RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part GF Ships Using Low-Flashpoint Fuels

Rules for the Survey and Construction of Steel Ships
Part GF 2017 AMENDMENT NO.1
Guidance for the Survey and Construction of Steel Ships
Part GF 2017 AMENDMENT NO.2

Rule No.92 / Notice No.96 25 December 2017
Resolved by Technical Committee on 26 July 2017

ClassNK
NIPPON KAIJI KYOKAI

An asterisk (*) after the title of a requirement indicates that there is also relevant information in the corresponding Guidance.

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

RULES

Part GF Ships Using Low-Flashpoint Fuels

2017 AMENDMENT NO.1

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Resolved by Technical Committee on 26 July 2017

An asterisk (*) after the title of a requirement indicates that there is also relevant information in the corresponding Guidance.

Rule No.92 25 December 2017
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Rules for the survey and construction of steel ships" has been partly amended as follows:

Part GF SHIPS USING LOW-FLASHPOINT FUELS

Chapter 14 ELECTRICAL INSTALLATIONS

14.3 General Requirements (*IGF Code* 14.3)

Paragraph 14.3.7 has been amended as follows.

14.3.7 Low-liquid Level Alarm

Arrangements are to be made to alarm in low-liquid level and automatically shutdown the motors in the event of ~~low-liquid level~~ low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level. This shutdown is to give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.

Chapter 15 CONTROL, MONITORING AND SAFETY SYSTEMS

15.4 Bunkering and Liquefied Gas Fuel Tank Monitoring (*IGF Code* 15.4)

Paragraph 15.4.10 has been amended as follows.

15.4.10 Protective Devices for Submerged Fuel-pump Motors

For submerged fuel-pump motors and their supply cables, arrangements are to be made to alarm in low-liquid level and automatically shutdown the motors in the event of ~~low-liquid level~~ low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level. This shutdown is to give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.

15.9 Fire Detection (*IGF Code* 15.9)

15.9.1 Fire Detection

Required safety actions at fire detection in the machinery space containing gas-fuelled engines and rooms containing independent tanks for fuel storage hold spaces are given in **Table GF15.1** below.

Table GF15.1 has been amended as follows.

Table GF15.1 Monitoring of Gas Supply System to Engines

Parameter	Alarm	Automatic shutdown of tank valve[6)]	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Comments
(Omitted)				
Fire detection in ventilation trunk ~~for fuel containment system below deck~~ to the tank connection space and in the tank connection space	X			
(Omitted)				

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 25 December 2017.

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part GF Ships Using Low-Flashpoint Fuels

GUIDANCE

2017 AMENDMENT NO.2

Notice No.96 25 December 2017
Resolved by Technical Committee on 26 July 2017

Notice No.96 25 December 2017
AMENDMENT TO THE GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Guidance for the survey and construction of steel ships" has been partly amended as follows:

Part GF SHIPS USING LOW-FLASHPOINT FUELS

Amendment 2-1

GF6 FUEL CONTAINMENT SYSTEM

GF6.4 Liquefied Gas Fuel Containment

Paragraph GF6.4.1 has been added as follows.

GF6.4.1 General

With respect to the wording "inspection/survey plan for the liquefied gas fuel containment system" specified in the requirements in **6.4.1-8, Part GF of the Rules**, reference is to be made to the special requirements for ships using low-flashpoint fuels specified in **Chapters 3** to **5**, **Part B of the Rules** as applicable to surveys for liquefied gas fuel containment systems in addition to the requirements specified in this Part.

GF15 CONTROL, MONITORING AND SAFETY SYSTEMS

Section GF15.4 has been added as follows.

GF15.4 Bunkering and Liquefied Gas Fuel Tank Monitoring

GF15.4.2 Overflow Control

The wording "each dry-docking" specified in **15.4.2-3, Part GF of the Rules** means docking surveys carried out at the times specified in **1.1.3-1(4)(a), Part B of the Rules**.

GF17 OPERATING REQUIREMENTS

Section GF17.2 has been added as follows.

GF17.2 Functional Requirements

GF17.2.2 Additional Requirements

The "operational procedures" specified in the requirements in **17.2.2-3, Part GF of the Rules** are to include following **(1)** and **(2)**:

(1) the instructions and manuals specified in Note 3 of **Table B3.11, Part B of the Rules**; and

(2) a notice that the logbooks and operating records specified in Note 4 of **Table B3.11, Part B of the Rules** are to be retained on board.

EFFECTIVE DATE AND APPLICATION (Amendment 2-1)

1. The effective date of the amendments is 1 January 2018.

Amendment 2-2

GF6 FUEL CONTAINMENT SYSTEM

GF6.4 Liquefied Gas Fuel Containment

Paragraph GF6.4.1 has been added as follows.

GF6.4.1 General

1 For the purpose of the requirements in **6.4.1-7**, **Part GF of the Rules**, the corrosion allowance for steel in cases where there are no environmental controls, such as inerting, around the fuel tank is to be 1 *mm*.

2 For the purpose of the requirements in **6.4.1-7**, **Part GF of the Rules**, no corrosion allowance may be required for the internal surface of pressure vessels including the type *C* independent tank except for the case where corrosive substances are to be loaded. For the exterior surface where there is no environmental control around the liquefied gas fuel tank such as inerting or where there is no protection by suitable insulation materials having the approved vapour barrier, the corrosion allowance for steel is to be the smaller of 1 *mm* or 1/6 of the required thickness excluding the corrosion allowance. Paint or other thin coatings are not to be credited as protection.

3 For the purpose of the requirements in **6.4.1-7**, **Part GF of the Rules**, in case where no corrosion allowance is considered for liquefied gas fuel tanks protected by insulation, the air-tightness of the vapour barrier of insulation structure is to have been verified. This air-tightness is to be verified in the test of insulation specified in the requirements in **6.4.13-3**, **Part GF of the Rules**.

4 With respect to the wording "An inspection/survey plan for the liquefied gas fuel containment system" specified in the requirements in **6.4.1-8**, **Part GF of the Rules,** reference is to be made to the special requirements for ships using low-flashpoint fuels specified in **Chapters 3** to **5**, **Part B of the Rules** as applicable to surveys for liquefied gas fuel containment systems in addition to requirements specified in this Part.

Paragraph GF6.4.4 has been added as follows.

GF6.4.4 Design of Secondary Barriers

1 For the purpose of the requirements in **6.4.4**, **Part GF of the Rules**, the secondary barriers of non-metal material are to conform to the following requirements **(1)** to **(3)**:

(1) Compatibility with the liquefied gas fuel is to have been verified, and to have necessary mechanical properties at the liquefied gas fuel temperature under the atmospheric pressure.

