**RULES FOR BUILDING AND CLASSING**

# STEEL VESSELS FOR SERVICE ON RIVERS AND INTRACOASTAL WATERWAYS 2018

**(Updated August 2018 – see next page)**

**American Bureau of Shipping**
**Incorporated by Act of Legislature of**
**the State of New York 1862**


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## Updates

### August 2018 consolidation includes:

- January 2018 version plus Corrigenda/Editorials

**RULES FOR BUILDING AND CLASSING**

# STEEL VESSELS FOR SERVICE ON RIVERS AND INTRACOASTAL WATERWAYS

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# Notices and General Information

## CONTENTS

# Notices and General Information

## Introduction

1. The year 2018 edition of the *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* consists of the seven (7) booklets as shown in Table 1. With regard to three booklets, Part 1, Part 2, and Part 7:

   a) The purpose of the generic title ABS *Rules for Conditions of Classification (Part 1)* is to reflect the expanded contents of PART 1, as a result of including consolidated requirements for "Classification" applicable to all types of and sizes of vessels, barges and specific shipboard arrangements/systems, etc., except for those in offshore service, as specified in the Foreword to Part 1. Additional specific requirements are contained in Part 1 of these *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length*

   b) The purpose of the generic title ABS *Rules for Materials and Welding* of PART 2 is to emphasize the common applicability of the requirements to ABS-classed vessels, other marine structures and their associated machinery, and thereby make PART 2 more readily a common "PART" of various ABS Rules and Guides, as appropriate.

   c) The purpose of the generic title ABS *Rules for Survey After Construction (Part 7)* is to reflect the expanded contents of PART 7, as a result of including consolidated requirements for "Surveys After Construction" applicable to all types and sizes of vessels, barges and specific shipboard arrangements/systems, etc., as specified in Part 7, Chapter 1, Section 1.

2. The numbering system applied in the Rules is shown in Table 2.

3. The primary changes from the 2017 edition of the Rules are identified and listed in Table 3. The effective date of the indicated Rule Changes is 1 January 2018, unless specifically indicated otherwise.

4. The effective date of each technical change since 1993 is shown in parenthesis at the end of the subsection/paragraph titles within the text of each Part. Unless a particular date and month are shown, the years in parentheses refer to the following effective dates:

| | | | |
|---|---|---|---|
| *(2000)* and after | 1 January 2000 (and subsequent years) | *(1996)* | 9 May 1996 |
| *(1999)* | 12 May 1999 | *(1995)* | 15 May 1995 |
| *(1998)* | 13 May 1998 | *(1994)* | 9 May 1994 |
| *(1997)* | 19 May 1997 | *(1993)* | 11 May 1993 |

5. Until the next edition of the *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* is published, Notices and/or Corrigenda, as necessary, will be published on the ABS website – www. eagle.org – only, and will be available free for downloading. It is not intended to publish hard copies of future Notices and/or Corrigenda to existing Rules or Guides. The consolidated edition of the *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*, which includes Notices and/or Corrigenda using different colors for easy recognition, will be published on the ABS website only when Notices and/or Corrigenda are issued.

6. The listing of CLASSIFICATION SYMBOLS AND NOTATIONS is available from the ABS website www.eagle.org for download.

## TABLE 1
## Applicable Editions of Booklets Comprising 2018 River Rules

| **Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways** | | |
|---|---|---|
| Notices and General Information | | 2018 |
| Part 1: | Conditions of Classification (Supplement to the ABS *Rules for Conditions of Classification*) [1] | 2018 |
| Part 3: | Hull Construction and Equipment | 2018 |
| Part 4: | Vessel Systems and Machinery | 2018 |
| **Rules for Conditions of Classification – not included [1,2]** | | |
| Part 1: | Rules for Conditions of Classification | 2018 |
| **Rules for Materials and Welding – not included [2]** | | |
| Part 2: | Rules for Materials and Welding | 2018 |
| **Rules for Survey After Construction – not included [2]** | | |
| Part 7: | Rules for Survey After Construction | 2018 |

*Notes:*

1 The requirements for conditions of classification are contained in the separate, generic ABS *Rules for Conditions of Classification (Part 1).* Additional specific requirements are contained in Part 1 of these Rules.

2 The latest edition of these Rules is to be referred to. These Rules may be downloaded from the ABS website at www.eagle.org, Rules and Guides, Downloads or may be ordered separately from the ABS Publications online catalog at www.eagle.org, Rules and Guides, Catalog.

## TABLE 2
## Division and Numbering of Rules

| *Division* | *Number* |
|---|---|
| Part | Part 1 |
| Chapter | Part 1, Chapter 1 |
| Section | Section 1-1-1 |
| Subsection (see Note 1) | 1-1-1/1 |
| Paragraph (see Note 1) | 1-1-1/1.1 |
| Subparagraph | 1-1-1/1.1.1 |
| Item | 1-1-1/*1.1.1(a)* |
| Subitem | 1-1-1/*1.1.1(a)i)* |
| Appendix | Appendix 1-1-A1 or Appendix 1-A1-1 |

*Note:*

1 An odd number (1, 3, 5, etc.) numbering system is used for the Rules. The purpose is to permit future insertions of even-numbered paragraphs (2, 4, 6, etc.) of text and to avoid the necessity of having to renumber the existing text and associated cross-references, as applicable, within the Rules and associated process instructions, check sheets, etc.

## Change Notice *(2018)*

### TABLE 3
### Summary of Changes from the 2017 Rules

Notice No. 1 (effective on 1 July 2017) to the 2017 Rules, which is incorporated into the 2018 Rules, is summarized below.

**EFFECTIVE DATE 1 July 2017** – shown as *(1 July 2017)*
(based on the contract date for new construction between builder and Owner)

| *Part/Para. No.* | *Title/Subject* | *Status/Remarks* |
|---|---|---|
| **PART 4** | **Vessel Systems and Machinery** | |
| 4-2-3/3.25.6 (New) | System Response Under Failure | To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1) |
| 4-2-3/3.27.6 | Low Oil Level Alarm | To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1) |
| 4-2-3/3.27.11 (New) | Earth Fault | To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1) |
| 4-2-3/3.27.12 (New) | Deviation | To require a deviation alarm in addition to basic failure detection, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1) |
| 4-3-1/7.21 | Hose | To clarify the cases in which flexible hoses need not be of fire-resistant type. (Incorporates Notice No. 1) |
| 4-5-2/7.9 | Harmonics | To specify that the harmonic distortion calculation report is to be kept on board for exceptions to the 8% limit in cases where all installed equipment and systems have been designed for higher THD levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1) |
| 4-5-2/9.18 (New) | Harmonic Distortion for Ship Electrical Distribution System including Harmonic Filters | To introduce requirements for survey of harmonic filters and harmonic distortion levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1) |
| 4-5-2/9.19 | Protection of Harmonic Filter Circuits Associated with Electric Propulsion | To introduce requirements for survey of harmonic filters and harmonic distortion levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1) |
| 4-5-4/13.1.1 | General | To identify the standards that have been withdrawn or replaced by new ones and to consider approaches for cables not manufactured to IEC standards identified, in line with IACS UR E7 Rev.4 Apr. 2016. (Incorporates Notice No. 1) |

**EFFECTIVE DATE 1 January 2018** – shown as *(2018)*
(based on the contract date for new construction between builder and Owner)

| *Part/Para. No.* | *Title/Subject* | *Status/Remarks* |
|---|---|---|
| **PART 3** | **Hull Construction and Equipment** | |
| 3-2-1/13.3.1 | Permissible Load | To modify the permissible load to consider material yield strength. |
| 3-2-2/11.3.1 | Permissible Load | To modify the permissible load to consider material yield strength. |
| 3-2-4/11.1 | Permissible Load | To modify the permissible load to consider material yield strength. |
| 3-2-5/13.1 | Permissible Load | To modify the permissible load to consider material yield strength. |

| *Part/Para. No.* | *Title/Subject* | *Status/Remarks* |
|---|---|---|
| 3-6-1 | Tank, Bulkhead and Rudder Tightness Testing | To reflect the comments from Administrations, Industry Organizations and IMO considered during review of the proposed Testing Guidelines associated with SOLAS Chapter II-1, Regulation 11, reflected in IACS UR S14 (Rev.6, Sept 2016). |
| **PART 4** | **Vessel Systems and Machinery** | |
| 4-4-1/19.3.2(a) | General | To align the requirements for the location of the control panel with Chapter 10, paragraph 2.4.1.2 of the FSS Code (as amended by resolution MSC.292(87) as interpreted by IMO MSC.1/Circ. 1487 and IACS UI SC 260 (Rev. 1). |
| 4-5-3/Table 1 | Minimum Degree of Protection | To permit plugs and socket outlets installed in hazardous areas, in line with IEC 61892-7 Para. 8.11.1 and IEC 60079-14 Para. 5.13. |
| 4-5-4/Table 6 | Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers, Motor Control Centers and Controllers | To align the requirement with IEC 60092-302 and IEC 61892-3. |
| 4-5-4/Table 7 | Equipment and Instrumentation for Switchboard | To provide a reference to the requirements for high voltage systems. |
| 4-5-5/1.3.5 | Earth Fault Detection and Indication | To clarify the requirements for audible and visual indication of earth faults for high voltage systems. |
| 4-5-6/9.1.1(a) | Location | To explicitly prohibit the installation of other unrelated equipment in the emergency generator room. |

PART

# 1

## Conditions of Classification
## (Supplement to the ABS Rules for Conditions of Classification)

### CONTENTS

PART

# 1

## Foreword *(1 January 2008)*

For the 2008 edition, Part 1, "Conditions of Classification" was consolidated into a generic booklet, entitled *Rules for Conditions of Classification (Part 1)* for all vessels other than those in offshore service. The purpose of this consolidation was to emphasize the common applicability of the classification requirements in "Part 1" to ABS-classed vessels, other marine structures and their associated machinery, and thereby make "Conditions of Classification" more readily a common Rule of the various ABS Rules and Guides, as appropriate.

Thus, this supplement specifies only the unique requirements applicable to steel vessels for service on rivers and Intracoastal waterways. This supplement is always to be used with the aforementioned *Rules for Conditions of Classification (Part 1)*.

PART

# 1

## CHAPTER 1 Scope and Conditions of Classification

### CONTENTS

PART

# 1

## CHAPTER 1 Scope and Conditions of Classification

## SECTION 1 Classification *(1 January 2008)*

The requirements for conditions of classification are contained in the separate, generic ABS *Rules for Conditions of Classification (Part 1)*.

Additional requirements specific to steel vessels for service on rivers and intracoastal waterways are contained in the following Sections of this Part.

PART
# 1

## CHAPTER 1 Scope and Conditions of Classification

## SECTION 2 Classification Symbols and Notations
*(1 January 2008)*

A listing of Classification Symbols and Notations available to the Owners of vessels, offshore drilling and production units and other marine structures and systems, "List of ABS Notations and Symbols" is available from the ABS website "http://www.eagle.org".

The following notations are specific to vessels intended for service on rivers or Intracoastal waterways.

### 1 River Service

Vessels which have been built to the satisfaction of the ABS Surveyors to the requirements of these Rules, where approved by the Committee, will be classed and distinguished in the *Record* by the symbols ✠ **A1**, followed by the service limitation **River Service**.

### 3 Special Rules

Vessels which have been built to the satisfaction of the ABS Surveyors to the requirements as contained in the Rules for special types of vessels and which are approved by the Committee will be classed and distinguished in the *Record* by the symbols ✠ **A1** followed by appropriate notation and service limitation such as **Oil Tank Barge, River Service**, **Barge, River Service**, **Towing Vessel, River Service**, **Chemical Tank Barge, River Service**, **Passenger Vessel, River Service**, etc.

PART

# 1

## CHAPTER 1 Scope and Conditions of Classification

## SECTION 3 Rules for Classification *(1 January 2008)*

### 1 Application

#### 1.1 General

These Rules have been developed for barges, towboats, cargo vessels and passenger vessels in service on major rivers and on connecting intracoastal waterways. These Rules provide for certain features peculiar to this service such as push-towing, integrated tows consisting of barges in contact and frequent transiting of locks. However, they are intended to apply to and may be used in development of designs for vessels intended for service in other bodies of comparatively smooth water. These Rules are not intended to apply to vessels in service on the Great Lakes of North America, coastwise operation, or on any ocean. In the design of self-propelled vessels intended to carry dry or liquid cargoes, the arrangements and scantlings in way of the cargo spaces may be taken from the appropriate Sections for barges.

These requirements are applicable to those features that are permanent in nature and can be verified by plan review, calculation, physical survey or other appropriate means. Any statement in the Rules regarding other features is to be considered as a guidance to the designer, builder, owner, et al.

#### 1.3 Application *(2005)*

The application of the Rules is, in general, based on the contract date for construction between the shipbuilder and the prospective owner. (e.g., Rules which became effective on 1 July 2005 are not applicable to a vessel for which the contract for construction was signed on 30 June 2005.) See also 1-1-4/3 of the ABS *Rules for Conditions of Classification (Part 1)*.

PART
# 1

## CHAPTER 1 Scope and Conditions of Classification

## SECTION 4 Submission of Plans

### 1 Hull Plans *(2011)*

Plans showing the scantlings, arrangements, and details of the principal parts of the hull structure of each vessel to be built under survey are to be submitted and approved before the work of construction is commenced. These plans are to indicate clearly the scantlings and details of welding, and they are to include, if applicable, such particulars as the design draft and design speed. Where provision is to be made for any special type of cargo or for any exceptional conditions of loading, whether in ballast or with cargo, particulars of the weights to be carried and of their distribution are also to be given. In general, the following plans are to be submitted for review or reference.

- Vessel Specifications
- General Arrangement
- Midship Section
- Scantling Profile
- Bottom Construction, Floors, Girders, etc.
- Framing
- Rake Framing
- Bow Framing
- Stem
- Inner Bottom
- Shell Plating
- Decks
- Trusses
- Pillars and Girders
- Watertight and Deep Tank Bulkheads
- Shaft Tunnels
- Machinery Casings, Boiler, Engine and Main Auxiliary Foundations
- Stern Framing
- Stern Frame and Rudder
- Shaft Struts
- Superstructures and Deckhouses
- Hatches and Hatch-Closing Arrangements
- Ventilation System on Weather Decks

Plans should generally be submitted electronically to ABS. However, hard copies will also be accepted.

## 3 Machinery Plans

Plans showing the boiler, main propulsion engine, reduction gear, shafting and thrust bearing foundations (See 3-2-1/25 or 3-2-2/21), including holding-down bolts; also machinery general arrangement, installation and equipment plans as referenced in Part 4, are to be submitted and approved before proceeding with the work.

## 5 Additional Plans

Where certification under 1-1-5/3 or 1-1-5/5 of the ABS *Rules for Conditions of Classification (Part 1)* is requested, submission of additional plans and calculations may be required.

PART

# 2

## Materials and Welding

The independent booklet, ABS *Rules for Materials and Welding (Part 2),* for steels, irons, bronzes, etc., is to be referred to. This booklet consists of the following Chapters:

### Rules for Testing and Certification of Materials



### Rules for Welding and Fabrication

PART

# 3

## Hull Construction and Equipment

**CONTENTS**

PART
# 3

## CHAPTER 1 General

### CONTENTS

PART
# 3

## CHAPTER 1 General

## SECTION 1 Definitions

### 1 Application

Unless specified otherwise, the following definitions apply in all cases where reference is made in these Rules, Tables and equations.

### 3 Length

#### 3.1 Barges

*L* is the distance, in meters (feet), measured on the centerline between the inside surfaces of the head log plates at each end. For barges of special form such as those having rounded ends or with wells or recesses in the ends, the length for the purpose of these Rules is to be specially determined.

#### 3.3 Self-Propelled Vessels

*L* is the overall distance, in meters (feet), measured on the centerline, between the inside surfaces of the shell plates at each end.

### 5 Breadth

The breadth, *B*, is the greatest horizontal distance, in meters (feet), between the inner surfaces of the side shell plating.

### 7 Depth

The depth, *D*, is the vertical distance, in meters (feet), measured at the middle of *L* from the base line to the under surface of the deck plating at the side of the vessel.

### 9 Design Draft

The design draft, *d*, is the vertical distance, in meters (feet), measured at the middle of *L* from the baseline to the deepest design waterline.

### 11 Baseline

The *Baseline* is a horizontal line extending through the upper surface of the bottom shell plating at the centerline.

### 13 Truss

A *Truss* is a system of internal framing members comprised of top and bottom chords extending either longitudinally or transversely in association with regularly spaced stanchions and diagonals. A single laced truss is one having diagonal bracing in only one direction in each space between stanchions; a double laced truss is one having diagonal bracing in both directions in each space.

## 15 Amidships

Amidships is the middle of the length *L*.

## 17 Block Coefficient ($C_b$)

The *Block Coefficient ($C_b$)*, is given by

$$C_b = \nabla / LBd$$

where $\nabla$ is the volume of molded displacement, excluding appendages, in cubic meters (cubic feet).

## 19 Double Ended Rake Barge

A *Double Ended Rake Barge* is a barge with similar rakes at each end and fitted with towing bitts arranged in such a manner that the barge in normal circumstances may be towed from either end. Each end of barges with this configuration is to be considered as the forward end in the application of these Rules.

## 21 Oil

As used in these Rules, the term *Oil* refers to petroleum products having flash points at or below 60°C (140°F), (closed cup test).

## 23 Passenger

A *Passenger* is every person other than the master and the members of the crew or other persons employed or engaged in any capacity onboard a vessel on the business of that vessel and children under one year of age.

## 25 Superstructure

A *Superstructure* is a decked structure on the freeboard deck extending from side to side of the barge or vessel, or with the side plating not being inboard of the shell plating more than 0.04*B*.

## 27 Cargo Area

The *Cargo Area* is that part of a barge that contains cargo tanks, slop tanks and cargo pump rooms and includes ballast and void spaces, cofferdams and pump rooms adjacent to cargo tanks and also deck areas throughout the entire length and breadth of that part of the barge over the above mentioned spaces. In chemical and liquefied gas tank barges having independent cargo tanks installed in hold spaces, cofferdams or ballast or void spaces aft of the aftermost hold space bulkhead or forward of the forward-most hold space bulkhead are excluded from the cargo area.

## 29 Cargo Pump Room

A *Cargo Pump Room* is a space containing pumps and their accessories for the handling of the cargo.

## 31 Weathertight

*Weathertight* means that in any sea conditions water will not penetrate into the vessel.

## 33 Gross Tonnage

For vessels in domestic service, gross tonnage is the national gross tonnage as specified by the country in which the vessel is to be registered. For vessels which are engaged in international voyages, gross tonnage is to be determined by the International Convention on Tonnage Measurement of Ships, 1969.

## 35 Units

These Rules are written in two systems of units, i.e., MKS units and US customary units. Each system is to be used independently of any other system.

Unless indicated otherwise, the format of presentation in the Rules of the two systems of units is as follows:

MKS units (US customary units)

PART

# 3

CHAPTER 1 General

## SECTION 2 General Requirements

### 1 Materials

#### 1.1 Steel *(2017)*

These Rules are intended for barges and vessels of welded construction using steels complying with the requirements of Chapters 1 and 2 of the ABS *Rules for Materials and Welding (Part 2)*. Use of steels other than those in Chapters 1 and 2 of the above Part 2 and the corresponding scantlings will be specially considered. Where it is intended to use material of cold flanging quality, this steel is to be indicated on the plans. ASTM A36 steel otherwise manufactured by an ABS approved steel mill, tested and certified to the satisfaction of ABS may be used in lieu of Grade A for a thickness up to and including 12.5 mm (0.5 in.) for plates and up to and including 19 mm (0.75 in.) for sections.

#### 1.3 Aluminum Alloys

The use of aluminum alloys in hull structures will be considered upon submission of the proposed specification for the alloy and the method of fabrication.

#### 1.5 Design Consideration

Where scantlings are reduced in connection with the use of higher-strength steel or where aluminum alloys are used, adequate buckling strength is to be provided. Where it is intended to use material of cold flanging quality for important longitudinal strength members, this steel is to be indicated on the plans.

#### 1.7 Guidance for Repair

Where a special welding procedure is required for the special steels used in the construction, including any low temperature steel and those materials not in Chapters 1 and 2 of the ABS *Rules for Materials and Welding (Part 2)*, a set of plans showing the following information for each steel should be placed aboard the barge or vessel.

- Material Specification
- Welding procedure
- Location and extent of application

These plans are in addition to those normally placed aboard which are to show all material applications.

#### 1.9 Materials Containing Asbestos *(2005)*

See 4-1-1/21.

### 3 Scantlings

#### 3.1 General

Sections having appropriate section moduli or areas, in accordance with their functions in the structure as stiffeners, columns or combinations of both, are to be adopted, due regard being given to the thickness of all parts of the sections to provide a proper margin for corrosion. It may be required that calculations be submitted in support of resistance to buckling for any part of the vessel's structure.

### 3.3 Workmanship

All workmanship is to be of commercial marine quality and acceptable to the Surveyor. Welding is to be in accordance with the requirements of Section 3-2-6. The Surveyors are to satisfy themselves that all operators to be employed in the construction of barges and vessels to be classed are properly qualified in the type of work proposed and in the proper use of the welding processes and procedures to be followed.

## 5 Proportions

In general, these Rules are valid for vessels having lengths not exceeding 30 times their depth, and breadths not exceeding 6 times their depth. Vessels with other proportions will be specially considered.

## 7 Structural Sections

### 7.1 Required Section Modulus

The scantling requirements of these Rules are applicable to structural angles, channels, bars, and rolled or built-up sections. The required section modulus of members such as girders, webs, etc., supporting frames and stiffeners is to be obtained with an effective width of plating basis as described below, unless otherwise noted. The section modulus is to include the structural member in association with an effective width of plating equal to one-half the sum of the spacing on each side of the member or 33% of the unsupported span $\ell$, whichever is less. For girders and webs along hatch openings, an effective breadth of plating equal to one-half the spacing or 16.5% of the unsupported span $\ell$, whichever is less, is to be used. Where channel construction is adopted, as illustrated in 3-2-1/Figure 5 and 3-2-2/Figure 5, the required section modulus is to be obtained solely by the channel.

The required section modulus of frames and stiffeners is assumed to be provided by the stiffener and one frame space of the plating to which it is attached. . For bars or shapes which are not attached to the plating, the section modulus is to be obtained in the member only. It may be required that calculations be submitted in support of the resistance to buckling of longitudinals.

### 7.3 Serrated Sections

Serrated sections may be used for girders, webs, frames and stiffeners, but the depth of the member is not to be less than 2 times the depth of any cutout. The cutouts are to be arranged to provide regularly spaced points of contact with the plating sufficient to obtain the welding required. Where supporting members are cut out for framing and stiffening members, the depth of the cutout should not exceed 50% of the depth of the supporting member.

## 9 Structural Design Details

### 9.1 General

The designer shall give consideration to the following:

9.1.1

The thickness of internals in locations susceptible to rapid corrosion.

9.1.2

The proportions of built-up members to comply with established standards for buckling strength.

9.1.3

The design of structural details, such as noted below, against the harmful effects of stress concentrations and notches:

*i)* Details of the ends, the intersections of members and associated brackets.

*ii)* Shape and location of air, drainage, or lightening holes.

*iii)* Shape and reinforcement of slots or cut-outs for internals.

*iv)* Elimination or closing of weld scallops in way of butts, "softening" of bracket toes, reducing abrupt changes of section or structural discontinuities.

9.1.4

Proportions and thickness of structural members to reduce fatigue response due to cyclic stresses, particularly for higher-strength steels.

## 9.3 Termination of Structural Members

Unless permitted elsewhere in the Rules, structural members are to be effectively connected to the adjacent structures in such a manner as to avoid hard spots, notches and other harmful stress concentrations. Where members are not required to be attached at their ends, special attention is to be given to the end taper, by using soft-toed concave brackets or by a sniped end of not more than 30°. Where the end bracket has a face bar, it is to be sniped and tapered not more than 30°. Bracket toes or sniped ends are to be kept within 25 mm (1.0 in.) of the adjacent member, and the depth at the toe or snipe end is generally not to exceed 15 mm (0.60 in.). Where a strength deck or shell longitudinal terminates without end attachment, it is to extend into the adjacent transversely framed structure or stop at a local transverse member fitted at about one transverse frame space beyond the last floor or web that supports the longitudinal.

PART

# 3

## CHAPTER 2 Hull Structures and Arrangements

### CONTENTS

PART

# 3

## CHAPTER 2 Hull Structures and Arrangements

## SECTION 1 Tank Barges

### 1 Application

The following Rules and Tables apply to barges intended for the transportation of liquid cargoes in bulk in services which require operation in comparatively smooth water exclusively, such as in rivers, intracoastal waterways, etc. For additional chemical tank barge requirements see Section 3-2-3.

### 3 Classification

The classification ✠ **A1 Oil Tank Barge, River Service** is to be assigned to vessels designed for the carriage of oil (See 3-1-1/21) cargoes in bulk, and built to the requirements of this Section and other relevant Sections of these Rules. Vessels intended to carry fuel oil having a flash point above 60°C (140°F), closed cup test, and to receive classification ✠ **A1 Fuel Oil Tank Barge, River Service** are to comply with the requirements of this section and other relevant sections of these Rules with the exception that the requirements for cofferdams and gastight bulkhead may be modified.

### 5 Structural Arrangement

#### 5.1 Between the Rakes

5.1.1 Framing

Framing may be arranged either longitudinally, transversely or a combination of both. Longitudinal frames are to be supported by regularly spaced transverse deep frames formed either by channels extending across the inner faces of the longitudinal frames, or by flanged plates notched over the frames and attached to the shell or deck and the longitudinals.

At bulkheads, longitudinals are to be attached at their ends to develop effectively the sectional area and resistance to bending.

5.1.2 Trusses

Trusses are to be arranged as necessary for the support of the framing. In vessels with transverse frames, the trusses are to extend fore and aft and be arranged to limit the spans of the frames to a maximum of 4 m (13 ft). With longitudinal framing, they may extend either fore and aft or athwartships.

In all vessels where the ratio of $L$ to ($D$ + $^1/_2$ the deck crown) exceeds 20, at least one fore-and-aft single laced truss is to be fitted on each side of the centerline and where the ratio exceeds 25, at least one fore-and-aft double laced truss or two single laced trusses are to be fitted on each side; in the latter case the diagonal bracing in the two trusses on each side should be reversed in direction with each other to provide tension members whether the conditions of load create either hogging or sagging forces.

#### 5.1.3 Bilge and Gunwale Brackets

In tanks where the radius at the bilge exceeds 305 mm (12 in.), the bilge brackets connecting the lower ends of vertical side frames with transverse bottom frames are to be cut to fit against and support the bilge plate. In longitudinally framed vessels, a similar arrangement will be required at each main transverse frame and in addition, intermediate brackets are to be fitted spaced not over 0.9 m (3 ft) apart. See 3-2-1/Figures 1 and 2. Similar brackets may be required to be fitted at the gunwales where no gunwale angle is used. See 3-2-1/Figure 4. As an alternative to the fitting of bilge brackets, an additional inverted angle or flat bar longitudinal may be fitted as shown in 3-2-1/Figure 3.

### 5.3 Rakes

The bottom and deck framing is to consist of longitudinal bottom frames and beams, attached to the rake bulkheads by effective brackets and to the head log by deep diaphragm plates or by a system of vertical channels which in turn support horizontal stiffening on the head log. The longitudinal bottom frames and beams are to have intermediate supports obtained by a system of strut angles extending between each corresponding beam and frame to form an effective longitudinal truss, or as an alternative, stanchions and diagonals may be fitted on the longitudinal frames at regular intervals in association with channel or flanged plate transverses for the support of the intervening rake frames and beams. A typical arrangement is shown in 3-2-1/Figure 11.

The sides of rakes may be framed vertically, diagonally or horizontally.

Special heavy plates are to be fitted to form the head logs and these are to be terminated at the corners of the barge in special heavy castings or weldments.

### 5.5 Double Skin Construction

These Rules contain requirements for single skin as well as double skin tank barges. Consideration is to be given to double skin construction as may be required by governmental regulations for certain types of cargoes.

For an oil barge of U.S. registry less than 10,000 DWT in service exclusively on inland or limited short protected coastwise routes, 33CFR157.10d(d) specifies the following double hull dimensions and clearances:

- *Double Bottom* 610 mm (2 ft) measured at right angles to the bottom shell
- *Wing Tank or Space* 610 mm (2 ft) measured at right angles to the side shell.

A minimum clearance of 460 mm (18 in.) for passage between framing must be maintained throughout the double sides and double bottom.

## 7 Longitudinal Strength *(2001)*

### 7.1 Definitions

#### 7.1.1 Limiting Draft

A limiting draft is the maximum draft to which cargo of the specified densities may be loaded.

#### 7.1.2 Homogeneous Cargo

Homogeneous cargo is a cargo having a density which, when all cargo tanks are completely filled, will submerge the barge to the approved limiting draft. The density of homogeneous cargo is obtained by dividing the cargo deadweight at that limiting draft by the total volume of all cargo tanks.

#### 7.1.3 Approved Cargo Density

Approved cargo density is the maximum density corresponding to the limiting draft. It is not to be less than the density of homogeneous cargo or 1.05 whichever is greater.

### 7.3 Loading Conditions

The following definitions of loading conditions are to be understood for the purpose of these Rules.

#### 7.3.1 Normal Conditions

Normal conditions are those expected during the normal operation of the barge, including intermediate conditions during loading and unloading.

While in transit, the barge is assumed to be full with homogeneous cargo, unless bending moment calculations are submitted for other condition intended for normal operation.

#### 7.3.2 High Density Cargo Condition

A high density cargo condition is a condition expected during the normal operation of the barge including intermediate conditions during loading and unloading wherein tanks are loaded with cargo having the maximum approved density that is in excess of homogeneous cargo density.

### 7.5 Loading/Unloading Sequences and Bending Moment Calculations

For tank barges of 53 m (175 ft) or above in length, loading/unloading sequences and bending moment calculations are to be submitted for review as follows:

#### 7.5.1 Loading/unloading Sequences

For each cargo loading condition, a step by step description of the sequence of loading and unloading is to be submitted together with the mass of cargo in each tank at every step.

#### 7.5.2 Bending Moment Calculations

Bending moment calculations are to be submitted where any of the following conditions apply:

*i)* Where conditions other than homogeneous cargo condition are contemplated. See 3-2-1/7.3.1,

*ii)* For high density cargo conditions, or

*iii)* For any step of loading/unloading as may be required after review of the loading/unloading sequence required above.

### 7.7 Hull Girder Section Modulus *(1 July 2016)*

The hull girder section modulus within the midship 0.5$L$ for vessels of 53 meters (175 feet) in length or above is to be not less than obtained from the following equation:

$SM = M_{sw}/f_P$ cm$^2$-m (in$^2$-ft)

where

$SM$ = minimum required hull girder section modulus, in cm$^2$-m (in$^2$-ft)

$M_{sw}$ = maximum calculated still water bending moment or $M_s$, whichever is greater, in tf-m (Ltf-ft). See 3-2-1/7.5.

$M_s$ = a standard still water bending moment

= $L^2BD/5.76$ kN-m for SI units

= $L^2BD/56.44$ tf-m for MKS units

= $L^2BD/2025$ Ltf-ft for US units

$f_p$ = nominal permissible bending stress of 13.1 kN/cm$^2$ (1.34 tf/cm$^2$, 8.5 Ltf/in$^2$)

for compressive side, $f_p$ is not to be taken greater than 0.67 times the reference stress ($f_r$) as specified below, or permissible stress $f$ as specified in 3-2-3/7.5.3(b) whichever is less.

$f_r$ = $kf_c\{[C_2 + (a/st)]/[1 + (a/st)]\}\ f_y$ for longitudinally framed deck or bottom

= $[C_2 s/b + 0.115(1 - s/b)(1 + 1/\beta^2)^2]\ f_y$ for transversely framed deck or bottom

$C_2$ = $2.25/\beta - 1.25/\beta^2$ for $\beta > 1.25$

= 1 for $\beta < 1.25$

$k$ = 0.8 for serrated longitudinals

= 0.95 for non-serrated longitudinals

$f_c$ = $f_E$ for $f_E < 0.6$

= $1 - 0.24/f_E$ for $f_E > 0.6$

$f_E$ = $\pi^2 EI/[\ell^2(a + C_2 st)f_y]$

$a$ = area of longitudinal, in $mm^2$ ($in^2$)

$\ell$ = unsupported span of longitudinals in mm (in.)

$\beta$ = $(f_y/E)^{1/2}\ s/t$

$s$ = spacing of the deck/bottom longitudinals or beams, in mm (in.)

$b$ = unsupported length of the deck/bottom transverse beams/frames, in mm (in.)

$t$ = thickness of the deck/bottom plating, in mm (in.)

$f_y$ = yield strength of the deck/bottom material, in $N/cm^2$ ($kgf/cm^2$, $lbf/in^2$)

$E$ = modulus of elasticity, in $N/cm^2$ ($kgf/cm^2$, $lbf/in^2$)

$I$ = moment of inertia of the deck/bottom longitudinal with its associated effective deck/bottom plating in $cm^4$ ($in^4$)

*L*, *B* and *D* are as defined in Section 3-1-1.

