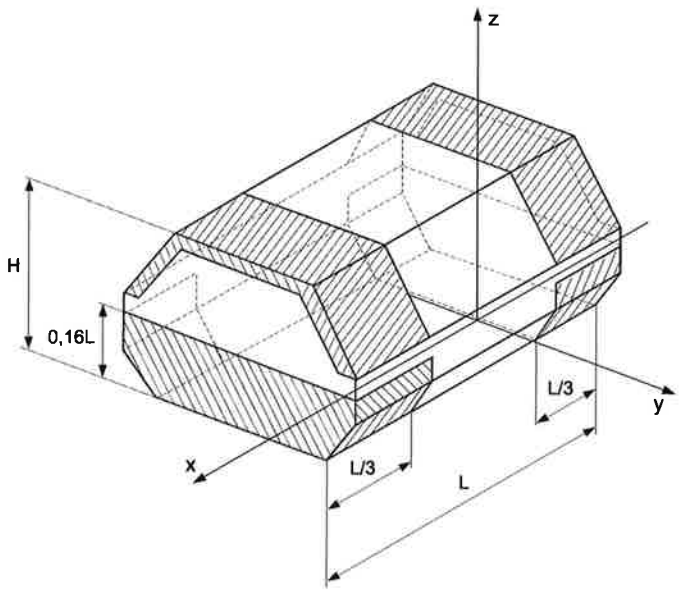
- ρ_L = 0,50 t/m³ for methane
- ρ_L according to Ch 9, Sec 19, Tab 1 for other products.

2.2 Internal pressure for integral tanks and membrane tanks

2.2.1 General

The inertial internal liquid pressure is to be calculated according to Part B, Chapter 5.

Figure 5 : Areas to be checked for sloshing



2.2.2 Sloshing pressure

Sloshing pressure in membrane tanks of ships having a total capacity over 155000 m³ is to be specially considered by the Society.

Sloshing pressure to be considered in membrane tanks of ships having a total capacity less than 155000 m³ is defined in [2.3].

2.3 Sloshing pressure for membrane tanks of ships having a capacity less than 155000 m³

2.3.1 Standard filling levels

Standard filling levels are:

- full load condition:
  the liquid height in the cargo tank is comprised between 70% and 98% of the cargo tank height
- ballast condition:
  the liquid height in the cargo tank is comprised between 0% and 10% of the cargo tank length.

2.3.2 Pressures and tank regions

For standard filling levels, the sloshing pressure is to be obtained, in kN/m², from the following formula

$p_s = p_{wi} + p_{pv}$

where:

p_{wi} : Quasi static pressure, in kN/m², taken equal to:

$p_{wi} = 240$ kN/m²

p_{pv} : Setting pressure of safety valves, in kN/m².

The areas to be checked accordingly are described in Fig 5 where:

H : Height of the tank, in m

L : Length of the tank, in m.

For filling levels other than standard filling levels, the sloshing pressure is to be specially considered by the Society.

3 Hull scantlings

3.1 Application

3.1.1

The requirements in [3.2] to [3.4] apply to the hull structure, with the exception of the independent tank structure.

3.2 Plating

3.2.1 Minimum net thicknesses

The net thickness of the weather strength deck, trunk deck, tank bulkhead and watertight bulkhead plating is to be not less than the values given in Tab 1.

3.2.2 Plating subjected to sloshing

For yielding check, the net thickness of the plating is to be checked using the formula given in Pt B, Ch 7, Sec 1, [3.5.1]. The partial safety factors to be used are given in Pt B, Ch 7, Sec 1, Tab 1, column "sloshing".

No buckling check is required.

3.3 Ordinary stiffeners

3.3.1 Minimum net thicknesses

The net thickness of the web of ordinary stiffeners is to be not less than the value obtained, in mm, from the following formulae:

$t_{MIN} = 0,8 + 0,013\ L\ k^{1/2} + 4,5\ s$ for $L < 220$ m

$t_{MIN} = 3\ k^{1/2} + 4,5 + s$ for $L \geq 220$ m

Table 1 : Minimum net thickness of the weather strength deck, trunk deck, tank bulkhead and watertight bulkhead plating

Plating	Minimum net thickness, in mm	
Weather strength deck and trunk deck, if any, for the area within 0,4L amidships **(1)**	Longitudinal framing	$1,6 + 0,032\ L\ k^{1/2} + 4,5\ s$ for $L < 220$ $6\ k^{1/2} + 5,7 + s$ for $L \geq 220$
	Transverse framing	$1,6 + 0,04\ L\ k^{1/2} + 4,5\ s$ for $L < 220$ $6\ k^{1/2} + 7,5 + s$ for $L \geq 220$
Weather strength deck and trunk deck, if any, at fore and aft parts and between hatchways **(1)**	$2,1 + 0,013\ L\ k^{1/2} + 4,5\ s$	
Tank bulkhead	$1,7 + 0,013\ L\ k^{1/2} + 4,5\ s$	
Watertight bulkhead	$1,3 + 0,013\ L\ k^{1/2} + 4,5\ s$	

(1) The minimum net thickness is to be obtained by linearly interpolating between that required for the area within 0,4 L amidships and that at the fore and aft part.

Note 1:

s : Length, in m, of the shorter side of the plate panel.

3.3.2 Ordinary stiffeners subjected to sloshing

For yielding check, the net section modulus and the net shear sectional area of the ordinary stiffeners, including longitudinals, is to be checked using the formulae given in Pt B, Ch 7, Sec 2, [3.7.4]. The partial safety factors to be used are given in Pt B, Ch 7, Sec 2, Tab 1.

No buckling check is required.

3.4 Primary supporting members

3.4.1 Minimum net thicknesses

The net thickness of plating which forms the webs of primary supporting members is to be not less than the value obtained, in mm, from the following formula:

$t_{MIN} = 4,1 + 0,015\ L\ k^{1/2}$

3.4.2 Primary supporting members subjected to sloshing

No primary supporting members reinforcement is required.

4 Structural analysis of integral tanks

4.1 Scantlings

4.1.1

IGC CODE REFERENCE: Ch 4, 4.4.1

The net scantlings of plating, ordinary stiffeners and primary supporting members of integral tanks are to be not less than those obtained from Part B, Chapter 7, where the hull girder loads and the internal pressure are to be calculated according to Part B, Chapter 5.

5 Structural analysis of membrane tanks

5.1 General

5.1.1 Specific allowable hull girder stresses and/or deflections, indicated by the Designer, are to be taken into account for the determination of the scantlings.

5.2 Scantlings

5.2.1

IGC CODE REFERENCE: Ch 4, 4.4.2

The net scantlings of plating, ordinary stiffeners and primary supporting members of membrane tanks are to be not less than those obtained from Part B, Chapter 7, where the hull girder loads and the internal pressure are to be calculated according to Part B, Chapter 5.

6 Structural analysis of type A independent tanks

6.1 Plating

6.1.1 Minimum gross thickness

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross thickness of plating of type A independent tanks, in mm, is to be not less than:

$t = 3,5 + 5\ s$

6.1.2 Plating subject to lateral pressure

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross thickness of plating subject to lateral pressure, in mm, is to be not less than:

$$t = 16,5 c_a c_r s \sqrt{\frac{p_{IGC}}{R_y}}$$

where:

p_{IGC} : Internal lateral pressure, in kN/m², in the tank, as defined in [2.1].

6.1.3 Plating subject to testing conditions

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross thickness of plating subject to testing pressure, in mm, is to be not less than:

$$t = 15,4 c_a c_r s \sqrt{\frac{p_{ST}}{R_y}}$$

where:

p_{ST} : Testing pressure, in kN/m², obtained according to IGC Ch 4, 4.10.10.

6.1.4 Plating subject to sloshing conditions

IGC CODE REFERENCE: Ch 4, 4.4.4

The thickness of plating subject to sloshing pressure, in mm, is to be obtained according to Pt B, Ch 7, Sec 1, [3].

6.2 Ordinary stiffeners

6.2.1 Minimum gross thickness

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross thickness of the web of ordinary stiffeners, in mm, is to be not less than:

$t = 4,5 + 0,02\ L\ k^{1/2}$

where L is to be taken not greater than 275.

6.2.2 Ordinary stiffeners subject to lateral pressure

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross section modulus w, in cm³, and the gross shear sectional area A_{sh}, in cm², of ordinary stiffeners subjected to lateral pressure are to be not less than the values obtained from the following formulae:

$$w = \beta_b \frac{p_{IGC}}{12\sigma_{ALL}} s\ell^2 10^3$$

$$A_{sh} = 10\beta_s \frac{p_{IGC}}{\sigma_{ALL}}\left(1 - \frac{s}{2\ell}\right)s\ell$$

where:

p_{IGC} : Internal lateral pressure, in kN/m², as defined in [2.1]

σ_{ALL} : Allowable stress, in N/mm², taken equal to the lower of R_m / 2,66 or R_{eH} / 1,33.

6.2.3 Ordinary stiffeners subject to testing conditions

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross section modulus w, in cm³, and the gross shear sectional area A_{sh}, in cm², of ordinary stiffeners subjected to testing pressure are to be not less than the values obtained from the following formulae:

$$w = 1,22\beta_b \frac{p_{ST}}{12R_y} s\ell^2 10^3$$

$$A_{sh} = 12,2\beta_s \frac{p_{ST}}{R_y}\left(1 - \frac{s}{2\ell}\right)s\ell$$

where:

p_{ST} : Testing pressure, in kN/m², obtained according to IGC Ch 4, 4.10.10.

6.2.4 Ordinary stiffeners subject to sloshing conditions

IGC CODE REFERENCE: Ch 4, 4.4.4

The scantlings of ordinary stiffeners subjected to sloshing pressure are to be obtained according to Pt B, Ch 7, Sec 2, [3].

6.3 Primary supporting members

6.3.1 Minimum gross thickness

IGC CODE REFERENCE: Ch 4, 4.4.4

The gross thickness of the web of primary supporting members, in mm, is to be not less than:

$t = 5 + 0,02\ L\ k^{1/2}$

where L is to be taken not greater than 275.

6.3.2 Scantlings of primary supporting members

IGC CODE REFERENCE: Ch 4, 4.4.4

The scantlings of primary supporting members are to be not less than those obtained from Pt B, Ch 7, Sec 3 where the hull girder loads and the lateral pressures are to be calculated according to Part B, Chapter 5, with the resistance partial safety factor γ_R obtained from:

- Tab 2, for general case of yielding check
- Pt B, Ch 7, Sec 3, for other criteria.

When calculating the internal pressure, the presence of the dome may be disregarded.

Table 2 : Type A independent tanks primary supporting members - Resistance partial safety factor γ_R

Type of three dimensional model	Resistance partial safety factor γ_R
Beam or coarse mesh finite element model	1,30
Fine mesh finite element model	1,15

7 Structural analysis of type B independent tanks

7.1 Plating and ordinary stiffeners

7.1.1 Strength check of plating and ordinary stiffeners subject to lateral pressure

IGC CODE REFERENCE: Ch 4, 4.4.5

The net scantlings of plating and ordinary stiffeners of type B independent tanks are to be not less than those obtained from the applicable formulae in Part B, Chapter 7, where the internal pressure is to be calculated according to [2.1].

7.1.2 Buckling check

IGC CODE REFERENCE: Ch 4, 4.4.5

The scantlings of plating and ordinary stiffeners of type B independent tanks are to be not less than those obtained from the applicable formulae in Part B, Chapter 7.

7.2 Primary supporting members

7.2.1 Analysis criteria

IGC CODE REFERENCE: Ch 4, 4.4.5

The analysis of the primary supporting members of the tank subjected to lateral pressure based on a three dimensional model is to be carried out according to the following requirements:

- the structural modelling is to comply with the requirements from Pt B, Ch 7, App 1, [1] to Pt B, Ch 7, App 1, [3]
- the stress calculation is to comply with the requirements in Pt B, Ch 7, App 1, [5]
- the model extension is to comply with [7.2.2]
- the wave hull girder loads and the wave pressures to be applied on the model are to comply with [7.2.3]
- the inertial loads to be applied on the model are to comply with [7.2.4].

7.2.2 Model extension

IGC CODE REFERENCE: Ch 4, 4.4.5

The longitudinal extension of the structural model is to comply with Pt B, Ch 7, App 1, [3.2]. In any case, the structural model is to include the hull and the tank with its supporting and keying system.

7.2.3 Wave hull girder loads and wave pressures

IGC CODE REFERENCE: Ch 4, 4.4.5

Wave hull girder loads and wave pressures are to be obtained from a complete analysis of the ship motion and accelerations in irregular waves, to be submitted to the Society for approval, unless these data are available from similar ships.

These loads are to be obtained as the most probable the ship may experience during its operating life, for a probability level of 10^{-8}.

7.2.4 Inertial loads

IGC CODE REFERENCE: Ch 4, 4.4.5

The inertial loads are to be obtained from the formulae in IGC Ch 4, 4.3.2.

7.2.5 Yielding check of primary supporting members of type B independent tanks primarily constructed of bodies of revolution

IGC CODE REFERENCE: Ch 4, 4.4.5

The equivalent stresses of primary supporting members are to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

where:

σ_E : Equivalent stress, in N/mm², to be obtained from the formula in IGC Ch 4, 4.5.1.8 for each of the following stress categories, defined in IGC Ch 4, 4.13:

- primary general membrane stress
- primary local membrane stress
- primary bending stress
- secondary stress

σ_{ALL} : Allowable stress, defined in IGC Ch 4, 4.5.1.4 for each of the stress categories above.

