GUIDE FOR BUILDING AND CLASSING

ASPHALT CARRIERS WITH INDEPENDENT TANKS

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Updates

August 2018 consolidation includes:

- August 2017 version plus Corrigenda/Editorials

Foreword

Asphalt (also commonly referred to as bitumen) is usually stored at an elevated temperature during transportation, which results in the design of asphalt carriers being quite different from conventional oil carriers. Asphalt carriers with independent cargo tanks have several advantages over the integral tank type (e.g., minimum thermal heat loss and less thermal stress in hull structure) and are now becoming a dominant ship type for carriage of asphalt solutions. This Guide is developed and issued in response to the market demand.

This Guide provides the requirements to verify the eligibility for the notation ✠ **A1 Asphalt Carrier with Independent Tanks (*temp*℃)** for vessels designed for carriage of asphalt solutions within independent tanks.

The strength criteria contained herein are developed based on requirements of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)* for fuel oil carriers and the ABS *Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks (LGC Guide)* with due consideration of the influence from high temperature cargo. This Guide is to be used in conjunction with the *Steel Vessel Rules* and the *LGC Guide*.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

GUIDE FOR BUILDING AND CLASSING

ASPHALT CARRIERS WITH INDEPENDENT TANKS

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SECTION 1 Introduction

1 General

1.1 Classification

In accordance with 1-1-3/3 of the ABS *Rules for Conditions of Classification (Part 1)*, the classification notation ✠ **A1 Asphalt Carrier with Independent Tanks (*temp*°C)** is to be assigned to vessels designed for carriage of asphalt solutions with maximum design cargo temperature of *temp*°C in independent tanks (during loading, steady state, etc.), and built to the requirements of this Guide and other relevant sections of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.

In addition, the classification notation **SH, SHCM** is to be assigned to vessels having lengths of 150 m (492 ft) and above.

As used in the Guide, the term "asphalt solutions" refers to asphalt solutions listed in Appendix I to Annex I of MARPOL 1973 as modified by the 1978 and 1997 Protocols, and having flash points above 60°C (140°F), closed cup test.

1.3 Optional Class Notation for Design Fatigue Life

Vessels designed and built to the requirements in this Guide are intended to have a structural fatigue life of not less than 20 years. Where a vessel's design calls for a fatigue life in excess of the minimum design fatigue life of 20 years, the optional class notation **FL (year)** will be assigned at the request of the applicant. This optional notation is eligible provided the excess design fatigue life is verified to be in compliance with the criteria in Appendix 3 of the ABS *Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks (LGC Guide)*. The **(year)** refers to the fatigue life equal to 25 years or more (in 5-year increments) as specified by the applicant. The fatigue life will be identified in the *Record* by the notation **FL (year)** (e.g., **FL(30)** if the minimum design fatigue life assessed is 30 years).

Only one design fatigue life value is published for the entire structural system. Where differing design fatigue life values are intended for different structural elements within the vessel, the **(year)** refers to the least of the varying target lives. The "design fatigue life" refers to the target value set by the applicant, not the value calculated in the analysis.

1.5 Application

1.5.1 General

In view of the similarity of structural arrangements, this Guide has many cross-references to the general requirements for hull construction in Part 3 of the *Steel Vessel Rules*, the particular requirements in Part 5C, Chapter 1 and 2 of the *Steel Vessel Rules* for vessels intended to carry oil in bulk, and the *LGC Guide*.

These cross-references are presented in a simple format throughout the Guide in order to provide quick reference to the users, (i.e., 1-2-3/4.5.6 of the *Steel Vessel Rules* denotes Part 1, Chapter 2, Section 3, Subparagraph 4.5.6 of the *Steel Vessel Rules*, and 1/2.3 of the *LGC Guide* denotes Section 1, Paragraph 2.3 of the *LGC Guide*).

1.5.2 Size and Proportion

The requirements contained in this Guide are applicable to asphalt carriers with independent tanks intended for unrestricted service, having lengths of 90 m (295 ft) or more, and having parameters within the ranges as specified in 3-2-1/1 of the *Steel Vessel Rules*.

1.5.3 SafeHull Construction Monitoring Program

For the class notation **SH, SHCM**, a Construction Monitoring Plan for the critical areas, prepared in accordance with the requirements of Appendix 5C-A1 of the *Steel Vessel Rules*, is to be submitted for approval prior to commencement of fabrication.

1.7 Internal Members

The requirements in 1/1.7 of the *LGC Guide* are to be complied with.

1.9 Breaks

The requirements in 1/1.9 of the *LGC Guide* are to be complied with.

1.11 Variations

Asphalt carriers with independent tanks of a special type or design, differing from those described in this Guide, will be specially considered on the basis of equivalent strength.

1.13 Loading Guidance

The tanks are to be pre-heated when loading hot cargo in order to minimize the temperature discrepancies. In addition, loading guidance is to be as required by 3-2-1/7 of the *Steel Vessel Rules*.

1.15 Pressure-Vacuum Valve Setting

Where pressure-vacuum valves of cargo tanks are set at a pressure in excess of the pressure appropriate to the length of the vessel (see 5C-1-7/11.11.2 of the *Steel Vessel Rules*), the tank scantlings will be specially considered. Particular attention is to be given to a higher pressure setting of pressure-vacuum valves as may be required for efficient operation of cargo vapor emission control systems, where installed.

1.17 Protection of Structure

For the protection of structure, see 3-2-18/5 of the *Steel Vessel Rules*.

1.19 Tank Design Pressures

The requirements of this Guide are for tanks intended for the carriage of liquid cargoes with design specific gravities not greater than 1.05. Where the specific gravity is greater than 1.05, the scantling head, h, is to be increased by the ratio of specific gravity to 1.05. See also 5C-1-7/11 of the *Steel Vessel Rules* with regard to pressure-vacuum valve setting and liquid level control.

1.21 Fire Protection, Fire Detection, and Fire Extinction

Asphalt carriers are typically considered tankers with cargo having a flashpoint exceeding 60°C (140°F), closed cup test. The requirements of SOLAS II-2 and Part 4 and 5C of the *Steel Vessel Rules* are to be complied with (See Regulation 1/6.4 of SOLAS II-2). If asphalt solutions are to be carried above their flashpoint, the fire safety measures are to comply with the requirements for tankers with cargo having a flashpoint below 60°C in SOLAS II-2 and Part 4 and 5C of the *Steel Vessel Rules*. The grades of bitumen to be carried and the flashpoint temperatures are to be included in the loading manual for guidance to the Master.

3 References

The following Rules, Guides, Codes and Standards are referenced in this Guide:

- ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*
- ABS *Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks (LGC Guide)*

SECTION 2 Ship Arrangement

1 General

The ship arrangements are to comply with the requirements in Annex I of MARPOL 1973, as amended with regard to oil fuel tank protection (Regulation 12A), double hull and double bottom requirements (Regulation 19), pump-room bottom protection (Regulation 22), accidental oil outflow performance (Regulation 23), and slop tanks (Regulation 29). Asphalt carrier of 30,000 tonnes deadweight is also to comply with requirements of segregated ballast tanks (Regulation 18) in Annex I of MARPOL 1973, as amended.

As per Regulation 19 of Annex I of MARPOL 1973, as amended, the independent cargo tanks are to be so located that the distance from the molded line of the bottom shell and side shell is to be not less than the limits as required by the aforementioned regulation.