(2) A model test may be required to prove that the secondary barrier has effective performance when the Society deems it necessary.

(3) For welded joints, welding procedure tests and production test are to be conducted. The test plans for the above are to have been approved by the Society beforehand.

2 For the purpose of the requirements in **6.4.4(1)**, **Part GF of the Rules**, no special analysis of the complete secondary barrier for verifying that "it is capable of containing any envisaged leakage of liquefied gas fuel for a period of 15 *days*" may be carried out except for cases where the Society deems it specially necessary.

3 In principal, openings such as manholes are not to be provided in secondary barriers.

4 For the purpose of the requirements in **6.4.4(4)**, **Part GF of the Rules**, the test procedure where visual inspection of the secondary barrier is not possible is to be in accordance with the following requirements **(1)** to **(3)**:

(1) The inspection method of the secondary barrier and its criteria relating to the performance to act as the secondary barrier are to be verified for their effectiveness through model test.
(2) The secondary barrier is to be verified by model test for the required performance. This model test is to be capable of verifying that the secondary barrier can maintain the necessary performance throughout the life of the ship.
(3) When sufficient data to prove the effectiveness and reliability relative to the preceding **(1)** and **(2)** are submitted to the satisfaction of the Society, this model test may be omitted.

5 For the purpose of the requirements in **6.4.4(6)**, **Part GF of the Rules**, the extent of the secondary barrier is, at least, to cover the surface of leaked liquid fuel corresponding to a static heel angle of 30°.

6 The "surface of leaked liquid fuel" referred to in the preceding **-5** means a surface of fully leakage of fully loaded fuel for the complete second barrier, and of liquid fuel determined in accordance with the requirements in **6.4.5-2**, **Part GF of the Rules** for the partial secondary barriers.

7 For spaces outside the extent of the secondary barriers specified in the preceding **-5**, the hull structures are to be protected against splashes of leaked fuel by the spray shields specified in the requirements in **6.4.5-1**, **Part GF of the Rules**, or the extent of the secondary barrier is to be suitably extended.

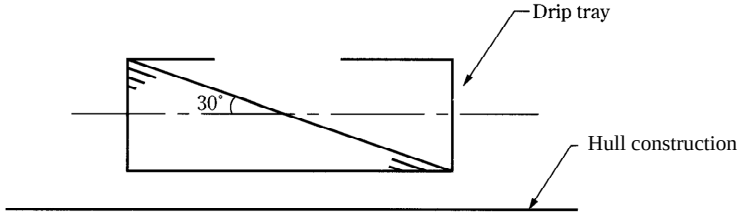
Paragraph GF6.4.5 has been added as follows.

GF6.4.5 Partial Secondary Barriers and Primary Barrier Small Leak Protection System

1 The spray shield specified in the requirements in **6.4.5-1**, **Part GF of the Rules** is to have been verified by test that it has satisfactory performance to act as the shield.

2 For the purpose of the requirements in **6.4.5**, **Part GF of the Rules**, in case where a drip tray is provided as a secondary barrier for example as shown in **Fig. GF6.4.5** and means are taken so as to not allow any leaked liquefied gas fuel to overflow from the secondary barrier, no protection may be required for the hull construction at the lower part of liquefied gas fuel tanks. However, in cases where no such means are taken, the hull construction is to be protected by insulation materials.

Fig. GF6.4.5 Drip Tray to Protect the Hull Construction



Paragraph GF6.4.6 has been added as follows.

GF6.4.6 Supporting Arrangements

1 In spaces between the refrigerated tanks and supports, suitable insulation materials are to be provided so that hull structure might not be cooled excessively through the supporting structures according to the requirement of **6.4.8**, **Part GF of the Rules**.

2 The analysis of supporting structures against the load conditions specified in the requirements in **6.4.9-3(3)(h)** and **6.4.9-4(1)(a)**, **Part GF of the Rules** is to be done while giving considerations to the following conditions **(1)** and **(2)**:

(1) A condition where, at a static heel angle of 30°, static load by the weight of liquefied gas fuel tank containing the liquefied gas fuel and the static sea water pressure without dynamic

pressure due to waves is imposed.

(2) A condition where load by the weight of liquefied gas fuel tank containing the liquefied gas fuel with the acceleration caused by ship motions specified in the requirements in **6.4.9-4(1)(a)**, **Part GF of the Rules** and the dynamic sea water pressure due to waves are imposed. Such dynamic sea water pressure due to waves may be determined by the requirements in **C31.1.3**, **Part C of the Guidance**.

3 The results of analysis for the conditions indicated in the preceding **-2** are not to exceed the allowable stress determined depending upon the type of liquefied gas fuel tank. Further, sufficient safety factor against the critical buckling stress is to be considered.

Paragraph GF6.4.9 has been added as follows.

GF6.4.9 Design Loads

1 For the purpose of the requirements in **6.4.9-3(3)(a)**, **Part GF of the Rules**, when a design vapour pressure either higher or lower than 45 °C is employed, the ambient temperature is to be of the highest atmospheric temperature of the sea area which is the permanent trade area of the ship obtained from the weather data covering a long period.

2 For the purpose of the requirements in **6.4.9-3(3)(c)i)**, **Part GF of the Rules**, arrangements for cooling down are to be provided so as not to cause excessive stress on the tank structures.

3 The arrangements shown in the preceding **-2** are to be such that safety in cooling down using the arrangements has been proved by records of liquefied gas tanks of similar design or cooling down operation is performed at a rate not exceeding the safe temperature reduction curve which has been proved by thermal stress analysis.

4 The installations shown in the preceding **-2** are to be also capable of performing cooling down at times when excessive thermal loads may be anticipated due to the splashing of residual liquefied gas fuel in the partially filled condition under heavy weather as well as at times of liquefied gas fuel loading.

5 For the purpose of the requirements in **6.4.9-3(3)(c)ii)**, **Part GF of the Rules**, the structural strength of liquefied gas fuel tanks is to be verified through thermal stress analysis by taking into account the vertical temperature distribution at time of cooling down and when the tank is in the partially filled condition. In addition, the temperature distribution in the direction of the plate thickness of plating of fully loaded tanks is to be taken into account when necessary.

6 For tanks other than those specified in the preceding **-5**, the Society may request thermal stress analysis of the liquefied gas fuel tank by taking into account the constraining condition of the liquefied gas fuel tank by tank supporting structure in case where the tank supporting system is special, and thermal analysis in consideration of the effect of materials with different coefficients of thermal expansion in case where such materials are used.