7.2.6 Yielding check of primary supporting members of type B independent tanks primarily constructed of plane surfaces

IGC CODE REFERENCE: Ch 4, 4.4.5

The equivalent stresses of primary supporting members are to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

where:

σ_E : Equivalent stress, in N/mm², to be obtained from the formulae in Pt B, Ch 7, App 1, [5.1], as a result of direct calculations to be carried out in accordance with [7.2.1]

σ_{ALL} : Allowable stress, in N/mm², to be obtained from Tab 3.

Table 3 : Allowable stress for primary supporting members primarily constructed of plane surfaces

Material	Allowable stress, in N/mm²
C-Mn steel and Ni-steels	The lesser of: • 0,75 R_{eH} • 0,5 R_m
Austenitic steels	The lesser of: • 0,80 R_{eH} • 0,4 R_m
Aluminium alloy	The lesser of: • 0,75 R_{eH} • 0,35 R_m
Note 1: R_{eH} : Minimum yield stress, in N/mm², of the material, as defined in Pt B, Ch 4, Sec 1, [2.1] R_m : Ultimate minimum tensile strength, in N/mm², of the material, as defined in Pt B, Ch 4, Sec 1, [2.1].	

7.2.7 Buckling check of local buckling of plate panels of primary supporting members

IGC CODE REFERENCE: Ch 4, 4.4.5

A local buckling check is to be carried out according to Pt B, Ch 7, Sec 1, [5] for plate panels which constitute primary supporting members.

In performing this check, the stresses in the plate panels are to be obtained from direct calculations to be carried out in accordance with [7.2.1].

7.3 Fatigue analysis

7.3.1 General

IGC CODE REFERENCE: Ch 4, 4.4.5.6

The fatigue analysis is to be performed for areas where high wave induced stresses or large stress concentrations are expected, for welded joints and parent material. Such areas are to be defined by the Designer and agreed by the Society on a case-by-case basis.

7.3.2 Material properties

IGC CODE REFERENCE: Ch 4, 4.4.5.6

The material properties affecting fatigue of the items checked are to be documented. Where this documentation is not available, the Society may request to obtain these properties from experiments performed in accordance with recognised standards.

7.3.3 Wave loads

In upright ship and in inclined ship conditions the wave loads to be considered for the fatigue analysis of the tank include:

- maximum and minimum wave hull girder loads and wave pressures, to be obtained from a complete analysis of the ship motion and accelerations in irregular waves, to be submitted to the Society for approval, unless these data are available from similar ships. These loads are to be obtained as the most probable the ship may experience during its operating life, for a probability level of 10^{-8}.
- Maximum and minimum inertial pressures, to be obtained from the formulae in IGC Ch 4, 4.3.2 as a function of the arbitrary direction β.

7.3.4 Simplified stress distribution for fatigue analysis

IGC CODE REFERENCE: Ch 4, 4.3.4.3

The simplified long-term distribution of wave loads indicated in IGC Code 4.3.4.3 may be represented by means of 8 stress ranges, each characterised by an alternating stress $\pm \sigma_i$ and a number of cycles n_i (see Fig 6). The corresponding values of σ_i and n_i are to be obtained from the following formulae:

$$\sigma_i = \sigma_0\left(1{,}0625 - \frac{i}{8}\right)$$

$$n_i = 0{,}9 \cdot 10^i$$

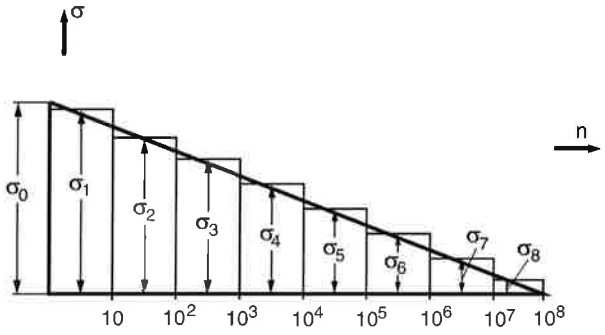
where:

σ_i : Stress (i = 1, 2,..., 8), in N/mm² (see Fig 6)

σ_0 : Most probable maximum stress over the life of the ship, in N/mm², for a probability level of 10^{-8}

n_i : Number of cycles for each stress σ_i considered (i = 1, 2,..., 8).

Figure 6 : Simplified stress distribution for fatigue analysis



7.3.5 Conventional cumulative damage

IGC CODE REFERENCE: Ch 4, 4.4.5.6

For each structural detail for which the fatigue analysis is to be carried out, the conventional cumulative damage is to be calculated according to the following procedure:

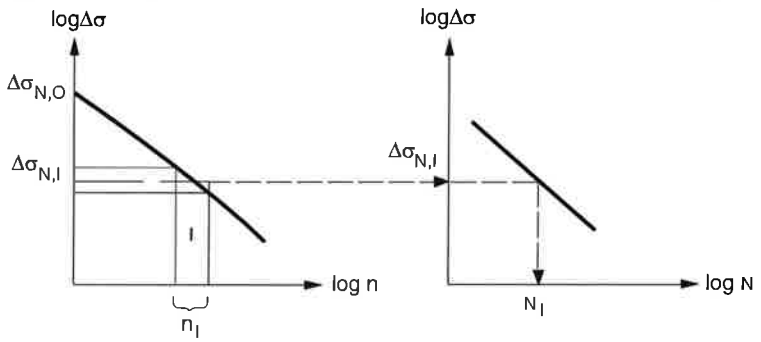
- The long-term value of hot spot stress range $\Delta\sigma_{S,0}$ is to be obtained from the following formula:

  $$\Delta\sigma_{S,0} = |\sigma_{S,MAX} - \sigma_{S,MIN}|$$

  where:

  $\sigma_{S,MAX}$, $\sigma_{S,MIN}$: Maximum and minimum hot spot stress to be obtained from a structural analysis carried out in accordance with Pt B, Ch 7, App 1, where the wave loads are those defined in [7.3.3].
- The long-term value of the notch stress range $\Delta\sigma_{N,0}$ is obtained from the formulae in Pt B, Ch 7, Sec 4, [4.3] as a function of the hot spot stress range $\Delta\sigma_{S,0}$.
- The long-term distribution of notch stress ranges $\Delta\sigma_{N,I}$ is to be calculated. Each stress range $\Delta\sigma_{N,I}$ of the distribution, corresponding to n_i stress cycles, is obtained from the formulae in [7.3.4], where σ_0 is taken equal to $\Delta\sigma_{N,0}$.
- For each notch stress range $\Delta\sigma_{N,I}$, the number of stress cycles N_I which cause the fatigue failure is to be obtained by means of S-N curves corresponding to the as-rolled condition (see Fig 7). The criteria adopted for obtaining the S-N curves are to be documented. Where this documentation is not available, the Society may require the curves to be obtained from experiments performed in accordance with recognised standards.

Figure 7 : Fatigue check based on conventional cumulative damage method



Distribution of notch stress ranges

S-N curve corresponding to the as-rolled condition

- The conventional cumulative damage for the i notch stress ranges $\Delta\sigma_{N,i}$ is to be obtained from the formula in IGC Ch 4, 4.4.5.6.

7.3.6 Check criteria

The conventional cumulative damage, to be calculated according to [7.3.5], is to be not greater than C_W, defined in IGC Ch 4, 4.4.5.6.

7.4 Crack propagation analysis

7.4.1 General

IGC CODE REFERENCE: Ch 4, 4.4.5

The crack propagation analysis is to be carried out for highly stressed areas. The latter are to be defined by the Designer and agreed by the Society on a case-by-case basis. Propagation rates in the parent material, weld metal and heat-affected zone are to be considered.

The following checks are to be carried out:

- crack propagation from an initial defect, in order to check that the defect will not grow and cause a brittle fracture before the defect is detected; this check is to be carried out according to [7.4.4]
- crack propagation from an initial through thickness defect, in order to check that the defect, resulting in a leakage, will not grow and cause a brittle fracture less than 15 days after its detection; this check is to be carried out according to [7.4.5].

7.4.2 Material properties

IGC CODE REFERENCE: Ch 4, 4.4.5

The material fracture mechanical properties used for the crack propagation analysis, i.e. the properties relating the crack propagation rate to the stress intensity range at the crack tip, are to be documented for the various thicknesses of parent material and weld metal alike. Where this documentation is not available, the Society may request to obtain these properties from experiments performed in accordance with recognised standards.

7.4.3 Simplified stress distribution for crack propagation analysis

IGC CODE REFERENCE: Ch 4, 4.3.4.4

The simplified wave load distribution indicated in IGC Code 4.3.4.4 may be represented over a period of 15 days by means of 5 stress ranges, each characterised by an alternating stress $\pm \sigma_i$ and number of cycles, n_i (see Fig 8). The corresponding values of σ_i and n_i are to be obtained from the following formulae:

$$\sigma_i = \sigma_0\left(1{,}1 - \frac{i}{5{,}3}\right)$$

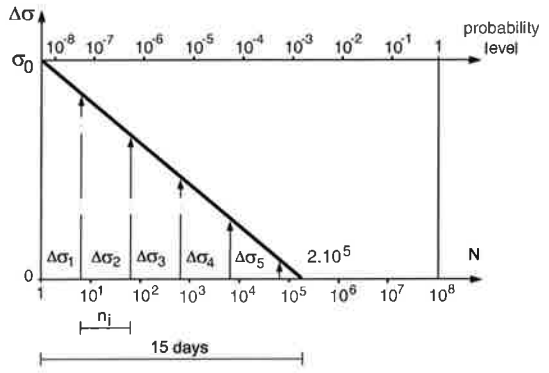
$$n_i = 0{,}913 \cdot 10^i$$

where:

σ_i : Stress (i = 1,06; 2,12; 3,18; 4,24; 5,30), in N/mm² (see Fig 8)

σ_0 : Defined in [7.3.4]

Figure 8 : Simplified stress distribution for crack propagation analysis



n_i : Number of cycles for each stress σ_i considered (i = 1,06; 2,12; 3,18; 4,24; 5,30).

7.4.4 Crack propagation analysis from an initial defect

IGC CODE REFERENCE: Ch 4, 4.4.5

It is to be checked that an initial crack will not grow, under wave loading based on the stress distribution in [7.3.4], beyond the allowable crack size.

The initial size and shape of the crack is to be considered by the Society on a case-by-case basis, taking into account the structural detail and the inspection method.

The allowable crack size is to be considered by the Society on a case-by-case basis; in any event, it is to be taken less than that which may lead to a loss of effectiveness of the structural element considered.

7.4.5 Crack propagation analysis from an initial through thickness defect

IGC CODE REFERENCE: Ch 4, 4.4.5

It is to be checked that an initial through thickness crack will not grow, under dynamic loading based on the stress distribution in [7.4.3], beyond the allowable crack size.

The initial size of the through thickness crack is to be taken not less than that through which the minimum flow size that can be detected by the monitoring system (e.g. gas detectors) may pass.

The allowable crack size is to be considered by the Society on a case-by-case basis; in any event, it is to be taken far less than the critical crack length, defined in [7.4.6].

7.4.6 Critical crack length

IGC CODE REFERENCE: Ch 4, 4.4.5

The critical crack length is the crack length from which a brittle fracture may initiate and it is to be considered by the Society on a case-by-case basis. In any event, it is to be evaluated for the most probable maximum stress experienced by the structural element in the ship life, which is equal to the stress in the considered detail obtained from the structural analysis to be performed in accordance with [7.2.1].

8 Structural analysis of type C independent tanks

8.1 Scantlings

8.1.1

IGC CODE REFERENCE: Ch 4, 4.4.6

The type C independent cargo tanks are to comply with the requirements of Pt C, Ch 1, Sec 3 related to class 1 pressure vessels, the allowable stresses being those required by the IGC Code.

8.2 Stiffening rings in way of tank supports

8.2.1 Structural model

IGC CODE REFERENCE: Ch 4, 4.4.6

The stiffening rings in way of supports of horizontal cylindrical tanks are to be modelled as circumferential beams constituted by web, flange, doubler plate, if any, and plating attached to the stiffening rings.

8.2.2 Width of attached plating

IGC CODE REFERENCE: Ch 4, 4.4.6

On each side of the web, the width of the attached plating to be considered for the yielding and buckling checks of the stiffening rings, as in [8.2.5] and [8.2.6], respectively, is to be obtained, in mm, from the following formulae:

- $b = 0{,}78\sqrt{rt}$ for cylindrical shell,
- $b = 20\ t_b$ for longitudinal bulkheads (in the case of lobe tanks)

where:

r : Mean radius, in mm, of the cylindrical shell

t : Shell thickness, in mm

t_b : Bulkhead thickness, in mm.

A doubler plate, if any, may be considered as belonging to the attached plating.

8.2.3 Boundary conditions

IGC CODE REFERENCE: Ch 4, 4.4.6

The boundary conditions of the stiffening ring are to be modelled as follows:

- circumferential forces applied on each side of the ring, whose resultant is equal to the shear force in the tank and calculated through the bi-dimensional shear flow theory
- reaction forces in way of tank supports, to be obtained according to [9.2].

8.2.4 Lateral pressure

IGC CODE REFERENCE: Ch 4, 4.4.6

The lateral pressure to be considered for the check of the stiffening rings is to be obtained from [2.1].