3 Supports of Independent Tanks

3.1 General

The supports of independent tanks are to be so designed that the loads from the independent tanks are effectively transmitted to the tank supports, while the independent tanks are allowed to expand in all directions without restraint to reduce thermal stresses in the structures of independent tanks. Generally, the supports of independent tanks are also to be designed to limit transmission of loads relative to global and local hull deflection from the hull structures to the independent tanks as required in 3/9.1.

The supports of independent tanks are usually consist of the following:

- Vertical supports
- Anti-rolling chocks
- Anti-pitching chocks
- Anti-flotation chocks

3.3 Documents to Be Submitted

For supports of independent tanks, the following information is to be submitted:

- The tank supporting arrangement indicating the positions, type, and details of each supports
- Detailed hull/tank supporting structures in way of each supports
- Evidence (e.g., test reports or certificates) showing mechanical properties of the materials of supports, which are to include at least the compressive strength, shear strength, frictional coefficient and elasticity
- Test report of interface temperature of hull support structures in way of pads and pads with chocking compound

3.5 Materials of Supports

Contact surfaces of supports (vertical supports, anti-roll and anti-pitch chocks, etc.) are usually made of synthetic material such as resin, plywood and adhesive. Those materials are to be type approved.

5 Access to Space in Cargo Area

Note: Text in *italics* comes from the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).

5.1 General

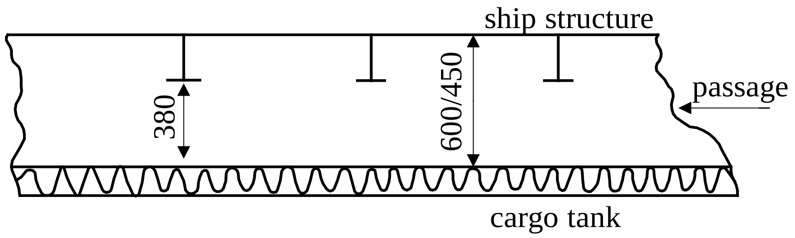
The access to space in cargo area of asphalt carriers with independent tanks is to comply with the requirements specified in 2/5.3 and 2/5.5. Asphalt carriers with independent tanks need not comply with SOLAS Regulation II-1/3-6, which is applicable to oil tankers having integral tanks for carriage of oil in bulk as contained in the definition of oil in Annex I of MARPOL 1973, as amended.

5.3 Access to Space Adjacent to Cargo Tank

5.3.1

Where it is required to pass between the surface to be inspected, flat or curved, and structures such as deck beams, stiffeners, frames, girders, etc., the distance between that surface and the free edge of the structural elements shall 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, shall be at least 450 mm for a curved tank surface, or 600 mm for a flat tank surface. (See Section 2, Figure 1).

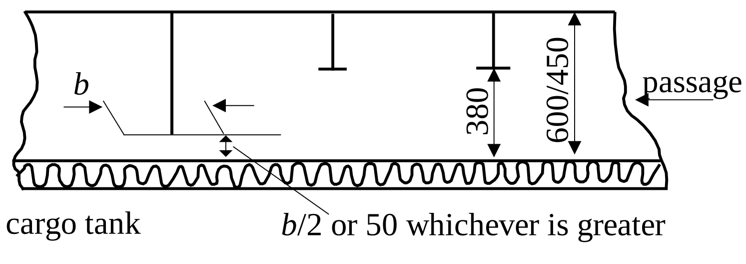
FIGURE 1



5.3.2

where it is not required 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 shall be at least 50 mm or half the breadth of the structure's face plate, whichever is the larger (See Section 2, Figure 2).

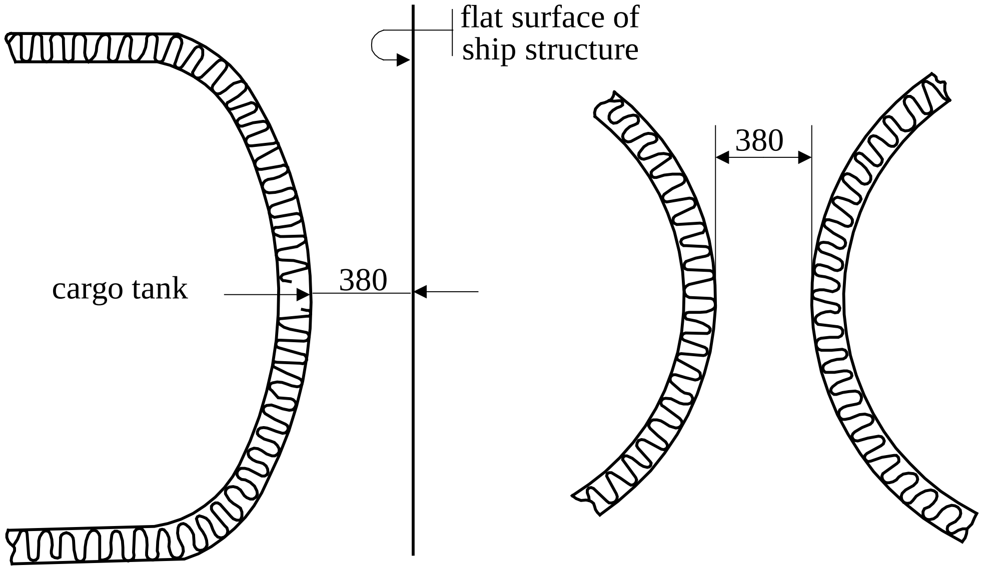
FIGURE 2



5.3.3

If for inspection of a curved surface where it is required to pass between that surface and another surface, flat or curved, to which no structural elements are fitted, the distance between both surfaces shall be at least 380 mm (see Section 2, Figure 3). Where it is not required to pass between that curved surface and another surface, a smaller distance than 380 mm may be accepted taking into account the shape of the curved surface.

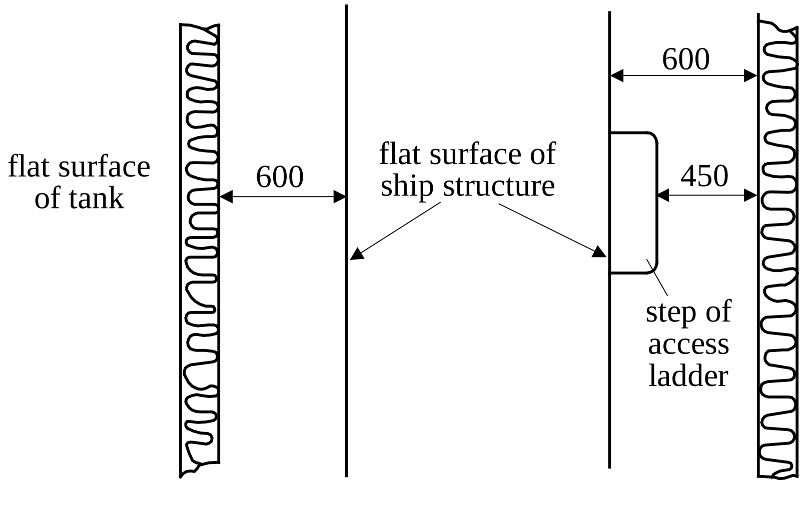
FIGURE 3



5.3.4

If for inspection of an approximately flat surface where it is required to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted, the distance between those surfaces shall be at least 600 mm. Where fixed access ladders are fitted, a clearance of at least 450 mm shall be provided for access (See Section 2, Figure 4).