7 In the cases referred to in the preceding **-5** and **-6** where the type of tank supporting system is special, the Society may request thermal analysis on the tank supporting structure itself.

8 For the purpose of the requirements in **6.4.9-3(3)(d)**, **Part GF of the Rules**, the liquefied gas fuel tank plates and stiffeners are to have such scantlings as not to be caused harmful effects by resonance with the vibrations of exciting sources such as propeller and main engine. The natural frequencies of the liquefied gas fuel tanks and stiffeners used in the above assessment are to be the minimum values in a state in contact with fuel liquid.

9 For the purpose of the requirements in **6.4.9-3(3)(g)**, **Part GF of the Rules**, in the case of type *B* and *C* independent tanks, that their stress levels under the pressure tests are to be confirmed that they are within the stress range specified in the **16.5.3** and **16.5.4**, **Part GF of the Rules**.

10 The liquefied gas fuel tanks other than those indicated in the preceding **-9**, are to be verified in strength undergoing the enough analysis required for each tank type in considering the internal

pressure distribution at the time of the pressure test. However, when the detailed analysis is carried out, the preceding **-9** may apply.

11 For the purpose of the requirements in **6.4.9-3(3)(h)**, **Part GF of the Rules**, the added mass due to hull damage or flooding may not be considered.

12 The "ships for restricted service" referred to in **6.4.9-4(1)(a)**, **Part GF of the Rules** means those ships with notations "*Coasting Service*" or "*Smooth Water Service*" affixed. In this case, the dynamic load may be determined by the results of calculation of ship motions carried out on the basis of the data on sea and weather conditions at the navigating area which are considered appropriately by the Society.

13 For the purpose of the requirements in **6.4.9-4(1)(c)**, **Part GF of the Rules**, sloshing loads are to be determined in such a way that assessments are made by model experiment for each type of liquefied gas fuel tanks. Data concerning the resonant period of the hull and natural period of the liquids are to be available on board the ship for avoiding the danger of resonance.

14 Notwithstanding the requirements in the preceding **-13**, in the type *C* independent tank in ships with L_f not exceeding 90 *m*, consideration for structural strength of liquefied gas fuel tanks due to sloshing loads may not be necessary. However, sufficient consideration is to be taken for the installation of equipment in liquefied gas fuel tanks such as liquefied gas fuel piping and pump, against impact loads due to sloshing.

Paragraph GF6.4.12 has been added as follows.

GF6.4.12 Design Conditions

1 For the purpose of the requirements in **6.4.12(1)(a)iii)**, **Part GF of the Rules**, the values of R_e and R_m when the strength of welds is less than that of the parent metal as in the case of 9% nickel steel are to be of the required values of mechanical properties of the weld metal. For welded joints of aluminium alloys 5083-*O* and 5083/5183 and 9% nickel steel, the values of R_e and R_m may be modified in consideration of the increase in the yield stress and tensile stress at low temperature after taking into account the welding procedure employed.

2 For the purpose of the requirements in **6.4.12(2)(e)**, **Part GF of the Rules**, the stress due to fatigue load may be generally determined by using the cumulative probability curve as shown in **Fig. GF6.4.12**.

3 When the fatigue strength analysis specified in the requirements in **6.4.15-2(3)(c)**, **Part GF of the Rules** is carried out using the frequency distribution of cyclic stress shown in the preceding **-1**, the number of representative stress (σ_i) is to be eight, and σ_i and its number of repetition n_i may be obtained from the following equation:

$$\sigma_i = \frac{17-2i}{16}\sigma_{max}$$

$$n_i = 0.9 \times 10^i$$

where:

$i = 1,2,\ldots,8$

σ_{max}: Stress induced by the predicted maximum dynamic load (half amplitude)

4 For the purpose of **6.4.12(2)(f)**, **Part GF of the Rules**, the fatigue load used in the calculation of propagation speed of fatigue cracks is, as a rule, to be the predicted maximum load value that can occur at the most severe period in the trade area specified. In case where analysis is made by using the load frequency distribution given in **Fig. GF6.3**, **Part GF of the Rules**, the number of representative stress (σ_i) is to be set at five and σ_i and its number of repetition n_i may be obtained from the following equations:

$$\sigma_i = \frac{5.5 - i}{5.3}\sigma_{max}$$

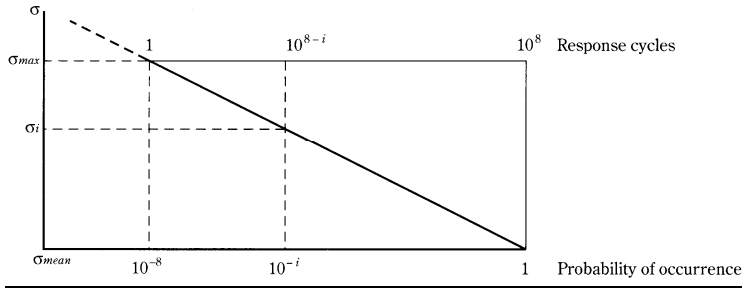
$$n_i = 1.8 \times 10^i$$

where:

$i = 1,2,\ldots,5$

σ_{max}: Stress created by the predicted maximum load

Fig. GF6.4.12



Paragraph GF6.4.13 has been amended as follows.

GF6.4.13 Materials and Construction

1 For the purpose of the requirements in **6.4.13-1(1)(a)**, **Part GF of the Rules**, the calculation conditions in computing the temperature of hull structures are to be in accordance with the following **(1)** through **(4)**:

(1) The loading condition of the ship for the calculation is to be full-loaded condition at the upright.

(2) Liquefied gas fuel leakage is to be considered for the calculation in accordance with the following **(a)** through **(d)**. However, no leakage may be considered for type *C* independent tanks.

(a) It is to be assumed that the failure of all liquefied gas fuel tanks located between transverse watertight bulkheads are caused. However, in case where the cross section of the ship is divided into more than one compartments by longitudinal bulkheads of the ship, it is to be assumed that the failure of all liquefied gas fuel tanks within each such compartment are caused.

(b) It is to be assumed that the locations of the failure of the liquefied gas fuel tank cover all conceivable ones.

(c) It is to be assumed that only the liquefied gas fuel leaks out where the liquefied gas fuel tank, supports and hull remain intact without involving any deflections or fracture.

(d) For liquefied gas fuel tanks where the complete secondary barrier is required according to the requirements in **6.4.3**, **Part GF of the Rules**, it is to be assumed that the leakage of liquefied gas fuel occurs instantaneously and the levels of residual liquefied gas fuel in damaged liquefied gas fuel tank and the leaked liquid level in the fuel storage hold space reach the same level instantaneously.