8.2.5 Yielding check

IGC CODE REFERENCE: Ch 4, 4.4.6

The equivalent stress in stiffening rings in way of supports is to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

where:

σ_E : Equivalent stress in stiffening rings calculated for the load cases defined in IGC Ch 4, 4.6.2 and IGC 4.6.3, in N/mm², and to be obtained from the following formula:

$$\sigma_E = \sqrt{(\sigma_N + \sigma_B) + 3\tau^2}$$

σ_N : Normal stress, in N/mm², in the circumferential direction of the stiffening ring

σ_B : Bending stress, in N/mm², in the circumferential direction of the stiffening ring

τ : Shear stress, in N/mm², in the stiffening ring

σ_{ALL} : Allowable stress, in N/mm², to be taken equal to the lesser of the following values:

- $0{,}57\ R_m$
- $0{,}85\ R_{eH}$

8.2.6 Buckling check

IGC CODE REFERENCE: Ch 4, 4.4.6

The buckling strength of the stiffening rings is to be checked in compliance with the applicable formulae in Pt B, Ch 7, Sec 2.

9 Supports

9.1 Structural arrangement

9.1.1 General

REFERENCE IGC CODE: Ch 4, 4.6

The reaction forces in way of tank supports are to be transmitted as directly as possible to the hull primary supporting members, minimising stress concentrations.

Where the reaction forces are not in the plane of primary members, web plates and brackets are to be provided in order to transmit these loads by means of shear stresses.

9.1.2 Structure continuity

Special attention is to be paid to continuity of structure between circular tank supports and the primary supporting members of the ship.

9.1.3 Openings

IGC CODE REFERENCE: Ch 4, 4.6

In primary supporting members of tank supports and hull structures in way of tank supports which constitute hull supports, openings are to be avoided and local strengthening may be necessary.

9.1.4 Antiflotation arrangements

IGC CODE REFERENCE: Ch 4, 4.6.7

Adequate clearance between the tanks and the hull structures is to be provided in all operating conditions.

9.2 Calculation of reaction forces in way of tank supports

9.2.1

IGC CODE REFERENCE: Ch 4, 4.6

The reaction forces in way of tank supports are to be obtained from the structural analysis of the tank or stiffening rings in way of tank supports, considering the loads specified in:

- [6.3], for the structural analysis of type A independent tanks
- [7], for the structural analysis of type B independent tanks
- [2.1], for the structural analysis of type C independent tanks.

The final distribution of the reaction forces at the supports is not to show any tensile forces.

9.2.2

IGC CODE REFERENCE Ch 4, 4.6.2

Moreover the tanks with supports are also to be designed for a static angle of heel of 30°.

9.3 Supports of type A and type B independent tanks

9.3.1 General

Fillings lower than 90% are generally not admitted for tanks having no upper antirolling supports.

9.3.2 Supports

The structure of the tank and of the ship is to be reinforced in way of the supports so as to withstand the reactions and the corresponding moments.

It is to be checked that the combined stress, in N/mm², in supports is in compliance with the following formula:

$\sigma_C \leq \sigma_{ALL}$

where:

σ_{ALL} : Allowable stress, in N/mm², defined in:

- Tab 4, for type A independent tanks
- IGC Ch 4, 4.6, for type B independent tanks.

9.3.3 Antirolling supports

Antirolling supports are to be checked under transverse and vertical accelerations, as defined in [9.2.1] for the inclined ship conditions, and applied on the maximum weight of the full tank.

It is to be checked that the combined stress, in N/mm², in antirolling supports is in compliance with the following formula:

$\sigma_C \leq \sigma_{ALL}$

where:

σ_{ALL} : Allowable stress, in N/mm², defined in:

- Tab 4, for type A independent tanks
- IGC Ch 4, 4.6, for type B independent tanks.

9.3.4 Antipitching supports

Antipitching supports are to be checked under longitudinal accelerations and vertical accelerations, as defined in [9.2.1]for the upright conditions, and applied on the maximum weight of the full tank.

It is to be checked that the combined stress, in N/mm², in antipitching supports is in compliance with the following formula:

$\sigma_C \leq \sigma_{ALL}$

where:

σ_{ALL} : Allowable stress, in N/mm², defined in:

- Tab 4, for type A independent tanks
- IGC Ch 4, 4.6, for type B independent tanks.

Table 4 : Allowable stresses in supports of type A independent tanks

Type of support	Allowable stress σ_{ALL}, in N/mm²	
	Three dimensional model	Beam model
Support Antirolling support Antipitching support	230/k	The lower of: • R_m / 2,66 • R_{eH} / 1,33

9.3.5 Anticollision supports

Anticollision supports are to be provided to withstand a collision force acting on the tank corresponding to one half the weight of the tank and cargo in the forward direction and one quarter the weight of the tank and cargo in the aft direction.

Antipitching supports may be combined with anticollision supports.

It is to be checked that the combined stress, in N/mm², in anticollision supports is in compliance with the following formula:

$$\sigma_C \leq \frac{235}{k}$$

9.3.6 Antiflotation supports

Antiflotation supports are to be provided and are to be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the summer load draught of the ship.

It is to be checked that the combined stress, in N/mm², in anticollision supports is in compliance with the following formula:

$$\sigma_C \leq \frac{235}{k}$$

9.4 Supports of type C independent tanks

9.4.1

IGC CODE REFERENCE: Ch 4, 4.6

The net scantlings of plating, ordinary stiffeners and primary supporting members of tank supports and hull structures in way are to be not less than those obtained by applying the criteria in Part B, Chapter 7.

The hull girder loads and the lateral pressure to be considered in the formulae above are to be obtained from the formulae in Part B, Chapter 5.

9.4.2

IGC CODE REFERENCE: Ch 4, 4.6

In addition to [9.4.1], the anticollision supports and antiflotation supports are to be checked according to [9.3.5] and [9.3.6].

9.5 Materials

9.5.1 Insulating materials for tank supports are to be type approved by the Society.

Note 1: In addition to the justification of mechanical properties, the water absorption of the material should not be more than 6% when determined in accordance with DIN 53 495.

10 Secondary barrier

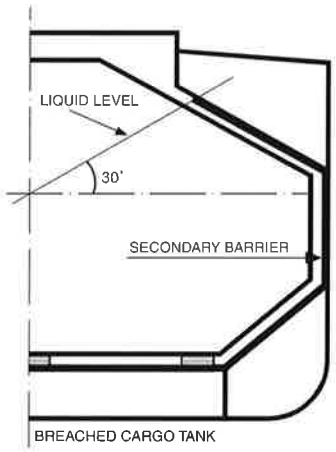
10.1 Secondary barrier extent

10.1.1

IGC CODE REFERENCE: Ch 4, 4.7

The extent of the secondary barrier is to be not less than that necessary to protect the hull structures assuming that the cargo tank is breached at a static angle of heel of 30°, with an equalisation of the liquid cargo in the tank (see Fig 9).

Figure 9 : Secondary barrier extension



11 Insulation

11.1 Heating of structures

11.1.1 Segregation of heating plant

IGC CODE REFERENCE: Ch 4, 4.8.4

Where a hull heating system complying with IGC Ch 4, 4.8.4 is installed, this system is to be contained solely within the cargo area or the drain returns from the hull heating coils in the wing tanks, cofferdams and double bottom are to be led to a degassing tank. The degassing tank is to be located in the cargo area and the vent outlets are to be located in a safe position and fitted with a flame screen.

11.1.2 First loaded voyage

Attention is drawn to the requirements of Ch 9, Sec 1, [4.2.4] regarding the satisfactory operation of the heating plant, that is to be ascertained during the first full loading and the subsequent first unloading of ships carrying liquefied natural gases (LNG) in bulk.

12 Materials

12.1 Insulation material characteristics

12.1.1

IGC CODE REFERENCE: Ch 4, 4.9.5 AND 4.9.6

The materials for insulation are to be approved by the Society.

The approval of bonding materials, sealing materials, lining constituting a vapour barrier or mechanical protection is to be considered by the Society on a case-by-case basis. In any event, these materials are to be chemically compatible with the insulation material.

A particular attention is to be paid to the continuity of the insulation in way of tank supports.

12.1.2

IGC CODE REFERENCE: Ch 4, 4.9.5 AND 4.9.6

Before applying the insulation, the surfaces of the tank structures or of the hull are to be carefully cleaned.

12.1.3

IGC CODE REFERENCE: Ch 4, 4.9.5 AND 4.9.6

Where applicable, the insulation system is to be suitable to be visually examined at least on one side.

12.1.4

IGC CODE REFERENCE: Ch 4, 4.9.5 AND 4.9.6

When the insulation is sprayed or foamed, the minimum steel temperature at the time of application is to be not less than the temperature given in the specification of the insulation.

13 Construction and testing

13.1 Construction and welding

13.1.1

IGC CODE REFERENCE: Ch 4, 4.10.9

The following provisions apply to independent tanks:

- Tracing, cutting and shaping are to be carried out so as to prevent, at the surface of the pieces, the production of defects detrimental to their use. In particular, marking the plates by punching and starting welding arcs outside the welding zone are to be avoided.
- Before welding, the edges to be welded are to be carefully examined, with possible use of non-destructive examination, in particular when chamfers are carried out.
- In all cases, the working units are to be efficiently protected against bad weather.
- The execution of provisional welds, where any, is to be subjected to the same requirements as the constructional welds. After elimination of the fillets, the area is

to be carefully ground and inspected (the inspection is to include, if necessary, a penetrant fluid test).

- All welding consumables are subject to agreement. Welders are also to be agreed.

13.2 Integral tank testing

13.2.1

IGC CODE REFERENCE: Ch 4, 4.10.6

The testing of integral tanks is to comply with the requirements in Pt B, Ch 12, Sec 3.

13.3 Membrane and semi-membrane tanks testing

13.3.1

IGC CODE REFERENCE: Ch 4, 4.10.7

The testing of membrane and semi-membrane tanks is to comply with the requirements in Pt B, Ch 12, Sec 3.

13.4 Independent tank testing

13.4.1

IGC CODE REFERENCE: Ch 4, 4.10.10

The conditions in which testing is performed are to simulate as far as possible the actual loading on the tank and its supports.

13.4.2

IGC CODE REFERENCE: Ch 4, 4.10.10

When testing takes place after installation of the cargo tank, provision is to be made prior to the launching of the ship in order to avoid excessive stresses in the ship structures.

13.5 Final tests

13.5.1

IGC CODE REFERENCE: Ch 4, 4.10

The tests on the completed system are to be performed in the presence of a Surveyor and are to demonstrate that the cargo containment arrangements are capable of being inerted, cooled, loaded and unloaded in a satisfactory way and that all the safety devices operate correctly.

13.5.2

IGC CODE REFERENCE: Ch 4, 4.10

Tests are to be performed at the minimum service temperature or at a temperature very close to it.

13.5.3

IGC CODE REFERENCE: Ch 4, 4.10

The reliquefaction and inert gas production systems, if any, and the installation, if any, for use of gas as fuel for boilers and internal combustion engines are also to be tested to the satisfaction of the Surveyor.

13.5.4

IGC CODE REFERENCE: Ch 4, 4.10

- All operating data and temperatures read during the first voyage of the loaded ship are to be sent to the Society.
- Attention is drawn to the requirements of Ch 9, Sec 1, [4.2.4] regarding the cold spots examination that is to be carried out on ships carrying liquefied natural gases (LNG) in bulk during the first loaded voyage.

13.5.5

IGC CODE REFERENCE: Ch 4, 4.10

All data and temperatures read during subsequent voyages are to be kept at the disposal of the Society for a suitable period of time.

14 Structural details

14.1 Special structural details

14.1.1 The specific requirements in Pt B, Ch 12, Sec 2, [2.4] for ships with the service notation **liquefied gas carrier** are to be complied with.

14.2 Knuckles of the inner hull plating

14.2.1

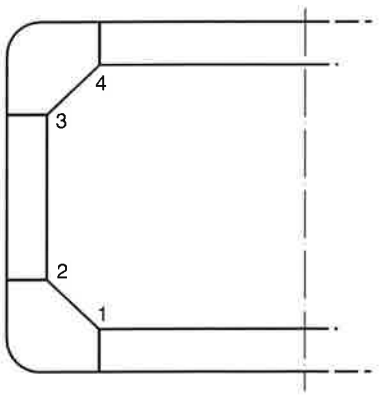
IGC CODE REFERENCE: Ch 4, 4.10

The detail arrangement of knuckles of the inner hull plating is to be made according to:

- Pt B, Ch 12, App 2, Tab 36 to Pt B, Ch 12, App 2, Tab 38 for position 1 in Fig 10
- Pt B, Ch 12, App 2, Tab 61 and Pt B, Ch 12, App 2, Tab 62 for position 2 in Fig 10
- for positions 3 and 4 in Fig 10, in a similar way to positions 1 and 2.

14.2.2 Where there is no prolonging bracket in way of knuckle joints in positions 1 and/or 2, the connection of transverse webs to the inner hull and longitudinal girder plating is to be made with partial penetration welds over a length not less than 400 mm.

Figure 10 : Positions of connections



14.3 Connections of inner bottom with transverse cofferdam bulkheads

14.3.1 General

In addition to sheet 3.5 in Pt B, Ch 12, App 2, the requirements in [14.3.2] to [14.3.4] apply.

14.3.2 Floors

IGC CODE REFERENCE: Ch 4, 4.10

The thickness and material properties of the supporting floors are to be at least equal to those of the cofferdam bulkhead plating.

14.3.3 Vertical webs within cofferdam bulkhead

IGC CODE REFERENCE: Ch 4, 4.10

Vertical webs fitted within the cofferdam bulkhead are to be aligned with the double bottom girders.

14.3.4 Manholes

IGC CODE REFERENCE: Ch 4, 4.10

Manholes in double bottom floors aligned with the cofferdam bulkhead plating are to be located as low as practicable and at mid-distance between two adjacent longitudinal girders.