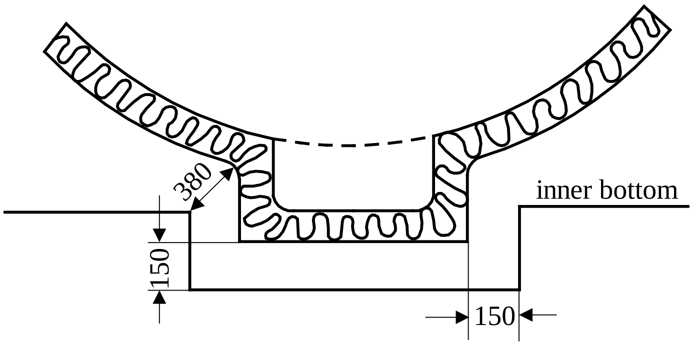
FIGURE 4



5.3.5

The minimum distances between a cargo tank sump and adjacent double bottom structure in way of a suction well shall not be less than those shown in Section 2, Figure 5 (Section 2, Figure 5 shows that the distance between the plane surfaces of the sump and the well is a minimum of 150 mm and that the clearance between the edge between the inner bottom plate, and the vertical side of the well and the knuckle point between the spherical or circular surface and sump of the tank is at least 380 mm). If there is no suction well, the distance between the cargo tank sump and the inner bottom shall not be less than 50 mm.

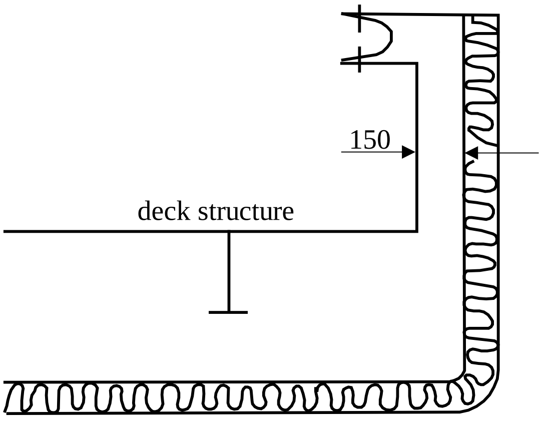
FIGURE 5



5.3.6

The distance between a cargo tank dome and deck structures shall not be less than 150 mm (see Section 2, Figure 6).

FIGURE 6



5.3.7

Fixed or portable staging shall be installed as necessary for inspection of cargo tanks, cargo tank supports and restraints (e.g. anti-pitching, anti-rolling and anti-flotation chocks), cargo tank insulation etc. This staging shall not impair the clearances specified in 2/5.3.1 through 2/5.3.4.

5.3.8

If fixed or portable ventilation ducting shall be fitted, such ducting shall not impair the distances required under 2/5.3.1 through 2/5.3.4.

5.5 Access through Openings

5.5.1

Access through horizontal openings, hatches or manholes. The dimensions shall be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening shall be not less than 600 mm × 600 mm.

5.5.2

Access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening shall be not less than 600 mm × 800 mm at a height of not more than 600 mm from the bottom plating unless gratings or other footholds are provided.

5.5.3

Circular access openings to cargo tanks shall have a diameter of not less than 600 mm.

5.7 Cofferdams

The clear width of the cofferdams in cargo area, if fitted, is not to be less than 600 mm (23.6 in.) in order to access easily.

5.9 Pipe Tunnels

Sufficient space is to be provided for pipe tunnels, if fitted, to allow easy inspection.

SECTION 3 Initial Scantling Criteria

1 General

1.1 Strength Requirements

This Section specifies the minimum scantling requirements based on the gross scantling approach for hull and cargo tank structures. These minimum scantlings are to be further evaluated in accordance with the strength criteria in Section 4.

For those structures whose requirements are not specified in this Section, the relevant sections of the *Steel Vessel Rules* are to be complied with.

1.3 Structural Details

The requirements specified in this Section and Section 4 are based on the assumptions that all structural joints and welded details are properly designed and fabricated, and are compatible with the anticipated working stress levels at the locations considered. It is critical to closely examine the loading patterns, stress concentrations, and potential failure modes of structural joints and details during the design of highly stressed regions.

1.5 Evaluation of Grouped Stiffeners

Sequentially positioned stiffeners of equal scantlings may be considered a group. Where several members in a group have variation in section modulus requirements, the required section modulus may be taken as the average of each individual requirement in the group. However, the section modulus requirement for the group is not to be taken as less than 90% of the largest section modulus required for an individual stiffener within the group.

3 High Temperature Cargo

3.1 General

For asphalt carriers whose cargoes are carried at an elevated temperature, the thermal effect is to be considered in the strength assessment of the tank and surrounding structures. A thermal calculation, or evidence showing temperature distribution in the structure considering insulation covering cargo tanks, is to be submitted by the designer to determine the temperature distribution in hull structures.

The temperature distribution calculation is to consider at least the following two conditions for ambient temperatures of normal service:

i) 5°C (41°F) for air and 0°C (32°F) for seawater;

ii) 45°C (113°F) for air and 32°C (90°F) for seawater;

For service zones outside of the above conditions, the specified design temperatures are also to be submitted and considered in the design.

The basic requirements of hull structures and independent cargo tanks in this Section are based on the maximum temperature up to 80°C (176°F) of steel. The requirements at an elevated temperature greater than 80°C (176°F) are to be obtained by modifying the relevant basic requirements based on minimum yield point at temperature θ, as specified in 3/3.3. Also, see 3/9.7 & 9.9.

3.3 Material

For steel used at an elevated temperature θ between 80°C and 300°C (176°F and 572°F), unless other information is specified, the minimum yield point, R_{eH}, and Young's modulus, E, is to be taken as follows:

$$R_{eH} = R_{eH0}\left(1.04 - \frac{0.75}{1000}\theta\right)$$

$$E = E_0\left(1.03 - \frac{0.5}{1000}\theta\right)$$

$$C_{temp} = 1.04 - \frac{0.75}{1000}\theta$$

where

R_{eH0} = minimum yield point as specified in 2-1-2/Table 2 of the ABS *Rules for Materials and Welding (Part 2)* for ordinary-strength steel, and 2-1-3/Table 2 of the ABS *Rules for Materials and Welding (Part 2)* for higher-strength steel.

E_0 = 2.06×10^5 N/mm^2 (21,000 kgf/mm^2, 30×10^6 psi).

C_{temp} = cargo temperature coefficient for allowable stress used in TSA, also see Subsection 4/13

The allowable strength at an elevated temperature θ between 80°C and 300°C (176°F and 572°F) is to be adjusted accordingly.

3.5 Thermal Stress

For hull structures where the air temperature in the space between the hold and independent cargo tank is not more than 50°C (122°F) greater than the ambient temperatures, the thermal stress in hull structures may be neglected.

For independent cargo tanks, where the design of the tank supports allows free thermal elongation or contraction and temperature distribution in the tank structures is relatively uniform in all designed loading conditions, the thermal stress may also be neglected. In addition, the tanks are to be pre-heated when loading hot cargo in order to minimize the temperature discrepancies.

Otherwise, the thermal stress in hull structures and cargo tanks is to be considered and analyzed.