Beyond the midship 0.5*L*, scantlings may be tapered to their normal requirements.

### 7.9 Items Included in the Section Modulus Calculation

In general, the following items may be included in the calculation of the section modulus.

- Deck and trunk plating
- Shell and inner bottom plating
- Deck and bottom girders
- Plating and longitudinal stiffeners of longitudinal bulkheads
- All longitudinals of deck, trunk, sides, bottom and inner bottom

All items are to be continuous or effectively developed at the transverse bulkheads and all other joints. In general, the net sectional areas of longitudinal-strength members are to be used in the hull girder section modulus calculation.

## 9 Deck and Trunk Plating

### 9.1 Between the Rakes

The thickness of deck, trunk and trunk side plating between the rakes is to be not less than the greater of 3-2-1/9.1.1 or 3-2-1/9.1.2 below.

#### 9.1.1 Minimum Thickness

The thickness of plating is to be not less than determined by the following equations.

- *With Transverse Beams*

$t = 0.066L + 3.5$ mm $\qquad t = 0.0008L + 0.14$ in.

- *With Longitudinal Beams*

  $t = 0.066L + 2.5$ mm $\qquad t = 0.0008L + 0.10$ in.

*Note* The thickness of decks and trunk tops and sides with longitudinal beams and $L \geq 79$ meters (260 feet) need not be greater than 8.0 mm (0.31 in. except as required to provide adequate hull girder strength and resistance to buckling. For decks and trunks with longitudinal beams, for $L \geq 30.5$ meters (100 feet), the thickness of the deck and trunk top and side plating is to be not less than 4.5 mm (0.18 in.).

#### 9.1.2 Thickness for Compression *(2001)*

The thickness of plating is to be not less than what is required for longitudinal hull girder strength (see 3-2-1/7).

### 9.3 Rake Decks

The thickness of rake deck plating is to be not less than 0.01 mm (0.01 in.) per mm (in.) of frame spacing.

## 11 Frames

Each frame, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $\qquad SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = coefficient appropriate to the member under consideration and the type of construction employed as given in 3-2-1/Figures 5 through 11

= 1.0 for rake side frames

$h$ = distance from the middle of $\ell$ to the deck at side, in m (ft)

= for rake bottom frames, the vertical distance from the middle of $\ell$ to the height of the deck at side at the rake bulkhead, in m (ft)

= for rake deck transverses and longitudinals, 1.2 m (4.0 ft)

= in way of tanks, $h$ as defined in 3-2-1/17, but not to be taken less than $h_e$ as indicated in 3-2-1/Figures 8 and 9 for bottom transverses and floors on double skin tank barges with void wing compartments

$s$ = member spacing in m (ft)

$\ell$ = unsupported span of the member, in m (ft). Where brackets of the thicknesses given in 3-2-1/Table 1 are fitted, $\ell$ may be measured to a point 25% of the extent of the bracket beyond its toe.

Rake side vertical frames are to be fitted at their upper and lower ends with brackets extending over to the first adjacent longitudinal beam or frame.

## 13 Trusses

### 13.1 Top and Bottom Chords

Each top and bottom chord is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $\qquad SM = 0.0041chs\ell^2$ in$^3$

where $c$, $h$, $s$ and $\ell$ are as defined in 3-2-1/11.

### 13.3 Stanchions

The spacing of truss stanchions is generally not to exceed the depth of the truss.

#### 13.3.1 Permissible Load *(2018)*

The permissible load, $W_a$, of each stanchion is to be obtained from the following equation and is to be not less than the calculated load $W$ given in 3-2-1/13.3.2 below.

$$W_a = [k - n\ell/r]A \quad \text{kN (tf, Ltf)}$$

where

| | | | |
|---|---|---|---|
| $k$ | = | 12.09 (1.232, 7.83) | ordinary strength steel |
| | = | 16.11 (1.643, 10.43) | HT32 strength steel |
| | = | 18.12 (1.848, 11.73) | HT36 strength steel |
| $n$ | = | 0.0444 (0.00452, 0.345) | ordinary strength steel |
| | = | 0.0747 (0.00762, 0.581) | HT32 strength steel |
| | = | 0.0900 (0.00918, 0.699) | HT36 strength steel |

$\ell$ = unsupported span of the stanchion, in cm (ft)

$r$ = least radius of gyration, in cm (in.)

$A$ = cross sectional area of the stanchion, in $cm^2$ ($in^2$)

#### 13.3.2 Calculated Load

The calculated load for each truss stanchion is to be determined by the following equation:

$$W = nbhs \quad \text{tf (Ltf)}$$

where

$n$ = 1.07 (0.03)

$b$ = mean breadth of the area supported, in m (ft)

$h$ = distance from the bottom shell at the center of the area supported to the underside of the deck plating at side, in m (ft)

$s$ = spacing of the stanchions, in m (ft)

### 13.5 Diagonals

Diagonals in trusses are to have a sectional area of approximately 50% of that of the stanchions.

## 15 Web Frames, Girders and Stringers

Each web frame, girder and stringer is to have a section modulus, $SM$, not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \quad \text{cm}^3 \qquad SM = 0.0041chs\ell^2 \quad \text{in}^3$$

where $c$, $h$, $s$ and $\ell$ are as defined in 3-2-1/11.

## 17 Tank Head for Scantlings

Except for stanchions (see 3-2-1/13.3.2), the scantling head of structural members in tanks is to be obtained from 3-2-1/17.1 or 3-2-1/17/3 depending upon the pressure setting of the pressure-vacuum valve.

### 17.1 Pressure Setting 0.12 kgf/cm² (1.7 psi) or Less

The scantling head, $h$, in m (ft), is not to be less than $h_1$, nor less than $h_o$, where spill valves or rupture disks are fitted in lieu of high level alarms.

$h_1 = \rho h_t + 1.2$ m $\qquad$ $h_1 = \rho h_t + 4.0$ ft

$h_1$ is not to be less than the distance to the top of the hatch.

where

$h_o$ = $(2/3)(\rho h_s + 10p_s)$ m $\qquad$ $h_o = (2/3)(\rho h_s + 2.3p_s)$ ft

$\rho$ = 1.0 where specific gravity of the liquid is 1.05 or less

= specific gravity of liquid where it is in excess of 1.05

$h_t$ = head from the center of the supported area or lower edge of the plating to the deck at side for tanks outside trunks, or to the top of the trunk at side for tanks within trunks.

$h_s$ = head to the spill valve or rupture disc, where fitted, in m (ft)

$p_s$ = relieving pressure of spill valve or rupture disc, where fitted, in kgf/cm² (psi)

### 17.3 Pressure Setting Over 0.12 kgf/cm² (1.7 psi)

The scantling head is to be in accordance with 3-2-1/17.1, except that $h_2$ is to be used in lieu of $h_1$.

$h_2 = \rho h_t + 10p$ m $\qquad$ $h_2 = \rho h_t + 2.3p$ ft

where

$p$ = pressure setting of pressure-vacuum valve, in kgf/cm² (psi)

## 19 Bulkheads

### 19.1 Arrangement

#### 19.1.1 Subdivision

It is assumed that those responsible for the design of the vessels have assured themselves that the subdivision is such as to ensure sufficient stability in service when the tanks are being filled or emptied. The length of the tanks and the positions of longitudinal bulkheads are to be such as to avoid excessive stresses in the hull structure.

#### 19.1.2 Cofferdams

In vessels intended for the carriage of flammable or combustible liquids having flash points at or below 60°C (140°F) (closed-cup test), bulkheads are to be arranged to provide cofferdams between the cargo tanks and any spaces used for living quarters, general cargo, or containing machinery where sources of vapor ignition are normally present. Spaces containing cargo pumps, steam pumping engines or which are used as tanks for products having flash points not less than 60°C (140°F) (closed-cup test) may be considered as cofferdams for the purpose of this requirement, but in the latter case the piping and pumping arrangements for the high flash point liquid are to be entirely separate from and have no means for connection with the arrangements for handling the low flash point products.

#### 19.1.3 Pump Rooms

Spaces containing pumps, piping and valves for handling flammable or combustible liquids having flash points below 60°C (140°F) (closed-cup test) are to be completely separated from all sources of vapor ignition by gastight bulkheads. Steam driven engines are not considered sources of vapor ignition for the purposes of this requirement. The gastight bulkheads may be pierced by fixed lights for lighting from outside sources and by pumping engine shafts and control rods, provided the shafts and rods are fitted with efficient stuffing boxes where they pass through the bulkhead.

## 19.3 Construction of Tank Boundary Bulkheads

### 19.3.1 Plating

Plating is to be of thickness obtained from the following equation:

$t = (s\sqrt{h}/254) + 1.78$ mm (min. $t$ = 5 mm)

$t = (s\sqrt{h}/460) + 0.07$ in. (min. $t$ = 0.20 in.)

where

$h$ = height, in m (ft), in accordance with 3-2-1/17.

$s$ = for flat plate bulkheads, the spacing of stiffeners. in mm (in.)

= for corrugated bulkheads, the greater of dimensions $a$ or $c$ as indicated in Section B-B of 3-2-1/Figures 8 and 9.

For corrugated bulkheads, the angle is to be 45° or more

### 19.3.2 Stiffening

The ends of stiffeners are to be either bracketed or clipped, and those of trunk top transverse beams are to be effectively attached as shown in 3-2-1/Figure 8a or 3-2-1/Figure 9a. Each stiffener, in association with the plating to which it is attached, is to have a section modulus $SM$ not less than obtained from the following equation:

$SM = 7.8csh\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 1.00

$h$ = height, in m (ft), in accordance with 3-2-1/17

$s$ = stiffener spacing, in m (ft)

= for corrugated bulkheads, $a + b$ where $a$ and $b$ are as indicated in Section B-B of 3-2-1/Figures 8 and 9

$\ell$ = as defined in 3-2-1/11

= for corrugated bulkheads, the distance between the supporting members, in m (ft)

The developed section modulus, $SM$, for corrugated bulkheads may be obtained from the following equation, where $a$, $t$ and $d$ are as indicated in Section B-B, 3-2-1/Figures 8 and 9.

$SM = (td^2/6) + (adt/2)$

### 19.3.3 Drainage and Air Escape

Limber and air holes are to be cut in all parts of the structure as required to ensure the free flow to the suction pipes and the escape of air to the vents. Efficient arrangements are to be made for draining the spaces above deep tanks.

## 19.5 Construction of Other Watertight Bulkheads

### 19.5.1 Plating

Plating is to be of thickness obtained from the following equation:

$t = (s\sqrt{h}/290) + 1.0$ mm (min. $t$ = 4.5 mm)

$t = (s\sqrt{h}/525) + 0.04$ in. (min. $t$ = 0.18 in.)

where

$s$ = as defined in 3-2-1/19.3.1

$h$ = vertical distance measured in m (ft) from the lower edge of the plate to the height of the deck at centerline.

19.5.2 Stiffening

Each stiffener, in association with the plating to which it is attached, is to have a section modulus *SM* not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 0.46

$h$ = vertical distance from the middle of $\ell$ to the deck at centerline, in m (ft)

$s$ = for flat plate bulkheads, stiffener spacing, in m (ft)

= for corrugated bulkheads, $a + b$ where $a$ and $b$ are as indicated in Section B-B of 3-2-1/Figures 8 and 9

$\ell$ = as defined in 3-2-1/19.3.2

Stiffeners on these bulkheads may have unattached sniped ends provided the above value of *SM* is increased 25%.

The developed section modulus, *SM*, for corrugated bulkheads may be obtained as indicated in 3-2-1/19.3.2.

## 21 Shell Plating

### 21.1 Bottom Shell

The thickness of the bottom shell plating throughout is not to be less than determined by the following equation:

$t = 0.069L + 0.007s - 0.5$ mm (min. $t$ = 5 mm)

$t = 0.000825L + 0.007s - 0.02$ in. (min. $t$ = 0.20 in.)

where

$s$ = stiffener spacing, in mm (in.)

$L$ = length of the vessel, in m (ft)

### 21.3 Side Shell

The thickness of the side shell plating is to be not less than determined by the following equation and not less than 5 mm (0.20 in.).

$t = 0.069L + 0.007s - 1.0$ mm $L < 73$ m

$t = 0.069L + 0.007s - 1.5$ mm $L \geq 73$ m

$t = 0.000825L + 0.007s - 0.04$ in. $L < 240$ ft

$t = 0.000825L + 0.007s - 0.06$ in. $L \geq 240$ ft

### 21.5 Bilge Plating

Where radiused bilges are used, the bottom thickness is to extend to the upper turn of the bilge. Where the radius at the bilge exceeds 305 mm (12 in.), the thickness of the plating should be at least 1.5 mm (0.06 in.) greater than the required thickness for side plating.

### 21.7 Tank Spaces

In way of the cargo tanks the bottom, side and bilge plating are not to have less thickness than required by 3-2-1/19.3.1 for the plating of deep tank bulkheads where the spacing of the stiffeners is equal to the frame spacing and the value of *h* in accordance with 3-2-1/17.

### 21.9 Bilge Angles

Where angles are used at the bilges or gunwales they are to have a thickness at least 1.5 mm (0.06 in.) greater than that of the thinner of the two plates joined.

## 23 Hatches and Fittings

### 23.1 Hatchways

Hatchways of sufficient size to provide access and ventilation and having substantial oiltight steel covers are to be fitted to each tank. Where openings are located close to the gunwales, doubling plates or other compensation may be required.

### 23.3 Deck Fittings

The structure in way of cleats, bitts and chocks is to be suitably reinforced by installation of headers, additional beams, brackets or doubling plates

## 25 Barge Reinforcement

### 25.1 General

The following paragraphs are intended to provide for additional protection against contact with locks and river bottom and against other wear and tear damage associated with normal operation with other floating equipment.

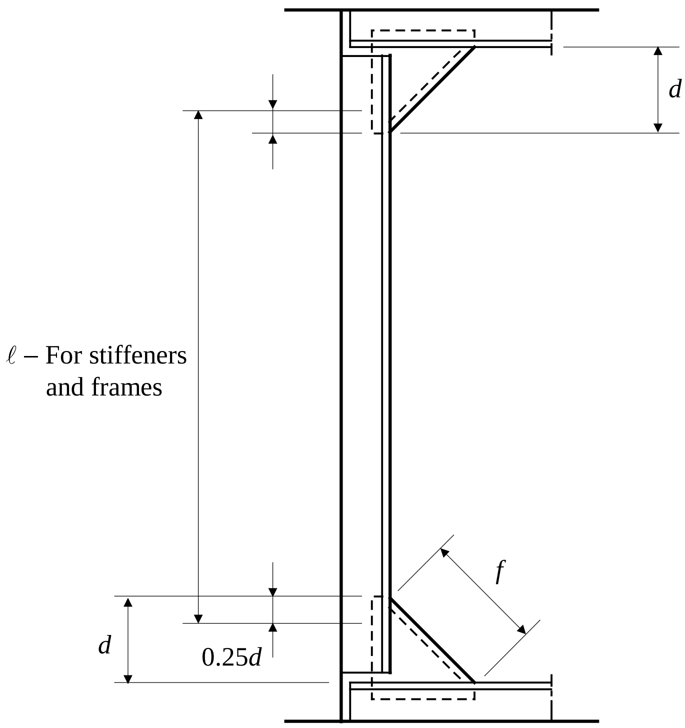
A design intended for Classification will be reviewed for compliance with 3-2-1/25.3 when requested. A notation **Reinforcement A** or **Reinforcement B** will be entered in the *Record* indicating compliance with all of the requirements for Reinforcement A or B in 3-2-1/25.3.

### 25.3 Reinforcement

Where the option for reinforcement in 3-2-1/25.1 is chosen, the hull parts to be reinforced are given in the following table, the reinforced plate thicknesses are to be not less than given in column Reinforcement A or column Reinforcement B, as appropriate.

| | *Reinforcement A* | *Reinforcement B* |
|---|---|---|
| Bilge radius for full-length of barge (knuckle plate) | $t_{min}$ = 16.0 mm ($^5/_8$ in.) | $t_{min}$ = 12.5 mm ($^1/_2$ in.) |
| Side shell | $t_{min}$ = 11.0 mm ($^7/_{16}$ in.) | $t_{min}$ = 9.5 mm ($^3/_8$ in.) |
| Headlog and sternlog plate | $t_{min}$ = 19.0 mm ($^3/_4$ in.) | $t_{min}$ = 16.0 mm ($^5/_8$ in.) |
| Transom side and bottom periphery (picture frame) plates | $t_{min}$ = 16.0 mm ($^5/_8$ in.) | $t_{min}$ = 12.5 mm ($^1/_2$ in.) |
| All side shell, bottom shell and deck structural members in wing and rake compartments | Use appropriate Rule coefficients with 1.83 m (6 ft) overflow above deck at side. Where no wing tanks are fitted, the reinforcement is to apply to the side shell structure in way of cargo tanks and the side, bottom and deck structure in way of rakes. | Use appropriate Rule coefficients with 1.22 m (4 ft) overflow above deck at side. |

## TABLE 1
## Brackets




*Metric Units*

| *Length of Face, f mm* | *Thickness, mm* | | *Width of Flange mm* |
|---|---|---|---|
| | *Plain* | *Flanged* | |
| Not exceeding 455 | 6.5 | --- | --- |
| Over 455 to 660 | 8.0 | 6.5 | 50 |
| Over 660 to 915 | 9.5 | 8.0 | 63 |
| Over 915 to 1370 | 11.0 | 9.5 | 75 |

*US Units*

| *Length of Face, f in.* | *Thickness, mm* | | *Width of Flange in.* |
|---|---|---|---|
| | *Plain* | *Flanged* | |
| Not exceeding 18 | $^{1}/_{4}$ | --- | --- |
| Over 18 to 26 | $^{5}/_{16}$ | $^{1}/_{4}$ | 2 |
| Over 26 to 36 | $^{3}/_{8}$ | $^{5}/_{16}$ | $2^{1}/_{2}$ |
| Over 36 to 54 | $^{7}/_{16}$ | $^{3}/_{8}$ | 3 |

**FIGURE 1**
**Bilge Bracket (see 3-2-1/5.1.3)**

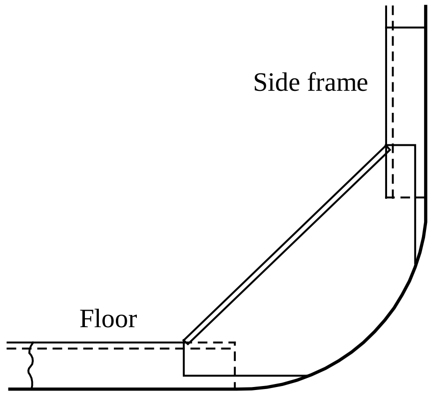



**FIGURE 2**
**Intermediate Bilge Bracket (see 3-2-1/5.1.3)**

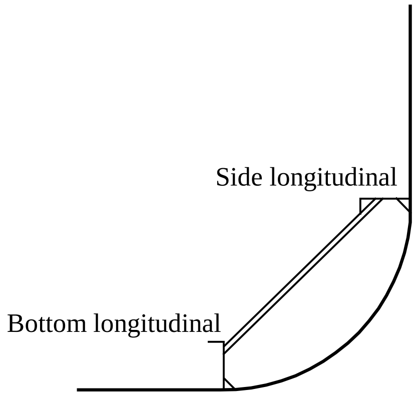



**FIGURE 3**
**Alternative Arrangement (see 3-2-1/5.1.3)**

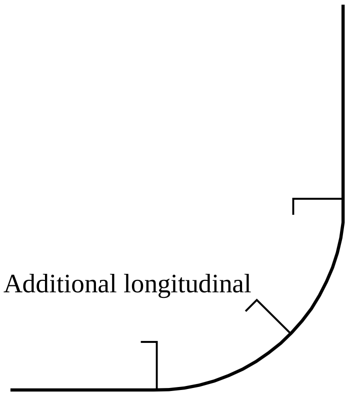
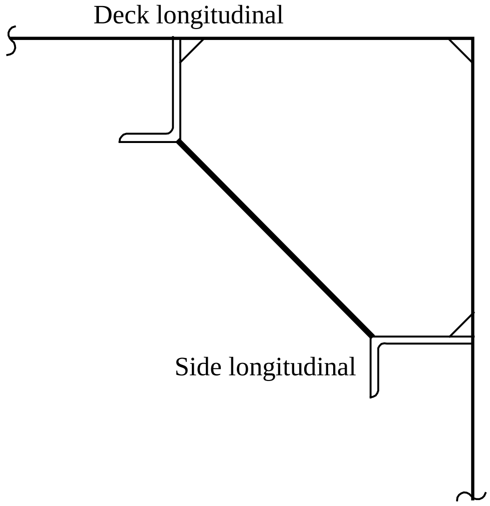
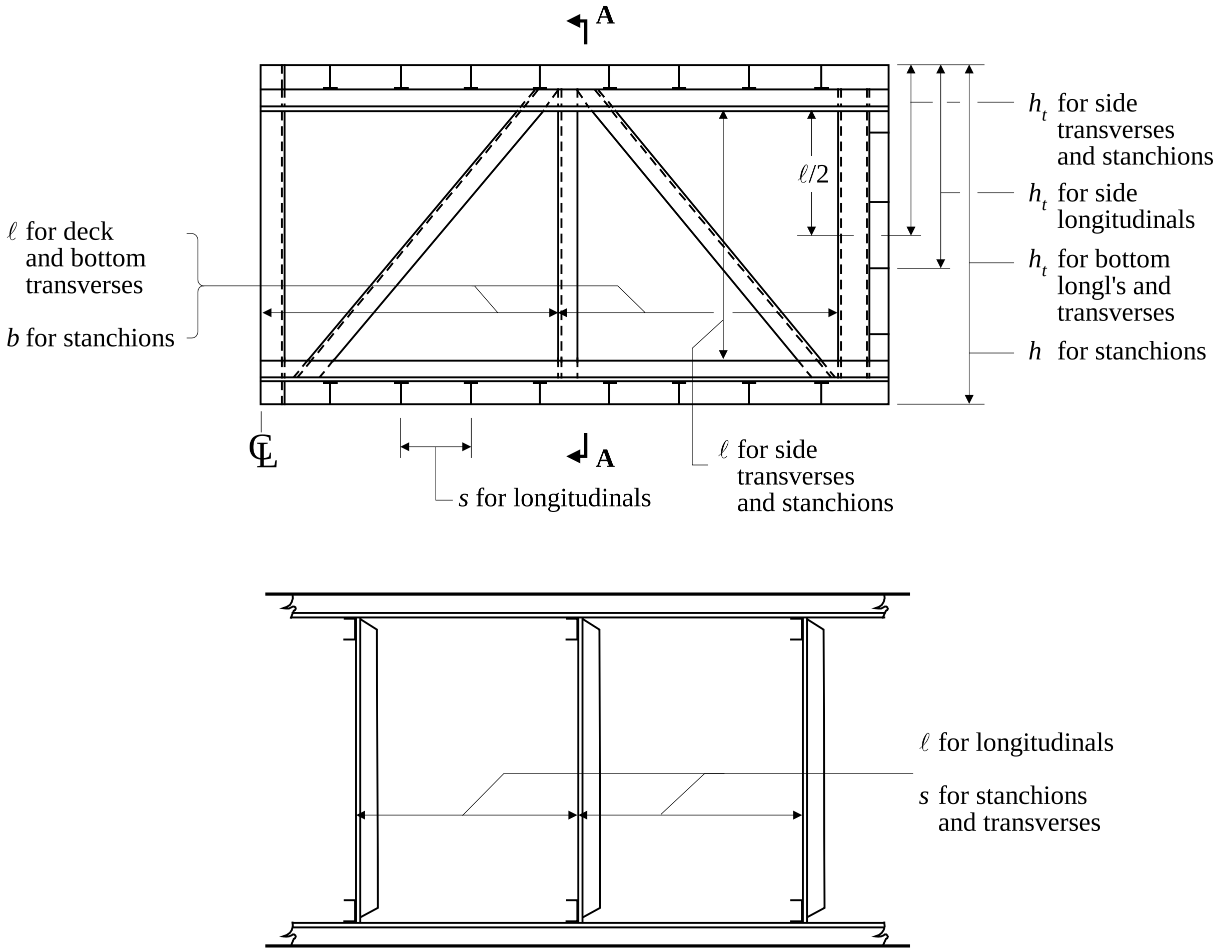


**FIGURE 4**
**Gunwale Bracket (see 3-2-1/5.1.3)**



## FIGURE 5
## Tank Barge

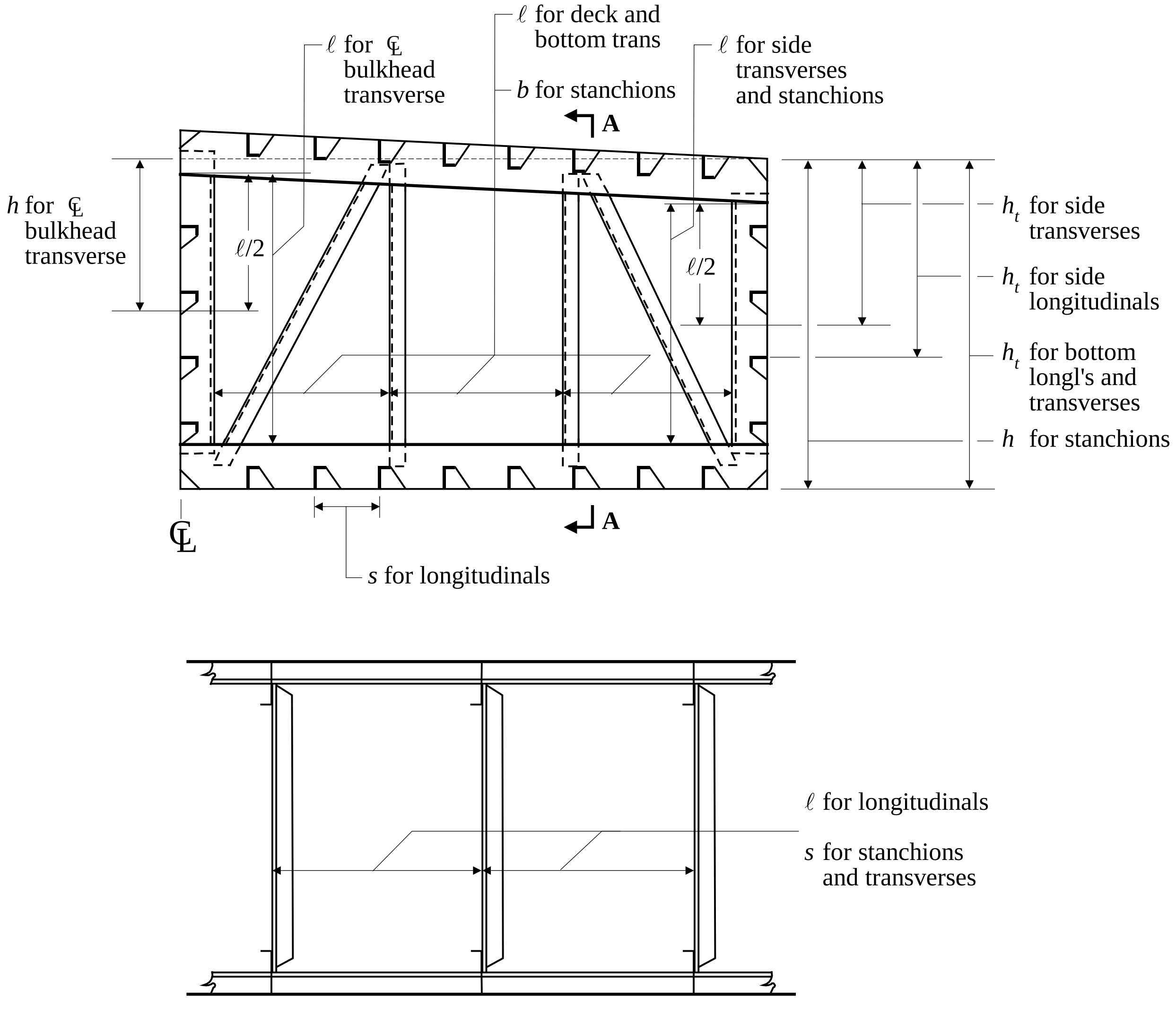



Section A-A

| | | | |
|---|---|---|---|
| Bottom transverse | $c = 1.08$ | Bottom longitudinal | $c = 1.28$ |
| Side transverse | $c = 1.75$ | Side longitudinal | $c = 1.28$ |
| Deck transverse | $c = 1.08$ | Deck longitudinal | $c = 1.75$ |

$h$ = in accordance with 3-2-1/17

## FIGURE 6
## Tank Barge

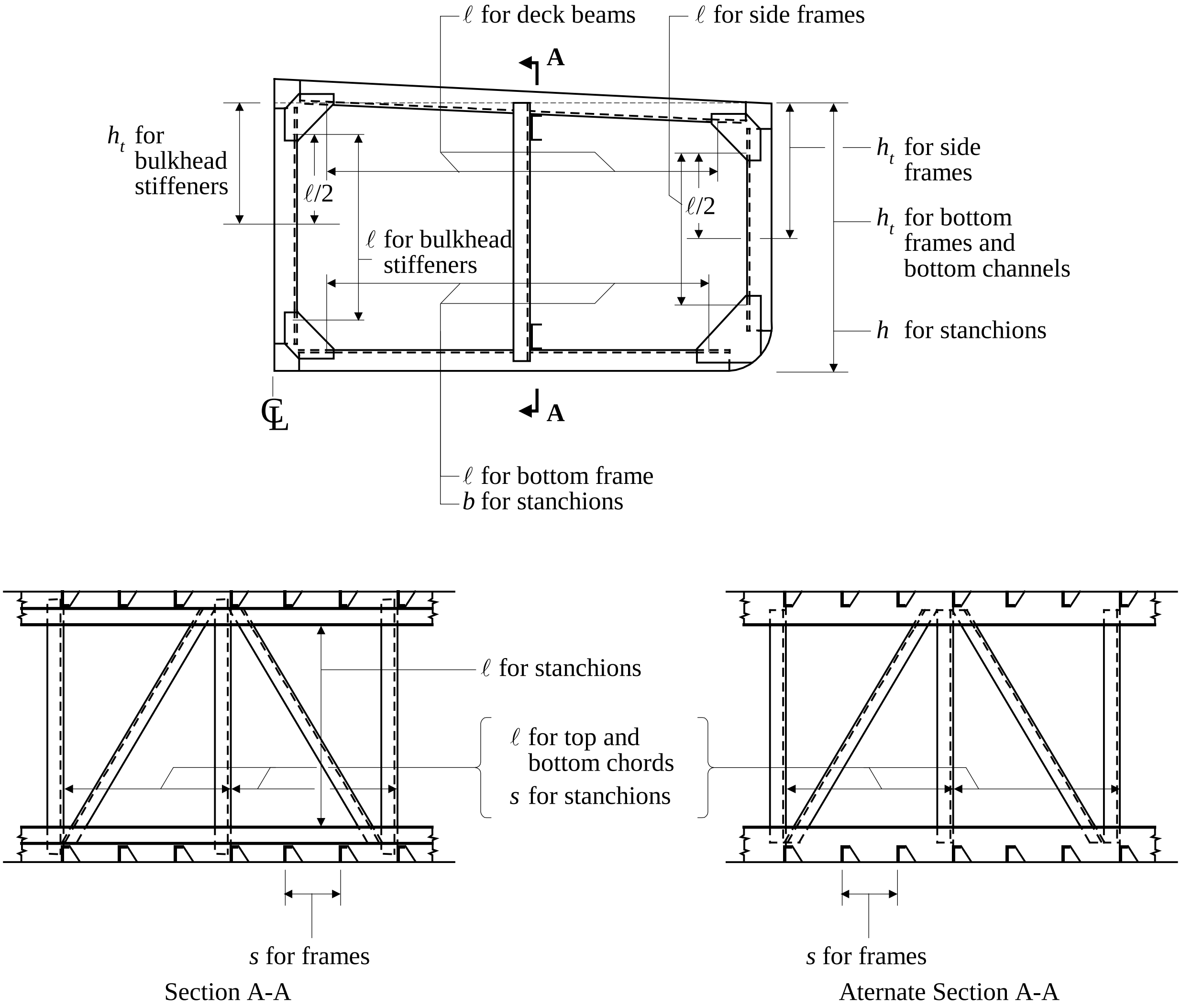



Section A-A

| | | | |
|---|---|---|---|
| Bottom transverse | $c = 1.08$ | Bottom longitudinal | $c = 1.28$ |
| Side transverse | $c = 1.75$ | Side longitudinal | $c = 1.28$ |
| Deck transverse | $c = 1.08$ | Deck longitudinal | $c = 1.75$ |
| C.L. Bulkhead transverse | $c = 1.08$ | C.L. Bulkhead longitudinal | $c = 1.00$ |