(3) The boundary conditions of the calculation model are to be in accordance with the following requirements **(a)** through **(i)**:

(a) The temperature of the compartment adjacent to fuel storage hold spaces is to be determined by heat transmission calculation. The atmosphere of the compartment which is adjacent to the compartment contiguous to fuel storage hold space may be taken as a still air at 0 °C. In the case of machinery space, it may be assumed as a still air at 5 °C.

(b) It is to be assumed that there is no radiation of sun beam.
(c) The structures in fuel storage hold space such as insulation materials and supports are to be assumed that they do not absorb liquid fuel.
(d) It is to be assumed that the gas and liquid within the same compartment are at the same temperature.
(e) At time of damage to the liquefied gas fuel tank, the gaseous phase in the liquefied gas fuel tank and that in fuel storage hold spaces are to be assumed to have a pressure equals to the atmospheric pressure.
(f) It is to be assumed that there is no transfer of gases within the insulation materials.
(g) It is to be assumed that there is no influence of moisture.
(h) The ship is to be assumed to stay upright.
(i) It is to be assumed that there is no influence of paints.

(4) The calculation conditions in heat transmission calculation are to be in accordance with the following requirements **(a)** through **(h)**:
(a) Temperature distribution and heat transmission are to be dealt with as the phenomena in a steady state. No transient condition may be considered.
(b) Sea water is to be assumed to have a density of 1,025 kg/m^3 and a coagulation point of -2.5 °C with physical properties compatible with those of fresh water for other items.
(c) The liquid fuel is to be assumed to have uniform temperature distribution.
(d) The heat transfer coefficients at various boundaries can be computed by using the numeral values given in **Table GF6.4.13**, but calculation may be carried out by using empirical equations given in the heat transfer engineering data which has been made public. In this case, heat transfer due to radiation is also to be taken into account.
(e) The substance for which temperature distribution is investigated is to be assumed to be of homogeneous one without directivity.
(f) Frames may be dealt with as fins.
(g) In case where fuel storage hold spaces located forward and afterward the fuel storage hold space under study are in the same conditions, they may be treated as a two-dimensional problem.
(h) The temperature of structural members is to be represented by the temperature at their half thickness, and for individual members, the following requirements **i)** through **iv)** are to be complied with:
i) The temperature of those frames fitted to plates is to be assumed to be the same as the temperature of the plates, but when the temperature distribution of the frame in the direction of depth is known, the area mean of the temperature distribution may be taken.
ii) The temperature of web frames supporting frames or plates is to be the temperature at their half depth for webs, and the temperature of face plates for these.
iii) The temperature of members connecting the inner shell and outer shell, e.g., brackets and girders is to be of the mean of the temperature of the inner shell and that of the outer shell.
iv) The temperature of brackets is to be the temperature at their centroid.

Table GF6.4.13 The Heat Transfer Coefficient at Various Boundaries

Boundaries			Heat transfer coefficients (W/m^2・°C)
Still gas	↔	Hull or liquid	5.8
Still sea water	↔	Hull	116.3
Fuel vapour	↔	Hull attached to air	11.6

2 When the design temperature of a material falls under the higher temperature range than the specified one for the material in **Table GF7.3** and **Table GF7.4**, **Part GF of the Rules** according to the requirements in **6.4.13-2(2)**, **Part GF of the Rules**, the impact test temperature given in **Table GF7.1** to **Table GF7.4**, **Part GF of the Rules** correspondingly to the design temperature may be used instead of the impact test temperature depending on the material. For example, in the case of 2.25 %*Ni* steel pipes used at the design temperature of -45°C, the impact test temperature may be -50°C, while in the case of 3.5 %*Ni* steel plates used at the design temperature of -61°C, the impact test temperature may be -70°C.

3 For the purpose of the requirements in **6.4.13-3(1)**, **Part GF of the Rules**, insulation materials of independent tanks are to be free from generating harmful defects that degrade the insulation performance even under such conditions of service that can actually take place in insulation structure including forced deflection and thermal expansion and contraction.

4 The performance referred to in the preceding **-3** is to be verified in the insulation procedure test specified in **-5** as necessary.

~~**1**~~**5** For the purpose of the requirements in **6.4.13-3(2)**, **Part GF of the Rules**, tests and inspection specified in the following **(1)** and **(2)** are to be carried out.

(1) The insulation materials are to be approved in accordance with the **Annex 1** "**Guidance for Equipment and Fittings of Ships Using Low-flashpoint Fuels**". In the above, tests and inspection are to be conducted according to the procedures on the manufacture, storage, handling and product quality control established by the manufacturer.

(2) The inspection for insulation work is to include the following items of tests and inspections **(a)** to **(c)**:

(a) Insulation procedure test
For insulation system and insulation procedure without previous records, tests are to be conducted in accordance with the test plan approved by the Society. The test may be conducted at the manufacturer of insulation materials or shipyard as necessary.

(b) Insulation production test
In accordance with the test plan approved by the Society in advance, tests are to be conducted to verify the work control, working environment control and product quality control during insulation procedure.

(c) Completion inspection
After the insulation work is completed, inspection is to be conducted for dimensions, shape, appearance, etc. in accordance with the procedures already approved by the Society, and in addition, the insulation performance is also to be verified in the test specified in **16.5.1-6, Part GF of the Rules**.

~~**2**~~**6** For the purpose of the requirements in **6.4.13-3(2), Part GF of the Rules**, the properties of insulation materials are, in general, to be verified by the tests given in **Table GF6.4.13**.

~~**3**~~**7** In addition to complying with the requirements in the preceding **-~~2~~6**, property verification test may be requested by the Society depending on the insulation system.

~~**4**~~**8** If the material, which has been approved according to the **Annex 1** "**Guidance for Equipment and Fittings of Ships Using Low-flashpoint Fuels**", satisfies the performance requirements and such performance is considered to serve the purpose, the tests referred to in the preceding **-~~2~~6** may be omitted.

~~**5**~~**9** For insulation materials to which the requirements in the preceding **-~~2~~6** to **-~~4~~8** do not apply, the following requirements **(1)** and **(2)** are to be complied with:

(1) For insulation materials used for supports of independent tanks, the requirements given in the column of membrane tank in **Table GF6.4.13** apply.

(2) For insulation materials provided in fuel tanks to which no provision of insulation is required according to the requirements in **6.4.8, Part GF of the Rules**, data on the necessary properties of those specified in **6.4.13-3(2), Part GF of the Rules** depending on the insulation system is to be submitted to the Society.

Paragraph GF6.4.14 has been added as follows.