Additionally, when the piping lines are heated or cooled, they may put additional loads into the ship structures; therefore, sufficient expansion bends are to be provided to reduce this thermal loading.

5 Hull Girder Strength

5.1 Hull Girder Section Modulus

The hull girder section modulus is to be not less than required by 3-2-1/3.7.1, 3-2-1/3.7.3, 3-2-1/5, 3-2-1/9 and 3-2-1/19 of the *Steel Vessel Rules*.

5.3 Hull Girder Moment of Inertia

The hull girder moment of inertia is to be not less than required by 3-2-1/3.7.2 of the *Steel Vessel Rules*.

5.5 Shearing Strength

The shearing strength of the hull structure is to be calculated in accordance with 3-2-1/3.9, 3-2-1/5, and 3-2-1/19 of the *Steel Vessel Rules*.

7 Hull Structures

7.1 Hull Structures in Way of Supports

Hull structures in way of tank supports (e.g., vertical supports, anti-roll and anti-pitch chocks) are to be of sufficient strength when subjected to reaction loads from independent tanks. These loads are to be transmitted to the hull main supporting members as directly as possible to minimize stress concentrations. Additional web plates and brackets are to be provided to transmit these loads to the adjacent main supporting members if the loads are not in the plane of them. The number of openings in structures in way of tank supports is to be kept to a minimum, compatible with the design and proper working of the vessel. Local reinforcements in way of those openings are to be provided as necessary.

The strength criteria of hull structures in way of supports as specified in Section 4 are to be complied with.

7.3 Bottom Shell Plating and Stiffeners

7.3.1 Bottom Shell Plating and Stiffener within 0.4L Amidships

7.3.1(a) Bottom Shell Plating. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-2/1 "Application"
- 3-2-2/3.13 "Bottom Shell Plating Amidships"
- 3-2-2/3.15 "Flat Plate Keel"
- 3-2-2/3.17 "Minimum Thickness"

  Note: Minimum thickness amidships
- 3-2-2/5.1 "Minimum Shell Plating Thickness"

  Note: Minimum thickness for all shell plating
- 3-2-2/7 "Bottom Shell Plating for Special Docking Arrangement"
- 3-2-2/13 "Bilge Keels"
- 3-2-2/9 "Compensations"
- 3-2-2/15 "Higher-strength Materials"

7.3.1(b) Bottom Shell Stiffeners. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-4/1.1 "General"
- 3-2-4/11.1 "General"
- 3-2-4/11.3 "Bottom Longitudinals"
- 3-2-4/15 "Higher-strength Materials"
- 3-2-5/3.17 "Longitudinal Frames"

  Note: Minimum requirements for bottom longitudinals

7.3.2 Bottom Shell Plating and Stiffeners beyond 0.4L Amidships

7.3.2(a) Bottom Shell Plating. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-2/1 "Application"
- 3-2-2/5.1 "Minimum Shell Plating Thickness"
- 3-2-2/5.3 "Immersed Bow Plating"
- 3-2-2/9 "Compensations"

- 3-2-2/7 "Bottom Shell Plating for Special Docking Arrangement"
- 3-2-2/15 "Higher-strength Materials"

7.3.2(b) Bottom Shell Stiffeners. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-4/1.1 "General"
- 3-2-4/11.1 "General"
- 3-2-4/7.3 "Frames & Reverse Frames"

  Note: Applicable to bottom transverse frames.

- 3-2-4/11.3 "Bottom Longitudinals"
- 3-2-4/15 "Higher-strength Materials"
- 3-2-5/3.17 "Longitudinal Frames"

  Note: Minimum requirements for bottom longitudinals

7.5 Side Shell Plating and Stiffeners

7.5.1 Side Shell Plating and Stiffeners within 0.4L Amidships

7.5.1(a) Side Shell Plating. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-2/1 "Application"
- 3-2-2/3.9 "Side Shell Plating"
- 3-2-2/3.11 "Sheerstrake"
- 3-2-2/5.1 "Minimum Shell Plating Thickness"
- 3-2-2/9 "Compensations"
- 3-2-2/13 "Bilge Keel"
- 3-2-2/15 "Higher-strength Materials"

7.5.1(b) Side Shell Longitudinals. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-5/1 "General"
- 3-2-5/3.17 "Longitudinal Frames"
- 3-2-4/15 "Higher-strength Materials"

7.5.1(c) Side Frames. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-5/1 "General"
- 3-2-5/3 "Hold Frames"
- 3-2-5/5 "Tween-Deck Frames"

For higher-strength materials, the required *SM* in 3-2-5/3 and 3-2-5/5 of the *Steel Vessel Rules* may be multiplied by the *Q* factor as defined in 3-2-1/5.5 of the *Steel Vessel Rules*.

7.5.2 Side Shell Plating and Stiffeners beyond 0.4L Amidships

7.5.2(a) Side Shell Plating. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-2/1 "Application"
- 3-2-2/5.1 "Minimum Shell Plating Thickness"
- 3-2-2/5.3 "Immersed Bow Plating"
- 3-2-2/5.7 "Forecastle Side Plating"
- 3-2-2/5.9 "Poop Side Plating"
- 3-2-2/5.11 "Bow and Stern Thruster Tunnels"
- 3-2-2/5.13 "Special Heavy Plates"
- 3-2-2/9 "Compensations"
- 3-2-2/11 "Breaks"
- 3-2-2/13 "Bilge Keels"
- 3-2-2/15 "Higher-strength Materials"
- 3-2-13/1.1 "Plate Stems"
- 3-2-13/5.7 "Shell Plating"

7.5.2(b) Side Shell Longitudinals. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-5/1 "General"
- 3-2-5/3.17 "Longitudinal Frames"
- 3-2-4/15 "Higher-strength Materials"

7.5.2(c) Side Frames. The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-5/1 "General"
- 3-2-5/3 "Hold Frames"
- 3-2-5/5 "Tween-Deck Frames"

For higher-strength materials, the required *SM* in 3-2-5/3 and 3-2-5/5 of the *Steel Vessel Rules* may be multiplied by the *Q* factor as defined in 3-2-1/5.5 of the *Steel Vessel Rules*.

7.7 Inner Bottom Plating and Stiffeners

7.7.1 Inner Bottom Plating

The requirements in the followings sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-4/9 "Inner-bottom Plating"
- 3-2-4/15 "Higher-strength Materials"

7.7.2 Inner Bottom Stiffeners

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-4/11.5 "Inner Bottom Longitudinals"
- 3-2-4/15 "Higher-strength Materials"

7.9 Deck Plating, Stiffeners, Pillars, Girders, and Transverses

7.9.1 Deck Plating

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-3/1 "General"
- 3-2-3/3 "Hull Girder Strength"
- 3-2-3/5 "Deck Plating"

  Note: The requirement in 3-2-3/Table 2, Equation 2b of the *Steel Vessel Rules* need not be greater than the buckling requirement in Appendix 3-2-A4 of the *Steel Vessel Rules*. The stringer plate is not to be less than the required thickness of the adjacent deck plating.