14.4 Cut-outs and connections

14.4.1 Cut-outs

IGC CODE REFERENCE: Ch 4, 4.10

Cut-outs for the passage of inner hull and cofferdam bulkhead ordinary stiffeners through the vertical webs are to be closed by collar plates welded to the inner hull plating.

14.4.2 Connection of the cargo containment system to the hull structure

IGC CODE REFERENCE: Ch 4, 4.10

Where deemed necessary, adequate reinforcements are to be fitted in the double hull and transverse cofferdams at connection of the cargo containment system to the hull structure. Details of the connection are to be submitted to the Society for approval.

SECTION 5 PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR AND PRESSURE PIPING SYSTEMS

1 General

1.1 Process pressure vessels

1.1.1

IGC CODE REFERENCE: Ch 5, 5.1.2

Process pressure vessels handling cargo are to be considered as class 1 pressure vessels, in accordance with Pt C, Ch 1, Sec 3, [1.4.1].

2 Cargo and process piping

2.1 General

2.1.1 Other requirements

Cargo and process pipings have to comply with the applicable requirements of Pt C, Ch 1, Sec 10 for class I pressure piping, unless otherwise specified in IGC Code or in the present Article.

2.1.2 Provisions for protection of piping against thermal stress

IGC CODE REFERENCE: Ch 5, 5.2.1.2

Expansion joints are to be protected from extensions and compressions greater than the limits fixed for them and the connected piping is to be suitably supported and anchored. Bellow expansion joints are to be protected from mechanical damage.

2.1.3 Segregation of high temperature piping

IGC CODE REFERENCE: Ch 5, 5.2.1.3

High temperature pipes are to be thermally isolated from the adjacent structures. In particular, the temperature of pipelines is not to exceed 220°C in gas-dangerous zones.

2.1.4 Pressure relief valve setting

IGC CODE REFERENCE: Ch 5, 5.2.1.6

Pressure relief valves are to be set to discharge at a pressure not greater than the design pressure such that the overpressure during discharge does not exceed 110% of the design pressure.

2.1.5 Protection against leakage

IGC CODE REFERENCE: Ch 5, 5.2.1

Where the piping system is intended for liquids having a boiling point lower than –30°C, permanent means to avoid possibility of contact between leaks and hull structures are to be provided in all those locations where leakage might be expected, such as shore connections, pump seals, flanges subject to frequent dismantling, etc.

2.1.6 Means to detect the presence of liquid cargo

IGC CODE REFERENCE: Ch 5, 5.2.1

The means to detect the presence of liquid cargo may be constituted by electrical level switches whose circuit is intrinsically safe. The alarm signals given by the level switches are to be transmitted to the wheelhouse and to the cargo control station, if provided.

2.1.7 Connections of relief valve discharges to cargo tanks

IGC CODE REFERENCE: Ch 5, 5.2.1

The connections, if any, to the cargo tanks of relief valve discharges fitted on the liquid phase cargo piping are not to be fitted with shut-off valves, but are to be provided with non-return valves in the proximity of the tanks.

2.1.8 Centrifugal pumps

IGC CODE REFERENCE: Ch 5, 5.2.1

Overpressure relief valves on cargo pumps may be omitted in the case of centrifugal pumps having a maximum delivery head, the delivery valve being completely closed, not greater than that permitted for the piping.

2.1.9 Type approval

IGC CODE REFERENCE: Ch 5, 5.3.1

The piping components mentioned in the present Article are subject to a type approval by the Society.

2.1.10 Examination before and after the first loaded voyage

IGC CODE REFERENCE: Ch 5, 5.5.4

Attention is drawn to the requirements of Ch 9, Sec 1, [4.2.4] regarding the examination of the on-deck cargo pipping system, that are to be conducted on ships carrying liquefied natural gases (LNG) in bulk during the first full loading and the subsequent first unloading of the ship.

2.2 Scantlings based on internal pressure

2.2.1 Piping subject to green seas

IGC CODE REFERENCE: Ch 5, 5.2.2

In particular for piping subject to green seas, the design pressure P in the formula in paragraph 5.2.3 of the IGC Code is to be replaced by an equivalent pressure P' given by the following formula:

$$P' = \frac{1}{2}\left(P + \sqrt{P^2 + 6R'K\frac{D_C}{D}}\right)$$

Table 1 : Drag R' corresponding to the effect of green seas (in MPa)

External diameter of pipe (1)	Aft of the quarter of the ship's length			Forward of the quarter of the ship's length		
	H ≤ 8	H = 13	H ≥ 18	H ≤ 8	H = 13	H ≥ 18
≤ 25	0,015	0,0025	0,0015	0,022	0,0035	0,0015
50	0,014	0,0025	0,0015	0,020	0,0035	0,0015
75	0,011	0,0025	0,0015	0,016	0,0035	0,0015
100	0,007	0,0025	0,0015	0,007	0,0035	0,0015
≥150	0,005	0,0025	0,0015	0,007	0,0035	0,0015
(1) D_C if the pipe is insulated, D otherwise.						

where:

K : Allowable stress, in MPa.

K is to be the lower of (R/2,7) and (R_e/1,8), where:

R : Specified minimum tensile strength at room temperature, in MPa

R_e : Specified lower minimum yield stress or 0,2% yield stress at room temperature, in MPa

D : External diameter of the pipe, in mm

D_C : External diameter of the pipe taking into account the insulation (in mm), whose thickness is to be taken at least equal to:

40 mm if D ≤ 50 mm
80 mm if D ≥ 150 mm

Intermediate values are to be determined by interpolation.

R' : Drag corresponding to the effect of green seas, in MPa, such as given in Tab 1 as a function of the location of the pipes and of their height H (in m) above the deepest loadline; intermediate values are to be determined by interpolation.

2.3 Design pressure

2.3.1 Design pressure definition

IGC CODE REFERENCE: Ch 5, 5.2.3.1

For each piping section, the maximum pressure value among those applicable in paragraph 5.2.2.1 of the IGC Code is to be considered.

2.4 Permissible stress

2.4.1 Flanges not complying with standards

IGC CODE REFERENCE: Ch 5, 5.2.4.5

For flanges not complying with a standard, the dimensions and type of gaskets are to be to the satisfaction of the Society.

2.5 Stress analysis

2.5.1 Calculations in accordance with recognised standards

IGC CODE REFERENCE: Ch 5, 5.2.5

When such an analysis is required, it is to be carried out in accordance with the requirements listed below. Subject to this condition, calculations in accordance with recognised standards are admitted by the Society.

2.5.2 Calculation cases

IGC CODE REFERENCE: Ch 5, 5.2.5

The calculations are to be made for every possible case of operation, but only those leading to the most unfavourable results are required to be submitted.

2.5.3 Loads to be taken for calculation

IGC CODE REFERENCE: Ch 5, 5.2.5

The calculations are to be carried out taking into account the following loads:

a) piping not subject to green seas:
- pressure
- weight of the piping and of the internal fluid
- contraction

b) piping subject to green seas that is liable to be in operation at sea and in port:
- pressure
- weight of the piping and of the internal fluid
- green seas
- contraction
- ship motion accelerations

c) piping subject to green seas that is in operation only in port; the more severe of the following two combinations of loads:
- pressure
- weight of the pipe and of the internal fluid
- contraction

and
- weight of the piping
- green seas
- expansion, assuming that the thermal stresses are fully relaxed.

2.5.4 Green sea directions

IGC CODE REFERENCE: Ch 5, 5.2.5

When green seas are considered, their effects are to be studied, unless otherwise justified, in the following three directions:

- axis of the ship
- vertical
- horizontal, perpendicular to the axis of the ship. The load on the pipes is the load R' defined in [2.2.1].

2.5.5 Stress intensity

IGC CODE REFERENCE: Ch 5, 5.2.5

The stress intensity is to be determined as specified in the formulae in Pt C, Ch 1, Sec 10, [2.3.2] for pipes intended for high temperatures:

a) for primary stresses resulting from:
   - pressure
   - weight
   - green seas

b) for primary stresses and secondary stresses resulting from contraction.

2.5.6 Stress intensity limits

IGC CODE REFERENCE: Ch 5, 5.2.5

a) For the first case, the stress intensity is to be limited to the lower of:

   $0,8\ R_e$ and $0,4\ R_m$

b) For the second case, the stress intensity is to be limited to the lower of:

   $1,6\ R_e$ and $0,8\ R_m$.

2.5.7 Piping with expansion devices

IGC CODE REFERENCE: Ch 5, 5.2.5

For piping fitted with expansion devices, their characteristics are to be submitted to the Society. Where these characteristics are such that the forces and moments at the ends of the devices are negligible for the contraction they must absorb, the calculation of the loads due to contraction in the corresponding piping is not required. It is, however, to be checked that the stress intensity corresponding to the primary stresses does not exceed the limits given in [2.5.6].

2.5.8 Flexibility coefficient

IGC CODE REFERENCE: Ch 5, 5.2.5

The flexibility coefficient of elbows is to be determined from the formulae given in Pt C, Ch 1, Sec 10, [2.3.2] for pipes intended for high temperatures.

2.5.9 Local stresses

IGC CODE REFERENCE: Ch 5, 5.2.5

Particular attention is to be paid to the calculation of local stresses in the assemblies subjected to axial forces and bending moments. The Society reserves the right to request additional justifications or local strengthening where considered necessary.

2.6 Aluminised pipes

2.6.1

IGC CODE REFERENCE: Ch 5, 5.2.6

Aluminised pipes may be fitted in ballast tanks, in inerted cargo tanks and, provided the pipes are protected from accidental impact, in hazardous areas on open deck.

3 Cargo system valving requirements

3.1 Cargo tank connections for gauging

3.1.1 Exemption

IGC CODE REFERENCE: Ch 5, 5.6.2

The requirements in paragraph 5.6.2 of the IGC Code relevant to cargo tank connections for pressure gauges and measuring devices do not apply to tanks with an MARVS not exceeding 0,07 MPa.

3.2 Emergency shutdown

3.2.1 Clarification on location of fusible elements

IGC CODE REFERENCE: Ch 5, 5.6.4

The cargo stations in way of which the fusible elements mentioned in paragraph 5.6.4 of the IGC Code are to be fitted are to be intended as the loading and unloading manifolds.

4 Cargo transfer methods

4.1 Discharge into common header

4.1.1

IGC CODE REFERENCE: Ch 5, 5.8

When two or more pumps located in different cargo tanks are operating at the same time discharging into a common header, the stopping of the pumps is to activate an alarm at the centralised cargo control location.

5 Bonding

5.1 Static electricity

5.1.1 Acceptable resistance

IGC CODE REFERENCE: Ch 5, 5.2.1

To avoid the hazard of an incentive discharge due to the build-up of static electricity resulting from the flow of the liquid/ gases/vapours, the resistance between any point on the surface of the cargo and slop tanks, piping systems and equipment, and the hull of the ship is not to be greater than $10^6\ \Omega$.

5.1.2 Bonding straps

IGC CODE REFERENCE: Ch 5, 5.2.1

Bonding straps are required for cargo and slop tanks, piping systems and equipment which are not permanently connected to the hull of the ship, for example:

a) independent cargo tanks

b) cargo tank piping systems which are electrically separated from the hull of the ship

c) pipe connections arranged for the removal of the spool pieces.

Where bonding straps are required, they are to be:

a) clearly visible so that any shortcoming can be clearly detected

b) designed and sited so that they are protected against mechanical damage and are not affected by high resistivity contamination, e.g. corrosive products or paint

c) easy to install and replace.

SECTION 6 MATERIALS FOR CONSTRUCTION

1 Material requirements

1.1 Tubes, forgings and castings for cargo and process piping

1.1.1

IGC CODE REFERENCE: Ch 6, Table 6.4

a) In general, impact tests are not required for forgings, rolled products and seamless pipes in stainless austenitic steel of grades 304, 304L, 316, 316L, 321 and 347.

b) Impact tests are required for:

- castings in steel grades 304, 304L, 321 and 347 when the service temperature is below –60°C
- castings in steel grades 316 and 316L (which contain molybdenum) at any temperature. A reduction of the tests may be granted for design temperatures above –60°C after examination of each case by the Society.

1.2 Aluminium coatings

1.2.1

IGC CODE REFERENCE : Ch 6, 6.2

The use of aluminium coatings is prohibited in the cargo tanks, cargo tank deck area, pump rooms, cofferdams or any other area where cargo gas may accumulate.

2 Welding and non-destructive testing

2.1 Welding consumables

2.1.1

IGC CODE REFERENCE : Ch 6, 6.3.2

The content of paragraph 6.3.2 of the IGC Code is also to cover process pressure vessels and secondary barriers.

2.2 Test requirements

2.2.1 Bend tests

IGC CODE REFERENCE : Ch 6, 6.3.4.2

As an alternative to the bend test indicated in paragraph 6.3.2 of the IGC Code, a test over a mandrel having a diameter equal to 3 times the thickness with a bend angle up to 120° may be required.

SECTION 7 CARGO PRESSURE/TEMPERATURE CONTROL

1 Additional requirements for refrigerating plants

1.1

1.1.1

IGC CODE REFERENCE: Ch 7, 7.2

In general, in addition to the requirements of 7.2 of the IGC Code, refrigerating plants are to comply with the provisions of Pt C, Ch 1, Sec 13 and Part E, Chapter 8, as applicable.

1.1.2 Examination before and after the first loaded voyage

Attention is drawn to the requirements of Ch 9, Sec 1, [4.2.4] regarding the satisfactory operation of the reliquefaction plant, if installed, and of any other equipment fitted for the burning of cargo vapors, that is to be ascertained during the first full loading and the subsequent first unloading of ships carrying liquefied natural gasses (LNG) in bulk.