GF6.4.14 Construction Processes

1 The "dome-to-shell connections" referred to in the requirements in **6.4.14-1(1)**, **Part GF of the Rules** are applicable to tanks with *MARVS* is 0.07 *MPa* or below, and the connections mean ordinary liquefied gas fuel pipes or other penetrations of equivalent size sufficiently small when compared with the size of dome.

2 In welding of the penetrations referred to in the preceding **-1** full penetration type welding may not be required, but are to have proper grooves. In this case, all the weld lines for penetrations of pipes with outside diameter exceeding 100 *mm*, and the partial weld lines for those with outside diameter of 100 *mm* or below, are to be subjected to non-destructive test as appropriate.

3 The "very small process pressure vessels" referred to in the requirements in **6.4.14-1(2)(a)**, **Part GF of the Rules** means pressure vessels which are so small that it is difficult to remove their backing strip.

Paragraph GF6.4.15 has been added as follows.

GF6.4.15 Tank Types

1 For the purpose of the requirements in **6.4.15-1(2)(b)**, **Part GF of the Rules**, the following **(1)** to **(3)** are to be considered for loads and ship deflections.

(1) Ship deflections due to longitudinal bending moment in waves and longitudinal still water bending moment.

(2) Ship deflections due to horizontal bending moment in waves and torsional moment, when necessary due to type of supporting structures.

(3) Internal pressure specified in the requirements in **6.4.9-3(3)(a)**, **Part GF of the Rules**.

2 The "classical analysis procedures" referred to in the requirements in **6.4.15-1(3)(a)**, **Part GF of the Rules** means the beam theory where the type of stress to be assessed is the combined stress of bending stress and axial stress.

3 For the purpose of the requirements in **6.4.15-1(3)(a)**, **Part GF of the Rules**, the allowable stress for the equivalent stress σ_c when detailed stress calculations are made on primary members is to be as given in **Table GF6.4.15**.

4 For the purpose of the requirements in **6.4.15-1(3)(b)**, **Part GF of the Rules**, in structures where the membrane or axial force due to internal pressure can not be neglected, the calculation equation specified in **Chapter 14, Part C of the Rules** may be used after suitable modification.

5 For the purpose of the requirements in **6.4.15-1(3)(b)**, **Part GF of the Rules**, in case where no corrosion allowance specified in **6.4.1-7**, **Part GF of the Rules** is required, stiffeners may have section modulus more than 1/1.2 of one required in **14.2.3, Part C of the Rules**.

Table GF6.4.15 Allowable Stresses for the Primary Equivalent Stress

Ferrite steels	Austenic steels	Aluminium alloys
$0.79R_e$	$0.84R_e$	$0.79R_e$
$0.53R_m$	$0.42R_m$	$0.42R_m$

Note:
For each member, the smaller of the above values is to be used with R_e and R_m as specified in **6.4.12-1(1)(c), Part GF of the Rules**.

6 In applying the requirements in **6.4.15-2(2)**, **Part GF of the Rules**, the following requirements **(1)** through **(9)** are to be complied with:

(1) The liquefied gas fuel tank structure is to be analyzed by three-dimensional frame structural analysis method or finited element method. The model for the analysis is to include concerned hull structures and support construction considering ship deflections and local deflections of hull due to vertical, horizontal and torsional moments.

(2) The strength members of liquefied gas fuel tanks are to be computed in details by the finite element method. In case where compatible results can be obtained, however, the frame structural analysis method may be used in replacement therewith.

(3) In the preceding **(1)** and **(2)**, dynamic loads necessary for the calculation of interactions between the hull and liquefied gas fuel tanks are, as a rule, to be determined by long-term distribution in accordance with the requirements in **6.4.9-4(1)(a)**, **6.4.12(2)** and **6.4.15-2(2)(c)**, **Part GF of the Rules** where the most probable largest load in terms of the probability of occurrence as deemed appropriate by the Society is to be used. The dynamic stress (σ_{dyn}) due to such loads are to be evaluated for their phase difference according to the requirements in **6.4.11-2(3)**, **Part GF of the Rules**, and the total stress including dynamic stress is to be the sum of such dynamic stress and static stress (σ_{st}). However, the load within liquefied gas fuel tanks may be considered as the internal pressure specified in the requirements in **6.4.9-3(3)(a)v)**, **Part GF of the Rules** by using the value of long-term distribution of acceleration computed by direct calculation according to the requirements in **6.4.9-4(1)(a)**, **6.4.12(2)** and **6.4.15-2(2)(c)**, **Part GF of the Rules**.

(4) The scantlings of liquefied gas fuel tank plates and stiffeners fitted to tank plates are to the satisfaction of the Society in consideration of the stress distribution and the mode of stress.

(5) In case where bulkheads are provided in liquefied gas fuel tanks, the scantlings of bulkhead plates and stiffeners fitted to the bulkhead plates are to the satisfaction of the Society.

(6) The strength members in liquefied gas fuel tanks are to be subjected to fatigue strength analysis for both the base metal and welded joints of high stress regions and stress concentration regions. *S-N* curves are to be plotted by experiment by the taking into account the following **(a)** through **(f)**.

(a) Shape and size of test specimen
(b) Stress concentration and notch sensitivity
(c) Mode of stress
(d) Mean stress
(e) Welding conditions
(f) Ambient temperature

(7) Relative to the design standards for the secondary barrier, the crack propagation analysis specified in the requirements in **6.4.15-2(2)(a)**, **Part GF of the Rules** is to be carried out to verify that the assumed initial cracks would not reach the critical crack length in a particular period. The rate of liquefied gas fuel leakage is to be computed on the basis of the crack length obtained by this analysis.

(8) It is to be verified that the liquefied gas fuel tank plates and associated structural members have sufficient strength against compressive buckling, torsional buckling of stiffeners, shearing buckling, and bending buckling of tripping brackets.

(9) The accuracy in stress analysis is to be verified by model tank test or pressure measurements taken at time of pressure tests on a real ship in accordance with the requirements in **16.5.1-5**, **Part GF of the Rules**.

7 For the purpose of the requirements in **6.4.15-3(1)**, **Part GF of the Rules**, for the scantlings, shapes and reinforcements of openings of liquefied gas fuel tanks against internal pressure in

liquefied gas fuel tanks, the requirements for Group 1 Pressure Vessels in **Chapter 10**, **Part D of the Rules** apply.