$h$ = in accordance with 3-2-1/17

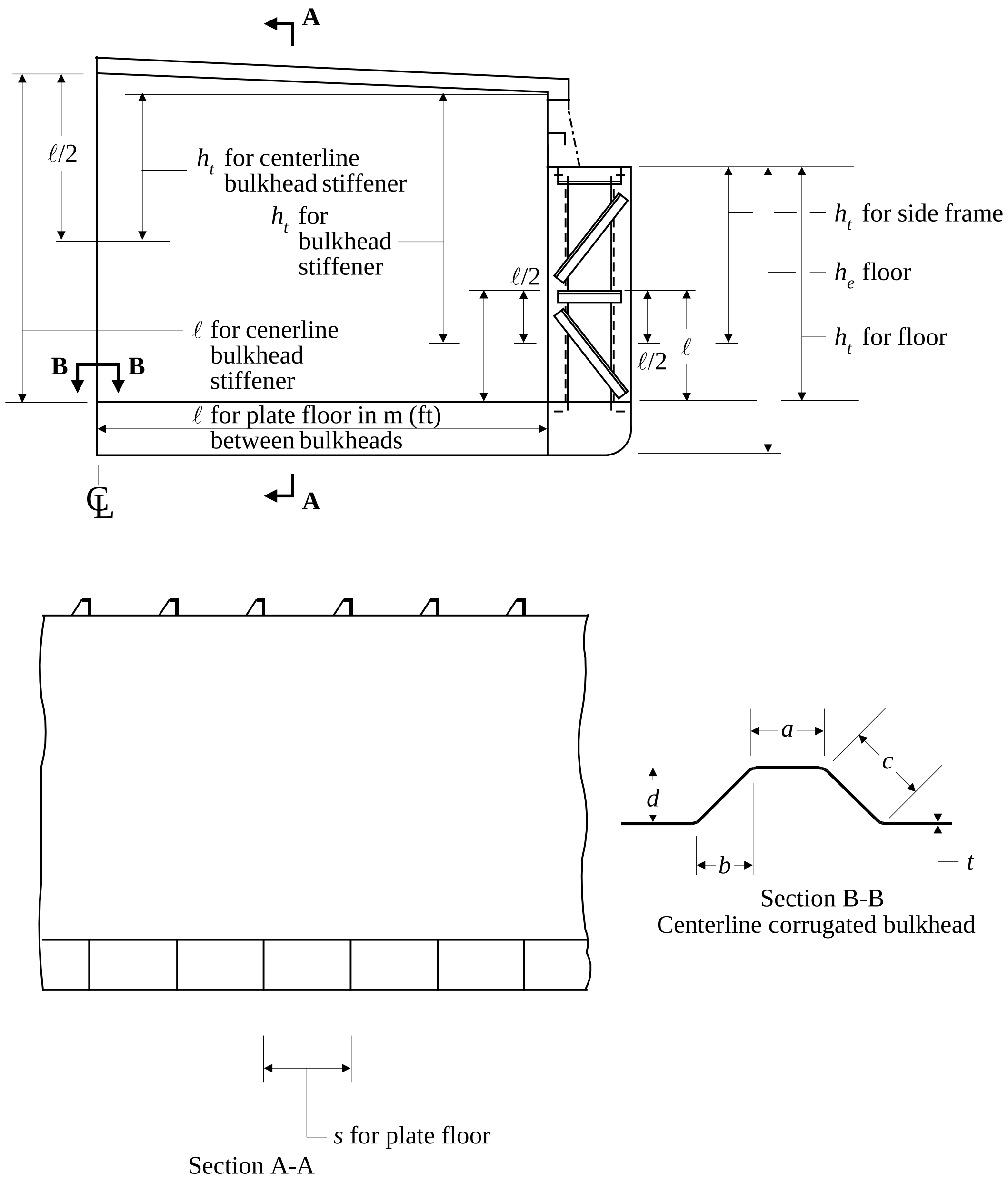
**FIGURE 7**
**Tank Barge**




| | | | |
|---|---|---|---|
| Bottom frame | $c = 1.00$ | Deck beam | $c = 1.00$ |
| Truss bottom chord | $c = 1.08$ | Side frame | $c = 1.00$ |
| Truss top chord | $c = 1.08$ | | |

$h$ = in accordance with 3-2-1/17

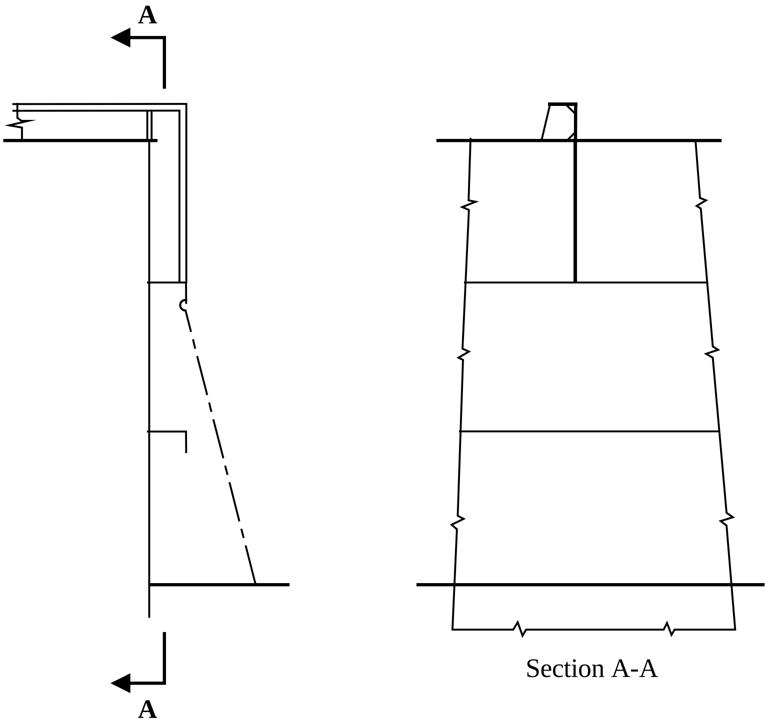
**FIGURE 8**
**Double Skin Tank Barge**



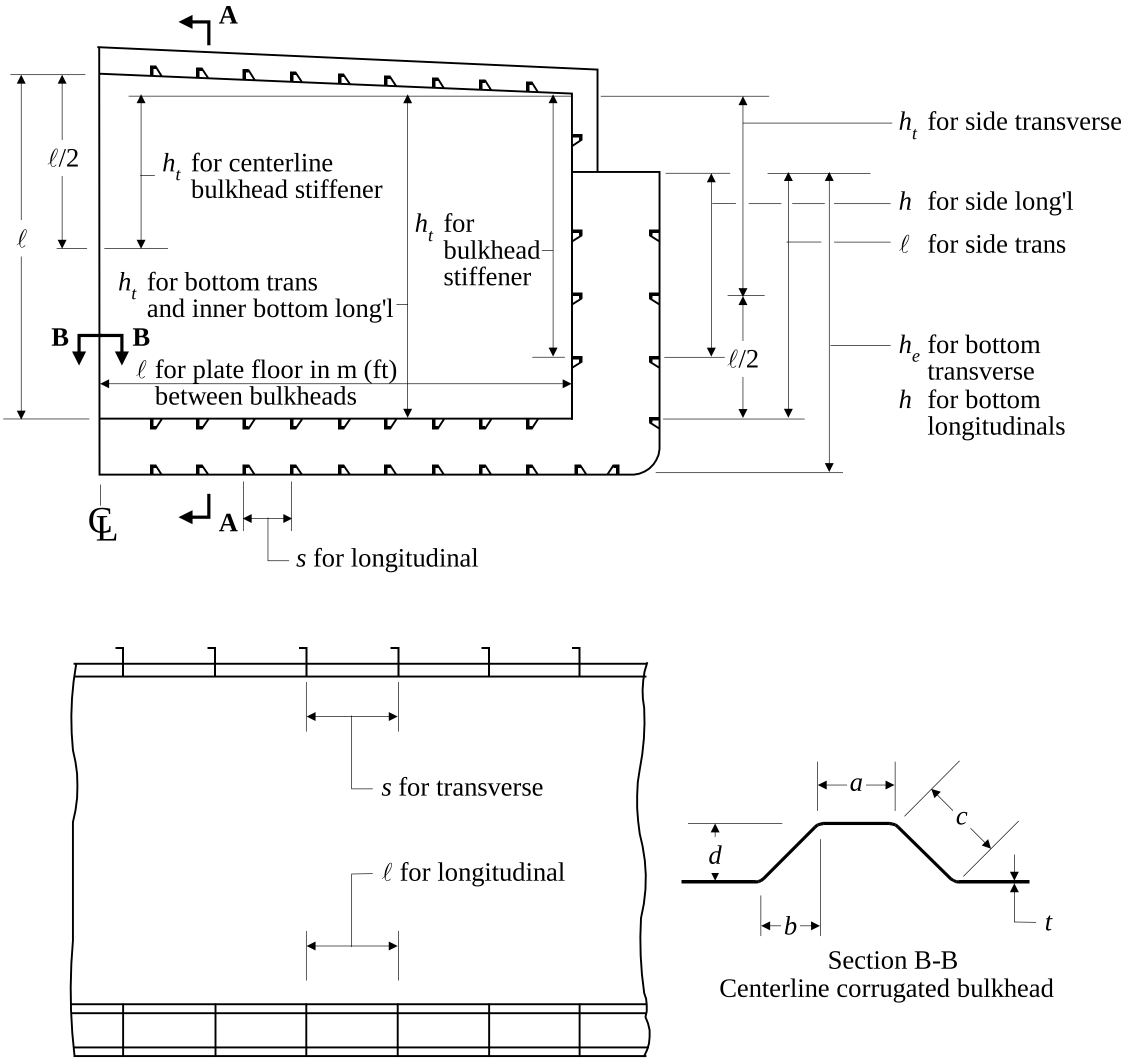

| | | | |
|---|---|---|---|
| Floor | $c$ = 1.00 | Bulkhead Stiffener | $c$ = 1.00 |
| Centerline bulkhead stiffener | $c$ = 1.00 | Side frame | $c$ = 1.00 |
| Deck beam | $c$ = 1.00 | | |

$h$ = in accordance with 3-2-1/17
(Center compartment – liquid cargo)
(Wing compartment – void or ballast)

## FIGURE 8A
## Trunk Top Beam End Connection



## FIGURE 9
## Double Skin Tank Barge



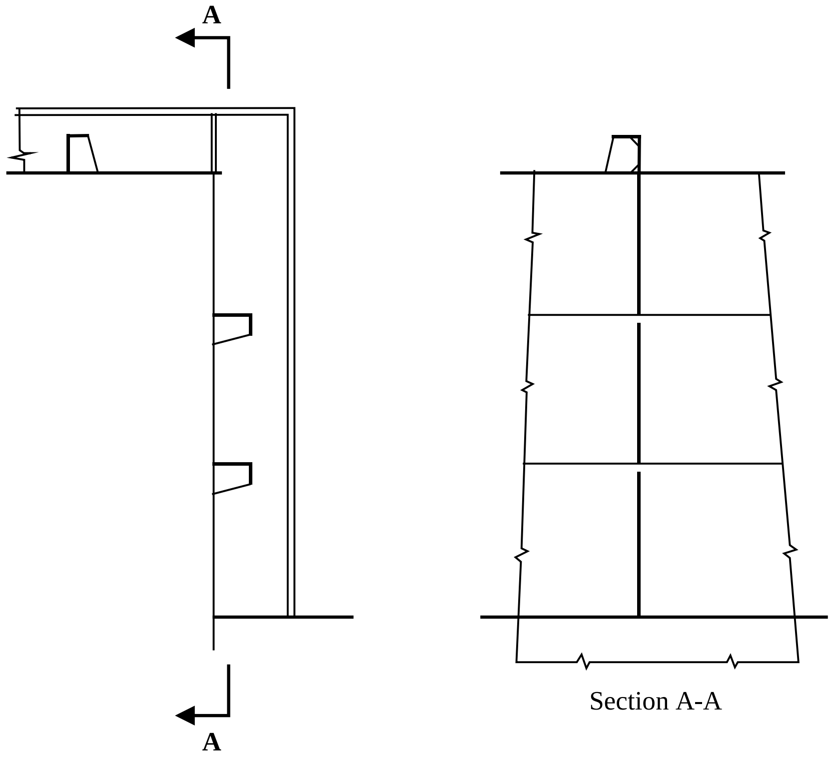

Section B-B
Centerline corrugated bulkhead

Section A-A

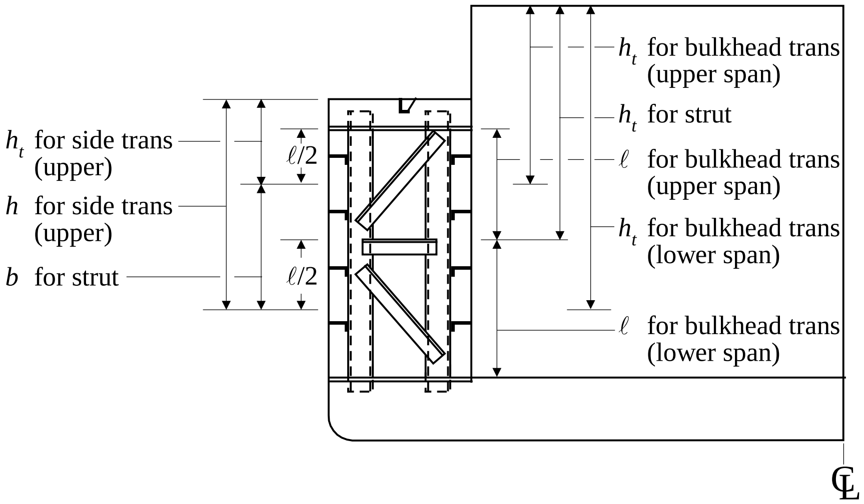
| | | |
|---|---|---|
| Bottom longitudinal | $c = 1.08$ | |
| Side longitudinal | $c = 1.08$ | (Wing compartment – void) |
| | $c = 1.28$ | (Wing compartment – ballast) |
| Inner bottom longitudinal | $c = 1.00$ | |
| Bulkhead stiffener | $c = 1.00$ | |
| Centerline bulkhead stiffener | $c = 1.00$ | |
| Bottom transverse | $c = 1.08$ | |
| Side transverse | $c = 1.08$ | |
| Deck transverse | $c = 1.08$ | |
| Deck longitudinal | $c = 1.75$ | |

$h$ = in accordance with 3-2-1/17
(Center compartment – liquid cargo)
(Wing compartment – void or ballast)

## FIGURE 9A
## Trunk Top Transverse End Connection



## FIGURE 10
## Double Skin Tank Barge




| | |
|---|---|
| Side transverse | $c$ = 1.75 |
| Deck transverse | $c$ = 1.08 |
| Bulkhead transverse | $c$ = 1.08 |

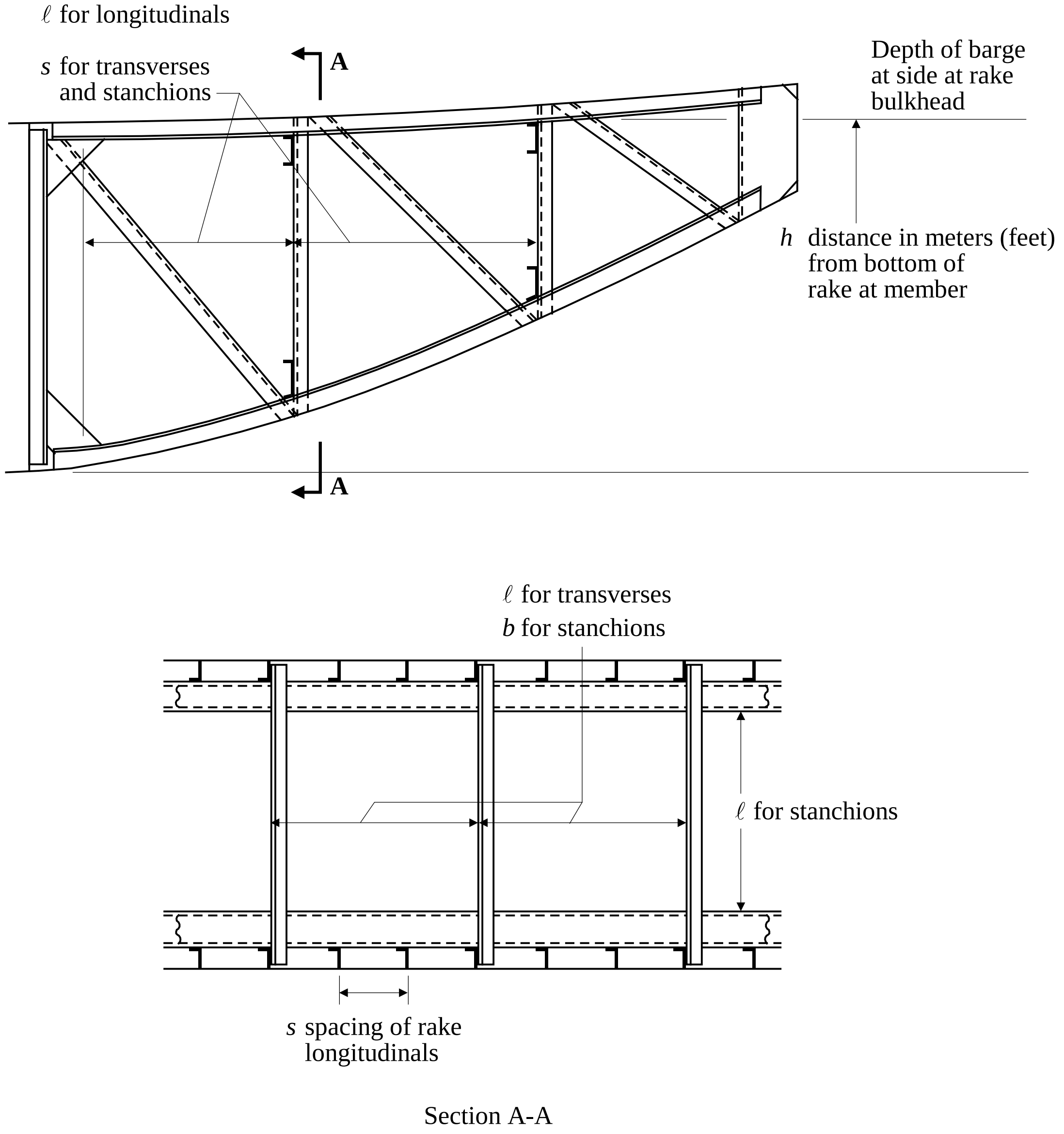
$h$ = in accordance with 3-2-1/17

(Center compartment – liquid cargo)

(Wing compartment – liquid cargo or ballast)

For side and deck transverses where wing compartment is void, see 3-2-2/Figure 12.

## FIGURE 11
## Rake Framing




| | | | |
|---|---|---|---|
| Bottom transverse | $c = 1.08$ | Bottom longitudinal | $c = 1.28$ |
| Deck transverse | $c = 1.08$ | Deck longitudinal | $c = 1.75$ |

PART

# 3

# CHAPTER 2 Hull Structures and Arrangements

# SECTION 2 Dry Cargo Barges

## 1 Application

The following Rules and Tables apply to barges intended for the transportation of general or bulk cargoes in services which require operation in comparatively smooth water exclusively, such as in rivers, intracoastal waterways, etc.

## 3 Structural Arrangement

### 3.1 Between the Rakes

#### 3.1.1 Framing

Framing may be arranged either longitudinally, transversely or a combination of both. Longitudinal frames are to be supported by regularly spaced transverse deep frames formed either by channels extending across the inner faces of the longitudinal frames, or by flanged plates notched over the frames and attached to the shell or deck and the longitudinals.

At bulkheads, longitudinals are to be attached at their ends to effectively develop the sectional area and resistance to bending.

#### 3.1.2 Trusses

Trusses are to be arranged as necessary for the support of the framing. In vessels with transverse frames, the trusses are to extend fore and aft. With longitudinal framing, they may extend either fore and aft or athwartships.

In all vessels where the ratio of *L* to the overall depth of the effective longitudinal material included in the section modulus calculation (see 3-2-2/5) exceeds 20, special consideration is to be given to the introduction of longitudinal bulkheads or trusses.

#### 3.1.3 Bilge and Gunwale Brackets

In holds where the radius at the bilge exceeds 305 mm (12 in.), the bilge brackets connecting the lower ends of vertical side frames with transverse bottom frames are to be cut to fit against and support the bilge plate. In longitudinally framed vessels, a similar arrangement is to be required at each main transverse frame and in addition, intermediate brackets are to be fitted spaced not over 0.9 m (3 ft) apart (see 3-2-2/Figures 1 and 2). Similar brackets may be required to be fitted at the gunwales where no gunwale angle is used. As an alternative to the fitting of bilge brackets, an additional inverted angle or flat bar longitudinal may be fitted as shown in 3-2-2/Figure 3.

### 3.3 Rakes

For structural arrangement of rakes, see 3-2-1/5.3.

## 5 Longitudinal Strength

### 5.1 Section Modulus

The required hull girder section modulus, *SM*, at amidships is to be obtained from the following equation:

$SM = 0.347(B + 12.19)DL$ cm$^2$-m for $L < 76.2$ m

$SM = 0.00455(B + 12.19)DL^2$ cm$^2$-m for $L \geq 76.2$ m

$SM = 0.005(B + 40)DL$ in$^2$-ft for $L < 250$ ft

$SM = 2.0 \times 10^{-5} (B + 40)DL^2$ in$^2$-ft for $L \geq 250$ ft

where *L*, *B*, and *D* are as defined in Section 3-1-1.

In calculating the section modulus, bottom, bilge, side and inner bottom plating, all bilge, gunwale and other longitudinal angles and frames if continuous or adequately developed at the transverse bulkheads and hopper side and other continuous longitudinal bulkheads may be included. The section modulus to the deck or bottom is obtained by dividing the moment of inertia by the distance from the neutral axis to the molded deck line at side amidships or to the base line, respectively.

### 5.3 Section Modulus with Continuous Coaming

Where longitudinal coamings of length greater than 0.14*L* are provided, they are to comply with the requirements of 3-2-2/19.7. Such continuous coamings may be included in the calculation of hull girder inertia which is to be divided by the sum of the distance from neutral axis to deck at side and the height of continuous hatch coaming, to obtain the section modulus to the top of the coaming.

## 7 Deck Plating

### 7.1 Minimum Thickness

The thickness of deck plating throughout is not to be less than 0.01 mm per millimeter (0.01 in. per inch) of the spacing of the beams, $s_b$.

### 7.3 Between the Rakes

The thickness of deck plating between the rakes is to be not less than determined by the following equations:

- *With Transverse Beams*

  $t = 0.066L + 3.5$ mm $t = 0.0008L + 0.14$ in.

- *With Longitudinal Beams*

  $t = 0.066L + 2.5$ mm $t = 0.0008L + 0.10$ in.

### 7.5 Watertight Decks

The thickness of plating of decks intended to provide tight divisions for protection against damage to the shell is not to be less than that required for ordinary bulkhead plating at the same level plus 1.0 mm (0.04 in.).

### 7.7 Cargo Decks *(2002)*

The thickness of plating on which cargo is to be carried is not to be less than determined by the following equations:

$t = 0.00395s\sqrt{h} + 1.5$ mm but not less than 5.0 mm

$t = 0.00218s\sqrt{h} + 0.06$ in. but not less than 0.20 in.

where

$h$ = $p/0.721$ m ($p/45$ ft)

$p$ = uniformly distributed deck load, in tonnes/m$^2$ (lbs/ft$^2$)

$s$ = spacing of the beams, in mm (in.)

In vessels regularly engaged in trades where cargo is handled by grabs or similar mechanical appliances, it is recommended that flush plating be used in way of the cargo and that increased framing and thickness be provided.

### 7.9 Wheel Loaded Strength Decks

Where provision is to be made for the operation or stowage of vehicles having rubber tires, and after all other requirements are met, the thickness of strength deck plating is to be not less than 110% of the thickness required for wheel loaded inner bottoms in 3-2-2/19.1.2.

## 9 Frames

Each frame, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $\qquad$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = coefficient appropriate to the member under consideration and the type of construction employed as given in 3-2-2/Figures 5 through 12

= 1.0 for rake side frames

$h$ = distance, in m (ft), as given in 3-2-2/Figures 5 through 12

= for rake bottom frames, the vertical distance, in m (ft), from the middle of $\ell$ to the height of the deck at side at the rake bulkhead

= for rake deck transverses and longitudinals, 1.2 m (4.0 ft)

$s$ = member spacing, in m (ft)

$\ell$ = unsupported span of the member, in m (ft)

Where brackets of the thicknesses given in 3-2-1/Table 1 are fitted, $\ell$ may be measured to a point 25% of the extent of the bracket beyond the its toe.

Where fitted, rake side vertical frames are to have brackets at their upper and lower ends extending over to the first adjacent longitudinal beam or frame.

## 11 Trusses

### 11.1 Top and Bottom Chords

Each top and bottom chord is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $\qquad$ $SM = 0.0041chs\ell^2$ in$^3$

where $c$, $h$, $s$ and $\ell$ are as defined in 3-2-2/9.

### 11.3 Stanchions

The spacing of truss stanchions is generally not to exceed the depth of the truss.

#### 11.3.1 Permissible Load *(2018)*

The permissible load, $W_a$, of each stanchion is to be obtained from the following equation and is to be not less than the calculated load $W$ given in 3-2-2/11.3.2 below.

$$W_a = [k - n\ell/r]A \quad \text{kN (tf, Ltf)}$$

where

| | | | |
|---|---|---|---|
| $k$ | = | 12.09 (1.232, 7.83) | ordinary strength steel |
| | = | 16.11 (1.643, 10.43) | HT32 strength steel |
| | = | 18.12 (1.848, 11.73) | HT36 strength steel |
| $n$ | = | 0.0444 (0.00452, 0.345) | ordinary strength steel |
| | = | 0.0747 (0.00762, 0.581) | HT32 strength steel |
| | = | 0.0900 (0.00918, 0.699) | HT36 strength steel |
| $\ell$ | = | unsupported span of the stanchion, in cm (ft) | |
| $r$ | = | least radius of gyration, in cm (in.) | |
| $A$ | = | cross sectional area of the stanchion, in cm$^2$ (in$^2$) | |

#### 11.3.2 Calculated Load

The calculated load for each truss stanchion is to be determined by the following equation, except where indicated otherwise by 3-2-2/Figure 10 or 3-2-2/Figure 11.

$$W = nbhs \quad \text{tf (Ltf)}$$

where

$n$ = 1.07 (0.03)

$b$ = mean breadth of the area supported, in m (ft)

$h$ = distance from the bottom shell at the center of the area supported to the underside of the deck plating at side, in m (ft)

$s$ = spacing of the stanchions, in m (ft)

### 11.5 Diagonals

Diagonals in trusses are to have a section area of approximately 50% of that of the stanchions.

## 13 Web Frames, Girders and Stringers

Each web frame, girder and stringer is to have a section modulus, $SM$, not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \quad \text{cm}^3 \qquad\qquad SM = 0.0041chs\ell^2 \quad \text{in}^3$$

where $c$, $h$, $s$ and $\ell$ are as defined in 3-2-2/9.

Where transverse buck frames are formed by channels extending over the inner faces of longitudinal frames, these channels are to be attached at the bilge and deck as shown in 3-2-2/Figure 5. Where it is desirable to avoid any direct attachment between the channel frames and the shell plating, alternative construction shown in 3-2-2/Figure 4 may be accepted.

# 15 Bulkheads

## 15.1 Construction of Tank Boundary Bulkheads

### 15.1.1 Plating

Plating is to be of thickness obtained from the following equation:

$t = (s\sqrt{h}/254) + 1.78$ mm (min. $t$ = 5 mm)

$t = (s\sqrt{h}/460) + 0.07$ in. (min. $t$ = 0.20 in.)

where

$s$ = spacing of stiffeners, in mm (in.)

$h$ = vertical distance measured from the lower edge of the plate to 1.2 m (4 ft) above the deck at side, or to the top of the hatch, whichever is greater.

### 15.1.2 Stiffening

The ends of stiffeners are to be either bracketed or clipped. Each stiffener, in association with the plating to which it is attached, is to have a section modulus *SM* not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 1.00

$h$ = vertical distance from the middle of $\ell$ to the top of the overflow, in m (ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = as defined in 3-2-2/9

## 15.3 Construction of Other Watertight Bulkheads

### 15.3.1 Plating

Plating is to be of thickness obtained from the following equation:

$t = (s\sqrt{h}/290) + 1.0$ mm (min. $t$ = 4.5 mm)

$t = (s\sqrt{h}/525) + 0.04$ in. (min. $t$ = 0.18 in.)

where

$s$ = spacing of stiffeners, in mm (in.)

$h$ = vertical distance measured from the lower edge of the plate to the height of the deck at centerline, in m (ft)

### 15.3.2 Stiffening

Each stiffener, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 0.46

$h$ = vertical distance from the middle of $\ell$ to the deck at centerline, in m (ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = as defined in 3-2-2/9

Stiffeners on these bulkheads may have unattached sniped ends provided the above value of *SM* is increased 25%.

## 17 Shell Plating

The thickness of the bottom, side and bilge plating is to be as required below. In addition, the thickness of plating in these locations is to be not less than as required by 3-2-2/15.3.1 for tank bulkheads where the spacing of the stiffeners is equal to the frame spacing and the value of h is equal to the distance from the lower edge of the plate to the under surface of the deck plating at side.

### 17.1 Bottom Shell

The thickness of the bottom shell plating throughout is not to be less than determined by the following equation:

$t = 0.069L + 0.007s - 0.8$ mm (min. $t = 5$ mm)

$t = 0.000825L + 0.007s - 0.02$ in. (min. $t = 0.20$ in.)

where

$s$ = stiffener spacing, in mm (in.)

$L$ = length of the vessel, in m (ft)

### 17.3 Side Shell

The thickness of the side shell plating is to be not less than determined by the following equation and not less than 5 mm (0.20 in.).

$t$ = Rule Bottom Shell – 0.5 mm $L < 73$ m

$t$ = Rule Bottom Shell – 1.0 mm $L \geq 73$ m

$t$ = Rule Bottom Shell – 0.02 in. $L < 240$ ft

$t$ = Rule Bottom Shell – 0.04 in. $L \geq 240$ ft

### 17.5 Bilge Plating

Where radiused bilges are used the bottom thickness is to extend to the upper turn of the bilge; where the radius at the bilge exceeds 305 mm (12 in.), the thickness of the plating should be at least 1.5 mm (0.06 in.) greater than the required thickness for side plating.

### 17.7 Bilge Angles

Where angles are used at the bilges or gunwales they are to have a thickness at least 1.5 min (0.06 in.) greater than that of the thinner of the two plates joined.

## 19 Inner Bottoms, Hatches and Fittings

### 19.1 Inner Bottom Plating

#### 19.1.1 Inner Bottom Plating on which Cargo is to be Carried

The thickness of plating, $t$, is not to be less than determined by the following equations:

$t = 0.01s_b + (0.83h - 1.78)$ mm $s_b \leq 610$ mm

$t = 0.005s_b + (0.83h - 1.78) + 3.1$ mm $s_b > 610$ mm

$t = 0.01s_b + 0.01(h - 7)$ in. $s_b \leq 24$ in.

$t = 0.005s_b + 0.01(h - 7) + 0.12$ in. $s_b > 24$ in.

where

$s_b$ = spacing of the frames, in mm (in.)

$h$ = height to which cargo may be loaded, in m (ft). Where the density of the cargo exceeds 715 kg/m$^3$ (45 lbs/ft$^3$), the height is to be proportionally increased.

In vessels regularly engaged in trades where cargo is handled by grabs or similar mechanical appliances, it is recommended that flush plating be used in way of the cargo and that increased framing and thickness be provided.

#### 19.1.2 Inner Bottom Under Wheel Loading *(2014)*

Where provision is to be made for the operation or stowage of vehicles having rubber tires, and after all other requirements are met, the thickness of inner bottom plating is to be not less than obtained from the following equation:

$$t = kKn\sqrt{W} \quad \text{mm (in.)}$$

where

$k$ = 26.4 (1.05)

$K$ = $[21.99 + 0.316(a/s)^2 - 5.328(a/s) + 2.6(a/s)(b/s) - 0.895(b/s)^2 - 7.624(b/s)]10^{-2}$, derived from the curves indicated in 3-2-2/Figure 13

$n$ = 1.0 where $\ell/s \geq 2.0$ and 0.85 where $\ell/s = 1.0$, for intermediate values of $\ell/s$, $n$ is to be obtained by interpolation

$W$ = static wheel load, in tf (Ltf)

$a$ = wheel imprint dimension parallel to the longer edge, $\ell$, of the plate panel, in mm (in.)

$b$ = wheel imprint dimension perpendicular to the longer edge, $\ell$, of the plate panel, in mm (in.)

$s$ = spacing of deck beams or deck longitudinals, in mm (in.)

$\ell$ = length of the plate panel, in mm (in.)

Where the wheels are close together, a combined imprint and load are to be used.

### 19.3 Hatchways

Hatchways or manholes of sufficient size to provide access and ventilation are to be fitted to each compartment. Where openings are located close to the gunwales, doubling plates or other compensation may be required.