2 Reliquefaction plant of motor-driven LNG carriers

2.1 Mechanical refrigeration fitted as the primary system for cargo pressure control

2.1.1 General

IGC CODE REFERENCE: Ch 7, 7.2

Paragraph 7.2 of the IGC Code relative to refrigerating systems is based on the assumption that maintenance of the cargo pressure described in 7.1 of the IGC Code is complied with by using means defined in 7.1.1.2 of the Code. That is to say, a mechanical refrigeration system is fitted as the primary means of maintaining the cargo tank pressure below MARVS.

2.1.2 Standby refrigerating units

IGC CODE REFERENCE: Ch 7, 7.2

Paragraph 7.2 of the IGC Code is to apply to refrigeration systems fitted on LNG carriers, i.e. the standby capacity required is to be as detailed in 7.2.1 of the IGC Code. A standby LNG/refrigerant heat exchanger need not be provided and the fitted LNG/refrigerant heat exchanger is not required to have 25% excess capacity over that for normal requirements. Other heat exchangers utilising water cooling are to have a standby or to have at least 25% excess capacity.

2.1.3 Alternative means for cargo pressure/temperature control

IGC CODE REFERENCE: Ch 7, 7.2

Paragraph 7.2.1 of the IGC Code states that unless an alternative means of controlling the cargo pressure/temperature is provided to the satisfaction of the Administration, a standby unit (or units) affording spare capacity at least equal to the largest required single unit is (are) to be fitted.

For the purpose of complying with the above, a suitable alternative means of pressure/temperature control would be:

a) auxiliary boiler(s) capable of burning the boil-off vapours and disposing of the generated steam or an alternative waste heat system acceptable to the Society. Consideration will be given to systems burning only part of the boil-off vapour if it can be shown that MARVS will not be reached within a period of 21 days.

b) controlled venting of cargo vapours as specified in paragraph 7.1.1.5 of the IGC Code if permitted by the Administration concerned.

2.2 Mechanical refrigeration fitted as a secondary system for cargo pressure control

2.2.1

IGC CODE REFERENCE: Ch 7, 7.2

Where a refrigeration plant is fitted as a means of disposing of excess energy as detailed in the second sentence of 7.1.1.2, no standby unit will be required for the refrigeration plant.

2.3 Examination before and after the first loaded voyage

2.3.1 Attention is drawn to the requirements of Ch 9, Sec 1, [4.2.4] regarding the satisfactory operation of the inert gas generating plant and of the associated control system that is to be ascertained during the first full loading and the subsequent first unloading of ships carrying liquefied natural gasses (LNG) in bulk.

SECTION 8 CARGO TANK VENTING SYSTEM

1 Pressure relief systems

1.1 Interbarrier spaces

1.1.1 Protection of interbarrier spaces

IGC CODE REFERENCE : Ch 8, 8.2.2

a) The formula for determining the relieving capacity given in paragraph 8.3.2 of the IGC Code is developed for interbarrier spaces surrounding independent type A cargo tanks, where the thermal insulation is fitted to the cargo tanks.

b) The relieving capacity of pressure relief devices of interbarrier spaces surrounding independent type B cargo tanks may be determined on the basis of the method given in paragraph 8.2 of the IGC Code; however, the leakage rate is to be determined in accordance with 4.7.6.1 of the IGC Code.

c) The relieving capacity of pressure relief devices for interbarrier spaces of membrane and semi-membrane tanks is to be evaluated on the basis of specific membrane/semi-membrane tank design.

d) The relieving capacity of pressure relief devices for interbarrier spaces adjacent to integral type cargo tanks may, if applicable, be determined as for type A independent cargo tanks.

e) Interbarrier space pressure relief devices in the scope of this interpretation are emergency devices for protecting the hull structure from being unduly overstressed in the event of a pressure rise in the interbarrier space due to primary barrier failure. Therefore such devices need not comply with the requirements of paragraphs 8.2.9 and 8.2.10 of the IGC Code.

1.1.2 Size of pressure relief devices

IGC CODE REFERENCE : Ch 8, 8.2.2

The combined relieving capacity, in m^3/s, of the pressure relief devices for interbarrier spaces surrounding type A independent cargo tanks where the insulation is fitted to the cargo tanks may be determined by the following formula:

$$Q_{sa} = 3,4 \cdot A_C \cdot \frac{\rho}{\rho_V} \cdot \sqrt{h}$$

where:

Q_{sa} : Minimum required discharge rate of air in standard conditions of 273 K and 1,013 bar

A_C : Design crack opening area, in m^2, equal to:

$$A_C = \frac{\pi}{4} \cdot \delta \cdot l$$

where:

δ : Maximum crack opening width, in m, equal to:

$\delta = 0,2\ t$

t being the thickness of tank bottom plating, in m

l : Design crack length, in m, equal to the diagonal of the largest plate panel of the tank bottom (see Fig 1)

h : Maximum liquid height above tank bottom plus 10 × MARVS, in m

ρ : Density of product liquid phase, in kN/m^3, at the set pressure of the interbarrier space relief device

ρ_V : Density of product vapour phase, in kN/m^3, at the set pressure of the interbarrier space relief device and a temperature of 273 K.

1.2 Vents

1.2.1

IGC CODE REFERENCE : Ch 8, 8.2.9

The height of vent exits as indicated in paragraph 8.2.9 of the IGC Code is also to be measured above storage tanks and cargo liquid lines, where applicable.

1.3 Segregation of vents

1.3.1 Additional requirements on vent location

IGC CODE REFERENCE : Ch 8, 8.2.10

a) The distances of the vent exits are to be measured horizontally.

b) In the case of carriage of flammable and/or toxic products, the vent exits are to be arranged at a distance of at least 5 m from exhaust ducts and at least 10 m from intake ducts serving cargo pump rooms and/or cargo compressor rooms.

c) The distances are also intended to refer to outlets of ventilation ducts of safe spaces.

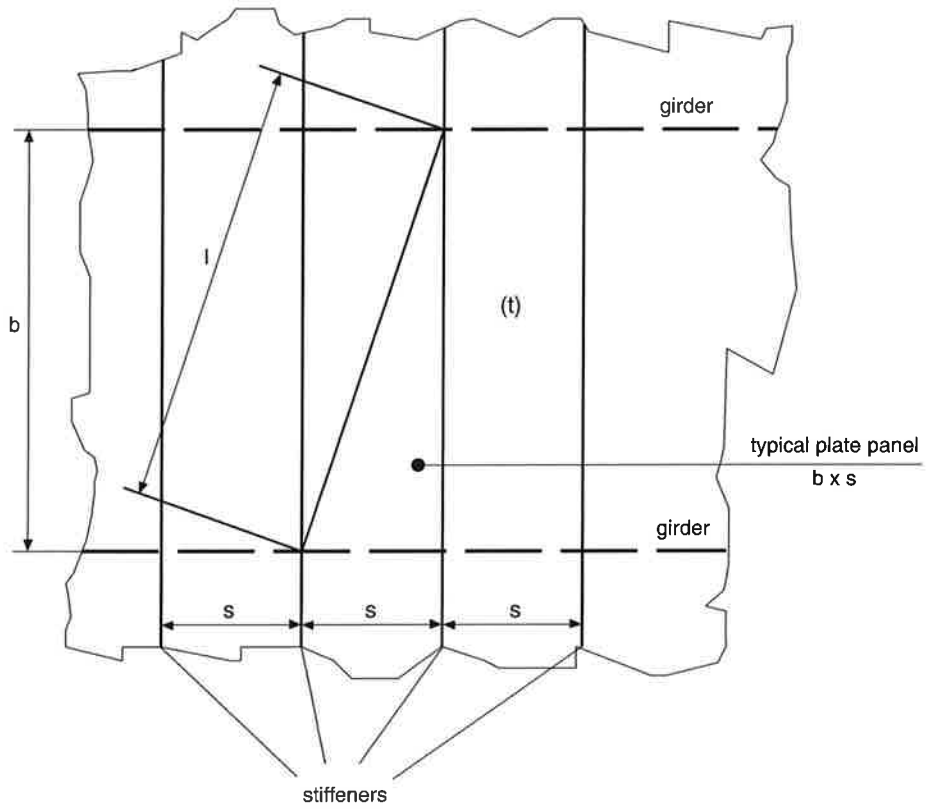
1.4 Back pressure

1.4.1 Pressure drop in vent lines

IGC CODE REFERENCE : Ch 8, 8.2.16

The pressure drop in the vent line from the tank to the pressure relief valve inlet is not to exceed 3% of the valve set pressure. For unbalanced pressure relief valves the back pressure in the discharge line is not to exceed 10% of the gauge pressure at the relief valve inlet with the vent lines under fire exposure.

Figure 1 : Determination of l



2 Additional pressure relieving system for liquid level control

2.1 General

2.1.1 Additional pressure relieving system

IGC CODE REFERENCE : Ch 8, 8.2.2

The override arrangement indicated in paragraph 8.3.1.2 of the IGC Code is to be capable of being manually operated. As an alternative, means for manual venting are to be provided.

2.1.2 Tank filling limits

IGC CODE REFERENCE : Ch 8, 8.2.2

The words 'to prevent the tank from becoming liquid full' in paragraph 8.3.1.1 of the IGC Code have the following meaning:

At no time during the loading, transport or unloading of the cargo including fire conditions will the tank be more than 98% liquid full, except as permitted by 15.1.3 of the IGC Code. These requirements, together with those of 8.2.17 of the IGC Code, are intended to ensure that the pressure relief valves remain in the vapour phase.

SECTION 9 ENVIRONMENTAL CONTROL

1 Inerting

1.1 General

1.1.1 Dew point

IGC CODE REFERENCE: Ch 9, 9.3 and Ch 9, 9.4.1

As far as the IGC Code requirements relevant to the dew point are concerned, the following additional provisions apply:

a) where cargo tank insulation is not protected from water vapour penetration by means of an effective vapour barrier, accepted by the Society, the maximum value of the dew point is to be less than the design temperature

b) where cargo tank insulation is protected by an effective vapour barrier, accepted by the Society, the maximum value of the dew point is to be less than the minimum temperature which may be found on any surface within the spaces filled with dry inert gas or dry air

c) the temperature of the hull structures adjacent to cargo tanks is not to become lower than the minimum permissible working temperature, specified in Ch 9, Sec 6, for the steel grade employed for such hull structures

d) The capacity of dry air or inert gas equipment to produce dry air is to be verified in workshop

e) Means are to be provided on board to measure the dryness of the hold space atmosphere. The equipment may be portable provided permanent connections and/or. sampling pipes are fitted.

1.1.2 Precautions against fire

IGC CODE REFERENCE: Ch 9, 9.4.1

Precautions are to be taken to minimise the risk that static electricity generated by the inert gas system may become a source of ignition.

2 Inert gas production on board

2.1 Exemptions

2.1.1

IGC CODE REFERENCE: Ch 9, 9.5

a) Inert gas generating systems are to be considered as essential services and are to comply with the applicable Sections of the Rules, as far as applicable.

b) Where, in addition to inert gas produced on board, it is possible to introduce dry air into the above-mentioned spaces, where this is acceptable depending on the type of cargo tank adopted, or to introduce inert gas from a supply existing on board, it is not necessary that standby or spare components for the inert gas system are kept on board.

2.2 Engineering specifications

2.2.1 The requirements of Ch 8, Sec 9, [2] are to be complied with, as far as applicable.

SECTION 10 ELECTRICAL INSTALLATIONS

1 General

1.1 Application

1.1.1 The requirements in this Section apply, in addition to those contained in Part C, Chapter 2, to gas carriers.

1.1.2 The design is to be in accordance with IEC publication 60092-502.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation requested in Pt C, Ch 2, Sec 1, Tab 1, the following are to be submitted for approval:

a) plan of hazardous areas

b) document giving details of types of cables and safety characteristics of the equipment installed in hazardous areas

c) diagrams of tank level indicator systems, high level alarm systems and overflow control systems where requested.

1.3 System of supply

1.3.1 Acceptable systems of supply

IGC CODE REFERENCE: Ch 10, 10.1.1

The following systems of generation and distribution of electrical energy are acceptable:

a) direct current:

- two-wire insulated

b) alternating current:

- single-phase, two-wire insulated
- three-phase, three-wire insulated.

In insulated distribution systems, no current carrying part is to be earthed, other than:

a) through an insulation level monitoring device

b) through components used for the suppression of interference in radio circuits.

1.3.2 Earthed system with hull return

IGC CODE REFERENCE: Ch 10, 10.1.1

Earthed systems with hull return are not permitted, with the following exceptions to the satisfaction of the Society:

a) impressed current cathodic protective systems

b) limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any hazardous area

c) insulation level monitoring devices, provided that the circulation current of the device does not exceed 30 mA under the most unfavourable conditions.

1.3.3 Earthed systems without hull return

IGC CODE REFERENCE: Ch 10, 10.1.1

Earthed systems without hull return are not permitted, with the following exceptions:

a) earthed intrinsically safe circuits and the following other systems to the satisfaction of the Society

b) power supplies, control circuits and instrumentation circuits in non-hazardous areas where technical or safety reasons preclude the use of a system with no connection to earth, provided the current in the hull is limited to not more than 5 A in both normal and fault conditions, or

c) limited and locally earthed systems, such as power distribution systems in galleys and laundries to be fed through isolating transformers with the secondary windings earthed, provided that any possible resulting hull current does not flow directly through any hazardous area, or

d) alternating current power networks of 1,000 V root mean square (line to line) and over, provided that any possible resulting current does not flow directly through any hazardous area; to this end, if the distribution system is extended to areas remote from the machinery space, isolating transformers or other adequate means are to be provided.