8 For the purpose of the requirements in **6.4.15-3(3)(a)**, **Part GF of the Rules**, the circumferential stress at supports of type *C* independent tanks is to be assessed in accordance with the following **(1)** through **(4)**:

(1) For horizontal cylindrical tanks made of carbon manganese steel supported in saddles, the equivalent stress in the stiffening rings is not to exceed the following values if calculated using finite element method:

$\sigma_e \le \sigma_{all}$

where:

$\sigma_{all} = \min(0.57R_m; 0.85R_e)$

$\sigma_e = \sqrt{(\sigma_n + \sigma_b)^2 + 3\tau^2}$

σ_e : von Mises equivalent stress (N/mm^2)

σ_n : normal stress (N/mm^2) in the circumferential direction of the stiffening ring

σ_b : bending stress (N/mm^2) in the circumferential direction of the stiffening ring

τ : shear stress (N/mm^2) in the stiffening ring

R_m and R_e as defined in **6.4.12(1)(a)iii)**, **Part GF of the Rules**.

Equivalent stress values σ_e are to be calculated over the full extent of the stiffening ring for a sufficient number of load cases.

(2) The following assumptions are to be made for the stiffening rings:

(a) The stiffening ring is to be considered as a circumferential beam formed by web, face plate, doubler plate, if any, and associated shell plating. The effective width of the associated plating is to be taken as the following **i)** and **ii)**:

i) For cylindrical shells:

An effective width (*mm*) not greater than $0.78\sqrt{rt}$ on each side of the web. A doubler plate, if any, may be included within that distance.

where:

r = mean radius of the cylindrical shell (*mm*)

t = shell thickness (*mm*)

ii) For longitudinal bulkheads (in the case of lobe tanks):

The effective width is to be determined according to established standards. A value of $20t_b$ on each side of the web may be taken as a guidance value.

where:

t_b = bulkhead thickness (*mm*).

(b) The stiffening ring is to be loaded with circumferential forces, on each side of the ring, due to the shear stress, determined by the bi-dimensional shear flow theory from the shear force of the tank.

(3) For calculation of reaction forces at the supports, the following **(a)** and **(b)** are to be taken into account:

(a) Elasticity of support material (intermediate layer of wood or similar material)

(b) Change in contact surface between tank and support, and of the relevant reactions, due to the following **i)** and **ii)**

i) thermal shrinkage of tank

ii) elastic deformations of tank and support material.

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

(4) The buckling strength of the stiffening rings are to be examined.

9 The "calculations using accepted pressure vessel buckling theory" referred to in the requirements in **6.4.15-3(3)(b)**, **Part GF of the Rules** means calculations based on standards such as *JIS*, *ASME*, etc. P_4 among design external pressure P_e is to be the value computed by applying the requirements in **10.2**, **18.2** and **19.2, Part C of the Rules** corresponding to the location of the tanks.

10 In case where the design vapour pressure is made higher than 0.025 *MPa* in accordance with the provision to the requirements in **6.4.15-4(1)(d)**, **Part GF of the Rules**, this vapour pressure is to be taken into account when model test specified in **16.5.5-1(1)**, **Part GF of the Rules** is conducted. In this case, special consideration is to be given to stress concentration for the welding and construction details of the adjacent hull structure.

11 For the purpose of the requirements in **6.4.15-4(2)(a)**, **Part GF of the Rules**, in the assessments of plastic deformations and fatigue of the membrane and thermal insulation materials, all static and dynamic stresses and thermal stress specified in **6.4.9**, **Part GF of the Rules** are to be taken into account.

12 In the assessments referred to in the preceding **-11**, verification is to be made through fatigue tests on a model combining the elements of the tank, second barrier, insulation structure and tank supporting structure considering the dimensional effects on real tank and the effects of dispersions in materials and fabrication accuracy as an integral part of the test specified in **16.5.5-1(1)**, **Part GF of the Rules**.

13 The assessments of loss of tank integrity referred to in the requirements in **6.4.15-4(3)**, **Part GF of the Rules** are to be made in accordance with the following requirements **(1)** and **(2)**:

(1) For overpressure and negative pressure in the interbarrier space, collapse test is to be conducted on a prototype model of the membrane to verify its ultimate strength.

(2) For sloshing loads, impact load experiment is to be carried out on a prototype model of the membrane to verify its strength when the Society considers necessary.

14 For the purpose of the requirements in **6.4.15-4(4)(b)**, **Part GF of the Rules**, the hull structure adjacent to membrane tanks is to comply with the requirements in **Chapter 14, Part C of the Rules** and, in addition, the stress in the hull structure is to be restricted in consideration of the structural strength of membrane tanks, if necessary. The allowable stresses of the membrane, membrane supporting structures and insulation materials are to be determined in each case according to the mechanical properties of materials, records of construction, product specifications and levels of product quality control practice.

GF7 MATERIAL AND GENERAL PIPE DESIGN

GF7.4 Regulations for Materials

GF7.4.1 Metallic Materials

Sub-paragraph -4(1) has been amended as follows.

4 For the purpose of the requirements in **Table GF7.4**, **Part GF of the Rules**, the following requirements **(1)** through **(5)** are to be complied with:

(1) The use of ~~vertically~~longitudinally or spirally welded pipes given in Note 1 of the Table is to be in accordance with the requirements in **Chapter 4** and **8**, **Part K of the Rules** ~~the preceding **-1(1)**~~.

(2) The requirements for forgings and castings given in Note 2 of the Table are to be in accordance with the relevant requirements in the **Part K of the Rules**, if specified.

(3) For the design temperature given in Note 3 of the Table lower than -165°C, the provision in the preceding **-3(1)** are to apply.

(4) The chemical composition limit given in Note 5 of the Table is to be in accordance with the requirements in the preceding **-3(3)**.

(5) The omission of the impact test given in Note 8 of this Table are to be in accordance with the requirements in the preceding **-3(4)**.

GF16 MANUFACTURE, WORKMANSHIP AND TESTING

Section GF16.4 has been added as follows.

GF16.4 Other Regulations for Construction in Metallic Materials

GF16.4.2 Independent Tank

For the purpose of the requirements in **16.4.2**, **Part GF of the Rules**, the allowable dimensional deviations for the manufacture and fabrication are to conform to the requirements in **11.5.2**, **Part D of the Rules**, and in addition to the requirements in *JIS B* 8265 or recognized standards.

GF16.4.4 Membrane Tanks

1 For the purpose of the requirements in **16.4.4**, **Part GF of the Rules**, quality assurance procedure, welding control, design details, quality control of materials, construction method, inspection and standards of production testing of components for membrane tanks are to be developed during the prototype test specified in **16.5.5-1**, **Part GF of the Rules** or another prototype test separately conducted for development of production procedure, and their effectiveness is to be verified. The relevant data is to be noted in the construction procedure manual for fuel tanks including the insulation construction of membrane tanks.