All openings in decks are to be so framed as to provide efficient support and attachment for the ends of the half beams.

### 19.5 Hatch Covers

#### 19.5.1 Within Closed Deck Houses

Beams and covers for cargo hatches within closed deck houses are to be designed for a load, in kilograms per square meter (pounds per square foot) equal to 220 (45) multiplied by the height of the house, in m (ft), and a factor of safety of not less than 3.25 based on the minimum ultimate tensile strength of the material.

#### 19.5.2 On Weather Decks

For all types of covered barges and for other types which may be noted in the *Record* as having covers fitted, the covers are to be weathertight. Where it is not intended to carry cargo on the covers they are to be designed to withstand a load of 171 kg/m$^2$ (35 lb/ft$^2$) exclusive of the weight of the cover itself with a factor of safety of not less than 3.25 on the minimum ultimate tensile strength of the material. Where cargo is intended to be carried, the design load is to be suitably increased.

#### 19.5.3 Under Wheel Loading

Where provision is to be made for the operation or stowage of vehicles having rubber tires, the thickness of the hatch cover plating is to be not less than obtained from 3-2-2/19.1.2 using a $k$ factor of 23.8 (0.94). Where the hatch cover plate panel is adjacent to the edges of the covers, this value of $t$ is to be increased by at least 15%.

### 19.7 Continuous Longitudinal Hatch Coamings

Where longitudinal hatch coamings of length greater than 0.14*L* are supported by longitudinal bulkheads or deep girders, they are in general to be longitudinally stiffened. The coaming plates and stiffeners are to have scantlings as required for decks. Special consideration will be given for barges less than 61 m (200 ft) in length or where calculations are submitted to show adequate buckling strength in the maximum expected sagging condition.

### 19.9 Deck Fittings

The structure in way of cleats, bitts and chocks is to be suitably reinforced by installation of headers, additional beams, brackets or doubling plates.

### 19.11 Cargo Boxes

Cargo boxes, flash boards, coamings or other structures for retaining deck cargo, are to be sufficiently strong for their height, and adequately bracketed to the deck. Effective means for drainage of these spaces are to be provided.

## 21 Barge Reinforcement

### 21.1 General

The following paragraphs are intended to provide for additional protection against contact with locks and river bottom and against other wear and tear damage associated with normal operation with other floating equipment.

A design intended for Classification will be reviewed for compliance with 3-2-2/21.3 when requested. A notation **Reinforcement A** or **Reinforcement B** will be entered in the *Record* indicating compliance with all of the requirements for Reinforcement A or B in 3-2-2/21.3.

### 21.3 Reinforcement

Where the option for reinforcement in 3-2-2/21.1 is chosen, the hull parts to be reinforced are given in the following table, the reinforced plate thicknesses are to be not less than given in column Reinforcement A or column Reinforcement B as appropriate.

| | *Reinforcement A* | *Reinforcement B* |
|---|---|---|
| Bilge radius for full-length of barge (knuckle plate) | $t_{min}$ = 16.0 mm ($^5/_8$ in.) | $t_{min}$ = 12.5 mm ($^1/_2$ in.) |
| Side shell | $t_{min}$ = 11.0 mm ($^7/_{16}$ in.) | $t_{min}$ = 9.5 mm ($^3/_8$ in.) |
| Deck stringer plate – hopper barge | $t_{min}$ = 11.0 mm ($^7/_{16}$ in.) | $t_{min}$ = 9.5 mm ($^3/_8$ in.) |
| Lower 1.83 m (6 ft) of sides and ends of hopper plating | $t_{min}$ = 9.5 mm ($^3/_8$ in.) | $t_{min}$ = 9.5 mm ($^3/_8$ in.) |
| Headlog and sternlog plate | $t_{min}$ = 19.0 mm ($^3/_4$ in.) | $t_{min}$ = 16.0 mm ($^5/_8$ in.) |
| Transom side and bottom periphery (picture frame) plates | $t_{min}$ = 16.0 mm ($^5/_8$ in.) | $t_{min}$ = 12.5 mm ($^1/_2$ in.) |
| All side shell, bottom shell and deck structural members in wing and rake compartments | Use appropriate Rule coefficients with 1.83 m (6 ft) overflow above deck at side. Where no wing tanks are fitted, this reinforcement is to apply to the side shell structure in cargo/void spaces and the side, bottom and deck structure in way of rakes. | Use appropriate Rule coefficients with 1.22 m (4 ft) overflow above deck at side. Where no wing tanks are fitted, this reinforcement is to apply to the side shell structure in cargo/void spaces and the side, bottom and deck structure in way of rakes. |

**FIGURE 1**
**Bilge Bracket (see 3-2-2/3.1.3)**

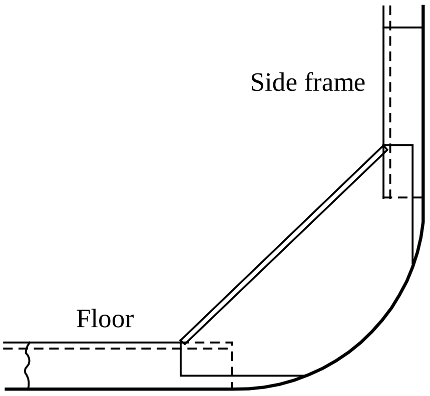



**FIGURE 2**
**Intermediate Bilge Bracket (see 3-2-2/3.1.3)**

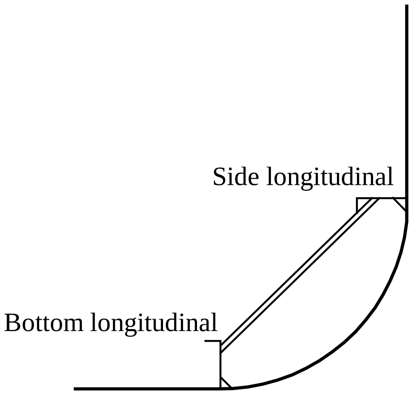



**FIGURE 3**
**Alternative Arrangement (see 3-2-2/3.1.3)**

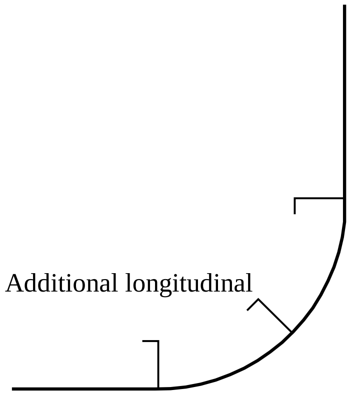
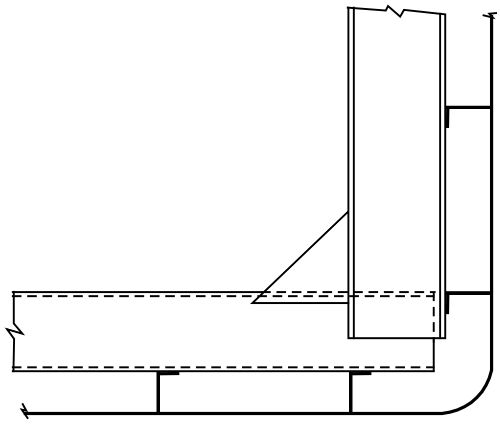
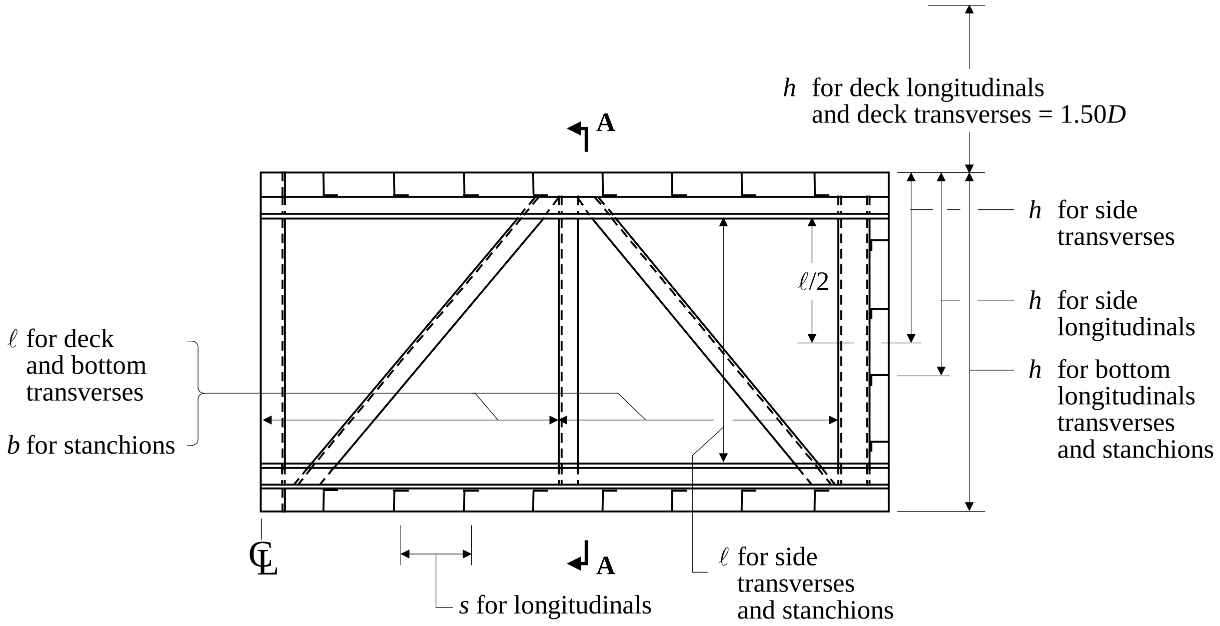
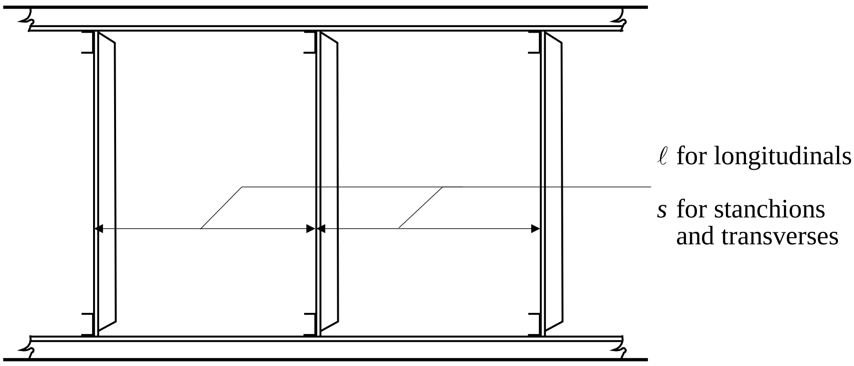


**FIGURE 4**
**Alternative Channel Construction at Bilge (see 3-2-2/3.1.3)**



## FIGURE 5
## Deck Barge

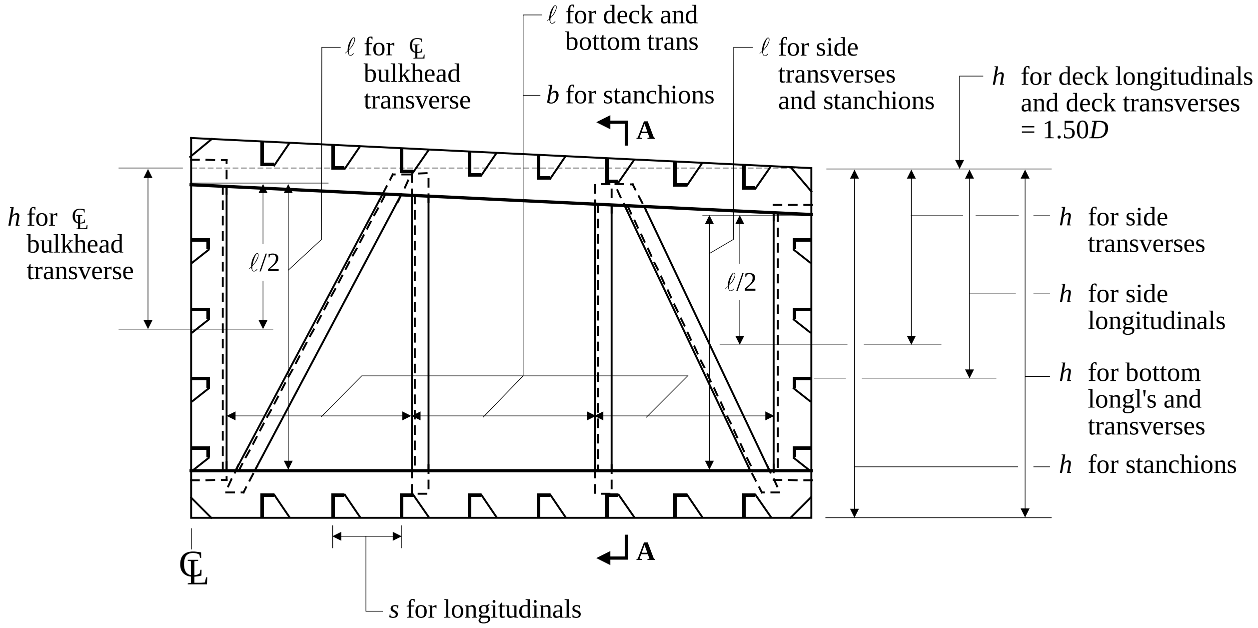


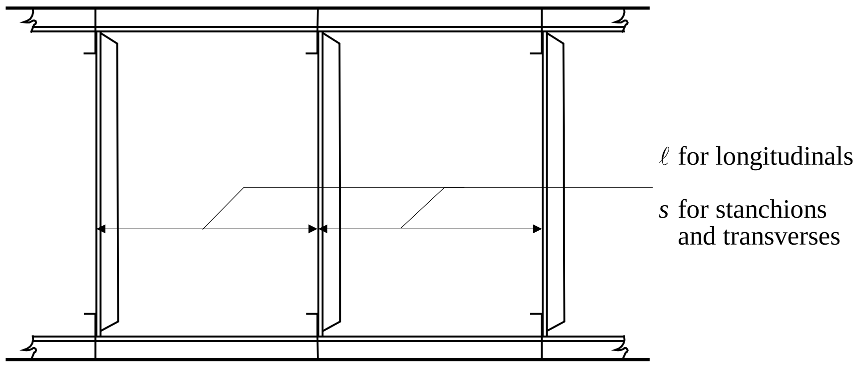




Section A-A

| | | | |
|---|---|---|---|
| Bottom transverse | $c = 1.00$ | Bottom longitudinal | $c = 1.08$ |
| Side transverse | $c = 1.00$ | Side longitudinal | $c = 1.08$ |
| Deck transverse | $c = 0.70$ | Deck longitudinal | $c = 0.70$ |

## FIGURE 6
## Deck Barge

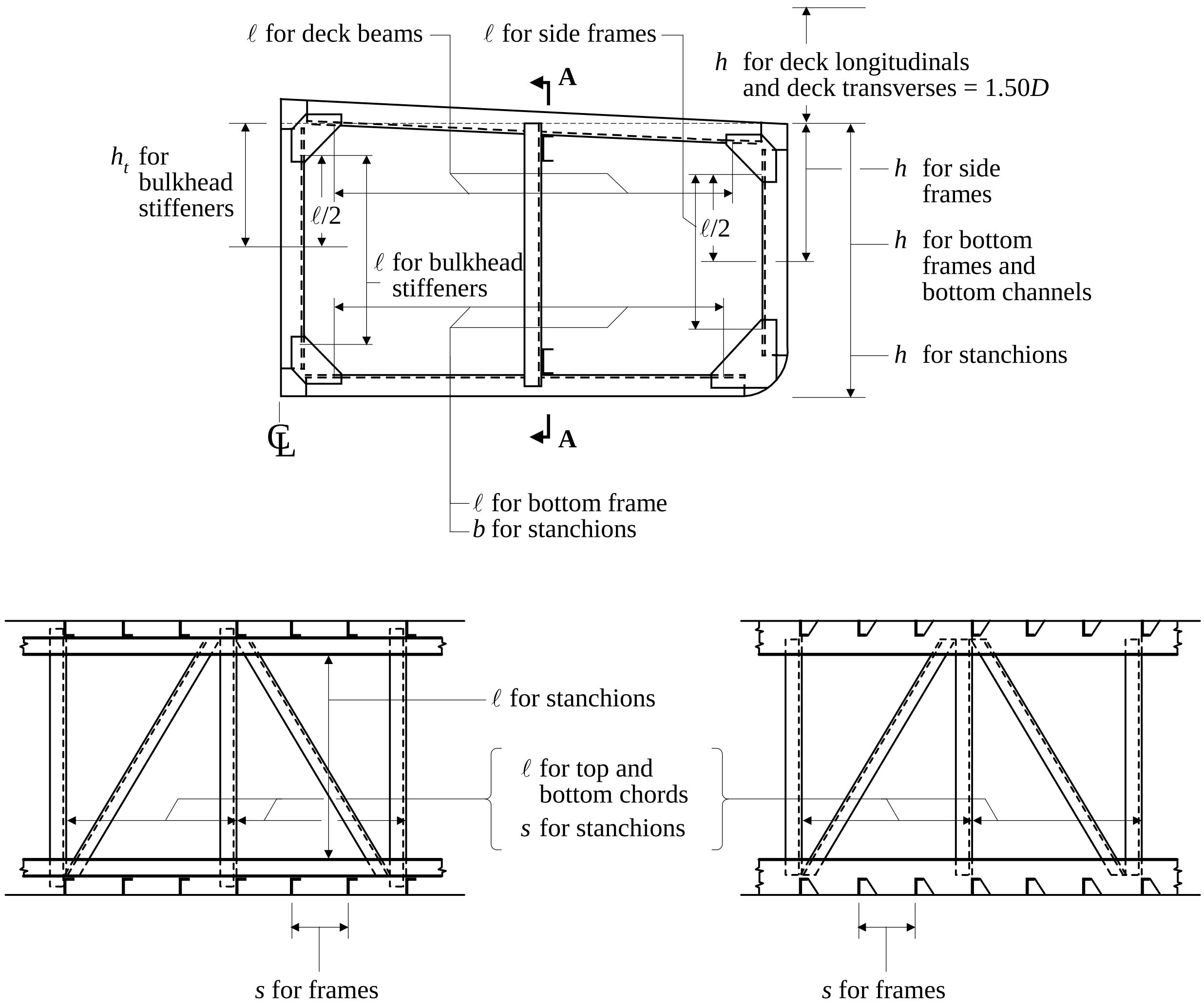



Section A-A

| | | | |
|---|---|---|---|
| Bottom transverse | $c = 1.00$ | Bottom longitudinal | $c = 1.08$ |
| Side transverse | $c = 1.00$ | Side longitudinal | $c = 1.08$ |
| Deck transverse | $c = 0.70$ | Deck longitudinal | $c = 0.70$ |
| C.L. Bulkhead transverse | $c = 0.70$ | C.L. Bulkhead longitudinal | $c = 0.70$ |

## FIGURE 7
## Deck Barge

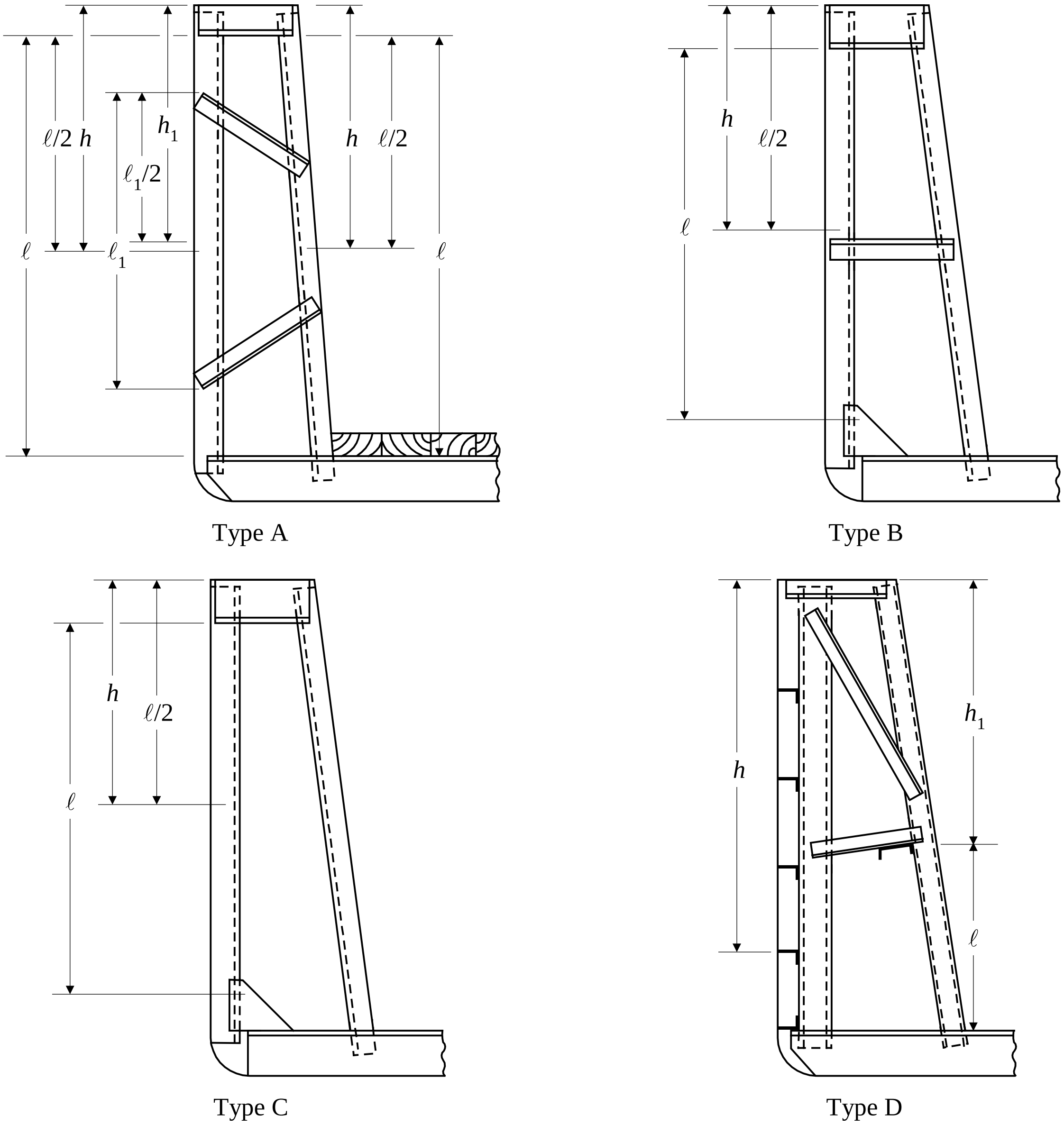



Section A-A

Alternate Section A-A

| | | | |
|---|---|---|---|
| Bottom frame | $c = 1.00$ | Deck beam | $c = 0.56$ |
| Truss bottom chord | $c = 1.00$ | Side frame | $c = 1.00$ |
| Truss top chord | $c = 0.70$ | | |

## FIGURE 8
## Hopper Barge




**Side Frame**

| | |
|---|---|
| Type A (for $\ell$) | $c$ = 1.15 |
| Type A (for $\ell_1$) | $c$ = 2.00 |
| Type B | $c$ = 1.30 |
| Type C | $c$ = 1.45 |
| Type D | $c$ = 1.08 |

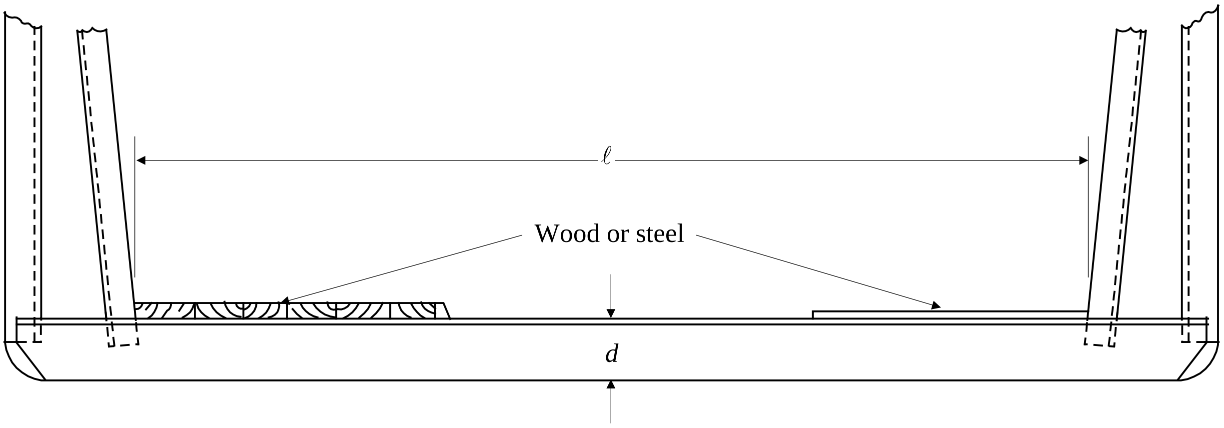
**Hopper Side Stiffener**

| | |
|---|---|
| Type A | $c$ = 1.00 |
| Type B | $c$ = 1.10 |
| Type C | $c$ = 1.20 |
| Type D | $c$ = 1.00 |

**Hopper Side Chord**

| | |
|---|---|
| Type D | $c$ = 1.00 |

## FIGURE 9
## Hopper Barge

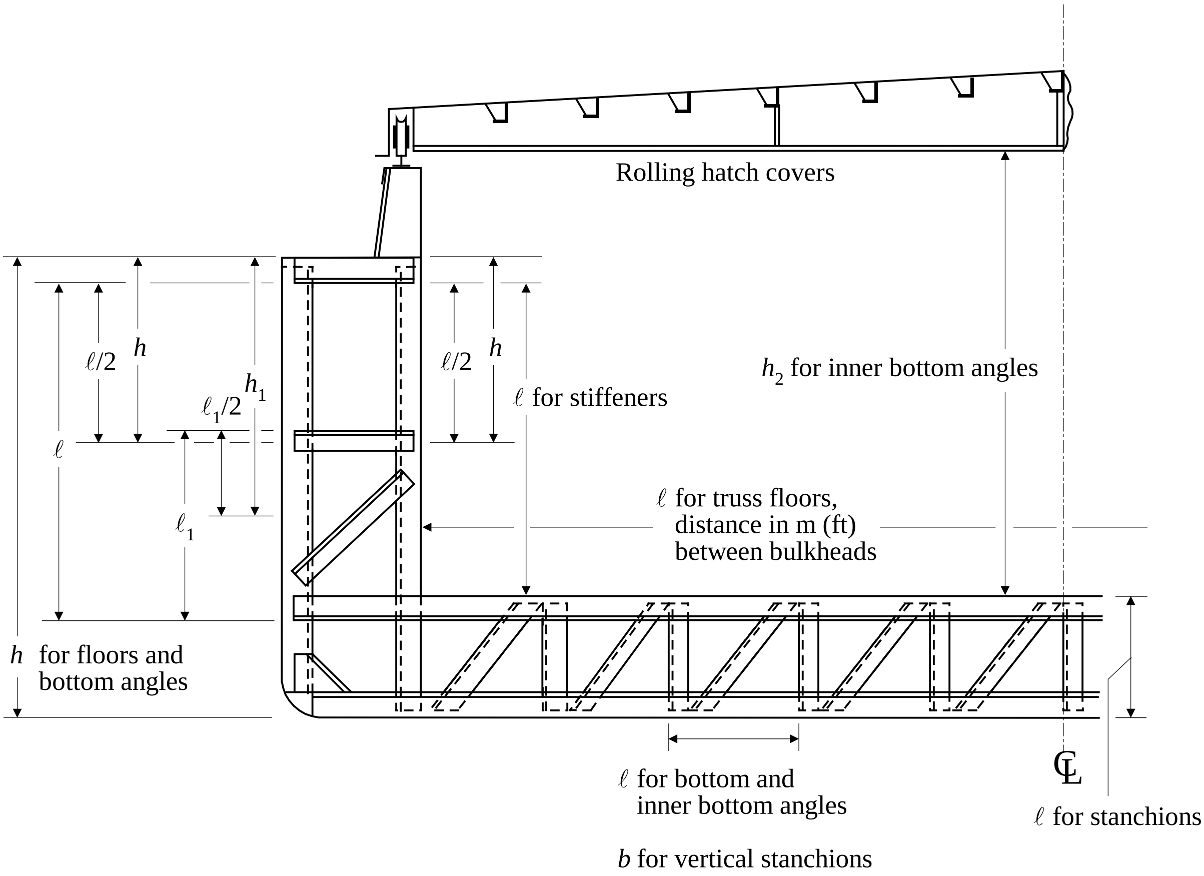



**Floors**

| | |
|---|---|
| Minimum | $d = \ell/24$ with wood inner bottom |
| Minimum | $d = \ell/30$ with steel inner bottom effectively attached to each floor |
| | $s$ = spacing of floors, in m (ft) |
| | $h$ = vertical distance from the baseline to the under surface of the deck plating at side, in m (ft) |
| | $c$ = 1.00 |

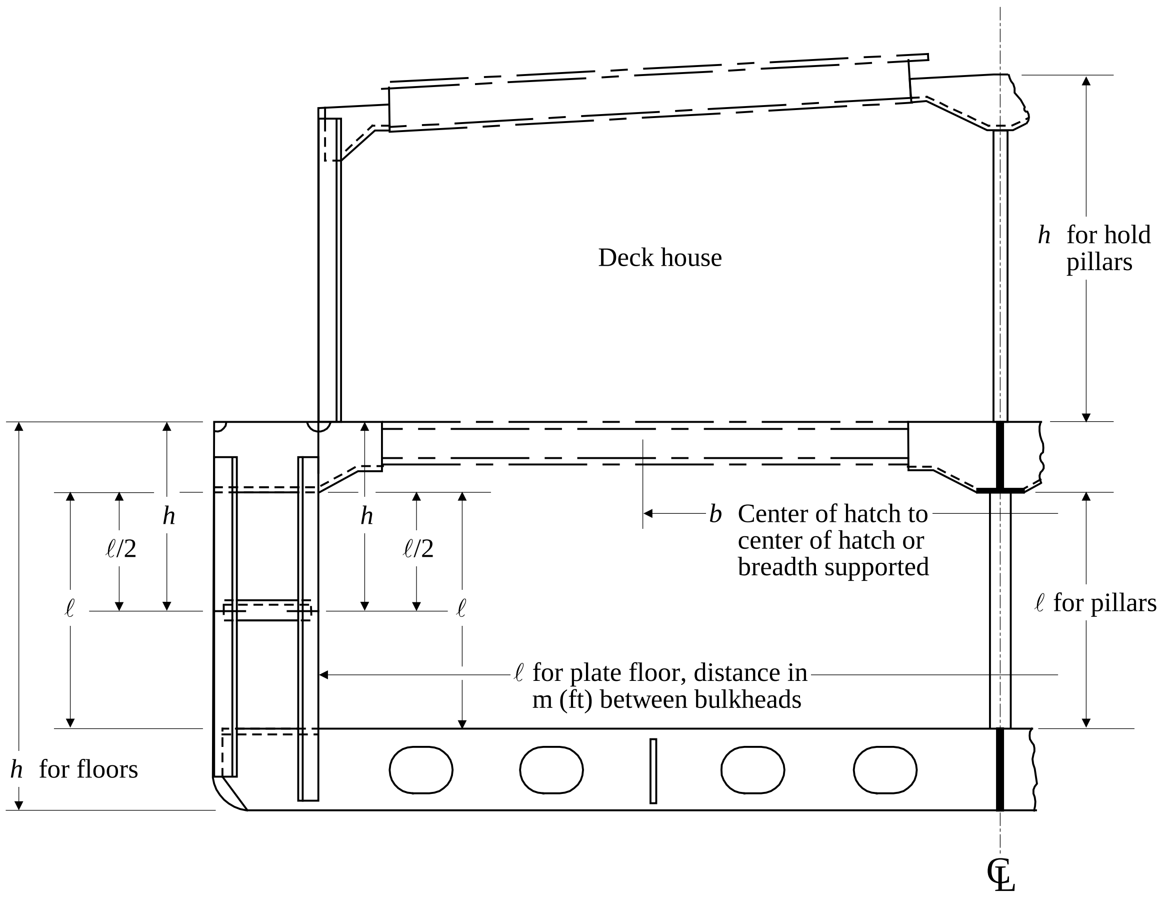
Where barges are designed exclusively for carrying uniformly distributed dry bulk cargoes and are classed **Bulk Cargo Barge**, $c$ = 0.55.