1.4 Earth detection

1.4.1 Monitoring of circuits in hazardous areas

IGC CODE REFERENCE: Ch 10, 10.1.1

The devices intended to continuously monitor the insulation level of all distribution systems are also to monitor all circuits, other than intrinsically safe circuits, connected to apparatus in hazardous areas or passing through such areas. An audible and visual alarm is to be given, at a manned position, in the event of an abnormally low level of insulation.

1.5 Mechanical ventilation of hazardous spaces

1.5.1 Electric motors driving fans of the ventilating systems of hazardous spaces are to be located outside the ventilation ducting.

1.5.2 At the discretion of the Society, motors driving ventilating fans may be located within the ducting provided that they are of a certified safe type and are arranged with an additional enclosure (having a degree of protection of at least IP 44) which prevents the impingement of the ducted air stream upon the motor casing.

1.5.3 The materials used for the fans and their housing are to be in compliance with Ch 7, Sec 1, [1.3.10].

1.5.4 Cargo compressor rooms and other enclosed spaces which contain cargo-handling equipment and similar spaces in which work is performed on the cargo should be fitted with mechanical ventilation systems, capable of being controlled from outside such spaces.

1.5.5 Provisions are to be made to ventilate the spaces defined in [1.5.4] prior to entering the compartment and operating the equipment.

1.6 Electrical installation precautions

1.6.1 Precautions against inlet of gases or vapours

IGC CODE REFERENCE: Ch 10, 10.1.2

Suitable arrangements are to be provided, to the satisfaction of the Society, so as to prevent the possibility of gases or vapours passing from a gas-dangerous space to another space through runs of cables or their conduits.

2 Hazardous locations and types of equipment

2.1 Electrical equipment permitted in gas-dangerous spaces and zones

2.1.1 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zone 0, 1 and 2 according to Pt C, Ch 2, Sec 1, [3.24.3]. The different spaces are to be classified according to Tab 1.

The types of electrical equipment admitted, depending on the zone where they are installed, are specified in Pt C, Ch 2, Sec 3, [10].

2.1.2 A space separated by a gastight boundaries from a hazardous area may be classified as zone 0, 1, 2 or considered as non hazardous, taking into account the sources of release inside that space and its conditions of ventilation.

2.1.3 Access door and other openings are not to be provided between an area intended to be considered as non-hazardous and a hazardous area or between a space intended to be considered as zone 2 and a zone 1, except where required for operational reasons.

2.1.4 In enclosed or semi-enclosed spaces having a direct opening into any hazardous space or area, electrical installations are to comply with the requirements for the space or area to which the opening leads.

2.1.5 Where a space has an opening into an adjacent, more hazardous space or area, it may be made into a less hazardous space or non-hazardous space, taking into account the type of separation and the ventilation system.

2.1.6 A differential pressure monitoring device or a flow monitoring device, or both, are to be provided for monitoring the satisfactory functioning of pressurisation of spaces having an opening into a more hazardous zone.

In the event of loss of the protection by the over-pressure or loss of ventilation in spaces classified as zone 1 or zone 2, protective measures are to be taken.

2.2 Submerged cargo pumps

2.2.1 Exceptions

Submerged cargo pumps are not permitted in connection with the following cargoes:

- diethyl ether
- vinyl ethyl ether
- ethylene oxide
- propylene oxide
- mixtures of ethylene oxide and propylene oxide.

2.2.2 Submerged electric motors

a) Where submerged electric motors are employed, means are to be provided, e.g. by the arrangements specified in paragraph 17.6 of the IGC Code, to avoid the formation of explosive mixtures during loading, cargo transfer and unloading.

b) Arrangements are to be made to automatically shut down the motors in the event of low liquid level. This may be accomplished by sensing low pump discharge pressure, low motor current, or low liquid level. This shutdown is to be alarmed at the cargo control station. Cargo pump motors are to be capable of being isolated from their electrical supply during gas-freeing operations.

3 Product classification

3.1 Temperature class and explosion group

3.1.1 Tab 2 specifies temperature class and explosion group data for the products indicated in Chapter 19 of the IGC Code. The data shown in brackets have been derived from similar products.

Table 1 : Space descriptions and hazardous area zones

N°	Description of spaces	Hazardous area
1	The interior of cargo tanks, any pipework of pressure-relief or other venting systems for cargo, pipes and equipment containing the cargo or developing flammable gases and vapours.	Zone 0
2	Interbarrier spaces, hold spaces where cargo is carried in a cargo containment system requiring a secondary barrier.	Zone 0
3	Void space adjacent to, above or below integral cargo tanks.	Zone 1
4	Hold spaces where cargo is carried in a cargo containment system not requiring a secondary barrier.	Zone 1
5	Cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks.	Zone 1
6	Cargo pump rooms and cargo compressor rooms.	Zone 1
7	Enclosed or semi-enclosed spaces, immediately above cargo tanks (for example, between decks) or having bulkheads above and in line with cargo tank bulkheads, unless protected by a diagonal plate acceptable to the society.	Zone 1
8	Spaces, other than cofferdam, adjacent to and below the top of a cargo tank (for example, trunks, passageways and hold).	Zone 1
9	Areas on open deck, or semi-enclosed spaces on open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets, cargo compressor room ventilation outlets and cargo tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.	Zone 1
10	Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet intended for the passage of large volumes of gas or vapour mixture during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet.	Zone 1
11	Areas on open deck, or semi-enclosed spaces on open deck, within 1.5 m of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams, cargo compressor room entrances, cargo compressor room ventilation inlets or other zone 1 spaces.	Zone 1
12	Areas on open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.	Zone 1
13	Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3 m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck.	Zone 1
14	Compartments for cargo hoses.	Zone 1
15	Enclosed or semi-enclosed spaces in which pipes containing cargoes are located.	Zone 1
16	A space separated from a hold space, where cargo is carried in a cargo tank requiring a secondary barrier, by a single gastight boundary.	Zone 1
17	Enclosed or semi-enclosed spaces in which pipes containing cargo products for boil-off gas fuel burning systems are located, unless special precautions approved by the society are provided to prevent product gas escaping into such spaces.	Zone 1
18	Areas of 1,5 m surrounding a space of zone 1.	Zone 2
19	Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in item 10.	Zone 2
20	The spaces forming an air lock as defined in IEC publication 60092-502 [4.1.5.2.c].	Zone 2
21	Areas on open deck extending to the coamings fitted to keep any spills on deck and away from the accommodation and service area and 3 m beyond these up to a height of 2.4 m above the deck.	Zone 2
22	Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3 m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck surrounding open or semi-enclosed spaces of zone 1.	Zone 2
23	Spaces forward of the open deck areas to which reference is made in 13 and 22, below the level of the main deck, and having an opening on to the main deck or at a level less than 0.5 m above the main deck, unless: • the entrances to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilating system inlets and exhausts, are situated at least 5 m from the foremost cargo tank and at least 10 m measured horizontally from any cargo tank outlet or gas or vapour outlet, and • the spaces are mechanically ventilated.	Zone 2
24	An area within 2.4 m of the outer surface of a cargo tank where such surface is exposed to the weather.	Zone 2

Table 2 : Temperature class and explosion group of certain products

Product name	Temperature class	Explosion group	Product name	Temperature class	Explosion group
Acetaldehyde	T4	II A	Isopropylamine	T2	II A
Ammonia anhydrous	T1	II A	Methane	T1	II A
Butadiene	T2	II B	Methyl acetylene propadiene mixture	T4	II A
Butane	T2	II A	Methyl bromide	T3	II A
Butane/propane mixture	T2	II A	Methyl chloride	T1	II A
Butylenes	T3	II A	Monoethylamine	T2	II A
Carbon dioxide	NF	NF	Nitrogen	NF	NF
Chlorine	NF	NF	Pentane (all isomers)	(T2)	(II A)
Diethyl ether	T4	II B	Pentene (all isomers	(T3)	(II B)
Dimethylamine	T2	II A	Propane	T1	II A
Dimethyl ether	T3	II B	Propylene	T2	II B
Ethane	T1	II A	Propylene oxide	T2	II B
Ethyl chloride	T2	II A	Refrigerant gases	NF	NF
Ethylene	T2	II B	Sulphur dioxide	(T3)	(II B)
Ethylene oxide	T2	II B	Vinyl chloride	T2	II A
Ethylene oxide propylene oxide mixture (max. 30% w/w ethylene oxide)	T2	II B	Vinyl ethyl ether	T3	II B
Isoprene	T3	II B	Vinylidene chloride	T2	II A

SECTION 11 FIRE PROTECTION AND FIRE EXTINCTION

1 Fire safety requirements

1.1 Temperature of steam and heating media within the cargo area

1.1.1

REFERENCE IGC CODE: Ch 11, 11.1.2

The maximum temperature of the steam and heating media in the cargo area is to be adjusted to take into account the temperature class of the cargo.

2 Water spray system

2.1 Water-spray system coverage

2.1.1

REFERENCE IGC CODE: Ch 11, 11.3.1

The water spray system mentioned in paragraph 11.3.1 of the IGC Code is also to cover boundaries of spaces containing internal combustion engines and/or fuel treatment units, of store-rooms for flammable liquids having a flashpoint equal to or less than 60°C and of paint lockers.

2.2 Water-spray system capacity

2.2.1

REFERENCE IGC CODE: Ch 11, 11.3.2

.In general the vertical distance between the water spray nozzle rows protecting vertical surfaces should not exceed 3,7 m.

2.3 Protection of poop front

2.3.1

REFERENCE IGC CODE: Ch 11, 11.3

A stop valve is to be fitted on the water-spray main as close as possible to the poop front so that the accommodation spaces are always protected in the case of a spray-main failure.

3 Dry chemical powder fire-extinguishing system

3.1 System capacity

3.1.1

REFERENCE IGC CODE: Ch 11, 11.4.2

Any exposed point of the cargo area, including cargo piping, is to be capable of being reached by powder delivered from at least two hoses or from a fixed monitor and one hose, which are not to be supplied by the same powder unit.

3.2 System arrangement

3.2.1 Additional miscellaneous requirements on powder units

REFERENCE IGC CODE: Ch 11, 11.4.3

a) Two powder units, even if mutually connected through a common main, may be considered independent on condition that non-return valves or other arrangements suitable to prevent powder from passing from one unit to the other are fitted.

b) The powder units which constitute the system are to contain, in general, the same powder quantity and, when they are not grouped together in a single position, they are to be uniformly located over the area to be protected.

c) Where powder units are grouped together in a single position or, in the case of ships having a cargo capacity less than 1000 m^3, a single powder unit is installed, the said units are to be located aft of the cargo area.

4 Cargo compressor and pump rooms

4.1 Carbon dioxide system

4.1.1 Alarms

REFERENCE IGC CODE: Ch 11, 11.5.1

Audible alarms fitted to warn of the release of fire extinguishing medium into pump rooms, are to be of the pneumatic type or electric type.

a) In cases where the periodic testing of pneumatically operated alarms is required, CO_2 operated alarms should not be used owing to the possibility of the generation of static electricity in the CO_2 cloud. Air operated alarms may be used provided the air supply is clean and dry.

b) When electrically operated alarms are used, the arrangements are to be such that the electric actuating mechanism is located outside the pump room except where the alarms are certified intrinsically safe.

4.2 Portable fire extinguishers

4.2.1

REFERENCE IGC CODE: Ch 11, 11.5

In pump rooms and cargo compressor rooms, at least two portable extinguishers of a recognised type are to be fitted.

SECTION 12 MECHANICAL VENTILATION IN THE CARGO AREA

1 Spaces required to be entered during normal cargo handling operations

1.1 Location of discharges from dangerous spaces

1.1.1 Ventilation duct arrangement

IGC CODE REFERENCE: Ch 12, 12.1.6

a) Ventilation ducts are to be arranged at a suitable height from the weather deck. This height is not to be less than 2,4 m for intake ducts.

b) Ventilation ducts are to be fitted with metallic fire dampers provided with "open" and "closed" signs. These dampers are to be arranged in the open, in a readily accessible position.

c) Gas-dangerous spaces for the purpose of 1.1.1.a) are those mentioned in paragraph 12.1.5 of the IGC Code. For other spaces which are gas-dangerous only due to their position, some relaxation may be granted.

1.2 Recirculation prevention

1.2.1

IGC CODE REFERENCE: Ch 12, 12.1.7

a) Exhaust ducts from gas-dangerous spaces are to be arranged at a distance in the horizontal direction of at least 10 m from ventilation outlets of gas-safe spaces. Shorter distances may be accepted for ventilation outlets from safe spaces protected by air-locks.

b) Intakes of gas-dangerous spaces are to be arranged at a distance in the horizontal direction of at least 3 m from ventilation intakes and outlets and openings of accommodation spaces, control stations and other gas-safe spaces.

c) Exhaust and intake ducts for the same gas-dangerous space, or for the same space rendered safe by an air-lock, are to be arranged at a distance from each other in the horizontal direction of not less than 3 m.

1.3 Additional requirements for non-sparking fans

1.3.1 Non-sparking fans

IGC CODE REFERENCE: Ch 12, 12.1.9

a) A fan is considered as non-sparking if in both normal or abnormal conditions it is unlikely to produce sparks.

b) The air gap between the impeller and the casing is to be not less than 0,1 of the shaft diameter in way of the impeller bearing and not less than 2 mm. It need not be more than 13 mm.

c) Protection screens of not more than 13 mm^2 mesh are to be fitted in the inlet and outlet of ventilation ducts to prevent the entrance of objects into the fan housing.