2 The construction procedure manual referred to in the preceding **-1** is to be approved by the Society after being verified through prototype test.

Section GF16.5 has been added as follows.

GF16.5 Testing

GF16.5.1 Testing and Inspections during Construction

1 For the purpose of the requirements in **16.5.1-2**, **Part GF of the Rules**, in case where leakage of fuel tanks can not be inspected in the hydrostatic test or hydropneumatic test according to the requirements in **16.5.2** to **16.5.5**, **Part GF of the Rules**, the tightness test of fuel tanks is to be conducted separately. This test is to be of the airtightness test conducted at a pressure of *MARVS* or more of the fuel tank.

2 With respect to the requirements of **16.5.1-4**, **Part GF of the Rules**, it is to be verified that secondary barriers keep a specific level of tightness required in the system design in accordance with an appropriate procedures. However, low differential pressures tests are not to be considered an acceptable test for the tightness of secondary barriers. For fuel containment systems with glued secondary barriers, tests for verification of the tightness are to be carried out before and after initial cool down and related values obtained in the tests are to be recorded for the use as reference for periodical surveys. If the verification results do not satisfy acceptance criteria approved in advance, an investigation is to be carried out and additional testing such as thermographic or acoustic emissions testing is to be carried out.

3 For the purpose of the requirements in **16.5.1-5**, **Part GF of the Rules**, in case where stress measurements of the fuel tank previously built which can be regarded as the tank of the same design manufactured at the same shipyard had resulted in good agreement with design stress levels, provision of instrumentation of independent tanks stress levels for tanks subsequently built may be omitted.

4 In accordance with the requirements in **16.5.1-6** and **16.7.3-5**, **Part GF of the Rules** the following tests **(1)** and **(2)** are to be conducted in the attendance of the Surveyor to verify the performance of the fuel containment installations and fuel handling equipment:

(1) Gas trial

On items given in **Table GF16.5.1-1**, tests are to be conducted to verify the performance of the fuel containment system, fuel handling equipment and instrumentation using a suitable quantity of the fuel after the completion of all the construction work. However, for fuel tanks which do not require either cool-down operations or the fuel pressure/temperature controls specified in **6.9.1-1**, **Part GF of the Rules**, the omission of gas trials may be accepted in cases where the performance of the equipment specified in items **5** and **6** of **Table GF16.5.1-1** is verified through operating tests using a substitute medium at manufacturing plants or shipyards, except for the case where the tank is of the first fuel tank manufactured by the manufacturer of fuel tanks.

(2) Fuel full loading test

Where deemed necessary by the Society, tests are to be conducted after completion of all the construction work to verify that the fuel containment installations, fuel handling equipment and instrumentation satisfy the design conditions under the fully loaded condition of fuel.

5 The kinds of real liquid fuel and gas used in the gas trial and fuel full loading test specified in the preceding **-4** are to be such that reproduction of the most severe conditions of those design conditions of the fuel containment system, the transfer installations and the reliquefaction system, etc. In addition, the verification relative to design temperatures is to be made by reproducing the condition that the fuel on the basis of which design temperature has been determined is cooled down as close to the design temperature as practicable.

6 The quantities of the real fuel and vapour used in the gas trial and fuel full loading test referred to in the preceding **-4** are to be sufficient to conducting the tests specified in **-4**.

7 The fuel full loading test to capacity specified in the preceding **-4(2)** may be conducted simultaneously with the gas trial indicated in the preceding **-4(1)**.

8 The cold spot inspection of fuel tanks specified in **16.5.1-7**, **Part GF of the Rules** is to be carried out during the gas trial specified in the preceding **-4** for the membrane tank, and when necessary, independent tank.

Table GF16.5.1-1 Test Items at the Gas Trial

Test item	◎:Attendance of the Surveyor ○:Submission of the record	Inspection Equipment	Survey item
1. Drying test	○	・ Inert gas generator (*IGG*)	・ Dew point ・ Change of dryness in fuel tanks and fuel storage hold spaces
2. Inerting test	○	・ Inert gas generator	・ Operation of the inert gas generator ・ Measuring of atmosphere in fuel tanks
3. Inert gas purge test using fuel vapour	○	・ Fuel vapourizer ・ Compressor	・ Change of O_2/temperature of fuel vapour in fuel tanks ・ Quantity of fuel vapour (or liquid) supply ・ Capacity of the vapourizer ・ Capacity of the compressor
4. Cool-down test	◎/○	・ Spray pump ・ Compressor ・ Fuel piping ・ Temperature indicators for fuel tank ・ Spray piping	・ Temperature curve of fuel tanks ・ Inspection of fuel storage hold spaces/condition of insulation of tanks[1] (after cool-down) ・ Fuel tanks and supports (external examination) ・ Hull adjacent to fuel tanks (cold spot) ・ Insulation capacity of fuel tanks and supports (cold spot) ・ Cooling condition of spray piping ・ Cooling condition of fuel piping ・ Capacity of spray pump ・ Fuel consumption ・ Capacity of Compressor (property of return gas) ・ Temperature/pressure in fuel tank ・ Shrinkage of fuel tank[2]
5. Loading test of fuel liquid	◎/○	・ Compressor ・ Fuel piping related for loading ・ Level gauge/temperature indicator	・ Temperature/pressure level in fuel tanks ・ Temperature/pressure in fuel storage hold spaces ・ Temperature/pressure of fuel liquid/gas at manifolds ・ Service condition of fuel piping
6. Operation test offuel pump	◎/○	・ All fuel pumps	・ Discharge pressure/current of fuel pumps ・ Liquid level/pressure in fuel tanks ・ Stripping
7. Operation test of pressure/temperature control system	◎/○	・ Depend on the type of controls	・ Depend on the type of controls

Notes:

1) The Society may approve omission in consideration of quality control status and manufacturing records of insulation materials.

2) To be verified only in case of independent tanks.

GF16.5.2 Type *A* Independent Tanks

1 For the purpose of the requirements in **16.5.2** and **16.5.3**, **Part GF of the Rules**, the hydrostatic or hydropneumatic test of fuel tanks is to be conducted by simulating the actual load conditions (static load + dynamic load) in accordance with the following requirements **(1)** and **(2)**:

(1) Test of fuel tanks

Hydrostatic-hydropneumatic test is to simulate the static pressure of fuel, acceleration by ship motions and internal pressure including the vapour pressure by water head and pneumatic pressure. (*See* **Fig. GF16.5.2-1**, **Fig. GF16.5.2-2**, and **Fig. GF16.5.2-3**)

(2) Load test of supporting structures

Hydraulic test is to simulate the fuel weight and the load created by the acceleration due to ship motions solely by the weight of water. (*See* **Fig. GF16.5.2-4**)

2 All tests specified in the preceding **-1(1)** and **(2)** may be conducted individually.

3 In the case of the fuel tank of supports which can be regarded as those of the same type manufactured at the same manufacturing plant, implementation of the second and subsequent tests of fuel tanks and supports specified in the preceding **-1(2)** may be omitted when deemed acceptable by the Society.