## FIGURE 10
## Double Skin Hopper Barge




| | | |
|---|---|---|
| Truss floor | $c = 1.00$<br>$\ell$ as shown | where the section modulus is that of the combined section |
| Bottom angle | $c = 1.00$ | |
| Inner bottom angle | $c = 0.56$ | |
| Side frame (for $h$) | $c = 1.50$ | |
| (for $h_1$) | $c = 2.00$ | |
| Bulkhead stiffener | $c = 1.10$ | |
| Vertical stanchion truss floor | $W = 1.07bhs$ tf<br>$W = 1.07bh_2s$ tf | whichever is greater |
| | $W = 0.03bhs$ Ltf<br>$W = 0.03bh_2s$ Ltf | whichever is greater |

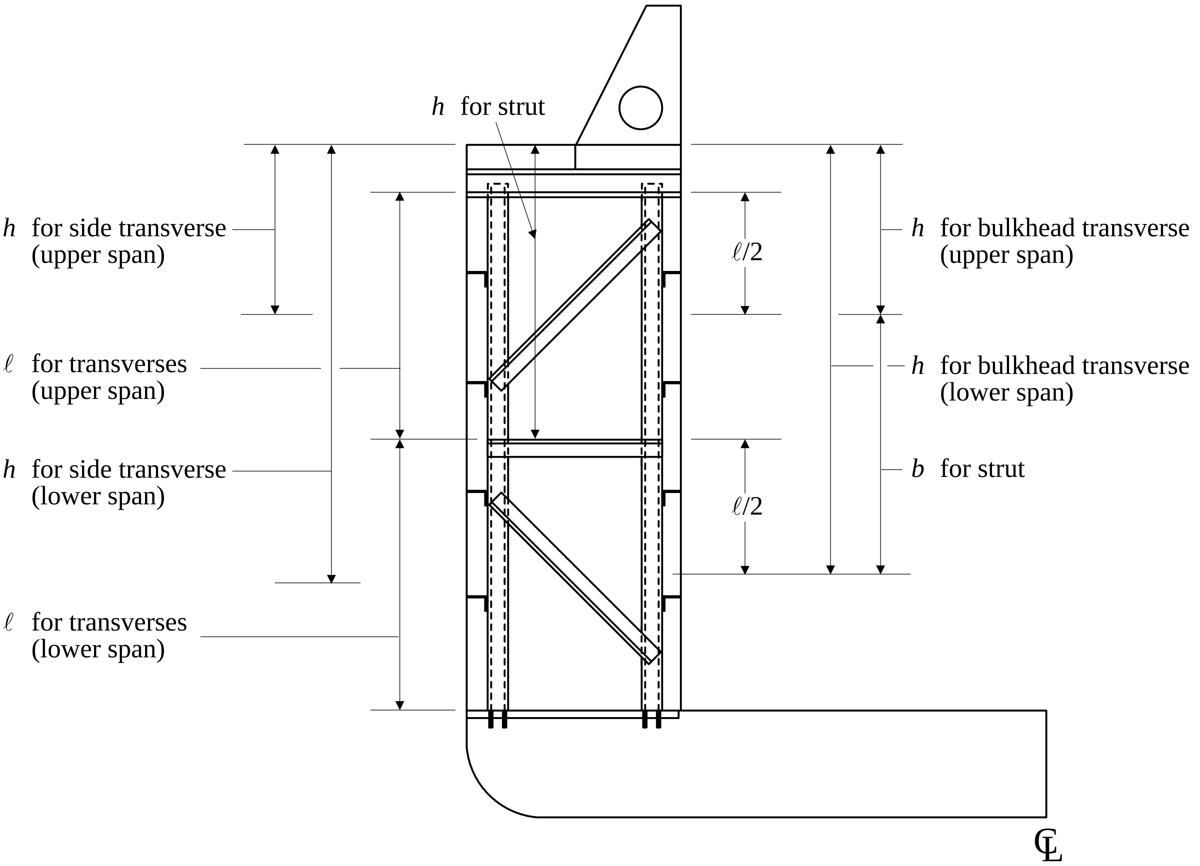
## FIGURE 11
## Double Skin Hopper Barge with Deckhouse




| | | |
|---|---|---|
| Floor | $c$ = 1.00<br>$\ell$ as shown | } where the section modulus is that of the combined section |
| Side frame | $c$ = 1.30 | |
| Bulkhead stiffener | $c$ = 1.10 | |
| Hold pillar | $W = 0.715b(h + 0.46)s_1$ tf | |
| | $W = 0.02b(h + 1.50)s_1$ Ltf | |
| | $s_1$ = spacing of pillars, in m (ft) | |

*Note:* Main deck scantlings within house are to be designed for a load in kgf/m$^2$ (lb/ft$^2$) equal to 200 (45) multiplied by the height of the house in meters (feet). Scantlings of the deckhouse top are to be designed for a load of 245 kgf/m$^2$ (50 lb/ft$^2$).

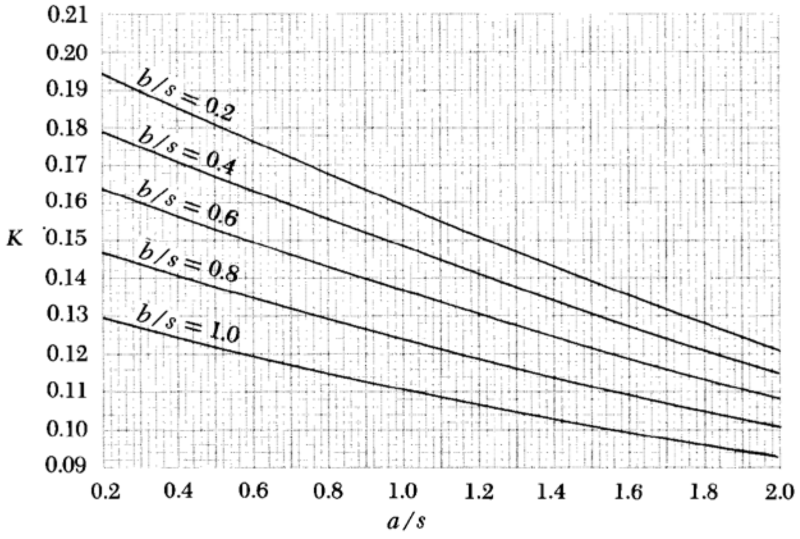
## FIGURE 12
## Double Skin Hopper Barge




| | |
|---|---|
| Side transverse | $c = 1.00$ |
| Deck transverse | $c = 0.70$ |
| Bulkhead transverse | $c = 0.70$ |

(Center compartment – dry cargo)
(Wing compartment – void)

## FIGURE 13
## Wheel Loading Curves of $K$



PART
# 3

## CHAPTER 2 Hull Structures and Arrangements

## SECTION 3 Barges Intended to Carry Dangerous Chemical Cargoes in Bulk

### 1 Application

This Section applies to barges intended to carry dangerous cargoes in bulk in services which require operation in comparatively smooth water exclusively, such as in rivers, intracoastal waterways, etc. All the applicable paragraphs of other Sections of these Rules are to be considered as requirements, except where the provisions of this Section are contrary to or in addition thereto. Self-propelled vessels will be specially considered, taking into account the cargoes carried and the degree of protection proposed.

### 3 Classification

The classification ✠ **A1 Chemical Tank Barge, River Service** followed by the appropriate notation indicating barge type designation as **Type I**, **Type II**, or **Type III*** is to be assigned to vessels designed for and specifically fitted for the carriage of dangerous chemicals in bulk, built to the requirements of this Section and other relevant sections of these Rules, and complying with 46 CFR Part 151 or other recognized standards.

* *Note:* Type Designation – See 46 CFR 151.10.

### 5 Submission of Data

The following plans, calculations and information as appropriate are to be submitted in addition to those required by 1-1-4/1 of the Supplement to the ABS *Rules for Conditions of Classification (Part 1)*.

Identification and properties of any dangerous chemical cargo which is intended to be carried on barges built in accordance with this Section are to be given and are to include chemical composition, specifying contaminants, density, vapor pressure, boiling point, combustible range, flash point, compatibility with tank materials and any peculiar characteristics. The temperature and pressure at which the cargo is to be carried and at which it is to be loaded and unloaded are also to be given. Where the cargo has been given a hazard rating by a recognized code or other authority, this is also to be stated.

Arrangement plans indicating watertight bulkheads, decks and all openings therein are to be submitted for review. Additional plans are to be submitted for each condition of loading in which a dangerous chemical cargo is carried showing specific gravity and maximum cargo weight in all spaces as well as draft of the vessel in each condition.

Except as indicated in 3-2-3/7, calculations showing compliance with 46 CFR Part 151 or other recognized standards are to be submitted for review. Written evidence that the U.S. Coast Guard has certified the vessel as being in compliance with their Regulations will be acceptable in lieu of calculations showing compliance with 46 CFR Part 151. Vessels designed to other recognized standards may be given similar consideration.

## 7 Type I and Type II Barges with Integral Tanks

Barges of Type I or Type II with integral tanks are to comply with the following requirements. Submitted calculations showing compliance with 46 CFR Part 151 as indicated in 3-2-3/5 need not include calculations for those items considered in this Subsection.

### 7.1 Definitions

#### 7.1.1 Type I Barge Hull

Barge hull Type I refers to those designed to carry products which require the maximum preventative measures to preclude the uncontrolled release of the cargo.

#### 7.1.2 Type II Barge Hull

Barge hull Type II refers to those designed to carry products which require significant preventative measures to preclude the uncontrolled release of the cargo.

#### 7.1.3 Limiting Draft

A limiting draft is the maximum draft to which cargo of specified densities may be loaded for a given hull type. A chemical barge may be assigned more than one limiting draft for different combinations of cargo density and hull type.

### 7.3 Tank Arrangement

#### 7.3.1 Collision Protection

Tanks containing products which are required to be carried in Type I or Type II hulls (See 46 CFR Table 151.05) are to be located beyond the following minimum distances from the members as shown.

*i)* *From Side Shell and Box End*

- Type I 1.22 m (4.0 ft)
- Type II 0.91 m (3.0 ft)

*ii)* *From the Headlog (Except Box Barges and Trail Barges)*

- Both Types 7.6 m (25 ft)

#### 7.3.2 Access Opening

Each tank is to be provided with a manhole with a cover plate and a minimum clear opening of 380 mm × 460 mm (15 in. × 18 in.). Access trunks, where fitted, are to have a diameter of at least 760 mm (30 in.).

### 7.5 Longitudinal Strength *(2001)*

#### 7.5.1 Loading Conditions

The following definitions of loading conditions are to be understood for the purpose of this Section.

*7.5.1(a) Normal and High Density Cargo Conditions (2001).* See 3-2-1/7.3.

*7.5.1(b) Grounding Conditions.* A grounding condition is a condition wherein the forward rake bulkhead rests on a pinnacle at the water surface with the barge loaded with cargo of approved density.

#### 7.5.2 Hull Girder Bending Moment

*7.5.2(a) Normal Conditions.* Subject to compliance with the requirements in Section 3-2-1, no bending moment calculations are required for these conditions except that those calculations mentioned in 3-2-3/7.5.1(a) for conditions other than homogeneous cargo are to be evaluated in accordance with 3-2-3/7.5.3(a) below.

*7.5.2(b) High Density Cargo and Grounding Conditions (2001).* Bending moment calculations are to be submitted for these conditions except that where grounding condition bending moment calculations for homogeneous cargo are not available, the following formula may be used.

$M_a = L^2Bd/(\alpha k)$

where

$M_a$ = expected grounding condition bending moment for barges with homogeneous cargo, in tf-m (Ltf-ft)

$L$ = length of barge, in m (ft), as defined in 3-1-1/3.1

$B$ = breadth of barge, in m (ft), as defined in 3-1-1/5

$d$ = limiting draft, in m (ft)

$k$ = $L$ – 10.9 m ($L$ – 35.7 ft), but not to be taken greater than 80.6 m (264.3 ft)

$\alpha$ = 0.461 $m^2$/tf (5.04 $ft^2$/Ltf)

7.5.3 Criterion *(2001)*

*7.5.3(a) Normal and High Density Cargo Conditions (2001).* The hull girder section modulus is to be in accordance with 3-2-1/7.7.

*7.5.3(b) Grounding Conditions (2001).* The hull girder section modulus is to be such that the hull girder stress, $\sigma$, in the deck or trunk side as obtained from the equation below does not exceed the permissible stress $f$ or the reference stress $f_r$ as defined in 3-2-1/7.7, whichever is less.

$\sigma = M/SM$

where

$M$ = hull girder bending moment, in tf-m (Ltf-ft), for grounding or overload conditions

$SM$ = as defined in 3-2-1/7.7

$f$ = $(1 - 0.25P/P_o) \times (1.09 - 0.00427\ell/r)Y$ for deck or trunk top/side with longitudinals

= $k(0.72 - 0.4B_o/B)Y$ for deck or trunk top/side with transverse beams

$P$ = pressure relief valve setting, in kgf/$cm^2$ (psi), or 0.105$h$ (0.455$h$), whichever is greater

$h$ = design head, in m (ft)

$P_o$ = 0.21 kgf/$cm^2$ (3 psi)

$\ell$ = unsupported span of the longitudinal, in cm (in.)

$r$ = $\sqrt{i / A}$

$i$ = moment of inertia of the longitudinal with deck plating, in $cm^4$ ($in^4$)

$A$ = cross sectional area of the longitudinal with deck plating, in $cm^2$ ($in^2$)

$Y$ = yield point of the material, in tf/$cm^2$ (Ltf/$in^2$)

$k$ = 1.0 for barge without trunk

= 0.87 for barge with trunk

$B_o$ = width of the transversely framed portion of the deck (if no trunk) or transversely framed trunk top

$B$ = breadth of barge, in m (ft), as defined in 3-1-1/5

### 7.7 Deck/Trunk Top Transverses

The moment of inertia in $cm^4$ ($in^4$) of the deck or trunk top transverses, where applicable, with associated deck plating, is to be not less than $I_o$ as given below.

$$I_o = 0.34K(b/\ell)^3(b/s)i$$

where

| | | | |
|---|---|---|---|
| $K$ | = | 1.0 | for transverses without effective end brackets if barge does not have centerline bulkhead or stanchions |
| | = | 0.3 | for the transverses without effective end brackets if barge has centerline bulkhead or stanchions |
| | = | 0.19 | for the transverses with effective end brackets with or without centerline bulkhead or stanchions |

$b$ = unsupported span of the transverses, in m (ft)

$\ell$ = spacing of the transverses, in m (ft)

$s$ = spacing of the longitudinals, in m (ft)

$i$ = moment of inertia of the longitudinal with deck plating that will satisfy 3-2-3/7.5.3(b)

Where applicable, width of effective deck flange for the transverses is to be taken as $b$/3 or $\ell$, whichever is less.

### 7.9 Transverse Beams

The moment of inertia in $cm^4$ ($in^4$) of the deck or trunk top transverse beam with associated deck plating, is to be not less than $I_o$ as given below.

$$I_o = 0.0367K(t/s)^3b^4$$

where

$s$ = spacing of the transverse beams, in mm (in.)

$t$ = thickness of the deck or trunk top, in mm (in.), that will satisfy 3-2-3/7.5.3(b)

$b$ = unsupported length of the transverse beam, in cm (in.)

$K$ = coefficient, specified in 3-2-3/7.7

Width of effective deck flange for transverse beam is to be taken as $s$.

PART

# 3

## CHAPTER 2 Hull Structures and Arrangements

## SECTION 4 Towboats

## 1 Application

The following Rules and Tables apply to self-propelled river towboat type vessels intended for towing operation in comparatively smooth water exclusively, such as in rivers, intracoastal waterways, etc.

## 3 Structural Arrangement

### 3.1 Framing

Framing may be arranged either longitudinally, transversely or a combination of both. Longitudinal frames are to be supported by regularly spaced transverse deep frames formed either by channels extending across the inner faces of the longitudinal frames, or by flanged plates notched over the frames and attached to the shell or deck and the longitudinals.

### 3.3 Longitudinal Webs

Trusses or non-tight bulkheads extending fore and aft are to be fitted, one on or near the centerline and one on each side of the centerline. An arrangement of deep girders at the deck and bottom connected by vertical members will be considered. They are to be arranged so that in association with auxiliary supporting girders. The spans of the bottom frames do not exceed 4 m (13 ft). Bulkheads may be offset or stepped in a transverse direction provided sufficient overlap is effected to maintain their longitudinal continuity.

## 5 Longitudinal Strength

The required hull girder section modulus, $SM$, within the midship 0.5$L$ is to be obtained from the following equation.

$SM = 0.764BDL$ cm$^2$-m $\qquad$ $SM = 0.011BDL$ in$^2$-ft

$L$, $B$ and $D$ are as defined in Section 3-1-1.

In calculating the actual section modulus, bottom, bilge and side plating, all bilge, gunwale and other longitudinal angles if continuous or adequately developed at the transverse bulkheads and the continuous deck plating may be included. Beyond the midship 0.5$L$, scantlings may be tapered to their normal requirements at the ends where these are less.

## 7 Deck Plating

### 7.1 Strength Decks

The thickness of strength deck plating throughout is not to be less than 0.01 mm per millimeter (0.01 in. per inch) of the spacing of the beams, $s_b$.

### 7.3 Other Locations

The thickness of plating forming the tops of deep tanks, watertight flats, bulkhead recesses and tunnel tops which may be used for stores space is to be 1 mm (0.04 in.) thicker than required for bulkhead plating at the same level.

# 9 Frames

## 9.1 Bottom Longitudinals

Each bottom longitudinal, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 1.08

$h$ = vertical distance from the longitudinal to the deck at side, in m (ft)

= for longitudinals in tanks, the vertical distance from the longitudinal to the top of the overflow, in m (ft)

$s$ = longitudinal spacing, in m (ft)

$\ell$ = unsupported span of the member in m (ft). Where brackets of the thicknesses given in 3-2-1/Table 1 are fitted, $\ell$ may be measured to a point 25% of the extent of the bracket beyond the its toe.

## 9.3 Side and Deck Framing

Each side frame or deck beam, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = coefficient appropriate to the type of construction employed as given in 3-2-4/Figure 1 for side frames

= 0.70 for deck beams in dry spaces

= 1.00 for deck beams in way of tanks

= 1.08 for side longitudinals

$h$ = distance, in m (ft), as given in 3-2-4/Figure 1

= in way of tanks, the vertical distance from the middle of $\ell$ to the top of the overflow, in m (ft), but not less than 1.2 m (4.0 ft) for deck beams

= 1.2 (4.0) for support of decks. For decks on which stores may be carried, *h* is not to be taken less than the height of the storage space.

$s$ = member spacing, in m (ft)

$\ell$ = as defined in 3-2-4/9.1

## 9.5 Framing in Tunnels

Special consideration is to be given to increasing the framing in way of propeller tunnels or special types of nozzles. It is recommended that nontight bulkheads and diaphragms be introduced in way of long tunnels (see also 3-2-4/17.5).

# 11 Stanchions

## 11.1 Permissible Load *(2018)*

The permissible load, $W_a$, of each stanchion is to be obtained from the following equation and is to be not less than the calculated load $W$ given in 3-2-4/11.3 below.

$W_a = [k - n\ell/r]A$ kN (tf, Ltf)

where

| | | | |
|---|---|---|---|
| $k$ | = | 12.09 (1.232, 7.83) | ordinary strength steel |
| | = | 16.11 (1.643, 10.43) | HT32 strength steel |
| | = | 18.12 (1.848, 11.73) | HT36 strength steel |
| $n$ | = | 0.0444 (0.00452, 0.345) | ordinary strength steel |
| | = | 0.0747 (0.00762, 0.581) | HT32 strength steel |
| | = | 0.0900 (0.00918, 0.699) | HT36 strength steel |

$\ell$ = unsupported span of the stanchion, in cm (ft)

$r$ = least radius of gyration, in cm (in.)

$A$ = cross sectional area of the stanchion, in $cm^2$ ($in^2$)

## 11.3 Calculated Load

The calculated load for each stanchion is to be determined by the following equation:

$W = nbhs$ tf (Ltf)

where

$n$ = 1.07 (0.03) where the stanchion supports bottom structure

= 0.715 (0.02) where the stanchion supports deck structure

$b$ = mean breadth of the area supported, in m (ft)

$h$ = distance from the bottom shell at the center of the area supported to the underside of the deck plating at side, in m (ft), for support of bottom structure

= 1.2 (4.0) for support of decks. Where decks are intended to carry stores, $h$ is not to be taken less than the height of the storage space.

$s$ = spacing of the stanchions, in m (ft)

# 13 Web Frames, Girders and Stringers

Each supporting girder, transverse floor and stringer with transverse framing, and each main transverse member with longitudinal framing, is to have a section modulus, $SM$, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ $cm^3$ $SM = 0.0041chs\ell^2$ $in^3$

where

$c$ = 1.00 for bottom and side supporting members and for deck supporting members in tanks

= 0.70 for deck supporting members in dry spaces

$h$ = for bottom and side supporting members, the distance from the middle of $\ell$ to the deck at side, in m (ft)

- in way of tanks $h$ is to be the vertical distance to the top of the overflow, in m (ft)

= for deck supporting members, 1.2 m (4.0 ft)

- for decks on which stores may be carried, $h$ is not to be less than the height of the storage space
- in way of deep tanks, $h$ is not to be less than the distance to the top of the overflow.

$s$ and $\ell$ are as defined in 3-2-4/9.1.

The thickness of floors or transverses is in general not to be less than 5 mm ($^3/_{16}$ in.) and those under the engines are to be suitably increased.

# 15 Bulkheads

## 15.1 Arrangement

Intact watertight collision bulkheads are to be fitted up to the deck in all vessels at a distance of not less than 0.05$L$ from the stem. Watertight after peak bulkheads are to be fitted. Machinery spaces below the deck are to be enclosed by transverse bulkheads which are watertight to the deck.

## 15.3 Construction of Tank Boundary Bulkheads

### 15.3.1 Plating

Plating is to be of thickness obtained from the following equation:

$$t = (s\sqrt{h}/254) + 1.78 \quad \text{mm} \qquad (\text{min. } t = 5 \text{ mm})$$

$$t = (s\sqrt{h}/460) + 0.07 \quad \text{in.} \qquad (\text{min. } t = 0.20 \text{ in.})$$

where

$s$ = spacing of stiffeners, in mm (in.)

$h$ = vertical distance measured from the lower edge of the plate to the top of the overflow

### 15.3.2 Stiffening

The ends of stiffeners are to be either bracketed or clipped. Each stiffener, in association with the plating to which it is attached, is to have a section modulus, $SM$, not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \quad \text{cm}^3 \qquad SM = 0.0041chs\ell^2 \quad \text{in}^3$$

where

$c$ = 1.00

$h$ = vertical distance from the middle of $\ell$ to the top of the overflow, in m (ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = as defined in 3-2-4/9.1

## 15.5 Construction of Other Watertight Bulkheads

### 15.5.1 Plating

Plating is to be of thickness obtained from the following equation:

$$t = (s\sqrt{h}/290) + 1.0 \quad \text{mm} \qquad (\text{min. } t = 4.5 \text{ mm})$$

$$t = (s\sqrt{h}/525) + 0.04 \quad \text{in.} \qquad (\text{min. } t = 0.18 \text{ in.})$$

where

$s$ = spacing of stiffeners, in mm (in.)

$h$ = vertical distance measured from the lower edge of the plate to the height of the deck at centerline, in m (ft)

15.5.2 Stiffening

Each stiffener, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $\qquad$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 0.46

$h$ = vertical distance from the middle of $\ell$ to the deck at centerline, in m (ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = as defined in 3-2-4/9.1

## 17 Shell Plating

The thickness of the bottom, side and bilge plating is to be as required below. In addition, the thickness of plating in these locations is to be not less than as required by 3-2-4/15.3.1 for tank bulkheads where the spacing of the stiffeners is equal to the frame spacing and the value of *h* is equal to the distance from the lower edge of the plate to the under surface of the deck plating at side. In way of deep tanks, *h* is to be measured to the top of the overflow.

### 17.1 Bottom Shell

The thickness of the bottom shell plating throughout is not to be less than determined by the following equation:

$t = 0.069L + 0.007s - 0.5$ mm (min. $t$ = 5 mm)

$t = 0.000825L + 0.007s - 0.02$ in. (min. $t$ = 0.20 in.)

where

$s$ = stiffener spacing, in mm (in.)

$L$ = length of the vessel, in m (ft)

### 17.3 Side Shell

The thickness of the side shell plating is to be not less than determined by the following equation and not less than 5 mm (0.20 in.).

$t = 0.069L + 0.007s - 1.0$ mm $\qquad L < 73$ m

$t = 0.069L + 0.007s - 1.5$ mm $\qquad L \geq 73$ m

$t = 0.000825L + 0.007s - 0.04$ in. $\qquad L < 240$ ft

$t = 0.000825L + 0.007s - 0.06$ in. $\qquad L \geq 240$ ft

### 17.5 Bilge and Tunnel Plating

Where radiused bilges are used, the bottom thickness is to extend to the upper turn of the bilge. Where the radius at the bilge exceeds 305 mm (12 in.), the thickness of the plating should be at least 1.5 mm (0.06 in.) greater than the required thickness for side plating. The shell plating in tunnels in way of propellers is to be increased above the requirements of this Subsection.

### 17.7 Bilge Angles

Where angles are used at the bilges or gunwales they are to have a thickness at least 1.5 mm (0.06 in.) greater than that of the thinner of the two plates joined.

## 19 Deckhouses

### 19.1 Scantlings

Deckhouses on towboats are to be of adequate construction, consideration being given to their size and the loads which may be imposed upon them. The plating of the deckhouses is to be not less than 3.5 mm (10 gauge), and where the spacing of stiffeners exceeds 610 mm (24 in.), the plating thickness is to be increased. Stiffeners are not to be less than 63.5 mm (2.5 in.) in depth and this depth is to be increased if the length of the stiffeners is over 2.44 m (8 ft). The scantlings of decks and platforms above the main deck are to be determined from 3-2-4/9.3 and 3-2-4/13 using an *h* not less than 0.61 m (2.0 ft) for the first level above the main deck and 0.457 m (1.5 ft) for the second level or higher.

### 19.3 Sill Height

Openings in exposed positions on the weather decks which lead to spaces below are to have sills at least 150 mm (6 in.) in height.

## 21 Keels, Stems and Stern Frames

### 21.1 Bar Keels

Where bar keels are used, their thicknesses and depths are to be not less than given by the following equations:

$t = 0.52L + 9.5$ mm $\qquad$ $t = 0.0062L + 0.37$ in.

$h = 1.06L + 94.5$ mm $\qquad$ $h = 0.0127L + 3.72$ in.

where

$t$ = thickness, in mm (in.)

$h$ = depth, in mm (in.)

$L$ = length of the vessel as defined in 3-1-1/3.1

### 21.3 Flat Plate Keels

Flat plate keels are not to be of less thickness than required for bottom plating.

### 21.5 Bar Stems

Where bar stems are used, their thicknesses and widths are to be not less than given by the following equations:

$t = 0.38L + 11.0$ mm $\qquad$ $t = 0.0046L + 0.44$ in.

$w = 1.09L + 80.0$ mm $\qquad$ $w = 0.0131L + 3.15$ in.

where

$t$ = thickness, in mm (in.)

$w$ = width, in mm (in.)

$L$ = length of the vessel as defined in 3-1-1/3.1

### 21.7 Sternposts

Where bar sternposts are fitted, their thicknesses and widths are to be not less than given by the following equations:

$t = 0.52L + 9.5$ mm $t = 0.0062L + 0.37$ in.

$w = 1.09L + 80.0$ mm $w = 0.0131L + 3.15$ in.

where

$t$ = thickness, in mm (in.)

$w$ = width, in mm (in.)

$L$ = length of the vessel as defined in 3-1-1/3.1

### 21.9 Stern Frames

#### 21.9.1 Inner Posts

Where stern frames are fitted, the thickness and width of the inner post below the shaft boss are to be not less than given by the following equations:

$t = 1.20L + 20.0$ mm $t = 0.0144L + 0.78$ in.

$w = 1.06L + 94.5$ mm $w = 0.0127L + 3.72$ in.

where

$t$ = thickness, in mm (in.)

$w$ = width, in mm (in.)

$L$ = length of the vessel as defined in 3-1-1/3.1

#### 21.9.2 Outer Posts

Where fitted, the outer post is to have a thickness not less than that required for inner posts and a width not less than 80% of that required for inner posts.

#### 21.9.3 Shoe Piece

The shoe piece is to be as short as possible. The depth is to be at least 10% greater than the above calculated thickness and the breadth at least 20% greater than the above calculated breadth. Gudgeons are to have a thickness of 25% of the rudder stock diameter if bushed and 27.5% if unbushed. The depth of gudgeons is to be not less than 75% of the stock diameter.

## 23 Rudders

### 23.1 Materials

Rudder parts such as stocks, palms, gudgeons, etc., may be of cast or forged steel or fabricated sections made from materials complying with the requirements of Chapter 1 of the ABS *Rules for Materials and Welding (Part 2)*.

### 23.3 Application

This Section refers to rudders of the balanced or partially balanced type having efficient neck bearings, with or without lower bearings. Where rudders are of unusual shape or design or are associated with construction features which make the formulas of this Subsection inapplicable, the design and calculations are to be submitted for approval. In such cases the design conditions are to be verified during the trials of the vessel.

## 23.5 Rudder Stocks

### 23.5.1 Upper Stocks

Upper stocks above the neck bearing are to have diameters not less than given by the following equation:

$$S = 100\sqrt[3]{AR} \quad \text{mm} \qquad S = 1.2\sqrt[3]{AR} \quad \text{in.}$$

where

$S$ = diameter of upper stock, in mm (in.)

$R$ = distance from the centerline of the stock to the center of gravity of the immersed rudder area forward or abaft the center of the rudder stock, in m (ft)

$A$ = area of the immersed rudder surface forward or abaft the center of the rudder stock, in $m^2$ ($ft^2$)

The values of $R$ and $A$ to be used are those which give the larger products of $R$ and $A$.

Where the design speed exceeds 16 km/h (10 mph), the diameter is to be increased in the ratio of the speed to 16 km/h (10 mph).

### 23.5.2 Lower Stocks

Lower stocks are to be equivalent to round bars having diameters obtained from the equation:

$$S_1 = 100\sqrt[3]{AR} \quad \text{mm} \qquad S_1 = 1.2\sqrt[3]{AR} \quad \text{in.}$$

where

$S_1$ = diameter of lower stock, in mm (in.)

$R$ = $0.25\left[a + \sqrt{(a^2 + b^2)}\right]$ for balanced rudders which have efficient neck and bottom bearings

= $a + \sqrt{(a^2 + b^2)}$ for balanced rudders which have no bottom bearings

$A$ = area of the immersed rudder surface, in $m^2$ ($ft^2$)

$a$ = vertical distance from the neck bearing to the center of gravity of $A$, in m (ft)

$b$ = horizontal distance from the center of the lower stock to the center of gravity of $A$, in m (ft)

Where the design speed exceeds 16 km/h (10 mph), the diameter is to be increased in the ratio of the speed to 16 km/h (10 mph).

*i)* Lower stocks of rudders having bottom bearings are to be the full diameter for two-thirds of the distance from the neck bearing to the bottom bearings, and may be tapered below this point to $0.75S_1$ in the bottom bearing. They are to extend into the bottom bearing a distance of $0.7S_1$.

*ii)* Lower stocks of rudders having no bottom bearings are to be of the full diameter from the top of the neck bearing to the top of the rudder and may be tapered to $0.33S_1$ at the bottom. The length of the neck bearing need not be greater than $1.5S_1$.

*iii)* Lower stocks within built-up is equivalent to the stacks required by the above formula.