1.3.2 Materials for non-sparking fans

IGC CODE REFERENCE: Ch 12, 12.1.9

a) The impeller and the housing in way of the impeller are to be made of alloys which are recognised as being spark proof by appropriate tests.

b) Electrostatic charges both in the rotating body and the casing are to be prevented by the use of antistatic materials. Furthermore, the installation on board of the ventilation units is to be such as to ensure their safe bonding to the hull.

c) Tests may not be required for fans having the following combinations:

- impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
- impellers and housings of non-ferrous materials
- impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller
- any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm design tip clearance.

d) The following impellers and housings are considered as sparking and are not permitted:

- impellers of an aluminium alloy or magnesium alloy and a ferrous housing, regardless of tip clearance
- housing made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
- any combination of ferrous impeller and housing with less than 13 mm design tip clearance.

1.3.3 Type test for non-sparking fans

IGC CODE REFERENCE: Ch 12, 12.1.9

Type tests on the finished product are to be carried out in accordance with the requirements of the Society or an equivalent national or international standard.

1.3.4 Motor shafting

IGC CODE REFERENCE: 12, 12.1.9

The shafting penetration of motors driving fans through bulkheads and decks of dangerous spaces or through ventilation ducts is to be fitted with a gas-tight sealing device, of the oil-seal type or equivalent, deemed suitable by the Society.

2 Spaces not normally entered

2.1 General requirements

2.1.1 Minimum number of air changes

IGC CODE REFERENCE: 12, 12.2

Both fixed and portable systems are to guarantee the efficient ventilation of such spaces in relation to the relative density, in respect of the air, and to the toxicity of the gases transported. Such ventilation system is to be capable of effecting not less than 8 air changes per hour. The type of portable fans and their connection to the spaces served are to be approved by the Society. In no case are portable electrical fans acceptable.

SECTION 13 INSTRUMENTATION (GAUGING, GAS DETECTION)

1 General

1.1 Cargo tank instrumentation

1.1.1 The instrumentation is to be of a type approved by the Society.

1.1.2 Attention is drawn to the requirements of Ch 9, Sec 1, [4.2.4] regarding the satisfactory operation of the cargo control and monitoring system and of the level alarm system, that is to be ascertained during the first full loading and the subsequent first unloading of ships carrying liquefied natural gasses (LNG) in bulk.

1.2 Detection of leak through secondary barrier

1.2.1

IGC CODE REFERENCE: Ch 13, 13.1.2

Upon special approval, appropriate temperature indicating devices may be accepted by the Society instead of gas detecting devices when the cargo temperature is not lower than –55°C.

1.3 Indicator location

1.3.1 Monitoring list

IGC CODE REFERENCE: Ch 13, 13.1.3

The following information and alarms are to be concentrated in the positions specified in this requirement.

a) The following is to be transduced to the "cargo control room" and the "control position" as defined in 3.4.1 of the IGC Code:

   1) the indication signalling the presence of water and/or liquid cargo in holds or interbarrier spaces
   2) the cargo heater low temperature alarm required in 4.2.7 of the IGC Code
   3) the alarm signalling the presence of liquid cargo in the vent main as per 5.2.1.7 of the IGC Code
   4) the indication of the hull temperature and the hull structure low temperature alarm required in 13.5.2 of the IGC Code
   5) the alarm signalling the automatic shutdown of electrically driven submerged pumps required in 10.2.2 of the IGC Code
   6) the indication of the cargo level and the cargo tank high level alarm required in 13.3.1 of the IGC Code
   7) the indication of the vapour space pressure and the vapour space pressure gauges of each cargo tank and associated high and low pressure alarms required in 13.4.1 of the IGC Code
   8) the gas detection equipment alarm required in 13.6.4 of the IGC Code
   9) the cargo compressor high temperature alarm required in 17.4.2.2 of the IGC Code
   10) the alarm for automatic shutdown of the cargo compressor for high pressure or high temperature, as required in 17.18.4.4 of the IGC Code.

   When the cargo system is not remote controlled and therefore the aforesaid "control positions" are not required, the above-mentioned controls, information and alarms are to be located in a suitable, easily accessible location.

   If this position is an enclosed space, it is to comply with the requirements of 3.3.3 of the IGC Code. This position should preferably be located in the wheelhouse.

b) Independently of the above, the following is to be transduced to the wheelhouse:

   1) the alarm signalling the presence of water and/or liquid cargo in holds or interbarrier spaces
   2) the cargo heater low temperature alarm required in 4.2.7 of the IGC Code
   3) the alarm signalling the presence of liquid cargo in the vent main as per 5.2.1.7 of the IGC Code
   4) the indication of the pressure value in the vapour space of each cargo tank mentioned in 13.4.1 of the IGC Code; such indication is to give the setting pressure value of the relief valve and the minimum allowable pressure value in the cargo tank concerned
   5) the high pressure and low pressure alarms, when required, for cargo tanks as per 13.4.1 of the IGC Code
   6) the hull structure low temperature alarm required in 13.5.2 of the IGC Code
   7) the gas detection equipment alarm required in 13.6.4 of the IGC Code
   8) the cargo compressor high temperature alarm required in 17.4.2.2 of the IGC Code
   9) the alarm for automatic shutdown of the cargo compressor for high pressure or high temperature, as required in 17.18.4.4 of the IGC Code.

c) Where the cargo control room is located within the accommodation spaces and is readily accessible, the alarms in 13.3.2 of the IGC Code may be grouped in a

single audible and visual alarm except for the indication and alarms in [1.3.1] item b) 4), item b) 5) and item b) 7), which are to be independent from each other.

d) The high level and high or low pressure audible and visual alarms for cargo tanks as per 13.3.1 and 13.3.2 of the IGC Code and the alarm signalling the presence of liquid in the vent main are to be located in such a position as to be clearly heard and identifiable by the personnel in charge of loading operation control.

2 Level indicators for cargo tanks

2.1 General

2.1.1

IGC CODE REFERENCE: Ch 13, 13.2.1

a) In order to assess whether or not one level gauge is acceptable, the wording "any necessary maintenance" is to be interpreted to mean that any part of the level gauge can be overhauled while the cargo tank is in service.

b) Where level gauges containing cargo are arranged outside the tank they serve, means are to be provided to shut them off automatically in the event of failure.

3 Overflow control

3.1 Overflow alarm and shutdown

3.1.1 Shut-off valve for overflow control

IGC CODE REFERENCE: Ch 13, 13.3.1

The sensor for automatic closing of the loading valve for overflow control may be combined with the liquid level indicators required by paragraph 13.2.1 of the IGC Code.

3.1.2 Shut-off valve closing time

IGC CODE REFERENCE: Ch 13, 13.3.1

The closing time of the valve referred to in 13.3.1 of the IGC Code (i.e. time from shutdown signal initiation to complete valve closure), in seconds, is to be not greater than:

$$\frac{3600 \cdot U}{LR}$$

where:

U : Ullage volume at operating signal level, in m^3

LR : Maximum loading rate agreed between ship and shore facility, in m^3/h.

The loading rate is to be adjusted to limit surge pressure on valve closure to an acceptable level taking into account the loading hose or arm, and the ship and shore piping systems, where relevant.

4 Pressure gauges

4.1 Pressure gauges in cargo tanks

4.1.1

IGC CODE REFERENCE: Ch 13, 13.4.1

The low pressure alarm indicated in paragraph 13.4.1 of the IGC Code is also to be located in the cargo control room.

5 Temperature indicating devices

5.1 General

5.1.1 Temperature recording

IGC CODE REFERENCE: Ch 13, 13.5.1

The temperatures are to be continuously recorded at regular intervals. Audible and visual alarms are to be automatically activated when the hull steel temperature approaches the lowest temperature for which the steel has been approved.

6 Gas detection requirements

6.1 Position of sampling heads

6.1.1

IGC CODE REFERENCE: Ch 13, 13.6.2

Sampling heads in cargo holds are not to be located in positions where bilge water may collect.

6.2 Gas sampling lines

6.2.1

IGC CODE REFERENCE: Ch 13, 13.6.5

Gas analysing units are to be in compliance with the requirements in Ch 7, Sec 6, [6.4].

6.3 Protected spaces

6.3.1

IGC CODE REFERENCE: Ch 13, 13.6.7

In addition to the list in paragraph 13.6.7 of the IGC Code, the gas detection system is also to serve spaces adjacent to pump rooms and compressor rooms.

6.4 Portable gas detectors

6.4.1

IGC CODE REFERENCE: Ch 13, 13.6.13

For ships intended to carry toxic and flammable gases, two sets for toxic gases and two sets for flammable gases are to be provided.

SECTION 14 PROTECTION OF PERSONNEL

1 Personnel protection requirements for individual products

1.1 Showers and eye wash

1.1.1

IGC CODE REFERENCE: Ch 14, 14.4.3

The showers and eye wash are to be fitted with a heating system, or other suitable installation, in order to avoid any ice formation in their piping.

SECTION 15 FILLING LIMITS FOR CARGO TANKS

1 General

1.1

1.1.1 This Section is void, as there are no additional or alternative requirements to those indicated in Chapter 15 of the IGC Code.

SECTION 16 USE OF CARGO AS FUEL

1 Gas fuel supply

1.1 Piping

1.1.1 Piping runs

IGC CODE REFERENCE: Ch 16, 16.3.1

a) The main gas line between the gas make-up station and the machinery space is to be as short as possible.

b) The gas piping is to be installed as high in the space as possible and at the greatest possible distance from the ship's hull.

1.1.2 Segregation of piping

IGC CODE REFERENCE: Ch 16, 16.3.1

Gas piping is to be independent of other systems and may only be used for the conveyance of gas. It is to be ensured by its arrangement that it is protected against external damage.

1.1.3 Earthing

IGC CODE REFERENCE: Ch 16, 16.3.1

Gas piping is to be suitably earthed.

1.1.4 Testing

IGC CODE REFERENCE: Ch 16, 16.3.1

Piping, valves and fittings are to be hydrostatically tested, after assembly on board, to 1,5 times the working pressure but to not less than 7 bar. Subsequently, they are to be pneumatically tested to ascertain that all the joints are perfectly tight.

1.2 Valves

1.2.1 Manual operation

IGC CODE REFERENCE: Ch 16, 16.3.6

The three valves indicated in paragraph 16.3.6 of the IGC Code are to be capable of being manually operated.

1.2.2 Automatic operation

IGC CODE REFERENCE: Ch 16, 16.3.6

It is to be possible to operate the valves indicated in paragraph 16.3.6 of the IGC Code locally and from each control platform. They are to close automatically under the following service conditions:

a) whenever the gas pressure varies by more than 10 % or, in the case of supercharged engines, if the differential pressure between gas and charging air is no longer constant

b) in the event of one of the following fault situations:

1) Gas supply to boiler burners
   - insufficient air supply for complete combustion of the gas
   - extinguishing of the pilot burner for an operating burner, unless the gas supply line to every individual burner is equipped with a quick-closing valve that automatically cuts off the gas
   - low pressure of the gas

2) Gas supply to internal combustion engines
   - failure of supply to pilot fuel injection pump
   - drop of engine speed below the lowest service speed
   - indication by the gas detector in the crankcase vent line that the gas concentration is approaching the lower explosion limit.

2 Gas make-up plant and related storage tanks

2.1 General

2.1.1 Location of equipment for making up gas

IGC CODE REFERENCE: Ch 16, 16.4.1

Means for purging of flammable gases before opening are to be provided in the equipment for making up gas.

2.1.2 Equipment located on weather deck

IGC CODE REFERENCE: Ch 16, 16.4.1

Where the equipment (heaters, compressors, filters) for making up the gas for its use as fuel and the storage tanks are located on the weather deck, they are to be suitably protected from atmospheric agents and the sea.

2.2 Compressors

2.2.1 Miscellaneous requirements

IGC CODE REFERENCE: Ch 16, 16.4.2

a) The compressors are to be capable of being remotely stopped from an always and easily accessible, non-dangerous position in the open, and also from the engine room.

b) In addition, the compressors are to be capable of automatically stopping when the suction pressure reaches a certain value depending on the setting pressure of the vacuum relief valves of the cargo tanks.

c) The automatic shutdown device of the compressors is to have a manual resetting.

d) Piston-type compressors are to be fitted with relief valves discharging to a position in the open, such as not to give rise to hazards.

e) Volumetric compressors are to be fitted with pressure/vacuum relief valves discharging into the suction line of the compressor.

f) The size of the pressure relief valves is to be determined in such a way that, with the delivery valve kept closed, the maximum pressure does not exceed the maximum working pressure by more than 10%.

g) The compressors are to be automatically stopped by the emergency shutdown system of the cargo valves.

h) The compressors are to be fitted with shut-off valves and flame screens on both the suction and delivery sides.

2.3 Heaters

2.3.1 Additional miscellaneous requirements

IGC CODE REFERENCE: Ch 16, 16.4.3

a) Operation of the heaters is to be automatically regulated depending on the gas temperature at the heater outlet.

b) Before it is returned to the machinery space, the heating medium (steam or hot water) is to go through a degassing tank located in the cargo area.

c) Provisions are to be made to detect and signal the presence of gas in the tank. The vent outlet is to be in a safe position and fitted with a flame screen.

3 Special requirements for main boilers

3.1 Boiler arrangement

3.1.1 Forced air circulation

IGC CODE REFERENCE: Ch 16, 16.5.1

Boilers are to be located as high as possible in boiler spaces and are to be of the membrane wall type or equivalent, so as to create a space with forced air circulation between the membrane wall and the boiler casing.

3.2 Combustion chamber

3.2.1 Gas detectors in the combustion chamber

IGC CODE REFERENCE: Ch 16, 16.5.3

The Society may, at its discretion, require gas detectors to be fitted in those combustion chamber areas where gas could accumulate, as well as the provision of suitable air nozzles.