- 3-2-3/7 "Higher-strength Material"

7.9.2 Deck Stiffeners

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-7/1 "General"
- 3-2-7/3 "Beams"
- 3-2-7/7 "Higher-strength Material"

7.9.3 Pillars

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-8/1 "General"
- 3-2-8/3 "Pillar"

7.9.4 Deck Girders and Transverses

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-8/5 "Deck Girders and Transverses"
- 3-2-8/9 "Higher-strength Material"

Alternatively, the scantlings may be determined based on the grillage analysis or FE analysis which are to be submitted for review. The minimum thickness of the web portion of deck girders and deck transverses may be determined in accordance with the formula below and subject to buckling evaluation of total strength assessment as per Subsection 4/15.

$$t = 0.012L + 7.7 + C \quad \text{mm}$$

$$= 0.144L \times 10^{-3} + 0.303 + C \quad \text{in.}$$

but t need not be taken greater than 11.0 mm (0.433 in.) + C

where

L = length of the vessel, in m (ft), as defined in 3-1-1/3.1 of the *Steel Vessel Rules*

C = 1.5 mm (0.06 in.) in tank spaces and 1.0 mm (0.04 in.) in hold/void spaces

In addition, the designed scantlings are to have stiffness at least equivalent to the depth/span ratio and required section modulus specified in 3-2-8/5 of the *Steel Vessel Rules*.

7.11 Bottom Floors and Girders

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-4/1 "Double Bottoms"
- 3-2-4/3 "Center and Side Girders"

Note: Pipe tunnels may be substituted for centerline girders, provided that the tunnel is suitably stiffened by fitting vertical webs, as may be required. The thickness of each girder forming the pipe tunnel and center girder within the pipe tunnel, if any, is not to be less than that required for the bottom side girder (see 3-2-4/3.7 of the *Steel Vessel Rules*) and for docking brackets (see 3-2-4/3.5 of the *Steel Vessel Rules*), as appropriate.

- 3-2-4/5 "Solid Floors"
- 3-2-4/15 "Higher-strength Materials"
- 3-2-4/17 "Structural Arrangements and Details"

7.13 Web Frames and Stringers

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-6/1 "General"
- 3-2-6/3 "Web Frames"
- 3-2-6/5 "Side Stringers"
- 3-2-6/7 "Structural Arrangements and Details"

Note: For higher-strength materials, the required *SM* in 3-2-6/3 and 3-2-6/5 of the *Steel Vessel Rules* may be multiplied by the *Q* factor as defined in 3-2-1/5.5 of the *Steel Vessel Rules*.

Alternatively, for double hull side webs and stringers, the minimum thickness of web portion of the web frames and stringers may be determined in accordance with the formula below and subject to buckling evaluation of total strength assessment as per Subsection 4/15.

$$t = 0.02L + 4.5 + C \quad \text{mm}$$

$$= 0.24L \times 10^{-3} + 0.177 + C \quad \text{in.}$$

where

L = length of the vessel, in m (ft), as defined in 3-1-1/3.1 of the *Steel Vessel Rules*

C = 1.5 mm (0.06 in.) in tank spaces and 1.0 mm (0.04 in.) in hold/void spaces

7.15 Frames, Stringers, and Web Frames in Fore and After-peak Tanks

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-5/1 "General"
- 3-2-5/7 "Fore-peak Frames"
- 3-2-5/9 "After-peak Frames"
- 3-2-6/1 "General"
- 3-2-6/3 "Web Frames"
- 3-2-6/5 "Side Stringers"
- 3-2-6/7 "Structural Arrangements and Details"
- 3-2-6/9 "Peak Stringers"

Note: For higher-strength materials, the required *SM* in 3-2-5/7, 3-2-5/9, 3-2-6/3 and 3-2-6/5 of the *Steel Vessel Rules* may be multiplied by the *Q* factor as defined in 3-2-1/5.5 of the *Steel Vessel Rules.*

7.17 Plating, Stiffeners, Girders, and Webs on Watertight Boundaries

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-9/1 "General"
- 3-2-9/3 "Arrangement of Watertight Bulkheads"
- 3-2-9/5 "Construction of Watertight Bulkheads"

Note: For higher-strength materials, the required *SM* for stiffeners, girders and webs may be multiplied by the *Q* factor as defined in 3-2-1/5.5 of the *Steel Vessel Rules*.

7.19 Plating, Stiffeners, Girders, and Webs on Deep Tank Boundaries

The requirements in the following sections of the *Steel Vessel Rules* are to be complied with:

- 3-2-10/1 "General"
- 3-2-10/3 "Construction of Deep Tank Bulkheads"
- 3-2-10/5 "Higher-strength Materials"

7.21 Bulkheads

7.21.1 Transverse Bulkheads

Transverse bulkheads used for ballast or cargo are to comply with the requirements for deep tank boundaries in 5/7.17 of the *LGC Guide*. Bulkheads not subject to hydrostatic loads are to be in accordance with the requirements for watertight boundaries in 5/7.15 of the *LGC Guide*.

7.21.2 Longitudinal Bulkheads

Scantlings of longitudinal bulkheads forming narrow wing tanks are to be in accordance with the deep tank requirements in 5/7.17 of the *LGC Guide*, except that the vertical distance, *h*, as used in the equations for supporting members may be measured to a point 1.22 m (4 ft) above the deck at the side.

7.23 Bottom Slamming

For an asphalt carrier with the heavy weather ballast draft forward less than 0.04*L*, bottom slamming is to be considered in the strength assessment of the flat of bottom plating forward and the associated stiffening system in the forebody region. In such case, the requirements specified in 5/7.21 "Bottom Slamming" of the *LGC Guide* are to be complied with.

7.25 Bowflare Slamming

The requirements specified in 5/7.23 of the *LGC Guide* are to be complied with.

7.27 Bow Strengthening

For vessels having lengths of 150 m (492 ft) or more, the impact loads on the bow are to be considered. The side shell structure above the waterline in the region forward of the collision bulkhead is to be in compliance with the requirements specified in 5/7.25 of the *LGC Guide*.

9 Independent Cargo Tank Structures

9.1 Hull Girder Stress

In general, the cargo tank supporting system is to be designed so no hull girder loads are transmitted to the independent cargo tanks. However, if the hull girder loads are not negligible for the cargo tank due to the tank supports arrangement, the stresses in cargo tanks due to the hull girder loads are to be considered and determined by finite elements analysis of hull and cargo tanks with tank supporting system.

9.3 Tank Head for Scantlings

The scantling head, h, in m (ft), of structural member in independent cargo tank is to be taken as the greater of the following distances, See also 1/1.13 and 1/1.17.

- The vertical distance, in m, from the lower edge of the plate or the center of the area supported to a point located 0.02L above the top of the tank at side in vessels having lengths from 90 m to 122 m (295 ft to 400 ft), and to a point located 2.44 m (8 ft) above the top of the tank at side in vessels 122 m (295 ft) in length and above. L, in m (ft), is the length of vessel as defined in 3-1-1/3.1 of the *Steel Vessel Rules*.
- The vertical distance, in m (ft), from the lower edge of the plate or the center of the area supported to the tops of the hatches, in m (ft).

9.5 Plating

The plating is not to be of a thickness less than required for deep-tank bulkheads by 3-2-10/3.1 of the *Steel Vessel Rules* with scantling head, h, as modified in 3/9.3. The minimum yield point, Y, as defined in 3-2-10/3.1 of the *Steel Vessel Rules* is to be modified in accordance with 3/3.3 based the elevated temperature θ in steel. Also see 3/3.1.