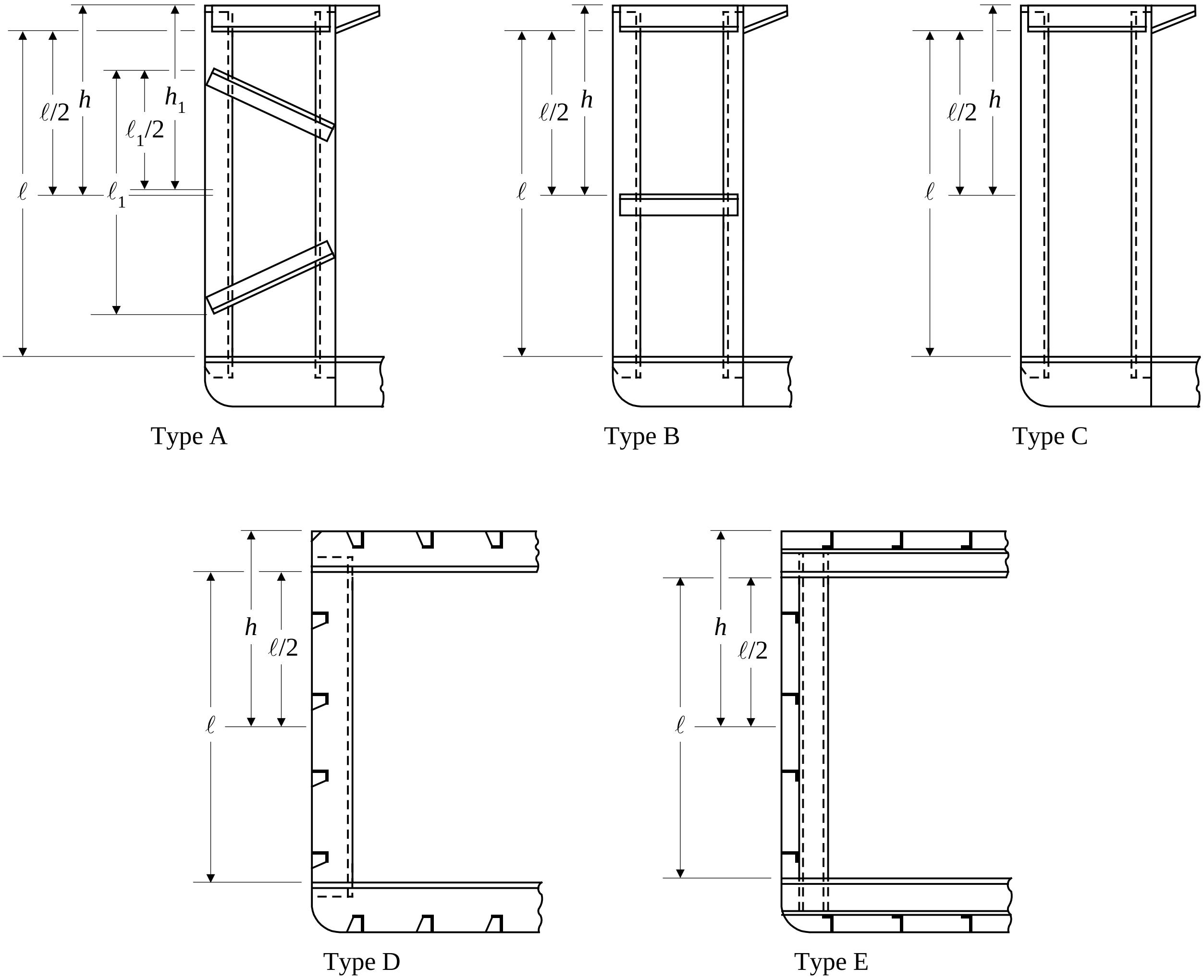
## 23.7 Rudders

Rudders may be of either single or double plate construction and are to have a sufficient number of arms or diaphragms to provide ample stiffness.

## 23.9 Couplings

Couplings in rudder stocks or between stock and rudder are to be equivalent to the required diameter of stock.

**FIGURE 1**
**Towboat Framing**




| **Side Frame** | |
|---|---|
| Type A | $c$ = 1.15 (for $h$) |
| Type A | $c$ = 2.00 (for $h_1$) |
| Type B | $c$ = 1.30 |
| Type C | $c$ = 1.45 |
| Type D | $c$ = 1.00 |
| Type E | $c$ = 1.00 |

PART 3

# CHAPTER 2 Hull Structures and Arrangements

# SECTION 5 Passenger Vessels

## 1 Application

### 1.1 Service

The following Rules apply to vessels carrying more than 12 passengers exclusively in smooth domestic water, such as in rivers, intracoastal waterways, etc. The requirements for river passenger vessels engaged in an international voyage will be subject to special consideration.

### 1.3 National Regulations

Where the flag Administration has Regulations acceptable to ABS, including those for stability, structural fire protection, lifesaving appliances, etc., such Regulations may be considered under 1-1-4/7.3 of the ABS *Rules for Conditions of Classification (Part 1)*.

## 3 Classification

The classification ✠ **A1 Passenger Vessel, River Service** is to be assigned to vessels designed and specifically fitted for the carriage of passengers and built to the requirements of this Section and other relevant sections of the Rules.

## 5 Structural Arrangement

### 5.1 Framing

Framing may be arranged either longitudinally, transversely or a combination of both. Longitudinal frames are to be supported by regularly spaced transverse deep frames formed either by channels extending across the inner faces of the longitudinal frames, or by flanged plates notched over the frames and attached to the shell or deck and the longitudinals. Where longitudinal beams are used on more than one deck, transverses on all decks are to be fitted at the same vertical plane.

### 5.3 Longitudinal Webs

Trusses or non-tight bulkheads extending fore and aft are to be fitted, one on or near the centerline and one on each side of the centerline. An arrangement of deep girders at the deck and bottom connected by vertical members will be considered. They are to be arranged so that in association with auxiliary supporting girders, the spans of the bottom frames do not exceed 4 m (13 ft). Bulkheads may be offset or stepped in a transverse direction provided sufficient overlap is effected to maintain their longitudinal continuity.

## 7 Longitudinal Strength

### 7.1 Hull Girder Section Modulus

The hull girder section modulus within the midship 0.5$L$ is to be not less than obtained from the following equations *i)* or *ii)*, whichever is greater.

*i)* $SM = M_{sw}/f_p$

*ii)* $SM = C_1C_2L^2B(C_b + 0.7)$

where

$SM$ = minimum required hull girder section modulus, in cm$^2$-m (in$^2$-ft)

$M_{sw}$ = maximum calculated still-water bending moment, in tf-m (Ltf-ft), which is to be submitted for review.

$f_p$ = nominal permissible bending stress of 1.34 tf/cm$^2$ (8.5 Ltf/in$^2$), but is not to be taken greater than 0.8 times the lowest critical buckling stress of the hull girder structure.

$C_1$ = $7.32 - 0.033L$ ($7.32 - 0.01L$) for $L < 61$ m (200 ft)

= $4.36 + 0.016L$ ($4.36 + 0.0048L$) for $L \geq 61$ m (200 ft)

$C_2$ = 0.01 ($1.44 \times 10^{-4}$)

$L$, $B$ and $C_b$ are as defined in Section 3-1-1.

Beyond the midship 0.5$L$, scantlings may be tapered to their normal requirements at the ends where these are less.

### 7.3 Hull Girder Moment of Inertia

The hull girder moment of inertia of the vessel at amidships is to be not less than obtained from the following equation:

$$I = L(SM/33.3)$$

where

$I$ = minimum required hull girder moment of inertia, in cm$^2$-m$^2$ (in$^2$-ft$^2$)

$L$ and $SM$ are as defined in 3-2-5/7.1.

### 7.5 Hull Girder Shear Strength

The hull girder nominal shear stress $f$ in the side shell plating, obtained from the following equation, is not to exceed nominal permissible shear stress, $f_s$, as defined below.

$$f_s = Fm/(2It)$$

where

$f_s$ = nominal permissible shear stress of 1.03 tf/cm$^2$ (6.5 Ltf/in$^2$), but is not to be taken greater than 0.8 times the lowest critical buckling shear stress of the hull girder structure.

$I$ = hull girder moment of inertia at the section under consideration, in cm$^4$ (in$^4$)

$F$ = maximum still water shear force calculated at the position being considered, in tf (Ltf)

$m$ = first moment of area of the material between the point under consideration and the vertical extremity of the effective longitudinal material, in cm$^3$ (in$^3$). $m$ is to be taken about the neutral axis at the section under consideration

$t$ = side shell thickness, in cm (in.)

## 9 Deck Plating

### 9.1 Strength Decks

The thickness of strength deck plating throughout is not to be less than 0.01 mm per millimeter (0.01 in. per inch) of the spacing of the beams, $s_b$.

### 9.3 Superstructure Decks

The thickness of superstructure deck plating is to be not less than obtained from the following equations:

$t = 0.0063s_b + 1.0$ mm (min, $t$ = 4.5 mm)

$t = 0.0063s_b + 0.04$ in. (min. $t$ = 0.18 in.)

where $s_b$ is the stiffener spacing in mm (inches).

### 9.5 Wheel Loaded Decks

Where provision is to be made for the operation or stowage of vehicles having rubber tires, and after all other requirements are met, the thickness of deck plating is to be not less than that required by 3-2-2/7.9.

### 9.7 Other Locations

The thickness of plating forming the tops of deep tanks, watertight flats, bulkhead recesses and tunnel tops which may be used for stores space is to be 1 mm (0.04 in.) thicker than required for bulkhead plating at the same level.

## 11 Frames

### 11.1 Bottom Longitudinals

Each bottom longitudinal, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 1.08

$h$ = vertical distance from the keel to the design draft, in m (ft), but not less than $^2/_3$ the distance from the keel to the main deck.

= for longitudinals in tanks, the vertical distance from the keel to the top of the overflow, in m (ft)

$s$ = longitudinal spacing, in m (ft)

$\ell$ = unsupported span of the member, in m (ft). Where brackets of the thicknesses given in 3-2-1/Table 1 are fitted, $\ell$ may be measured to a point 25% of the extent of the bracket beyond its toe.

### 11.3 Side and Deck Framing

Each side frame or deck beam, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = coefficient appropriate to the type of construction employed as given in 3-2-5/Figure 1 for side frames

- 0.70 for deck longitudinals in dry spaces
- 0.56 for deck beams in dry spaces
- 1.00 for deck beams in way of tanks
- 1.08 for side longitudinals

$h$ = distance, in m (ft), as given in 3-2-5/Figure 1

- for side longitudinals, the vertical distance from the middle of $\ell$ to the deck at side, in m (ft)
- in way of tanks, the vertical distance from the middle of $\ell$ to the top of the overflow, in m (ft)
- $0.01L + 0.61$ m ($0.01L + 2.0$ ft) for main decks.
- 0.67 m (2.2 ft) for superstructure decks. Where deck loading may exceed 360 kgf/m$^2$, (75 lb/ft$^2$), $h$ is to be proportionately increased.
- 0.30 m (0.98 ft) for rain covers

$s$ = member spacing, in m (ft)

$\ell$ = as defined in 3-2-5/11.1

### 11.5 Framing in Tunnels

Special consideration is to be given to increasing the framing in way of propeller tunnels or special types of nozzles, It is recommended that nontight bulkheads and diaphragms be introduced in way of long tunnels.

## 13 Stanchions

### 13.1 Permissible Load *(2018)*

The permissible load, $W_a$, of each stanchion is to be obtained from the following equation and is to be not less than the calculated load $W$ given in 3-2-5/13.3 below.

$$W_a = [k - n\ell/r]A \quad \text{kN (tf, Ltf)}$$

where

| | | | |
|---|---|---|---|
| $k$ | = | 12.09 (1.232, 7.83) | ordinary strength steel |
| | = | 16.11 (1.643, 10.43) | HT32 strength steel |
| | = | 18.12 (1.848, 11.73) | HT36 strength steel |
| $n$ | = | 0.0444 (0.00452, 0.345) | ordinary strength steel |
| | = | 0.0747 (0.00762, 0.581) | HT32 strength steel |
| | = | 0.0900 (0.00918, 0.699) | HT36 strength steel |

$\ell$ = unsupported span of the stanchion, in cm (ft)

$r$ = least radius of gyration, in cm (in.)

$A$ = cross sectional area of the stanchion, in cm$^2$ (in$^2$)

Special support is to be arranged at the ends and corners of deckhouses, in machinery spaces, at ends of partial superstructures and under heavy concentrated weights.

### 13.3 Calculated Load

#### 13.3.1 Bottom Support

Where the stanchions are intended to support bottom structure, the calculated load for each stanchion is to be determined by the following equation:

$$W = nbhs \quad \text{tf (Ltf)}$$

where

$n$ = 1.07 (0.03)

$b$ = mean breadth of the area supported, in m (ft)

$h$ = distance from the keel to the design waterline, in m (ft), or $^2/_3$ of the distance to the main deck, whichever is greater

$s$ = spacing of the stanchions, in m (ft)

13.3.2 Deck Support

Where the stanchions are intended to support deck structure, the calculated load for each stanchion is to be determined by the following equation, where the summations indicate the sum of the loads from all supported stanchions on the deck immediately above. In all cases, subscripts denote the level of the tier above the deck supported by the stanchion under consideration. Where the stanchion supports more than three tiers, the same method is to be extended to include the additional supported tiers.

$$W = n\left\{bhs + \sum c\left[b_1h_1s_1 + \sum c_1\left(b_2h_2s_2 + \sum c_2b_3h_3s_3\right)\right]\right\} \quad \text{tf (Ltf)}$$

where

$n$ = 0.715 (0.02)

$b$ = mean breadth of the area of the deck supported by the stanchion, in m (ft)

$b_1, b_2$... = for each supported stanchion supporting tiers above, the mean breadth of the area supported by that stanchion, in m (ft)

$h$ = head defined in 3-2-5/11.3 for the deck supported by the stanchion

$h_1, h_2$... = for each supported stanchion supporting tiers above, one half the head defined in 3-2-5/11.3 for the location supported by that stanchion

$s$ = mean length of the area of the deck supported by the stanchion, in m (ft)

$s_1, s_2$... = for each supported stanchion supporting tiers above, the mean length of the area supported by that stanchion, in m (ft)

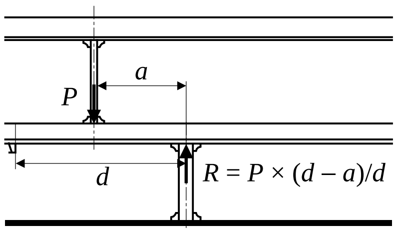
$c$ = $(d – a)/d$ at the deck supported

$c_1, c_2$... = $(d – a)/d$ at each tier above the deck supported

$c.$ = horizontal distance between the stanchion above deck and the stanchion below deck, in m (ft)

$d$ = horizontal distance between the stanchion below deck and next point of support of the girder or transverse supported, in m (ft)

$a$ = horizontal distance between the stanchion above deck and the stanchion below deck being considered, in m (ft)



## 15 Web Frames, Girders and Stringers

Each supporting girder, transverse floor and stringer with transverse framing, and each main transverse member with longitudinal framing, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 1.00 for bottom and side supporting members and for deck supporting members in tanks

= 0.70 for deck supporting members in dry spaces

$h$ = for bottom supporting member, the vertical distance from the keel to the design draft, in m (ft), but not less than $^2/_3$ the distance from the keel to the main deck

- for side supporting members, the distance from the middle of $\ell$ to the deck at side, in m (ft). In way of tanks, $h$ is to be the vertical distance to the top of the overflow, in m (ft)
- in way of tanks, the vertical distance from the middle of $\ell$ to the top of the overflow, in m (ft)
- $0.01L + 0.61$ m ($0.01L + 2.0$ ft) for main decks.
- height of storage space, in m (ft), on decks where stores are carried
- 0.67 m (2.2 ft) for superstructure decks. Where deck loading may exceed 360 kgf/m$^2$, (75 lb/ft$^2$), $h$ is to be proportionately increased.
- 0.30 m (0.98 ft) for rain covers

$s$ = sum of the half lengths of the supported members, in m (ft)

$\ell$ = as defined in 3-2-5/11.1.

### 15.1 Proportions

#### 15.1.1 Bottom and Side Web Frames

Bottom and side web frames are to have depths not less than $0.125\ell$ (1.5 in. per ft of span). Web thickness is not to be less than 1 mm per 100 mm (0.01 in. per in.) of depth plus 3.5 mm (0.14 in.) but need not exceed 14 mm (0.56 in.).

#### 15.1.2 Deck Girders and Transverses

*i)* Outside tanks, deck girders and transverses are to have depths not less than $0.0583\ell$ (0.7 in. per ft of span). Thickness is not to be less than 1 mm per 100 mm (0.01 in. per in.) of depth plus 4.0 mm (0.16 in.).

*ii)* In tanks, deck transverses and girders are to have depths not less than $0.0833\ell$ (1.0 in. per ft of span). Thickness is not to be less than 1 mm per 100 mm (0.01 in. per in.) of depth plus 4.0 mm (0.16 in.).

# 17 Bulkheads

## 17.1 Arrangement

Intact watertight collision bulkheads are to be fitted up to the deck in all vessels at a distance of not less than 0.05*L* from the stem. Watertight after peak bulkheads are to be fitted. Machinery spaces below the deck are to be enclosed by transverse bulkheads which are watertight to the deck. Additional transverse watertight bulkheads are to be provided in accordance with 3-2-5/17.1.1 or 3-2-5/17.1.2 below.

A watertight shaft tunnel or other watertight space(s) separate from the stern tube compartment is to be provided around the stern gland of such volume that, if flooded by leakage through the stern gland, the margin line will not be submerged.

### 17.1.1 Vessels of 43.5 m (143 ft) in Length or Greater

Each main transverse watertight bulkhead is to be a minimum of 3 m (10 ft) plus 3 percent of the vessel's length from the collision bulkhead, every other main transverse bulkhead and from the aft peak bulkhead.

### 17.1.2 Vessels Under 43.5 in (143 ft) in Length

Each main transverse watertight bulkhead is to be a minimum of 10 percent of the vessel's length or 1.8 m (6 ft), whichever is greater, from the collision bulkhead, from every other main transverse bulkhead and from the aft peak bulkhead.

## 17.3 Construction of Tank Boundary Bulkheads

### 17.3.1 Plating

Plating is to be of thickness obtained from the following equation:

$t = (s\sqrt{h}/254) + 1.78$ mm (min. $t$ = 5 mm)

$t = (s\sqrt{h}/460) + 0.07$ in. (min. $t$ = 0.20 in.)

where

$s$ = spacing of stiffeners, in mm (in.)

$h$ = vertical distance measured from the lower edge of the plate to the top of the overflow, in m (ft)

### 17.3.2 Stiffeners

Each stiffener, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation. The ends are to be either bracketed or clipped.

$SM = 7.8chs\ell^2$ cm$^3$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 1.00

$h$ = for double bottom tanks, height from the middle of $\ell$ to the tank top, plus $^2/_3$ of the distance from the tank top to the top of the overflow, in m (ft)

= for other tanks, vertical distance from the middle of $\ell$ to the top of the overflow, in m (ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = as defined in 3-2-5/11.1

### 17.3.3 Girders and Webs

*17.3.3(a) Strength Requirements.* Each girder and web supporting bulkhead stiffeners is to have a section modulus not less than required by 3-2-5/17.3.2 for stiffeners, where *s* is the sum of half lengths of the stiffeners supported on each side of the girder or web, in m (ft).

*17.3.3(b) Proportions.* Webs and girders are to have depths not less than 0.145$\ell$ (1.75 in. per ft of span $\ell$) where no struts or ties are fitted. Where struts are fitted, they are to have depths not less than 0.0833$\ell$ (1 in. per ft of span $\ell$) plus one-quarter of the depth of the slots for the stiffeners. In general, the depth is not to be less than 2 times the depth of the slots.

The thickness is not to be less than 1 mm per 100 mm (0.01 in. per in.) of depth plus 3 mm (0.12 in.) but need not exceed 11.5 mm (0.46 in.).

*17.3.3(c) Tripping Brackets.* Tripping brackets are to be fitted at intervals of about 3 m (10 ft) and where the width of the face flange exceeds 200 mm (8 in.) on either side of the girder or web, these are to be arranged to support the flange.

## 17.5 Construction of Other Watertight Bulkheads

### 17.5.1 Plating

Plating is to be of thickness obtained from the following equation:

$$t = (s\sqrt{h}/290) + 1.0 \quad \text{mm} \qquad (\text{min. } t = 4.5 \text{ mm})$$

$$t = (s\sqrt{h}/535) + 0.04 \quad \text{in.} \qquad (\text{min. } t = 0.18 \text{ in.})$$

where

$s$ = spacing of stiffeners, in mm (in.)

$h$ = vertical distance measured from the lower edge of the plate to the height of the deck at centerline, in m (ft)

### 17.5.2 Stiffeners

Each stiffener, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \quad \text{cm}^3 \qquad SM = 0.0041chs\ell^2 \quad \text{in}^3$$

where

$c$ = 0.46

$h$ = vertical distance from the middle of $\ell$ to the main deck at centerline, in m (ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = as defined in 3-2-5/11.1

Stiffeners on these bulkheads may have unattached sniped ends provided the above value of *SM* is increased 25%.

### 17.5.3 Girders and Webs

*17.5.3(a) Strength Requirements.* Each girder and web supporting bulkhead stiffeners is to have a section modulus not less than required by 3-2-5/17.3.2 for stiffeners using $c$ of 0.60 and where $s$ is the sum of half lengths of the stiffeners supported on each side of the girder or web, in m (ft).

*17.5.3(b) Proportions.* Webs and girders are to have depths not less than 0.0833$\ell$ (1 in. per ft of span $\ell$) plus one-quarter of the depth of the slots for the stiffeners.

The thickness is not to be less than 1 mm per 100 mm (0.01 in. per in.) of depth plus 3 mm (0.12 in.) but need not exceed 11.5 mm (0.46 in.).

*17.5.3(c) Tripping Brackets.* Tripping brackets are to be fitted at intervals of about 3 m (10 ft) and where the width of the face flange exceeds 200 mm (8 in.) on either side of the girder or web, these are to be arranged to support the flange.

## 19 Shell Plating

The thickness of the bottom, side and bilge plating is to be as required below. In addition, the thickness of plating in these locations is to be not less than as required by 3-2-5/17.3.1 for tank bulkheads where the spacing of the stiffeners is equal to the frame spacing and the value of $h$ is equal to the distance from the lower edge of the plate to the under surface of the deck plating at side.

### 19.1 Bottom Shell

The thickness of the bottom shell plating throughout is not to be less than determined by the following equation:

$t = 0.069L + 0.007s - 0.5$ mm (min. $t = 5$ mm)

$t = 0.000825L + 0.007s - 0.02$ in. (min. $t = 0.20$ in.)

where

$s$ = stiffener spacing, in mm (in.)

$L$ = length of the vessel, in m (ft)

### 19.3 Side Shell

The thickness of the side shell plating is to be not less than determined by the following equation and not less than 5 mm (0.20 in.).

$t = 0.069L + 0.007s - 1.0$ mm $L < 73$ m

$t = 0.069L + 0.007s - 1.5$ mm $L \geq 73$ m

$t = 0.000825L + 0.007s - 0.04$ in. $L < 240$ ft

$t = 0.000825L + 0.007s - 0.06$ in. $L \geq 240$ ft

### 19.5 Bilge and Tunnel Plating

Where radiused bilges are used the bottom thickness is to extend to the upper turn of the bilge; where the radius at the bilge exceeds 305 mm (12 in.), the thickness of the plating should be at least 1.5 mm (0.06 in.) greater than the required thickness for side plating. The shell plating in tunnels in way of propellers is to be increased above the requirements of this Subsection.

### 19.7 Bilge Angles

Where angles are used at the bilges or gunwales they are to have a thickness at least 1.5 mm (0.06 in.) greater than that of the thinner of the two plates joined.

## 21 Deckhouses

Side structure of multi-tier superstructure is to be designed to effectively withstand racking forces caused by wind loadings. If required, racking calculations are to be submitted to substantiate the design.

Tween deck pillars and structural bulkheads are to be provided and arranged to effectively transmit deck loadings to supports below. Stiffeners on exterior bulkheads are also to be designed to effectively transmit deck loadings to the main deck. See 3-2-5/13.

### 21.1 Side and End Bulkheads

#### 21.1.1 Plating

Plating is to be of thickness not less than obtained from the following equation:

$t = (3s\sqrt{h}) + 2.5$ mm $t = (s\sqrt{h}/50) + 0.10$ in.

where

$s$ = stiffener spacing, in m (ft)

$h$ = $0.0224L - 0.56$ m ($0.0224L - 1.82$ ft)

$L$ = length of the vessel, in m (ft), as defined in 3-1-1/3, but is not to be taken as less than 50 m (164 ft)

$t$ is not to be taken as less than $t_m$, as defined in the following equation:

$t_m = 4.0 + 0.01L$ mm $\quad$ $t_m = 0.16 + 0.00012L$ in.

21.1.2 Stiffeners

Each stiffener, in association with the plating to which it is attached, is to have a section modulus, *SM*, not less than obtained from the following equation:

$SM = 7.8chs\ell^2$ cm$^3$ $\quad$ $SM = 0.0041chs\ell^2$ in$^3$

where

$c$ = 0.45

$h$ = design head defined in 3-2-5/21.1.1, but not less than 1.4 m (4.6 ft)

$s$ = stiffener spacing, in m (ft)

$\ell$ = tween deck height or the distance between vertical webs, in m (ft)

21.1.3 Vertical Webs

Each vertical web supporting horizontal stiffeners on exterior side and end bulkheads, in association with the plating to which it is attached, is to have a section modulus, *SM*, as obtained from the equation in 3-2-5/21.1.2, where $s$ is the sum of half lengths of the stiffeners supported on each side of the web, in m (ft), and $\ell$ is the tween deck height, in m (ft).

Proportions are to comply with the requirements of 3-2-5/15.1.2i).

### 21.3 Openings in Bulkheads

All openings in exterior bulkheads of superstructures or deckhouses are to be provided with efficient means of closing. Opening and closing appliances are to be framed and stiffened so that the whole structure is equivalent to the unpierced bulkhead when closed.

### 21.5 Doors for Access Openings

Doors for access openings into superstructures or deckhouses are to be weathertight, permanently and strongly attached to the bulkhead, and so arranged that they can be operated from both sides of the bulkhead.

### 21.7 Sills of Access Openings

Openings in exposed positions on the weather decks which lead to spaces below are to have sills at least 150 mm (6 in.) in height. Where these openings lead into passenger areas with intact decks, this height may be reduced or the sills omitted entirely, provided the openings can be made weathertight. Similar consideration may be given where passenger areas contain below-deck access provided it can be shown that flooding of the below deck space into which water could enter through the deck access opening would not adversely affect the stability or trim of the vessel.

## 23 Keels, Stems and Stern Frames

### 23.1 Bar Keels

Where bar keels are used, their thicknesses and depths are to be not less than given by the following equations:

$t = 0.52L + 9.5$ mm $\quad$ $t = 0.0062L + 0.37$ in.

$h = 1.06L + 94.5$ mm $\quad$ $h = 0.0127L + 3.72$ in.

where

$t$ = thickness, in mm (in.)

$h$ = depth, in mm (in.)

$L$ = length of the vessel, as defined in 3-1-1/3.3

## 23.3 Flat Plate Keels

Flat plate keels are not to be of less thickness than required for bottom plating.

## 23.5 Bar Stems

Where bar stems are used, their thicknesses and widths are to be not less than given by the following equations:

$t = 0.38L + 11.0$ mm $t = 0.0046L + 0.44$ in.

$w = 1.09L + 80.0$ mm $w = 0.0131L + 3.15$ in.

where

$t$ = thickness, in mm (in.)

$w$ = width, in mm (in.)

$L$ = length of the vessel, as defined in 3-1-1/3.3

## 23.7 Sternposts

Where bar sternposts are fitted, their thicknesses and widths are to be not less than given by the following equations:

$t = 0.52L + 9.5$ mm $t = 0.0062L + 0.37$ in.

$w = 1.09L + 80.0$ mm $w = 0.0131L + 3.15$ in.

where

$t$ = thickness, in mm (in.)

$w$ = width, in mm (in.)

$L$ = length of the vessel, as defined in 3-1-1/3.3

## 23.9 Stern Frames

### 23.9.1 Inner Posts

Where stern frames are fitted, the thickness and width of the inner post below the shaft boss are to be not less than given by the following equations:

$t = 1.20L + 20.0$ mm $t = 0.0144L + 0.78$ in.

$w = 1.06L + 94.5$ mm $w = 0.0127L + 3.72$ in.

where

$t$ = thickness, in mm (in.)

$w$ = width, in mm (in.)

$L$ = length of the vessel, as defined in 3-1-1/3.3

### 23.9.2 Outer Posts

Where fitted, the outer post is to have a thickness not less than that required for inner posts and a width not less than 80% of that required for inner posts.

### 23.9.3 Shoepiece

The shoepiece is to be as short as possible, the depth is to be at least 10% greater than the above calculated thickness and the breadth at least 20% greater than the above calculated breadth. Gudgeons are to have a thickness of 25% of the rudder stock diameter if bushed and 27.5% if unbushed. The depth of gudgeons is to be not less than 75% of the stock diameter.

## 25 Rudders

### 25.1 Materials

Rudder parts such as stocks, palms, gudgeons, etc., may be of cast or forged steel or fabricated sections made from materials complying with the requirements of Chapter 1 of the ABS *Rules for Materials and Welding (Part 2)*.

### 25.3 Application

This Section refers to single or twin rudders of the balanced or partially balanced type having efficient neck bearings, with or without lower bearings. Where rudders are of unusual shape or design or are associated with construction features which make the formulas of this Subsection inapplicable, the design and calculations are to be submitted for approval. In such cases the design conditions are to be verified during the trials of the vessel.

### 25.5 Rudder Stocks

#### 25.5.1 Upper Stocks

Upper stocks above the neck bearing are to have diameters not less than given by the following equation:

$$S = 12.1\sqrt[3]{bAV^2} \quad \text{mm} \qquad S = 0.2\sqrt[3]{bAV^2} \quad \text{in.}$$

where

$S$ = diameter of upper stock, in mm (in.)

$b$ = horizontal distance from the center of the pintles to the centroid of $A$, in m (ft). See 3-2-5/Figure 2a, b and c.

$A$ = total projected area of the rudder, in m$^2$ (ft$^2$)

$V$ = design speed, in km/h (mph)

The stock diameter is to be adequate for the maximum astern speed.

#### 25.5.2 Lower Stocks on Vessels with Shoepieces

The stock in and below the neck bearing where a top pintle is not fitted is to have a diameter not less than obtained from the following equation:

$$S_1 = 12.1\sqrt[3]{RAV^2} \quad \text{mm} \qquad S_1 = 0.2\sqrt[3]{RAV^2} \quad \text{in.}$$

where

$S_1$ = diameter of lower stock, in mm (in.)

$R$ = $0.25\left[a + \sqrt{a^2 + 16b^2}\right]$

$A$ = total projected area of the rudder, in m$^2$ (ft$^2$)

$a$ = vertical distance from the center of the neck bearing to the centroid of $A$, in m (ft). See 3-2-5/Figure 2a.

$b$ = horizontal distance from the center of the pintles to the centroid of $A$, in m (ft). See 3-2-5/Figure 2a.

$V$ = design speed, in km/h (mph)

The stock is to be of the full diameter for at least two-thirds of the distance from the neck to the bottom bearing and the diameter may be gradually reduced below this point until it is not less than $0.75S_1$ at the bottom of the rudder. Where the diameter of the lower stock in the bottom bearing is less than the diameter of the lower stock at the bottom of the rudder, a suitable transition is to be provided. The bearings are to be bushed, and the bush is to be effectively secured against movement.

25.5.3 Lower Stocks on Vessels with Spade Rudders

The stock in way of and below the neck bearing is to have a diameter not less than obtained from the following equation:

$$S_1 = 12.1\sqrt[3]{RAV^2} \quad \text{mm} \qquad S_1 = 0.2\sqrt[3]{RAV^2} \quad \text{in.}$$

where

$S_1$ = diameter of lower stock, in mm (in.)

$R$ = $a + \sqrt{a^2 + b^2}$

$A$ = total projected area of the rudder in m$^2$ (ft$^2$)

$a$ = vertical distance from the center of the neck bearing to the centroid of $A$, in m (ft). See 3-2-5/Figure 2b.

$b$ = horizontal distance from the centerline of the rudder stock to the centroid of $A$, in m (ft). See 3-2-5/Figure 2b.

$V$ = design speed, in km/h (mph)

The stock is to be of the full diameter to the top of the rudder; the diameter may be gradually reduced below this point until it is $0.33S_1$ at the bottom. Above the neck bearing a gradual transition is to be provided where there is a change in the diameter of the rudder stock. The length of the neck bearing is to be at least $1.5S_1$. An effective upper bearing is to be provided above the neck bearing. This upper bearing may be either part of or separate from the rudder carrier. Both the upper and neck bearings are to be bushed and the bushings are to be effectively secured against movement.

25.5.4 Lower Stocks on Vessels with Horns

The stock in way of and below the neck bearing is to have a diameter not less than obtained from the following equation:

$$S_1 = 12.1\sqrt[3]{RAV^2} \quad \text{mm} \qquad S_1 = 0.2\sqrt[3]{RAV^2} \quad \text{in.}$$

where

$S_1$ = diameter of lower stock, in mm (in.), but in no case is it to be less than 1.05 times the required upper stock diameter.

$R$ = $0.33n + \sqrt{0.11n^2 + b^2}$

$A$ = total projected area of the rudder, in m$^2$ (ft$^2$)

$n$ = $\ell_A - \ell_p$ where $\ell_A \geq \ell_p$

= $(\ell_A/\ell_p)(\ell_A - \ell_p)$ where $\ell_A < \ell_p$

$\ell_A$ = vertical distance from the center of the neck bearing to the centroid of $A$, in m (ft). See 3-2-5/Figure 2c.

$\ell_p$ = vertical distance from the center of the neck bearing to the center of the pintle bearing, in m (ft). See 3-2-5/Figure 2c.

$b$ = horizontal distance from the centerline of the pintle to the centroid of $A$, in m (ft). See 3-2-5/Figure 2c.

$V$ = design speed, in km/h (mph)

The lower stock is to be of the full diameter to the top of the rudder. Below this, the strength of rudder in way of the axis of the stock is to be not less than that of the lower stock required by 3-2-5/25.5.2 and 3-2-5/25.5.3 above.

The bearing is to be bushed and the bushing effectively secured against movement.

Where the rudder horn supports an upper pintle gudgeon, $\ell_A$ and $\ell_p$, may be measured from the center of the upper pintle bearing, and the vertical extent of the upper stock for a rudder with an upper pintle may be as shown in 3-2-5/Figure 2a.