Fig. GF16.5.2-1
Simulating the Internal Pressure Distribution of Rectangular Tank

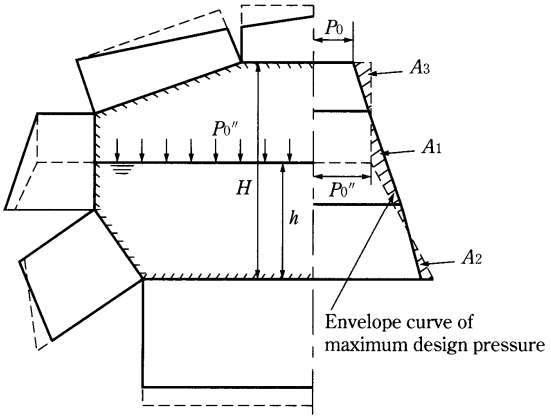


Fig. GF16.5.2-2
Simulating the Internal Pressure Distribution of Spherical Tank

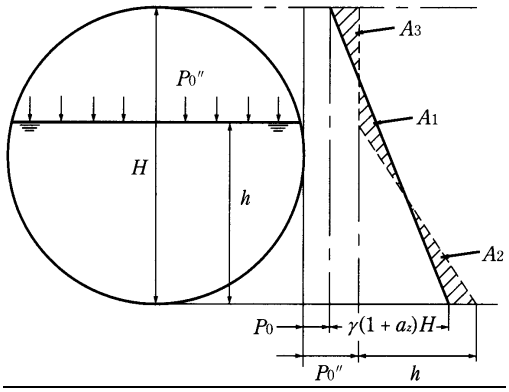


Fig. GF16.5.2-3
Simulating the Internal Pressure Distribution at Pressure Discharge

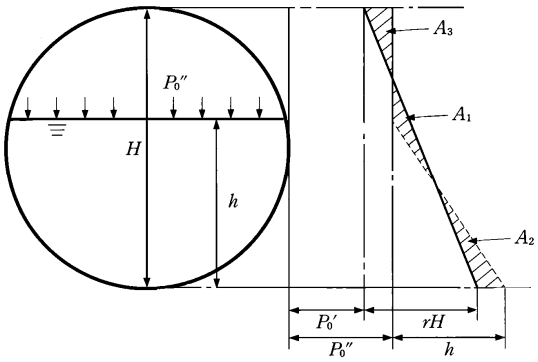
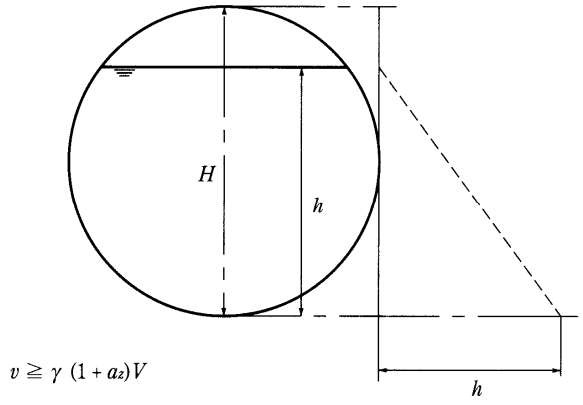


Fig. GF16.5.2-4
Simulating the Loading Condition of Supporting Structure



v: fuel tank volume for water pressure h
V: fuel tank volume for water pressure H

Notes:
Explanatory notes on symbols in **Fig.GF16.5.2-1** to **Fig. GF16.5.2-4**
——:maximum loading condition which is predicted to actually encounter
- - - -:pressure testing condition simulating as far as practicable (P_0'' and h are to be chosen so that $P_0'' \geq P_0$ or $P_0'' \geq P_0'$ and $A_2+A_3 \geq A_1$ as far as practicable)

H : depth of tank
h : water head
γ : specific gravity of fuel
a_z : maximum vertical acceleration (non-dimensional)
P_0 : design vapour pressure at ordinary passage
P_0' : design vapour pressure during pressurized unloading in port
P_0'' : air pressure

GF16.5.4 Type *C* Independent Tanks and Other Pressure Vessels

1 The "simple cylindrical and spherical pressure vessels" referred to in the requirements in **16.5.4-1**, **Part GF of the Rules** means those cylindrical or spherical pressure vessels with supporting structures of well proved records. In tanks of special shape having supporting structures likely to cause excessive bending stress or bicylindrical shape tanks, the stress levels are to be verified by strain measurement through prototype test.

2 "Where necessary" referred to in the requirements in **16.5.4-4**, **Part GF of the Rules** means a case in which the shipbuilding berth or hull structure can not withstand the hydrostatic load when fuel tanks are filled with water to the tank top level and another case in which a large load exceeding the design load is imposed on the structural members of the tank or adjacent structures by conducting the hydrostatic test.

3 For the purpose of the requirements in **16.5.4-6**, **Part GF of the Rules**, the leakage test is to be of the air-tightness test conducted at a pressure of *MARVS* or more of the pressure vessel.

GF16.5.5 Membrane Tanks

1 Tests specified in the requirements in **16.5.5-1(1)**, **Part GF of the Rules**, are to be conducted on a model in combination of the primary barrier, insulation structure and second barrier. Test object and testing procedure are to be determined for each type of tank in each case.

2 The "hydrostatically tested" referred to in the requirements in **16.5.5-2(1)**, **Part GF of the Rules** means the hydraulic test according to the requirements in **2.1.5**, **Part B of the Rules**. In this case, hydraulic pressure may be applied from hull structures such as ballast tanks and cofferdams.

3 The leakage test for the "all hold structure supporting the membrane" referred to in the requirements in **16.5.5-2(2)**, **Part GF of the Rules** is to be in accordance with the requirements specified in **2.1.5(1)**, **Part B of the Rules**.

EFFECTIVE DATE AND APPLICATION (Amendment 2-2)

1. The effective date of the amendments is 25 June 2018.

2. Notwithstanding the amendments to the Guidance, the current requirements apply to ships for which the date of contract for construction is before the effective date.