9.7 Stiffeners

The scantling of stiffeners is not to be less than required by 5C-2-2/15 of the *Steel Vessel Rules* with required section modulus, SM, modified in accordance with the following equations:

$SM = SM_{stiff} \times R_{eH0}/R_{eH}$ for ordinary-strength steel

$= SM_{stiff} \times K_1$ for higher-strength steel

where

SM = required section modulus of material proposed at the elevated temperature θ

SM_{stiff} = section modulus determined from 5C-2-2/15 of the *Steel Vessel Rules* for ordinary-strength steel with scantling head, h, as modified in 3/9.3.

K_1 = coefficient given in Section 3, Table 1

R_{eH} and R_{eH0} are defined in 3/3.3.

TABLE 1
Values of K_1

R_{eH} N/mm^2 (kgf/mm^2, ksi)	K_1
235 (24, 34)	1.0
315 (32, 46)	0.78
355 (36, 51)	0.72
390 (40, 57)	0.68

Note: Intermediated values of K_1 may be obtained by interpolation.

9.9 Main Supporting Members

The scantlings of main supporting members are not to be less than required by 5C-2-2/13 of the *Steel Vessel Rules* with required section modulus, SM, modified in accordance with the following equations:

$SM = SM_{msm} \times R_{eH0}/R_{eH}$ for ordinary-strength steel

$= SM_{msm} \times K_1$ for higher-strength steel

where

SM_{msm} = section modulus is determined from 5C-2-2/13 of the *Steel Vessel Rules* for ordinary-strength steel with scantling head, h, as modified in 3/9.3.

SM and K_1 are defined in 3/9.7, and R_{eH}, and R_{eH0} are defined in 3/3.3.

Alternatively, the scantlings may be determined based on the grillage analysis or FE analysis, which are to be submitted for review. The minimum thickness of vertical web portions may be determined in accordance with below formula and subject to buckling evaluation of total strength assessment as per Subsection 4/15.

$t = 0.012L + 7.7 + C$ mm

$= 0.144L \times 10^{-3} + 0.303 + C$ in.

but t need not be taken greater than 11.0 mm (0.433 in.) + C

where

L = length of the vessel, in m (ft), as defined in 3-1-1/3.1 of the *Steel Vessel Rules*

C = nominal design corrosion values specified in 5C-1-2/3 of the *Steel Vessel Rules*

In addition, the designed scantlings shall have stiffness at least equivalent to the depth/span ratio specified in 5C-2-2/13.9 of the *Steel Vessel Rules*.

9.11 Sloshing

In vessels fitted with long tanks, the scantlings of oil tight transverse bulkheads in smooth-sided tanks are to be specially considered when the spacing between tight bulkheads, non-tight bulkheads, or partial bulkheads exceeds 12 m (40 ft) in the case of corrugated-type construction, or 15 m (50 ft) in the case of flat-plate type of construction. Special consideration is to be given to the scantlings of longitudinal oil-tight bulkheads forming the boundaries of wide tanks. Where the length of the smooth-sided tanks exceeds 0.1L or the breadth exceeds 0.6B, non-tight bulkheads are to be fitted, unless calculations are submitted to prove that no resonance due to sloshing will occur in service, where L is the length of vessel as defined in 3-1-1/3.1 of the *Steel Vessel Rules* and B is the breadth of the vessel as defined in 3-1-1/5 of the *Steel Vessel Rules*.

Alternatively, reinforcements to the bulkheads and decks, without non-tight bulkheads, may be determined by an acceptable method of engineering analysis.

9.13 Non-tight Bulkhead

Non-tight bulkheads are to be fitted in line with transverse webs, bulkheads, or other structures with equivalent rigidity. They are to be suitably stiffened. Openings in the non-tight bulkhead are to have generous radii and their aggregate area is not to exceed 33%, nor be less than 10% of the area of the non-tight bulkhead. Plating is not to be of a thickness less than that required by 3/9.5. Section moduli of stiffeners and webs may be one-half of the requirements for watertight bulkheads in 3-2-9/5.3 and 3-2-9/5.7 of the *Steel Vessel Rules*. Alternatively, the opening ratio and scantlings may be determined by an acceptable method of engineering analysis.

11 Supports and Chocks

Independent cargo tanks are to be supported by the hull in a manner that will prevent bodily movement of the tanks under static and dynamic loads while allowing contraction and expansion of the tanks under temperature variations and hull deflections without undue stressing of the tanks and of the hull.

The strength of each contact surface is to be verified under the maximum contact force perpendicular to the surface and the associate friction parallel to the surface. The loads on each tank support are to be obtained from global finite element analysis (see Subsection 4/9). The representative value of frictional coefficient in global FEM analysis is to be taken as 0.1, while for evaluating the strength of each individual support or chock, the friction coefficient is to be taken as 0.3 based on the supports or chocks made of synthetic materials such as resin, plywood, and adhesive. Alternatively, the frictional coefficient may be taken from the measurement.

Average compressive and shear stresses in each layer of the synthetic contact surface are to be separately checked against the safe working stresses. The safety factors as specified in 6/5.11 of the *LGC Guide* for vertical supports and chocks under sea-going and accidental load cases are to be complied with.

Attention is to be paid to the temperature of hull construction in way of vertical supports and chocks if the cargo tank insulation is not provided in these area.

SECTION 4 Total Strength Assessment

1 General

For asphalt carriers with independent tanks, a finite element analysis is to be performed to verify the chock/support reaction force and the strength of main supporting members according to the requirements in this Section. The strength assessment procedure outlined in Appendix 1 of the *LGC Guide* is to be applied in principle.

3 Application

3.1 For Ships Having Lengths of 90 m (295 ft) and Above and Less than 150 m (492 ft)

A Total Strength Assessment is to be carried out. The following loading conditions are to be considered in the analysis:

- The standard design load cases (Dynamic Condition) in 4/5.1 are to be evaluated. The analysis will focus on the calculation and verification of the chock reaction force, evaluation of the yielding strength of main supporting members of the hull structures, and the independent tanks.
- In the case that there is any special ship design loading condition other than the standard design load cases above, the additional static load cases as described in Subsection 4/7 are to be analyzed, as warranted. The analysis is to focus on the yielding strength of the main supporting members of independent cargo tanks.

3.3 For Ships Having Lengths of 150 m (492 ft) and Above

A Total Strength Assessment is to be carried out. The following loading conditions are to be considered in the analysis:

- The standard design load cases (Dynamic Condition) in 4/5.1 and 4/5.3 are to be evaluated. The analysis is to cover the yielding, buckling, and fatigue strength assessment of all the structures within the target cargo tanks.
- In the case that there is any special ship design loading condition other than the standard design load cases above, the additional static load cases as described in Subsection 4/7 are to be analyzed, as warranted. The analysis is to focus on the yielding strength of the main supporting members of independent cargo tanks.