### 25.7 Rudders

Rudders may be of either single or double plate construction and are to have a sufficient number of arms or diaphragms to provide ample stiffness.

### 25.9 Couplings

Couplings in rudder stocks or between stock and rudder are to be equivalent to the required diameter of stock.

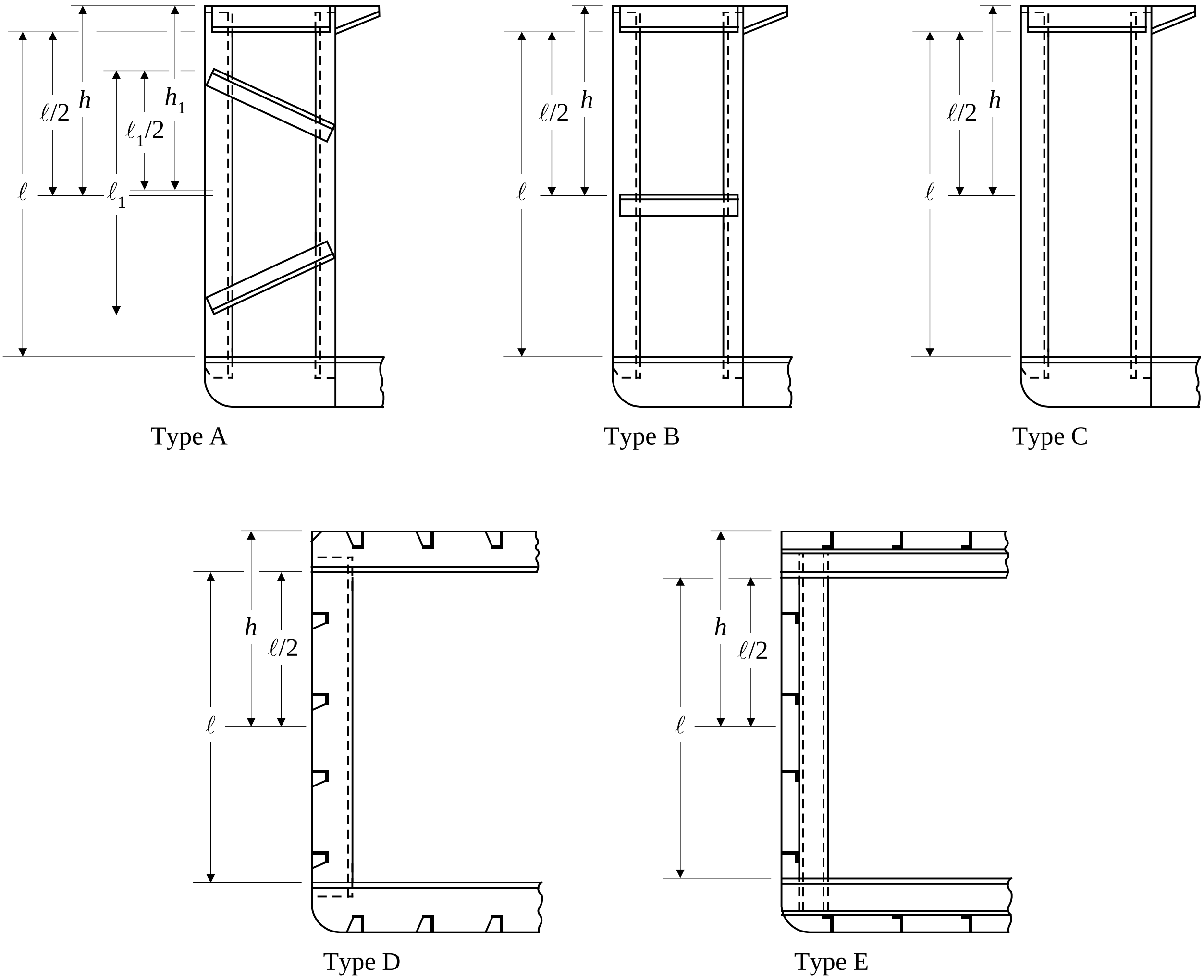
### 25.11 Rudder Stops

Strong and effective rudder stops are to be fitted. Where adequate positive stops are provided within the gear, structural stops will not be required.

### 25.13 Supporting and Anti-Lifting Arrangements

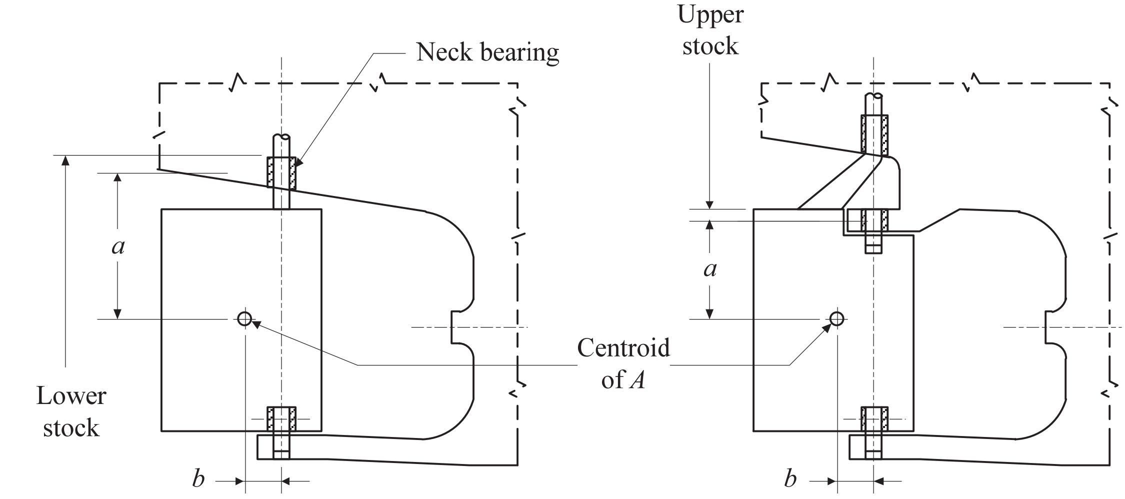
Effective means are to be provided for supporting the weight of the rudder assembly and the horizontal forces on the rudder stock without excessive bearing pressure. They are also to be arranged to prevent accidental unshipping or undue movement of the rudder which may cause damage to the steering gear.

## FIGURE 1
## Passenger Vessel Framing

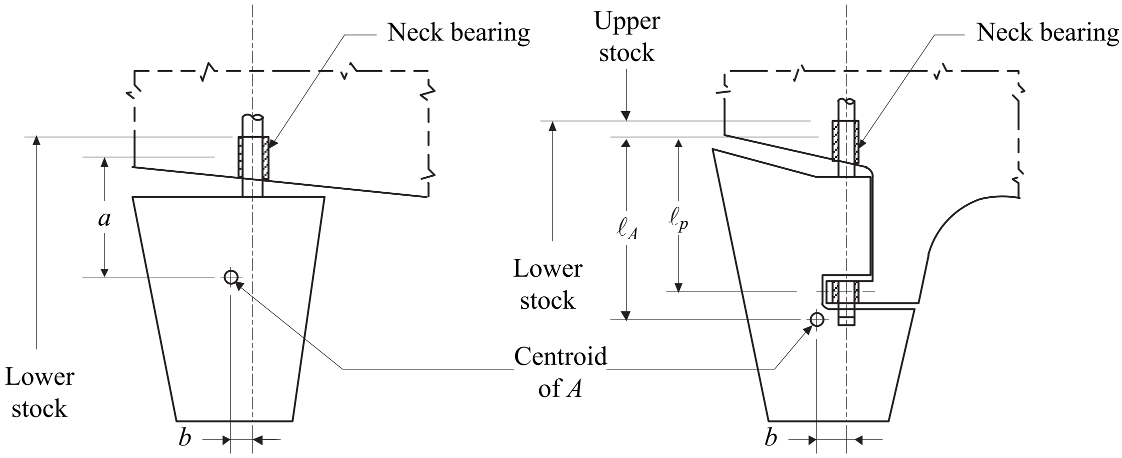



| **Side Frame** | |
|---|---|
| Type A | $c$ = 0.80 (for $h$) |
| Type A | $c$ = 1.38 (for $h_1$) |
| Type B | $c$ = 0.90 |
| Type C | $c$ = 1.00 |
| Type D | $c$ = 1.00 |
| Type E | $c$ = 1.00 |

## FIGURE 2
## Rudder Types




a Rudder on a vessel with shoepiece




b Spade rudder

c Rudder on vessel with horn

PART

# 3

## CHAPTER 2 Hull Structures and Arrangements

## SECTION 6 Weld Design

### 1 Fillet Welds

#### 1.1 General

The actual sizes of fillet welds are to be indicated on detail drawings or on a separate welding schedule and submitted for approval in each individual case.

In general, the weld throat size, *t*, is not to be less than 0.7 times the weld leg size, *w*. Continuous welding may be substituted for intermittent welding. It may be required that special precautions, such as the use of preheat or low-hydrogen electrodes or welding processes, be employed where small fillets are used for attachment to heavy plates. Fillet welds may be made by an approved manual or automatic process.

Where the opening between members exceeds 2.0 mm ($^1/_{16}$ in.) and is not greater than 5 mm ($^3/_{16}$ in.), the size of the fillets is to be increased by the amount of the opening. Spacing between plates forming tee joints is not to exceed 5 mm ($^3/_{16}$ in.).

#### 1.3 Tee-Type Boundary Connections

Tank boundary connections are to have double continuous welding in accordance with 3-2-6/Tables 1A and 1B.

Tight boundaries of dry spaces may have intermittent welding on one side in accordance with 3-2-6/Tables 2A and 2B.

#### 1.5 Tee-Type End Connections

Tee-type end connections where fillet welds are used are to have continuous welds on each side. In general the leg sizes of the welds are to be not less than $^3/_4$ times the thickness of the member being attached, but in special cases where heavy members are attached to relatively light plating, the sizes may be modified. Where only the webs of girders, beams and stiffeners are required to be attached to plating, it is recommended that the unattached face plate or flanges be cut back.

#### 1.7 Other Tee-Type Connections

Frames, beams, bulkhead stiffeners, floors and intercostals, etc., are to have at least the disposition and sizes of intermittent or continuous fillet welds as required by 3-2-6/Tables 1A, 1B, 2A and 2B.

The stem of a non-watertight tee connection is to be scalloped in way of the joint of both members forming the tee.

#### 1.9 Lapped Joints

Lapped joints are generally to have overlaps of not less width than twice the thinner plate thickness plus 25 mm (l. in.). Both edges of an overlap joint are to have fillet welds which, depending on the members to be connected, may be continuous or intermittent and of the size, *w*, as required by 3-2-6/1.11 or 3-2-6/1.13.

### 1.11 Overlapped End Connections

Overlapped end connections of longitudinal strength members within the midship 0.5*L* are to have continuous fillet welds on both edges each equal in size, *w*, to the thickness of the thinner of the two plates joined. All other overlapped end connections are to have continuous welds on each edge of sizes *w* such that the sum of the two is not less than 1.5 times the thickness of the thinner plate. In addition, for stanchions and diagonals, Note 3 of 3-2-6/Tables 1A, 1B, 2A and 2B is to be complied with. For channel members not attached to plating, the minimum weld area of the end connections based on the throat dimension of the fillet is not to be less than 75% of the sectional area of the channel.

### 1.13 Overlapped Seams

Overlapped seams are to have welds on both edges of the sizes required by 3-2-6/1.7 for tee connections at boundaries.

### 1.15 Plug Welds or Slot Welds

Plug welds or slot welds may be specially approved for particular applications. Where used in the body of doublers and similar locations, such welds may be spaced about 300 mm (12 in.) between centers in both directions.

### 1.17 Widely Spaced Floors *(2017)*

Widely spaced floors are those which typically support longitudinally framed bottom/inner bottom structure. Closely spaced floors which function as the stiffeners for bottom/inner bottom plating are not considered wide spaced floors.

## 3 Alternatives

The foregoing are considered minimum requirements for electric-arc welding in hull construction, but alternative methods, arrangements and details will be considered for approval. The *Steel Vessel Rules* will be an acceptable alternative. Fillet weld sizes may be determined from structural analyses based on sound engineering principles provided they meet the overall strength standards of the Rules.

## TABLE 1A
## Double Continuous Fillet Weld Sizes – Millimeters

For weld requirements for thicknesses intermediate to those shown in the Table use the nearest lower thickness shown in the table.

| *Structural Items* | | *Weld Size for Lesser Thickness of Members Joined, mm* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* |
| **Beams** | | | | | | | | | | | | |
| Transverse or longitudinal to deck | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| **Bulkhead Plating** | | | | | | | | | | | | |
| Oiltight, watertight bulkheads – periphery | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.5 | 4.5 | 5.0 | 5.5 | 5.5 | 6.0 |
| **Bulkhead Stiffeners** | | | | | | | | | | | | |
| Deep tank bulkhead | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Watertight bulkhead | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Non-watertight bulkhead | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| **Center Girder** | | | | | | | | | | | | |
| To inner bottom or rider plate in way of engine and to shell or bar keel | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 5.5 | 6.0 | 6.0 | 6.5 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.0 | 4.5 | 4.5 | 4.5 |
| To inner bottom or rider plate and clear of engine | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 5.5 | 6.0 | 6.0 | 6.5 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.0 | 4.5 | 4.5 | 4.5 |
| **Frames and Floors** | | | | | | | | | | | | |
| To shell in tanks and peaks | *w* | – | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 |
| | *t* | – | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 |
| To shell elsewhere | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| **Wide Spaced Frames and Floors** | | | | | | | | | | | | |
| To shell, deck, inner bottom and longitudinal bulkheads | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| **Floors – Single Bottom** | | | | | | | | | | | | |
| To center keelson | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.5 | 4.5 | 5.0 | 5.5 | 5.5 | 6.0 |
| **Floors – Double Bottom** | | | | | | | | | | | | |
| Solid floors to center vertical keel plate in engine room, under boiler bearers | *w* | 5.0 | 5.5 | 5.5 | 6.0 | 6.5 | 7.5 | 8.0 | 9.0 | 9.5 | 10.5 | 11.0 |
| | *t* | 3.5 | 4.0 | 4.0 | 4.5 | 4.5 | 5.5 | 5.5 | 6.5 | 6.5 | 7.5 | 8.0 |
| Solid floors to center vertical keel plate elsewhere and open floor brackets to center vertical keel | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Solid floors and open floor brackets to margin plate | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.5 | 4.5 | 5.0 | 5.5 | 5.5 | 6.0 |
| To inner bottom in engine room | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.5 | 4.5 | 5.0 | 5.5 | 5.5 | 6.0 |
| To inner bottom elsewhere | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |

## TABLE 1A (continued)
## Weld Sizes and Spacing – Millimeters

For weld requirements for thicknesses intermediate to those shown in the Table use the nearest lower thickness shown in the table.

| *Structural Items* | | *Weld Size for Lesser Thickness of Members Joined, mm* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* |
| **Foundations** | | | | | | | | | | | | |
| To top plates, shell or inner bottom for main engines and major auxiliaries | *w* | 5.0 | 5.0 | 5.5 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| | *t* | 3.5 | 3.5 | 4.0 | 4.0 | 4.5 | 4.5 | 5.0 | 5.5 | 5.5 | 6.0 | 6.5 |
| **Girders, Webs and Trusses** | | | | | | | | | | | | |
| To shell and to bulkheads or decks in tanks | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 5.5 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3,5 | 3.5 | 3.5 | 4.0 | 4.0 |
| To bulkheads or decks elsewhere | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 |
| Webs to face plates | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 |
| **Intercostals** | | | | | | | | | | | | |
| To shell and inner bottom in way of engines | *w* | – | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.5 | 5.5 | 6.0 | 6.0 | 6.5 |
| | *t* | – | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 4.0 | 4.5 | 4.5 | 4.5 |
| To shell and inner bottom elsewhere, to floors | *w* | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | *t* | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |

## TABLE 1B
## Double Continuous Fillet Weld Sizes – Inches

For weld requirements for thicknesses intermediate to those shown in the Table use the nearest lower thickness shown in the table.

| | *Weld Size for Lesser Thickness of Members Joined, in.* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Structural Items* | *0.20* | *0.24* | *0.28* | *0.32* | *0.36* | *0.40* | *0.44* | *0.48* | *0.52* | *0.56* | *0.60* |
| **Beams** | | | | | | | | | | | |
| Transverse or longitudinal to deck | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| **Bulkhead Plating** | | | | | | | | | | | |
| Oiltight, watertight bulkheads – periphery | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 |
| **Bulkhead Stiffeners** | | | | | | | | | | | |
| Deep tank bulkhead | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| Watertight bulkhead | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| Non-watertight bulkhead | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| **Center Girder** | | | | | | | | | | | |
| To inner bottom or rider plate in way of engine and to shell or bar keel | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4 | 1/4 | 1/4 |
| To inner bottom or rider plate and clear of engine | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4 | 1/4 | 1/4 |
| **Frames and Floors** | | | | | | | | | | | |
| To shell in tanks and peaks | – | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| To shell elsewhere | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| **Wide Spaced Frames and Floors** | | | | | | | | | | | |
| To shell, deck, inner bottom and longitudinal bulkheads | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| **Floors – Single Bottom** | | | | | | | | | | | |
| To center keelson | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 |
| **Floors – Double Bottom** | | | | | | | | | | | |
| Solid floors to center vertical keel plate in engine room, under boiler bearers | 3/16 | 7/32 | 7/32 | 1/4 | 1/4 | 5/16 | 5/16 | 3/8 | 3/8 | 7/16 | 7/16 |
| Solid floors to center vertical keel plate elsewhere and open floor brackets to center vertical keel | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| Solid floors and open floor brackets to margin plate | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 |
| To inner bottom in engine room | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 |
| To inner bottom elsewhere | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| **Foundations** | | | | | | | | | | | |
| To top plates, shell or inner bottom for main engines and major auxiliaries | 3/16 | 3/16 | 7/32 | 7/32 | 1/4 | 1/4 | 9/32 | 5/16 | 5/16 | 11/32 | 3/8 |
| **Girders, Webs and Trusses** | | | | | | | | | | | |
| To shell and to bulkheads or decks in tanks | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 |
| To bulkheads or decks elsewhere | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 |
| Webs to face plates | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |
| **Intercostals** | | | | | | | | | | | |
| To shell and inner bottom in way of engines | – | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 | 7/32 | 1/4 | 1/4 | 1/4 |
| To shell and inner bottom elsewhere, to floors | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 7/32 |

# TABLE 2A
# Intermittent Fillet Weld Sizes and Spacing – Millimeters

For weld requirements for thicknesses intermediate to those shown in the Table use the nearest lower thickness shown in the table.

Weld sizes other than given in the table may be used provided the spacing of welds is modified to give equivalent strength.

For double continuous weld sizes equivalent to the intermittent welds see 3-2-6/Table 1A.

| | *Weld size for lesser thickness of members joined, mm* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *5* | *6.5* | *8* | *9.5* | *11* | *12.5* | *14* |
| Length of fillet weld | 40 | 65 | 65 | 65 | 65 | 65 | 65 |
| Nominal leg size of fillet *w* | 4.5 | 5.0 | 6.5 | 6.5 | 8.0 | 8/0 | 9.5 |
| Nominal throat size of fillet *t* | 3.0 | 3.5 | 4.5 | 4.5 | 5.5 | 5.5 | 6.5 |
| *Structural Items* | *Spacing of Welds S, mm* | | | | | | |
| **Beams** | | | | | | | |
| Transverse or longitudinal to deck | *300 | *300 | 300 | 300 | 300 | 300 | 300 |
| **Watertight Bulkhead Plating – Periphery** | | | | | | | |
| One side | Continuous weld of leg size of plate thickness less than 2.0 mm | | | | | See 3-2-6/Table 1A for double continuous weld | |
| Other side | — | 250 | 250 | 250 | 250 | See 3-2-6/Table 1A for double continuous weld | |
| **Bulkhead Stiffeners (See Note 5)** | | | | | | | |
| Deep tank bulkhead | — | 250 | 250 | 250 | 250 | 250 | 250 |
| Watertight bulkhead | — | *300 | 300 | 300 | 300 | 300 | 300 |
| Non-watertight bulkhead | *300 | *350 | *350 | *350 | *350 | *350 | *350 |
| **Center Girder (See Note 6)** | | | | | | | |
| To inner bottom or rider plate in way of engine and to shell or bar keel † | — | 150 | 150 | 150 | 150 | 150 | 150 |
| To inner bottom or rider plate and clear of engine | — | 150 | 150 | 150 | 150 | 150 | 150 |
| **Frames and Floors (See Notes 5 & 7)** | | | | | | | |
| To shell in tanks and peaks | — | — | 250 | 250 | 250 | 250 | 250 |
| To shell elsewhere | *300 | *300 | 300 | 300 | 300 | 300 | 300 |
| **Wide Spaced Frames and Floor** | | | | | | | |
| To shell, deck, inner bottom and longitudinal | — | 150 | 150 | 150 | 150 | 150 | 150 |
| **Floors – Single Bottom** | | | | | | | |
| To center keelson | See 3-2-6/Table 1A for double continuous welds | | | | | | |
| **Floors – Double Bottom (See Note 7)** | | | | | | | |
| Solid floors to center vertical keel plate in engine room, under boiler bearers | See 3-2-6/Table 1A for double continuous welds | | | | | | |
| Solid floors to center vertical keel plate elsewhere, and open-floor brackets to center vertical keel | — | *250 | *250 | 250 | 250 | 250 | 250 |
| Solid floors and open-floor brackets to margin plate | See 3-2-6/Table 1A for double continuous welds | | | | | | |
| To inner bottom in engine room | See 3-2-6/Table 1A for double continuous welds | | | | | | |
| To inner bottom elsewhere | *300 | *300 | 300 | 300 | 300 | 300 | 300 |

## TABLE 2A (continued)
## Intermittent Fillet Weld Sizes and Spacing – Millimeters

| | *Weld size for lesser thickness of members joined, mm* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *5* | *6.5* | *8* | *9.5* | *11* | *12.5* | *14* |
| Length of fillet weld | 40 | 65 | 65 | 65 | 65 | 65 | 65 |
| Nominal leg size of fillet *w* | 4.5 | 5.0 | 6.5 | 6.5 | 8.0 | 8/0 | 9.5 |
| Nominal throat size of fillet *t* | 3.0 | 3.5 | 4.5 | 4.5 | 5.5 | 5.5 | 6.5 |

| *Structural Items* | *Spacing of Welds S, mm* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Foundations** | | | | | | | |
| To top plates, shell or inner bottom for main engines and major auxiliaries | See 3-2-6/Table 1A for double continuous welds | | | | | | |
| **Girders, Webs and Trusses** | | | | | | | |
| To shell and to bulkheads or decks in tanks | — | 200 | 225 | 225 | 225 | 225 | 225 |
| To bulkheads or decks elsewhere | — | 250 | 250 | 250 | 250 | 250 | 250 |
| Webs to face plate | *250 | *250 | 300 | 300 | 300 | 300 | 300 |
| **Intercostals** | | | | | | | |
| To shell and inner bottom in way of engine † | — | 150 | 150 | 150 | 150 | 150 | 150 |
| To shell and inner bottom elsewhere, to floors | *275 | *275 | 275 | 275 | 275 | 275 | 275 |

*See General Notes at beginning of Table.*

* Fillet welds are to be staggered.

† Length of fillet to be 75 mm

*Notes*

1. Where beams, stiffeners, frames, etc., pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection, and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.
2. Longitudinal frames are to have 150 mm of double continuous welding at their ends and in way of transverses except as follows. Deck longitudinals require 150 mm double continuous welding at ends. Side and deck longitudinals in way of cargo spaces in open hopper barges require a matched pair of welds at their ends.
3. The required welding area of end connections of stanchions and diagonals is not to be less than the following:
    - Stanchions – 75% of the area of the stanchions
    - Diagonals – 50% of the area of the diagonal

    In determining the weld area provided, the throat dimension of the fillet is to be used.
4. Brackets generally welded 75 mm on 150 mm centers, both sides. Length of fillet weld based on lesser thickness of members joined.
5. Unbracketed shell and bulkhead stiffeners are to have double continuous welds for one-tenth of their length at each end.
6. Where center girders are water- or oil-tight a continuous weld is to be used on one side of the connections.
7. Tank end floors are to be welded to shell, center girder and inner bottom as required for deep tank bulkheads.

## TABLE 2B
## Intermittent Fillet Weld Sizes and Spacing – Inches

For weld requirements for thicknesses intermediate to those shown in the Table use the nearest lower thickness shown in the table.

Weld sizes other than given in the table may be used provided the spacing of welds is modified to give equivalent strength.

For double continuous weld sizes equivalent to the intermittent welds see 3-2-6/Table 1B.

| | *Weld size for lesser thickness of members joined, in.* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *0.20* | *0.26* | *0.32* | *0.38* | *0.44* | *0.50* | *0.58* |
| Length of fillet weld | $1^{1}/_{2}$ | $2^{1}/_{2}$ | $2^{1}/_{2}$ | $2^{1}/_{2}$ | $2^{1}/_{2}$ | $2^{1}/_{2}$ | $2^{1}/_{2}$ |
| Nominal leg size of fillet *w* | $^{3}/_{16}$ | $^{3}/_{16}$ | $^{1}/_{4}$ | $^{1}/_{4}$ | $^{5}/_{16}$ | $^{5}/_{16}$ | $^{3}/_{8}$ |

| *Structural Items* | *Spacing of Welds S, in.* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Beams** | | | | | | | |
| Transverse or longitudinal to deck | *12 | *12 | 12 | 12 | 12 | 12 | 12 |
| **Watertight Bulkhead Plating – Periphery** | | | | | | | |
| One side | Continuous weld of leg size of plate thickness less than $^{1}/_{16}$ in. | | | | | See 3-2-6/Table 1B for double continuous weld | |
| Other side | — | 10 | 10 | 10 | 10 | See 3-2-6/Table 1B for double continuous weld | |
| **Bulkhead Stiffeners (See Note 5)** | | | | | | | |
| Deep tank bulkhead | — | 10 | 10 | 10 | 10 | 10 | 10 |
| Watertight bulkhead | — | *12 | 12 | 12 | 12 | 12 | 12 |
| Non-watertight bulkhead | *12 | *14 | *14 | *14 | *14 | *14 | *14 |
| **Center Girder (See Note 6)** | | | | | | | |
| To inner bottom or rider plate in way of engine and to shell or bar keel † | — | 6 | 6 | 6 | 6 | 6 | 6 |
| To inner bottom or rider plate and clear of engine | — | 6 | 6 | 6 | 6 | 6 | 6 |
| **Frames and Floors (See Notes 5 & 7)** | | | | | | | |
| To shell in tanks and peaks | — | — | 10 | 10 | 10 | 10 | 10 |
| To shell elsewhere | *12 | *12 | 12 | 12 | 12 | 12 | 12 |
| **Wide Spaced Frames and Floor** | | | | | | | |
| To shell, deck, inner bottom and longitudinal | — | 6 | 6 | 6 | 6 | 6 | 6 |
| **Floors – Single Bottom** | | | | | | | |
| To center keelson | See 3-2-6/Table 1B for double continuous welds | | | | | | |
| **Floors – Double Bottom (See Note 7)** | | | | | | | |
| Solid floors to center vertical keel plate in engine room, under boiler bearers | See 3-2-6/Table 1B for double continuous welds | | | | | | |
| Solid floors to center vertical keel plate elsewhere, and open-floor brackets to center vertical keel | — | *10 | *10 | 10 | 10 | 10 | 10 |
| Solid floors and open-floor brackets to margin plate | See 3-2-6/Table 1B for double continuous welds | | | | | | |
| To inner bottom in engine room | See 3-2-6/Table 1B for double continuous welds | | | | | | |
| To inner bottom elsewhere | *12 | *12 | 12 | 12 | 12 | 12 | 12 |

## TABLE 2B (continued)
## Intermittent Fillet Weld Sizes and Spacing – Inches

| | *Weld size for lesser thickness of members joined, in.* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *0.20* | *0.26* | *0.32* | *0.38* | *0.44* | *0.50* | *0.58* |
| Length of fillet weld | 1 1/2 | 2 1/2 | 2 1/2 | 2 1/2 | 2 1/2 | 2 1/2 | 2 1/2 |
| Nominal leg size of fillet *w* | 3/16 | 3/16 | 1/4 | 1/4 | 5/16 | 5/16 | 3/8 |

| *Structural Items* | *Spacing of Welds S, in.* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Foundations** | | | | | | | |
| To top plates, shell or inner bottom for main engines and major auxiliaries | See 3-2-6/Table 1B for double continuous welds | | | | | | |
| **Girders, Webs and Trusses** | | | | | | | |
| To shell and to bulkheads or decks in tanks | — | 8 | 9 | 9 | 9 | 9 | 9 |
| To bulkheads or decks elsewhere | — | 10 | 10 | 10 | 10 | 10 | 10 |
| Webs to face plate | *10 | *10 | 12 | 12 | 12 | 12 | 12 |
| **Intercostals** | | | | | | | |
| To shell and inner bottom in way of engine † | — | 6 | 6 | 6 | 6 | 6 | 6 |
| To shell and inner bottom elsewhere, to floors | *11 | *11 | 11 | 11 | 11 | 11 | 11 |

*See General Notes at beginning of Table.*

* Fillet welds are to be staggered.

† Length of fillet to be 3 in.

*Notes*

1 Where beams, stiffeners, frames, etc., pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection, and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.

2 Longitudinal frames are to have 6 inches of double continuous welding at their ends and in way of transverses except as follows. Deck longitudinals require 6 inches double continuous welding at ends. Side and deck longitudinals in way of cargo spaces in open hopper barges require a matched pair of welds at their ends.

3 The required welding area of end connections of stanchions and diagonals is not to be less than the following:

- Stanchions – 75% of the area of the stanchions
- Diagonals – 50% of the area of the diagonal

In determining the weld area provided, the throat dimension of the fillet is to be used.

4 Brackets generally welded 3 inches on 6 inch centers, both sides. Length of fillet weld based on lesser thickness of members joined.

5 Unbracketed shell and bulkhead stiffeners are to have double continuous welds for one-tenth of their length at each end.

6 Where center girders are water- or oil-tight a continuous weld is to be used on one side of the connections.

7 Tank end floors are to be welded to shell, center girder and inner bottom as required for deep tank bulkheads.

PART

# 3

## CHAPTER 3 Subdivision and Stability

### CONTENTS

PART

# 3

## CHAPTER 3 Subdivision and Stability

## SECTION 1 Passenger Vessels

### 1 Definitions

#### 1.1 Margin Line

The *Margin Line* is a line drawn at least 76 mm (3 in.) below the upper surface of the main deck at side.

#### 1.3 Deepest Subdivision Draft

*Deepest Subdivision Draft* is the waterline which corresponds to the greatest draft permitted by the subdivision requirements which are applicable.

### 3 Intact Stability

#### 3.1 Vessels Over 100 Gross Tons, Greater than 20 m (65 ft) in Length, or Carrying 50 or More Passengers

The metacentric height, *GM*, of these vessels is to be as indicated by the following equations in each condition of loading and operation, except that vessels under 20 m (65 ft) in length, of 100 gross tons or less, and carrying between 50 and 150 passengers need only comply with Equation 1.

$$GM \geq PAH/[W \tan(T)] \quad (1)$$

$$GM \geq Nb/[KW \tan(T)] \quad (2)$$

where

$P$ = $0.028 + (L/1309)^2$ tf/m$^2$ ($0.0025 + [L/14200]^2$ Ltf/ft$^2$)

$L$ = length of the vessel, in m (ft), as defined in 3-1-1/3

$A$ = projected lateral area of the portion of the vessel above the waterline, in m$^2$ (ft$^2$)

$H$ = vertical distance from the center of $A$ to the center of the vessel's underwater lateral area, or approximately to the one-half draft point, in m (ft)

$W$ = force corresponding to the displacement of the vessel, in tf (Ltf)

$T$ = 14° or the angle of heel at which one half of the freeboard to the deck edge is immersed, whichever is less.

$N$ = number of passengers

$b$ = distance from the centerline of the vessel to the geometric center of the passenger deck on one side of the centerline, in m (ft)

$K$ = 23.6 passengers/tf (24 passengers/Ltf)

### 3.3 Self-propelled Vessels Under 100 m (328 ft) in Length

These vessels are to comply with 3-3-1/3.3.1 or 3-3-1/3.3.2 below. For the purpose of demonstrating compliance with 3-3-1/3.3.1 or 3-3-1/3.3.2 below, at each angle of heel the vessel's righting arm is to be calculated after the vessel is permitted to trim freely until the trimming moment is zero.

#### 3.3.1 Vessels with Maximum Righting Arm Occurring at an Angle of Heel > 30°

These vessels are to have:

*i)* An initial metacentric height (*GM*) of at least 0.15 m (0.49 ft).

*ii)* A maximum righting arm (*GZ*) of at least 0.20 m (0.66 ft) at an angle of heel equal to or greater than 30°

*iii)* An area under each righting arm curve of at least 3.15 m-degrees (10.3 ft-degrees) up to an angle of heel of 30°.