3.3 Burner system

3.3.1 Safety devices

IGC CODE REFERENCE: Ch 16, 16.5.4

A mechanical device is to be installed to prevent the gas valve from opening until the air and the fuel oil controls are in the ignition position. A flame screen, which may be incorporated in the burner, is to be fitted on the pipe of each gas burner.

3.3.2 Shut-off

IGC CODE REFERENCE: Ch 16, 16.5.4

The gas supply is to be automatically stopped by the shut-off devices specified in paragraph 16.3.6 of the IGC Code.

4 Special requirements for gas fired internal combustion engines and gas fired turbines

4.1 Gas fuel supply to engine

4.1.1 Flame arresters

IGC CODE REFERENCE: Ch 16, 16.6

Flame arresters are to be provided at the inlet to the gas supply manifold for the engine.

4.1.2 Manual shut-off

IGC CODE REFERENCE: Ch 16, 16.6

Arrangements are to be made so that the gas supply to the engine can be shut off manually from the starting platform or any other control position.

4.1.3 Prevention of fatigue failure

IGC CODE REFERENCE: Ch 16, 16.6

The arrangement and installation of the gas piping are to provide the necessary flexibility for the gas supply piping to accommodate the oscillating movements of the engines without risk of fatigue failure.

4.1.4 Protection of gas line connections

IGC CODE REFERENCE: Ch 16, 16.6

The connecting of gas line and protection pipes or ducts as per [4.2.1] to the gas fuel injection valves is to provide complete coverage by the protection pipe or ducts.

4.2 Gas fuel supply piping systems

4.2.1 Fuel piping in machinery spaces

IGC CODE REFERENCE: Ch 16, 16.6

Gas fuel piping may pass through or extend into machinery spaces or gas-safe spaces other than accommodation spaces, service spaces and control stations provided that they fulfil one of the following conditions:

a) The system complies with paragraph 16.3.1.1 of the IGC Code, and in addition, with 1) to 3) below:

   1) The pressure in the space between concentric pipes is monitored continuously. Alarm is to be issued and the automatic valves specified in 16.3.6 of the IGC Code (hereafter referred to as "interlocked gas valves") and the master gas fuel valves specified in 16.3.7 of the IGC Code (hereafter referred to as "master gas valves") are to be closed before the pressure drops to below the inner pipe pressure (however, an interlocked gas valve connected to the vent outlet is to be opened).

   2) The construction and strength of the outer pipes are to comply with the requirements of 5.2 of the IGC Code.

   3) It is to be so arranged that the inside of the gas fuel supply piping system between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed; or

b) The system complies with paragraph 16.3.1.2 of the IGC Code, and, in addition, with 1) to 4) below:

1) The materials, construction and strength of protection pipes or ducts and mechanical ventilation systems are to be sufficiently durable against bursting and rapid expansion of high pressure gas in the event of gas pipe burst.

2) The capacity of mechanical ventilating systems is to be determined considering the flow rate of gas fuel and construction and arrangement of protective pipes or ducts, as deemed appropriate by the Society.

3) The air intakes of mechanical ventilating systems are to be provided with non-return devices effective for gas fuel leaks. However, if a gas detector is fitted at the air intakes, this requirement may be dispensed with.

4) The number of flange joints of protective pipes or ducts is to be minimised; or

c) Alternative arrangements to those given in a) and b) will be specially considered by the Society based upon an equivalent level of safety.

4.2.2 High pressure pipes

IGC CODE REFERENCE: Ch 16, 16.6

High pressure gas piping systems are to be checked for sufficient constructive strength by carrying out stress analysis taking into account the stresses due to the weight of the piping system including acceleration load, when significant, internal pressure and loads induced by hog and sag of the ship.

4.2.3 Valves and expansion joints

IGC CODE REFERENCE: Ch 16, 16.6

All valves and expansion joints used in high pressure gas fuel supply lines are to be of an approved type.

4.2.4 Pipe joints

IGC CODE REFERENCE: Ch 16, 16.6

Joints on the entire length of the gas fuel supply lines are to be butt-welded joints with full penetration and to be fully radiographed, except where specially approved by the Society.

4.2.5 Non-welded pipe joints

IGC CODE REFERENCE: Ch 16, 16.6

Pipe joints other than welded joints at the locations specifically approved by the Society are to comply with the appropriate standards recognised by the Society, or with joints whose structural strength has been verified through test analysis as deemed appropriate by the Society.

4.2.6 Post-weld heat treatment

IGC CODE REFERENCE: Ch 16, 16.6

For all butt-welded joints of high pressure gas fuel supply lines, post-weld heat treatment is to be performed depending on the kind of material.

4.3 Shut-off of gas fuel supply

4.3.1 Fuel supply shut-off

IGC CODE REFERENCE: Ch 16, 16.6

In addition to the causes specified in 16.3.6 of the IGC Code, supply of gas fuel to engines is to be shut-off by the interlocked gas valves in the event of the following abnormalities:

a) abnormality specified in Pt C, Ch 1, App 2

b) engine stops due to any cause.

4.3.2 Master gas valve shut-off

IGC CODE REFERENCE: Ch 16, 16.6

In addition to the causes specified in 16.3.7 of the IGC Code, the master gas valve is to be closed in the event of any of the following:

a) the oil mist detector or bearing temperature detector specified in Pt C, Ch 1, App 2 detects abnormality

b) any kind of gas fuel leakage is detected

c) abnormality specified in Pt C, Ch 1, App 2.

4.3.3 Automatic operation

IGC CODE REFERENCE: Ch 16, 16.6

The master gas valve is to close automatically upon activation of the interlocked gas valves.

4.4 Emergency stop of dual fuel engines

4.4.1

IGC CODE REFERENCE: Ch 16, 16.6

Dual fuel engines are to be stopped before the gas concentration detected by the gas detectors specified in 16.2.2 of the IGC Code reaches 60% of the lower flammable limit.

4.5 Gas fuel make-up plant and related storage tanks

4.5.1 Equipment construction

IGC CODE REFERENCE: Ch 16, 16.6

The construction, control and safety system of high pressure gas compressors, pressure vessels and heat exchangers constituting a gas fuel make-up plant are to be arranged to the satisfaction of the Society.

4.5.2 Fatigue

IGC CODE REFERENCE: Ch 16, 16.6

The possibility of fatigue failure of the high pressure gas piping due to vibration is to be considered.

4.5.3 Gas pressure pulsation

IGC CODE REFERENCE: Ch 16, 16.6

The possibility of pulsation of gas fuel supply pressure caused by the high pressure gas compressor is to be considered.

4.6 Requirements on dual fuel engines

4.6.1

IGC CODE REFERENCE: Ch 16, 16.6

Specific requirements on internal combustion engines supplied by gas are given in Pt C, Ch 1, App 2.

SECTION 17 SPECIAL REQUIREMENTS

1 Materials for construction

1.1 Materials exposed to cargo

1.1.1

IGC CODE REFERENCE: Ch 17, 17.2

Materials "exposed to cargo" are those constituting systems, cargo appliances or arrangements which are in contact with (liquid or vapour) cargo in normal operating conditions.

2 Inhibition

2.1 Polymerisation prevention - Alternative requirement

2.1.1

IGC CODE REFERENCE: Ch 17, 17.8.1

a) As an alternative to the addition of inhibited liquid, it may be accepted that, at the end of each refrigeration period, the liquid is completely removed from the refrigeration system by means of vapour from compressors or by means of inert gas. In such case, the following wording is to be entered on the Certificate of Fitness:

"At the end of each refrigeration period, the liquid is to be completely removed from the refrigeration system by means of vapour from compressors or by means of inert gas."

b) On the cargo compressor delivery side, a temperature switch is to be fitted, set at a suitable temperature, depending on the characteristics of the product carried (e.g. 60°C for butadiene), giving a visual and audible alarm on the navigation bridge and in the cargo control station, if any, which causes the compressor to stop when such temperature is exceeded.

3 Chlorine

3.1 Cargo containment system

3.1.1 Relief valves

IGC CODE REFERENCE: Ch 17, 17.14.1.4

Chlorine discharge from pressure relief valves is to be led to an absorption device deemed suitable by the Society.

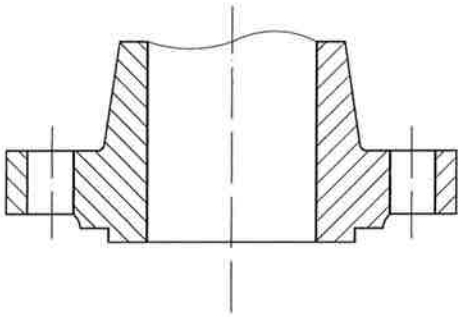
3.2 Cargo piping system

3.2.1 Piping design and fabrication

IGC CODE REFERENCE: Ch 17, 17.14.2.2

A welding neck type flange deemed suitable is shown in Fig 1 as an example.

Figure 1 : Suitable neck type flange



3.3 Instrumentation - Safety devices

3.3.1 Gas detection system

IGC CODE REFERENCE: Ch 17, 17.14.4.3

The gas detection system is to be permanently installed.

3.4 Protection of personnel

3.4.1 Additional equipment

IGC CODE REFERENCE: Ch 17, 17.14.5

In addition to the source of uncontaminated air, two complete and independent air breathing apparatuses, not employing oxygen supplies, each having a capacity of at least 1200 litres of non-compressed air and two sets of protective equipment, complete with gas-tight boots, gloves and eye protection, are to be provided. The above-mentioned equipment and clothing are to be kept in the space indicated in paragraph 17.14.5.1 of the IGC Code and are additional to those required in other parts of this Chapter.

3.5 Filling limits for cargo tanks

3.5.1

IGC CODE REFERENCE: Ch 17, 17.14.6.1

When determining the filling limits of the cargo tanks for the transport of chlorine, the effect of the refrigeration plant is not to be considered.

4 Carbon dioxide

4.1 Interpretation and application of the IGC Code for ships carrying liquefied carbon dioxide in bulk

4.1.1 Interpretation and application of the IGC Code for ships carrying liquefied carbon dioxide in bulk are given in Tab 1.

Table 1 : Interpretation and application of the IGC Code for ships carrying carbon dioxide in bulk

Paragraph	Interpretation
3.1.2	A single A-0 bulkhead is sufficient.
5.2.1.4	Electrical bonding of piping and tanks is not required.
5.6.4	Fusible elements in the emergency shutdown system are not required.
10	Certified safe electrical equipment is not required.
11	This entire chapter is not applicable.
12.1.9	Safe placing and safe construction of electrical fan motors is not required.
12.1.11	Protection screens in vent ducts are not required.
13.6	Only paragraphs 13.6.13 and 13.6.14 are applicable.

SECTION 18 OPERATING REQUIREMENTS

1 General

1.1

1.1.1 This Section is void, as the provisions of Chapter 18 of the IGC Code are operating requirements which are not mandatory for the class, with exception of 18.8.2 which is referred to in Ch 9, Sec 13, [3.1.2].

SECTION 19 SUMMARY OF MINIMUM REQUIREMENTS

1 Additional information on products

1.1

1.1.1

IGC CODE REFERENCE: Ch 19

Tab 1 lists some additional information for those products which are listed in the table in Chapter 19 of the IGC Code.

The list shown in Tab 1 gives properties for pure products. The specific gravity to be taken into account for the design of a ship might be altered considering the actual properties of the commercial product.

Information on temperature classes and explosion groups for electrical equipment in connection with the products to be carried is indicated in Ch 9, Sec 10, Tab 1.

Table 1 : Additional information on products

Product name	Boiling temperature (°C)	Specific gravity at boiling point (kg/m³)	Ratio vapour/air density
Acethaldehyde	20,8	780	1,52
Ammonia, anhhydrous	–33,4	680	0,60
Butiadene	–4,5	650	1,87
Butane	–0,5 / 11,7	600	2,02
Butylenes	–6,3 / –7	625	1,94
Carbon dioxide	– 79,0	1180	1,50
Chlorine	–34	1560	2,49
Diethyl ether	34,6	640	2,55
Dimethylamine	6,9	670	1,55
Dimethyl ether	– 24,4	720	1,62
Ethane	–88,6	549	1,04
Ethyl chloride	12,4	920	2,22
Ethylene	–104	570	0,97
Ethylene oxide	–10,7	870	1,52
Isoprene	34,5	680	2,35
Isopropylamine	32,5	700	2,03
Methane (LNG)	–161,5	420	0,55
Methyl acetylene/propadiene mixture	–32 / –14	–	–
Methyl bromide	4,5	1730	3,27
Methyl chloride	–23,7	1000	1,78
Monoethylamine	16,6	690	1,56
Nitrogen	–196	808	0,97
Pentanes (all isomers)	36,1	610	2,60
Pentene (all isomers)	30,1 / 37	610	2,60
Propane	–42,3	580	1,56
Propylene	–47,7	610	1,50
Propylene oxides	34,5	860	2,00
Refrigerant gases			
Dichlorodifluoromethane (R12)	–30	1486	4,26
Dichloromonofluoroethane (R21)	8,9	1480	3,90
Dichlorotetrafluoroethane (R114)	3,8	1510	1,31
Monochlorodifluoromethane (R22)	–42	1420	2,98
Monochlorotetrafluoroethane (R124)	–	–	4,70
Monochlorotrifluoromethane (R13)	–81,4	1520	3,60
Sulphur dioxide	–10	1460	2,30
Vinyl chloride	–13,9	970	2,15
Vinyl ethyl ether	35,5	754	2,50
Vinylidene chloride	31,7	1250	3,45