5 Standard Design Load Cases (Dynamic Condition)

5.1 Standard Design Load Cases for Yielding and Buckling Strength Assessment

To assess the yielding and buckling strength of the hull and cargo tank structures, the standard design load cases described in Section 4, Tables 1 and 2 of the *LGC Guide* are to be analyzed. These load cases can be categorized into the following groups:

- Dynamic sea load cases (LC1 ~ LC8 in Section 4, Table 1 of the *LGC Guide*)
- Port condition load case, as applicable (LC10 in Section 4, Table 2 of the *LGC Guide*)
- Flooded load case for transverse bulkhead (LC11 in Section 4, Table 2 of the *LGC Guide*)
- Accidental load cases for supports and chocks (LC12 ~ LC15 in Section 4, Table 2 of the *LGC Guide*)

The waves approach the vessel from the starboard side. If the hull structure is unsymmetrical with respect to the vessel's centerline, additional load cases mirroring those of the unsymmetrical load cases (LC5 ~ LC7) are to be analyzed. The dominant load parameter for each dynamic sea load case corresponds to a probability of exceedance of 10^{-8}, while the load combination factors for other load parameters represent phasing between all the load parameters.

5.3 Standard Design Load Cases for Fatigue Strength Assessment

To assess the critical details of the hull, cargo tanks and chock supporting structures, the accumulative fatigue damage may be calculated from the vessel operating in full cargo and ballast loading conditions. For each loading condition, eight dynamic sea load cases are to be analyzed to determine the stress ranges at critical details. These load cases are specified in Section 4, Tables 3 and 4 of the *LGC Guide*. The stress ranges to be used for the accumulative fatigue damage are to be calculated from the following four pairs of the load cases:

- Load Cases 1 and 2 for maximum vertical bending moment range
- Load Cases 3 and 4 for maximum local pressure range
- Load Cases 5 and 6 for maximum transverse acceleration range
- Load Cases 7 and 8 for maximum horizontal bending moment range.

The dominant load parameter for each dynamic sea load case corresponds to a probability of exceedance of 10^{-4}, while the load combination factors for other load parameters represent phasing between all the load parameters.

7 Special Design Load Cases (Static Condition)

For independent cargo tanks with the configurations as shown in Section 4, Figures 1 and 2, alternate loading condition and checkerboard loading condition, if designed, are to be analyzed by using FEMAP or other recognized FE software by applying static load manually. The analysis target is the main supporting members of transverse intermediate water-tight bulkhead and longitudinal water-tight bulkhead within the independent tanks.

For above loading cases, a thermal analysis is to be carried out to determine temperature distribution on cargo tank structures. Thermal stress in cargo tank structures is to be considered for cargo tank strength in case the temperature difference in tank structures is significant.

Otherwise, the restriction of the loading condition, such as "alternate loading and checkerboard loading are not permitted" is to be included in the loading manual as well as the Midship Section drawing.

FIGURE 1
Alternate Loading Condition of Independent Tank

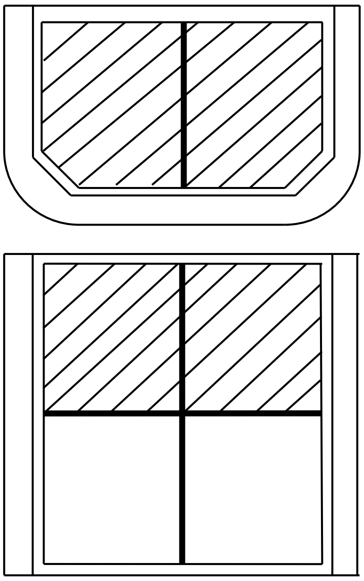
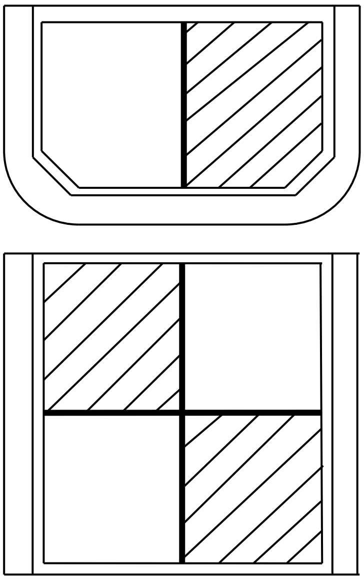


FIGURE 2
Checkerboard Loading Condition of Independent Tank



Note: Bold lines show the assessment target.

7.1 Loads

Hydrostatic tank pressure is taken as the greater of the "tank height + 2.44 m (8 ft)" and "tank height + setting pressure" with specific gravity of the cargo. Section 4, Figure 3 and 4 show the sample hydrostatic pressure distribution of the independent tanks under alternate loading condition and checkerboard loading condition, respectively.

FIGURE 3
Sample Hydrostatic Pressure of Alternate Loading Condition

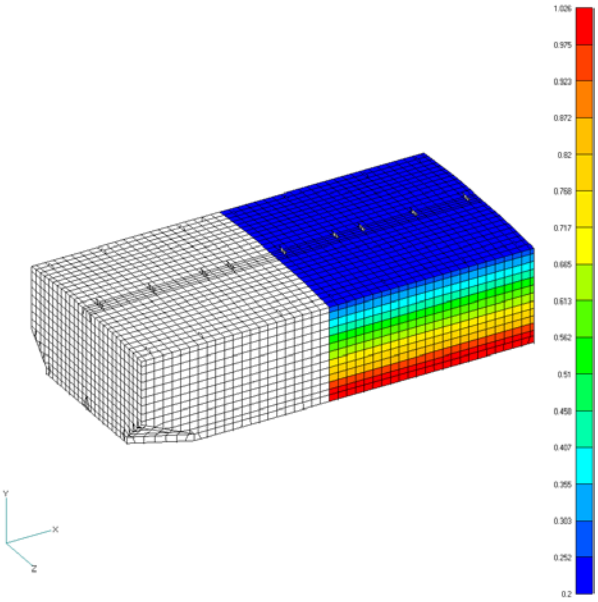
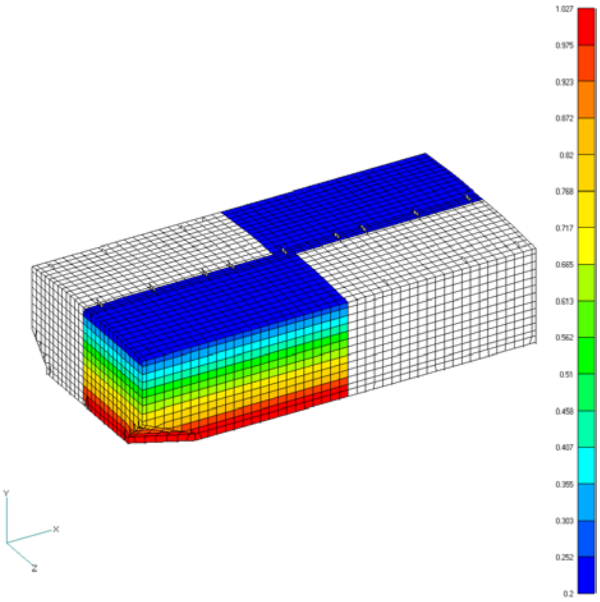


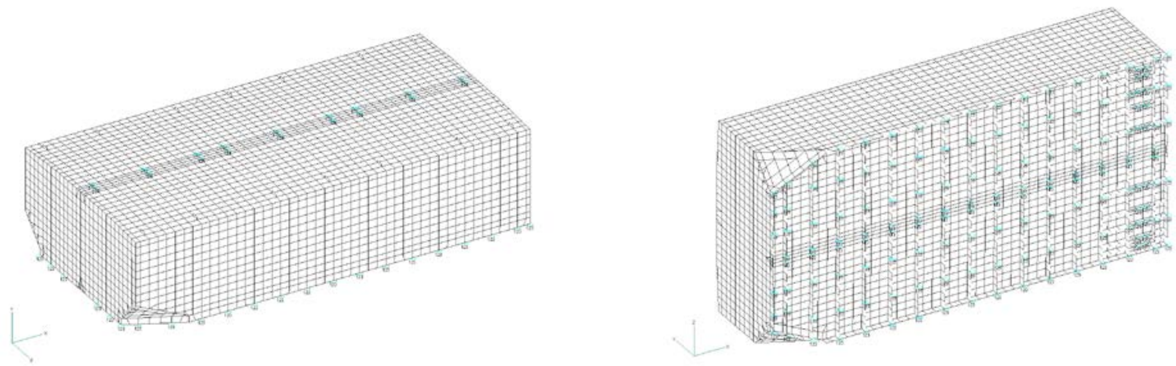
FIGURE 4
Sample Hydrostatic Pressure of Checkerboard Loading Condition



7.3 Boundary Condition

All the chock supports, excluding anti-floatation chocks, which are considered not effective in this analysis, are to be assumed as simply supported at the connection with the hull part. Section 4, Figure 5 shows the sample constraints of the chock supports.

FIGURE 5
Sample Constraints of Chock Supports



Constrain at independent tank top   Constrain at independent tank bottom (Rotated)

7.5 Acceptance Criteria

The allowable stress of main support members is be taken as $0.6S_m f_y C_{temp}$, where C_{temp} is to be calculated as per 3/3.3 for structure with temperature between 80°C (176°F) and 300°C (572°F) and to be taken as 1.00 for structure with temperature less than 80°C (176°F).

9 Global FE Analysis

Global FE analysis is applicable to the entire cargo hold region including the aft bulkhead of the aftmost cargo hold and the fore bulkhead of the foremost cargo hold. For the purpose of FE structural assessment and load application, the cargo hold region contains the midship cargo hold region, forward cargo hold region, aft cargo hold region, foremost cargo hold, and aftmost cargo hold, as applicable, which may vary depending on the ship length and cargo hold arrangement.

The scantlings of longitudinal hull girder structural members, main support members and bulkheads within the cargo hold region are to be assessed by global cargo hold FE analysis. The standard design load cases as specified in 4/5.1 and 4/5.3, as applicable, are be evaluated in global cargo hold FE analysis.

The requirements in the following sections of the *LGC Guide* are to be complied with:

- Section 3 "Dynamic Load Criteria"
- Appendix 1 "Structural Modeling and Analysis"
- Appendix 2 "Calculation of Critical Buckling Stresses"
- Appendix 3 "Rule-based Fatigue Strength Assessment"

In addition to requirements in Appendix 1 of the *LGC Guide*, all stiffeners may also be modelled with beam or bar elements having axial, torsional, bi-directional shear, and bending stiffness. The eccentricity of the neutral axial is to be modelled. Non-continuous stiffeners are to be modelled as continuous stiffeners (i.e., the height web reduction in way of the snip are not to be modelled).

11 Local FE Analysis

In general, local fine mesh FE analysis for yielding is to be carried out for critical structural areas identified by TSA global analysis results and in-service experience. The typical critical areas are listed as follows:

i) *Hull Structure*

- Dome opening
- Lower and upper brackets of side frame
- Access openings in double bottom floors and girders
- Vertical stiffeners of transverse bulkheads
- Brackets connecting transverse bulkhead vertical stiffeners and deck longitudinals
- Lower brackets of transverse bulkheads

ii) *Cargo Tank Structure*

- Bracket connections of transverse web frames
- Bracket connections of swash bulkheads
- Bracket connections of horizontal stringers

iii) *Seatings for Cargo Tank Supports and Chocks*

- Each type of vertical supports
- Each type of anti-roll chocks
- Each type of anti-pitch chocks
- Each type of anti-flotation chocks

However, local fine mesh analysis is not mandatory if the stress level in global FE analysis does not exceed 85% of the allowable stress as specified in Subsection 4/13.

Local very fine mesh FE analysis for fatigue is to be carried out for critical structural connections as per Appendix 3 of the *LGC Guide*.

13 Acceptance Criteria – Yielding

To assess the adequacy of the structural configuration and the initially selected scantlings, the hull and cargo tank structures are to be reviewed for compliance with the strength criteria for yielding, buckling, and fatigue. Individual elements are checked for yielding. The symbols are defined in Subsection 6/3 of the *LGC Guide*.

13.1 Allowable Stress for Watertight Boundaries

The allowable stresses as defined in Section 6, Table 1 of the *LGC Guide* multiplied by the temperature factor, C_{temp}, are applicable to plating and longitudinal stiffeners on watertight boundaries with recommended basic mesh size of one longitudinal spacing.

C_{temp} is to be calculated as per 3/3.3 for structure temperature between 80°C (176°F) and 300°C (572°F) and is to be taken as 1.00 for structure temperature less than 80°C (176°F).

13.3 Allowable Stress for Main Support Members and Structural Details

The allowable stresses as defined in Section 6, Table 2 of the *LGC Guide* multiplied by the temperature factor, C_{temp}, are applicable to main supporting members and structural details, except seatings for supports and chocks.

C_{temp} is to be calculated as per 3/3.3 for structure temperature between 80°C (176°F) and 300°C (572°F) and is to be taken as 1.00 for structure temperature less than 80°C (176°F).

13.5 Allowable Stress for Supports and Chocks

The allowable stresses as defined in Section 6, Table 3 of the *LGC Guide* multiplied by temperature factor, C_{temp}, are applicable to seatings for supports and chocks.

C_{temp} is to be calculated as per 3/3.3 for structure temperature between 80°C (176°F) and 300°C (572°F) and is to be taken as 1.00 for structure temperature less than 80°C (176°F).

15 Acceptance Criteria – Buckling and Ultimate Strength

The requirements in Subsection 6/7 of the *LGC Guide* are to be complied with.

17 Fatigue Damage

The requirements in Subsection 6/9 of the *LGC Guide* are to be complied with.

19 Chocks/Supports Reaction Forces

The chock reaction force calculated by global FE analysis is to be listed for verification of the chock strength. The total reaction force of typical load cases are to be checked manually to ensure the global FE iteration is converged and results are reliable.

SECTION 5 Asphalt Solutions and Associated Systems

1 General

For vessels intended to carry asphalt solutions in bulk, the provisions of 5C-1-7/1.9 of the *Steel Vessel Rules* for fuel oil carriers are applicable.

3 Additional Requirements for Heating Systems

3.1 General

For vessels intended to carry asphalt solutions in bulk, a heating system capable of preserving asphalt solutions in liquid state is to be provided for the cargo tanks. Valves are to be fitted on inlets and outlets of the heating system. Cargo piping and associated fittings outside cargo tanks are to be provided with suitable heating devices for the heating of piping and fittings.

3.3 Insulation

Cargo piping and associated fittings outside cargo tanks are to be provided with suitable insulation as necessary. In places where oil spray or leakage can occur, the insulation material is not to be of the oil-absorbing type unless encased in metal sheets or equivalent.

3.5 Temperature Measuring

Each cargo tank should be equipped with at least two temperature measuring devices in order to monitor the temperature of the asphalt solution.

3.7 Thermal Oil Heating System

Please refer to the provisions of 5C-1-7/9.5 of the *Steel Vessel Rules*.