*iv)* An area under each righting arm curve of at least 5.15 m-degrees (16.9 ft-degrees) up to an angle of heel of 40°, or the downflooding angle, whichever is less, and

*v)* An area under each righting arm curve between the angles of 30° and 40°, or between 30° and the downflooding angle, if this angle is less than 40°, of not less than 1.72 m-degrees (5.6 ft-degrees).

#### 3.3.2 Vessels with Maximum Righting Arm Occurring at an Angle of Heel ≤ 30°

These vessels are to comply with 3-3-1/3.3.1 or are to have;

*i)* An initial metacentric height (*GM*) of at least 0.15 m (0.49 ft).

*ii)* A maximum righting arm that occurs at an angle of heel not less than 15°.

*iii)* An area under each righting arm curve of at least 5.15 m-degrees (16.9 ft-degrees) up to an angle of heel of 40°, or the downflooding angle, whichever is less, and

*iv)* An area under each righting arm curve between the angles of 30° and 40°, or between 30° and the downflooding angle, if this angle is less than 40°, of not less than 1.72 m-degrees (5.6 ft-degrees).

*v)* An area under each righting arm curve up to the angle of maximum righting arm of not less than the area determined by the following equations:

$$A = 3.15 + 0.057(30 - Y) \text{ m-degrees} \qquad A = 10.3 + 0.187(30 - Y) \text{ ft-degrees}$$

where

$A$ = area, in m-degrees (ft-degrees)

$Y$ = angle of maximum righting, in degrees

## 5 Damage Stability

All vessels over 100 gross tons, greater than 20 m (65 ft) in length, or carrying more than 150 passengers, are to comply with a one-compartment standard of flooding (no damage to any main transverse watertight bulkhead), irrespective of the maximum number of passengers carried. The following assumptions are to be made in determining compliance with the one compartment standard.

### 5.1 Permeability

The following uniform average permeabilities are to be assumed:

*i)* Cargo, stores and baggage spaces: *60%.*

*ii)* Machinery spaces: 85%

*iii)* Tanks: 0% or 95%, whichever results in the most disabling condition.

*iv)* All other spaces: 95%.

### 5.3 Extent of Damage

#### 5.3.1 Vessels of 43.5 m (143 ft) in Length or Greater

For vessels 43.5 m (143 ft) or more in length, the following extent of damage is to be assumed:

*5.3.1(a) Longitudinal penetration.* 3 m (10 ft) plus 3% of the vessel's length, or 10.7 m (35 ft) whichever is less.

*5.3.1(b) Transverse penetration.* $B/5$ where $B$ is the mean of the maximum beam at the bulkhead deck and the maximum beam at the deepest subdivision draft, applied inboard from the side of the vessel, at right angles to the centerline, at the level of the deepest subdivision draft.

*5.3.1(c) Vertical penetration.* Upward without limit.

#### 5.3.2 Vessels Under 43.5 m (143 ft) in Length

For vessels less than 43.5 m (143 ft) in length, the following extent of damage is to be assumed:

*5.3.2(a) Longitudinal penetration.* 1.8 m (6 ft) or 10% of the vessel's length, whichever is greater.

*5.3.2(b) Transverse penetration.* $B/5$ where $B$ is the mean of the maximum beam at the bulkhead deck and the maximum beam at the deepest subdivision draft, applied inboard from the side of the vessel, at right angles to the centerline, at the level of the deepest subdivision draft.

*5.3.2(c) Vertical penetration.* Upward without limit.

## 7 Portlights in Cargo Spaces Located Below the Margin Line

Portlights located below the margin line are to be fitted with tempered monolithic glass of thickness obtained from the following equation and are to comply with *i)*, *ii)* and *iii)*, below.

$t = 0.033d$ $\qquad$ $t_{min} = 8.0$ mm (0.31 in.)

where

$d$ = clear glass diameter, in mm (in.)

$t$ = glass thickness, in mm (in.)

*i)* Portlights are not to be fitted in any spaces which are used exclusively for the carriage of cargo.

*ii)* Portlights may be fitted in spaces used alternatively for the carriage of cargo or passengers, but they are to be of such construction as will effectively prevent any unauthorized opening.

*iii)* If cargo is carried in spaces mentioned in *ii)*, the portlights and their deadlights are to be closed watertight and locked before the cargo is shipped.

## 9 Automatic Ventilating Portlights

Automatic ventilating portlights are not to be fitted in the shell plating below the margin line without special approval.

## 11 Shell Connections Located Below the Margin Line

### 11.1

All inlets and discharges in the shell plating are to be fitted with efficient and accessible arrangements for preventing the accidental ingress of water into the vessel.

### 11.3

Except as provided in 3-3-1/11.5, each separate discharge led through the shell plating from spaces below the margin line is to be provided with either one automatic non-return valve fitted with a positive means of closing from above the bulkhead deck or with two automatic non-return valves without positive means of closing, provided that the inboard valve is situated above the deepest draft and is always accessible for examination under service conditions. Where a valve with positive means of closing is fitted, the operating position above the bulkhead deck is always to be readily accessible, and means are to be provided for indicating whether the valve is open or closed.

### 11.5

Machinery space main and auxiliary sea inlets and discharges used in connection with the operation of machinery are to be fitted with readily accessible valves between the pipes and the shell plating or between the pipes and fabricated boxes attached to the shell plating. The valves may be controlled locally and are to be provided with indicators showing whether they are open or closed.

## 13 Gangway and Cargo Ports Located Below the Margin Line

### 13.1

Gangway and cargo ports fitted below the margin line are to be of sufficient strength. They are to be capable of being effectively closed and secured watertight. The scantlings of the ports are to be equivalent to the scantlings required by the Rules for the hull structure in that location. Ports should normally open outboard. Ports which open inboard are to have portable strong-backs or props in addition to the regular dogs. If accessible during service, they are to be fitted with a device which prevents unauthorized opening. Shell doublers or insert plates are to be fitted to compensate for the openings and the corners of openings are to be well rounded. Indicators showing whether the ports are open or secured closed are to be located in the wheelhouse or main control center.

### 13.3

Such ports are to be so located as to have their lowest point above the deepest draft waterline.

## 15 Openings and Penetrations in Watertight Bulkheads

### 15.1

The number of openings in watertight bulkheads is to be reduced to the minimum compatible with the design and proper working of the vessel; satisfactory means are to be provided for closing these openings.

### 15.3

Valves not forming part of a piping system are not permitted in watertight subdivision bulkheads.

### 15.5

Lead or other heat sensitive materials are not to be used in systems which penetrate watertight subdivision bulkheads, where deterioration of such material would in the event of a fire, impair the watertight integrity of the bulkheads.

### 15.7

Except as provided in 3-3-1/15.9, the collision bulkhead may be pierced below the margin line by not more than one pipe for dealing with fluid in the forepeak, provided that the pipe is fitted with a screwdown valve capable of being operated from above the bulkhead deck; the valve chest being located on the collision bulkhead inside the forepeak.

### 15.9

If the forepeak is divided to hold two kinds of liquids, the collision bulkhead may be pierced below the margin line by two pipes, each of which is fitted as required by paragraph d, provided there is no practical alternative to the fitting of such a second pipe and that, having regard to the additional subdivision provided in the forepeak, the safety of the vessel is maintained.

## 17 Doors, Manholes and Access Openings

Doors, manholes, or access openings are not permitted:

*i)* In the collision bulkhead below the margin line;

*ii)* In watertight transverse bulkheads dividing a cargo space from an adjoining cargo space or from a permanent or reserve bunker, except as provided in 3-3-1/25.

## 19 Shaft Tunnel Door and Doors within Propulsion Machinery Spaces

Within spaces containing the main and auxiliary propulsion machinery including boilers serving the needs of propulsion, not more than one watertight door, apart from the watertight doors to shaft tunnels, is to be fitted in each main transverse bulkhead. Where two or more shafts are fitted, the tunnels are to be interconnected by a passage. There is to be only one watertight door between the machinery space and the tunnel spaces where two shafts are fitted, and only two watertight doors where there are more than two shafts. All these watertight doors are to be of the sliding type and are to be so located as to have their sills as high as practicable. The hand gear for operating these doors from above the bulkhead deck is to be situated outside the spaces containing the machinery. See also 4-4-1/25.9.4.

## 21 Watertight Doors in Watertight Bulkheads

### 21.1

Watertight doors, except as provided in 3-3-1/25 are to be power-operated sliding doors complying with the requirements of 3-3-1/23 capable of being closed simultaneously from the central operating console at the navigation bridge (or main control station) in not more than 60 seconds with the vessel in the upright position.

### 21.3

The means of operation whether by power or by hand of any power-operated sliding watertight door is to be capable of closing the door with the vessel listed to 15° either way. Consideration is also to be given to the forces which may act on either side of the door as may be experienced when water is flowing through the opening applying a static head equivalent to a water height of at least 1 m (3.28 ft) above the sill on the centerline of the door.

### 21.5

Watertight door controls, including hydraulic piping and electric cables, are to be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimize the likelihood of them being involved in any damage which the vessel may sustain. The positioning of watertight doors and their controls are to be such that if the vessel sustains damage within one fifth of the breadth of the vessel, as defined in 3-1-1/5, such distance being measured at right angles to the centerline at the level of the deepest subdivision load line, the operation of the watertight doors clear of the damaged portion of the vessel is not impaired.

### 21.7

All power-operated sliding watertight doors are to be provided with means of indication which will show at all remote operating positions whether the doors are open or closed. Remote operating positions are to be at the navigation bridge (or main control station) as required by 3-3-1/23.1.5 and, at the location where hand operation above the bulkhead deck is required by 3-3-1/23.1.4.

### 21.9 *(2014)*

Watertight doors are to be tested for operation at the manufacturer's plant. Watertightness of doors which become immersed by an equilibrium or intermediate waterplane at any stage of assumed flooding is to be confirmed by prototype hydrostatic testing at the manufacturer's plant. The head of water used for the test shall correspond at least to the head measured from the lower edge of the door opening, at the location in which the door is to be fitted in the vessel, to:

*i)* The bulkhead deck or freeboard deck, as applicable, or

*ii)* The most unfavorable damage waterplane, if that be greater

Tests are to be carried out in the presence of the Surveyor and a test certificate is to be issued.

For large doors intended for use in the watertight subdivision boundaries of cargo spaces, structural analysis may be accepted in lieu of pressure testing subject to ABS review. Where gasket seals are utilized for such doors, a prototype pressure test is be carried out to verify that the gasket material under the compression is capable of withstanding any deflection indicated in the structural analysis.

Doors above freeboard or bulkhead deck, which are not immersed by an equilibrium or intermediate waterplane but become intermittently immersed at angles of heel in the required range of positive stability beyond the equilibrium position, are to be hose tested after installation onboard.

## 23 Power-operated Sliding Watertight Doors

### 23.1

Each power-operated sliding watertight door is to comply with the following:

#### 23.1.1

Have either a vertical or a horizontal motion;

#### 23.1.2

Subject to 3-3-1/27, normally being limited to a maximum clear opening width of 1.2 m (3.94 ft). Larger doors may be considered to the extent necessary for the effective operation of the vessel provided that other safety measures, including the following, are taken into consideration:

*i)* Special consideration is to be given to the strength of the door and its closing appliances in order to prevent leakages;

*ii)* The door is to be located inboard of the transverse extent of damage ($B$/5);

*iii)* The door is to be kept closed when the vessel is in service, except the door may be opened for limited periods when absolutely necessary.

#### 23.1.3

Be fitted with the necessary equipment to open and close the door using electric power, hydraulic power, or any other acceptable form of power.

#### 23.1.4

Be provided with an individual hand-operated mechanism. It is to be possible to open and close the door by hand from either side of the door, and in addition, close the door from an accessible position above the bulkhead deck with an all round crank motion or some other movement providing the same acceptable degree of safety. Direction of rotation or other movement is to be clearly indicated at all operating positions. The time necessary for the complete closure of the door, when operating by hand gear, is not to exceed 90 seconds with the vessel in the upright position;

23.1.5

Be provided with controls for opening and closing the door by power from both sides of the door and also for closing the door by power from the central operating console at the navigation bridge (or main control station);

23.1.6

Be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which is to sound for at least five seconds but no more than ten seconds before the door begins to move and is to continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving. Additionally, in passenger areas and areas of high ambient noise, the audible alarm is to be supplemented by a warning sign posted on each side of the door, an intermittent visual signal at the door; and

23.1.7

Have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position, is to be not less than 20 seconds or more than 40 seconds with the vessel in the upright position.

## 23.3

The electrical power required for power-operated sliding watertight doors is to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck. The associated control, indication and alarm circuits are to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck.

## 23.5

Power-operated sliding watertight doors are to have one of the following systems,

23.5.1

A centralized hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors. In addition, there are to be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times (i.e., closed-open-closed) against an adverse list of 15°. This operating cycle is to be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used is to be chosen considering the temperatures liable to be encountered by the installation during its service. The power operating system is to be designed to minimize the possibility of having a single failure in the hydraulic piping adversely affect the operation of more than one door. The hydraulic system is to be provided with a low-level alarm for hydraulic fluid reservoirs serving the power-operated system and a low gas pressure alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators. These alarms are to be audible and visual and are to be situated on the central operating console at the navigation bridge (or main control station).

23.5.2

An independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there is to be a hydraulic accumulator of sufficient capacity to operate the door at least three times (i.e., closed-open-closed) against an adverse list of 15°. This operating cycle is to be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used is to be chosen considering the temperatures liable to be encountered by the installation during its service. A low gas pressure group alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators is to be provided at the central operating console on the navigation bridge (or main control station). Loss of stored energy indication at each local operating position is to be provided.

For the systems specified in 3-3-1/23.5.1 and 3-3-1/23.5.2 above, the power systems for power-operated watertight sliding doors are to be separate from any other power system. A single failure in the electric or hydraulic power-operated system excluding the hydraulic actuator is not to prevent the hand operation of any door.

### 23.7

Control handles are to be provided at each side of the bulkhead at a minimum height of 1.6 m (5.25 ft) above the deck and are to be so arranged as to enable persons passing through the doorway to hold both handles in the open position without being able to set the power closing mechanism in operation accidentally. The direction of movement of the handles in opening and closing the door is to be in the direction of door movement and is to be clearly indicated.

### 23.9

As far as practicable, electrical equipment and components for watertight doors are to be situated above the bulkhead deck and outside hazardous areas and spaces.

### 23.11

The enclosures of electrical components necessarily situated below the bulkhead deck are to provide suitable protection against the ingress of water.

### 23.13

Electric power, control, indication and alarm circuits are to be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuits. Short circuits or other faults in alarm or indicator circuits of a door are not to result in a loss of power operation of that door. Arrangements are to be such that leakage of water into the electrical equipment located below the main deck will not cause the door to open.

### 23.15

A single electrical failure in the power operating or control system of a power-operated sliding watertight door is not to result in opening of a closed door. Availability of the power supplies is to be continuously monitored at a point in the electrical circuit as near as practicable to each of the motors required by 3-3-1/23.5 above. Loss of any such power supply is to activate an audible and visual alarm at the central operating console at the navigation bridge or main control station).

### 23.17 Central Operating Console

#### 23.17.1

The central operating console at the navigation bridge (or main control station) is to have a “master mode” switch with two modes of control: a “local control” mode which will allow any door to be locally opened and locally closed after use without automatic closure, and a “doors closed” mode which will automatically close any door that is open. The “doors closed” mode will permit doors to be opened locally and will automatically reclose the doors upon release of the local control mechanism. The “master mode” switch is to be normally in the “local control” mode.

#### 23.17.2

The central operating console at the navigation bridge (or main control station) is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light is to indicate a door is fully open and a green light is to indicate a door is fully closed. When the door is closed remotely the red light is to indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

#### 23.17.3

The arrangements are to be such as to prohibit the opening of any door from the central operating console.

## 25 Watertight Doors in Cargo Spaces *(2014)*

Watertight doors of substantial construction may be fitted in watertight bulkheads dividing cargo between deck spaces. Such doors may be hinged, rolling or sliding doors and are not to be remotely controlled. They are to be fitted at the highest level and as far from the shell plating as practicable, but in no case is the outboard vertical edge to be situated at a distance from the shell plating which is less than one fifth of the breadth of the vessel, such distance being measured at right angles to the centerline of the vessel at the level of the deepest draft.

All watertight doors in the cargo spaces are to be kept closed during navigation and should any of the doors be accessible during the voyage, they are to be fitted with a device which prevents unauthorized opening. When it is proposed to fit such doors, the number and arrangements are to be specially considered.

For vessels required to meet stability requirements specified in 3-3-1/3 and 3-3-1/5, the doors which become immersed by an equilibrium or intermediate waterplane at any stage of assumed flooding are to be hydrostatically tested at the manufacturer's plant. The head of water used for the test shall correspond at least to the head measured from the lower edge of the door opening, at the location in which the door is to be fitted in the vessel, to the most unfavorable damage waterplane.

## 27 Portable Plates

Portable plates on bulkheads are not permitted except in machinery spaces. The necessary precautions are to be taken in replacing them to ensure that the joints are watertight.

ABS will consider not more than one power-operated sliding watertight door in each main transverse bulkhead larger than 1.2 m (3.94 ft) in clear opening width being substituted for these portable plates, provided these doors are closed during navigation except, in case of urgent necessity, the doors may be opened at the discretion of the master. These doors need not meet the requirements of 3-3-1/23.1.4 regarding complete closure by hand-operated gear in 90 seconds provided the doors can be closed in a reasonable time.

## 29 Miscellaneous

### 29.1

Where trunkways or tunnels for piping, or for any other purpose are carried through main transverse watertight bulkheads, they are to be watertight and in accordance with the requirements of 3-2-5/17. The access to at least one end of each such tunnel or trunk-way, if used as a passage during service, is to be through a trunk extending watertight to a height sufficient to permit access above the margin line. The access to the other end of the trunk-way or tunnel may be through a watertight door of the type required by its location in the vessel. Such trunk-ways or tunnels are not to extend through the first subdivision bulkhead abaft the collision bulkhead.

### 29.3

Where it is proposed to fit tunnels piercing main transverse watertight bulkheads, these will be subject to special consideration.

### 29.5

Where trunkways in connection with refrigerated cargo and ventilation or forced draft trunks are carried through more than one watertight bulkhead, the means of closure at such openings are to be operated by power and be capable of being closed from a central position situated above the bulkhead deck.

## 31 Watertight Decks, Trunks, Tunnels, Duct Keels and Ventilators

Watertight decks, trunks, tunnels, duct keels and ventilators are to be of the same strength as watertight bulkheads at corresponding levels. The means used for making them watertight, and the arrangements adopted for closing openings in them are to be submitted for approval. Watertight ventilators and trunks are to be carried at least up to the main deck.

## 33 Inclining Experiment

A stability test (lightweight survey and inclining experiment) to determine the lightship displacement and center of gravity of the vessel is to be carried out in the presence of a Surveyor.

## 35 Deadweight Survey

In lieu of an inclining experiment, a deadweight survey may be performed to determine the lightweight displacement and longitudinal center of gravity, provided it can be shown that locating the precise position of the vessel's vertical center of gravity is not necessary to ensure that the vessel has adequate stability in all probable loading conditions.

## 37 Trim and Stability Booklets

Trim and stability booklets generally will not be required for river service passenger vessels of normal configuration with barge-type hulls. Vessels of unusual configuration or with ship-type hulls will be subject to special consideration.

## 39 Damage Control Plans

For the guidance of the officers in charge, plans showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with the means of closure and position of any controls thereof, and the arrangements for the correction of any heel due to flooding are to be permanently exhibited onboard the vessel. In addition, booklets containing the aforementioned information are to be made available to the officers of the vessel.

PART
# 3

## CHAPTER 3 Subdivision and Stability

## SECTION 2 Crane Barges *(2015)*

### 1 Stability Information

Each barge equipped for lifting heavy loads is to satisfy the following intact stability requirements. Stability calculations and corresponding information for the Master are to be submitted for review and approval. The submission of evidence showing approval by an Administration of stability of the barge for the lifting operations in accordance with a recognized standard may be accepted. The dynamic load chart for each crane shall be included in the guidance for the Master and shall be posted at the crane operator's station in the clear view of the crane operator.

#### 1.1 Specific Applicability

This Section applies to each barge that:

*i)* Is equipped for heavy lifting of cargo or other objects; and

*ii)* Has a maximum heeling moment due to hook load greater than or equal to:

$(0.67)(\Delta)(GM)(F/B)$ meter-metric tons (foot-long tons)

where:

| | | |
|---|---|---|
| $\Delta$ | = | displacement of the barge with the hook load included, in metric (long) tons |
| $GM$ | = | metacentric height with hook load included, in meters (feet) |
| $F$ | = | freeboard to the deck edge amidships, in meters (feet) |
| $B$ | = | beam, in meters (feet) |

#### 1.3 Definitions

As used in this Section:

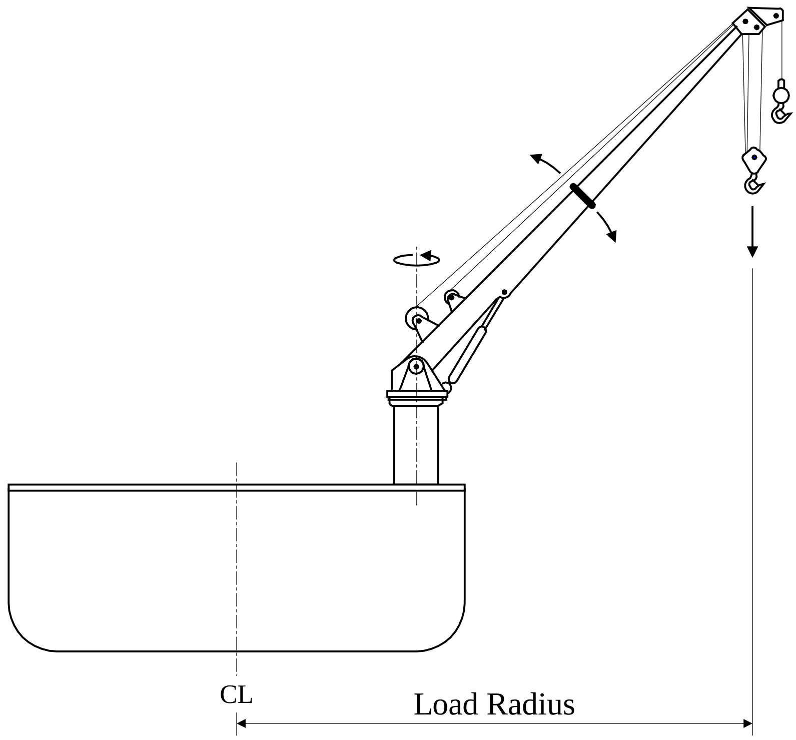
*i)* Hook load means the weight of the object lifted by the crane, the weight of all lifting gear beneath the boom point that is not included as part of the crane (i.e. blocks, weight ball, slings, sheaves, etc.) and the weight of the wire rope between the boom tip and lifted object.

*ii)* Load radius means the distance illustrated in 3-3-2/Figure 1

*iii)* Crane Heeling Moment is the maximum heeling moment developed by multiplying the weight of the hook load and boom by the horizontal distance from barge's centerline to the hook load and boom center of gravity, considering the full range of crane elevations and weights. The resulting heeling moment is to be converted to a heeling arm at zero degrees by dividing it by the barge displacement. The heeling arm is to be assumed constant for all heel angles.

*iv)* Equilibrium heel angle is the angle of heel under the combined effects of the hook load, counter-ballasting and a beam wind.

**FIGURE 1**
**Load Radius** *(2015)*




# 3 Intact Stability Requirements for Barges Equipped to Lift

## 3.1 Counter-balanced and Non-counter-balanced Barges

3.1.1

Each barge that is equipped to lift is to comply, by design calculations, with this section under the following conditions:

*i)* Either for each loading condition and pre-lift condition, or the range of conditions, including pre-lift conditions, delineated by the lifting operations guidelines contained in the trim and stability booklet; and

*ii)* Crane Heeling Moment, and

*iii)* The effect of beam wind on the projected area of the barge (including deck cargo or equipment) should be evaluated for 25.7 m/s (50 knots) wind speed. Should a lesser wind speed be used, that wind speed shall be listed in the trim and stability booklet as an operational restriction during lifting operations.

The wind heeling moment shall be calculated as:

$P \times A \times H$ N-m (kgf-m, lbf-ft)

where

$P$ = wind pressure, calculated as per below

$A$ = projected lateral area, in square meters (square feet), of all exposed surfaces (including deck cargo), in the upright condition

$H$ = vertical distance, in meters (feet), from the center of $A$ to the center of the underwater lateral area or approximately to the one-half draft point

This wind heeling moment is to remain constant for all heel angles.

$$P = f V_k^2 C_h C_s \quad \text{N/m}^2 \text{ (kgf/m}^2\text{, lbf/ft}^2\text{)}$$

where

$f$ = 0.611 (0.0623, 0.00338)

$V_k$ = wind velocity in m/s (m/s, knots)

$C_s$ = 1.0, shape coefficient

$C_h$ = height coefficient from 3-3-2/Table 1

**TABLE 1**
**Values of $C_h$ (2015)**

| *H (meters)* | *H (feet)* | $C_h$ |
|---|---|---|
| 0.0–15.3 | 0–50 | 1.00 |
| 15.3–30.5 | 50–100 | 1.10 |
| 30.5–46.0 | 100–150 | 1.20 |
| 46.0–61.0 | 150–200 | 1.30 |
| 61.0–76.0 | 200–250 | 1.37 |
| 76.0–91.5 | 250–300 | 1.43 |
| 91.5 and above | 300 and above | 1.48 |

3.1.2

Each barge is to have a righting arm curve with the following characteristics:

*i)* The area under the righting arm curve from the equilibrium heel angle (based upon the wind heeling moment) up to the smallest of the following angles must be at least 0.053 meter-radians (10 foot-degrees):

*a)* The second intercept

*b)* The downflooding angle

*c)* 40 degrees

*ii)* The lowest portion of the weather deck and downflooding point should not be submerged at the equilibrium heel angle.

*iii)* The heeling angle based on the crane heeling moment and effect of the beam wind shall not exceed the maximum heel angle from the crane manufacturer.

The righting arm curve is to be corrected for the increase in the vertical center of gravity due to the lifting operation. (The increase in the VCG is due to the boom being in the elevated position, and the hook load acting at the elevated end of the boom.).

## 3.3 Additional Intact Stability Standards – Counter-ballasted Barges

The following recommended criteria are based on crane operations taking place in favorable weather conditions. The analysis should be carried out for the counter-ballast case when the barge is floating with a heel and trim not exceeding the maximum cross angle. The maximum cross angle is the angle corresponding to the crane operational restrictions.

The righting arm curve is to be corrected for the increase in the vertical center of gravity due to the load. (The increase in the VCG is due to the boom being in the elevated position, and the hook load acting at the elevated end of the boom.).

*i)* For any condition of loading and crane heeling moment, the first intercept of the heeling arm curve with the righting arm curve (equilibrium point) is to occur prior to submergence of the deck edge.

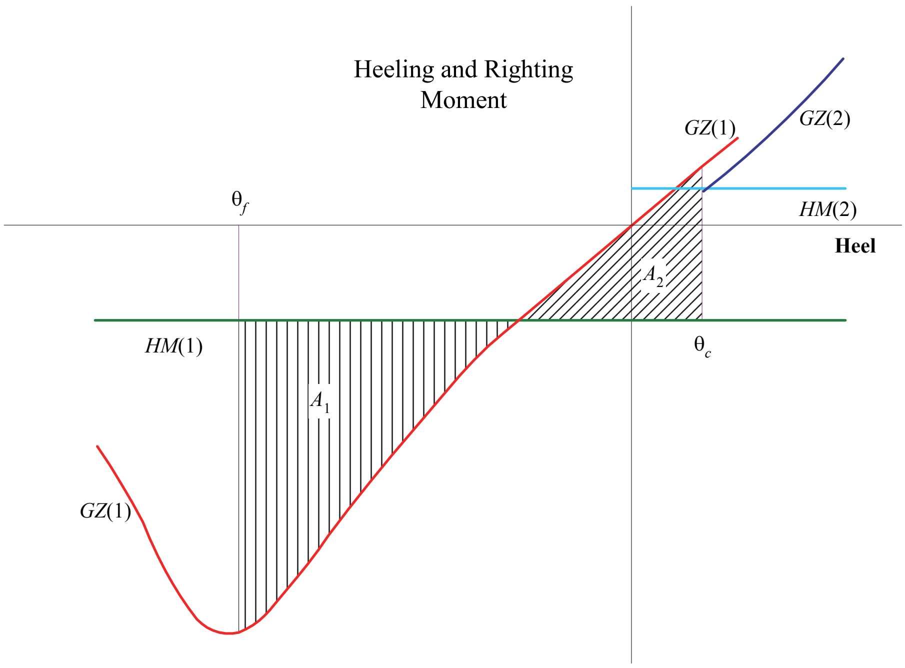
The following requirements are also to be met, with the vessel at the maximum allowable vertical center of gravity, to provide adequate stability in case of sudden loss of crane load:

*ii)* The residual area between the first intercept and the angle of downflooding or the second intercept, whichever occurs first, (area A1 in Figure 2) is not to be less than 30% in excess of area $A_2$ in 3-3-2/Figure 2.

*iii)* The angle of the first intercept between the righting lever curve after loss of crane load and the maximum permissible counter ballast lever curve is not to exceed 15° (angle of equilibrium after loss of crane load).

## FIGURE 2
## Criteria after Accidental Loss of Crane Load *(2015)*

$A_1 \geq 1.3 \times A_2$




GZ(1) = righting moment curve at the displacement corresponding to the barge without hook load.

GZ(2) = righting moment curve at the displacement corresponding to the barge with hook load.

HM(1) = heeling moment curve due to the heeling moment of the counter-ballast at the displacement without hook load.

HM(2) = heeling moment curve due to the combined heeling moments of the hook load and the counter-ballast at the displacement with hook load.

$\theta_f$ = Limit of area integration to the downflooding angle or second intercept on the counter-ballasted side of the barge.

$\theta_c$ = Limit of area integration to the angle of static equilibrium due to the combined hook load and counter-ballast heeling moment.

PART

# 3

## CHAPTER 4 Fire Safety Measures

### CONTENTS

PART
# 3

## CHAPTER 4 Fire Safety Measures

## SECTION 1 Passenger Vessels

### 1 Application

These requirements apply to steel vessels. The use of other materials may be accepted, provided that they provide an equivalent standard of safety.

### 3 Definitions

#### 3.1 Accommodation Space

*Accommodation Spaces* are those used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

#### 3.3 Public Space

*Public Spaces* are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

#### 3.5 High Risk Service Space

*High Risk Service Spaces* are those used for galleys, pantries containing cooking appliances, paint and lamp rooms, lockers and storerooms having areas of 4 $m^2$ (43 $ft^2$) or more, and workshops other than those forming part of the Machinery Spaces.

#### 3.7 Special Category Space

*Special Category Spaces* are those enclosed spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access.

#### 3.9 Corridors

*Corridors* are passenger and crew corridors and lobbies.

#### 3.11 Control Stations

*Control Stations* are spaces containing emergency sources of power and lighting, wheelhouse and chartroom space containing the ship's radio equipment, fire-extinguishing rooms, fire-control rooms, fire-recording stations and control rooms for propulsion machinery when located outside the machinery space.

#### 3.13 Machinery Spaces of Category A

*Machinery Spaces of Category A* are those spaces and trunks to such spaces which contain:

*i)* Internal combustion machinery used for main propulsion; or

*ii)* Internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 KW; or

*iii)* Any oil fire boiler or oil fuel unit.

### 3.15 Machinery Spaces

*Machinery Spaces* are all machinery spaces of category A and all other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces and trunks to such spaces.

### 3.17 Non Combustible Material

A *Non-combustible Material* is one which neither burns nor gives off flammable vapors in sufficient quantity for self-ignition when heated to approximately 750°C (1382°F), this being determined by an established recognized test procedure which is to be submitted for review.

### 3.19 Standard Fire Test

A *Standard Fire Test* is one in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time temperature curve. The specimen is to have an exposed surface of not less than 4.65 $m^2$ (50 $ft^2$) and height (or length of deck) of 2.44 m (8 ft), resembling as closely as possible the intended construction and including where appropriate at least one joint. The standard time-temperature curve is defined by a smooth curve drawn through the following temperature points measured above the initial furnace temperature:

At the end of the first:

- 5 minutes: 556°C (1033°F)
- 10 minutes: 659°C (1218°F)
- 15 minutes: 718°C (1324°F)
- 30 minutes: 821°C (1510°F)
- 60 minutes: 925°C (1697°F)

### 3.21 "A" Class Division

*"A" Class Divisions* are divisions formed by bulkheads and decks which comply with the following:

*i)* They are constructed of steel or other equivalent material

*ii)* They are suitably stiffened

*iii)* They are so constructed as to be capable of preventing the passage of smoke and flame until the end of the one hour standard fire test

*iv)* They are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 139°C (282°F) above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C (356°F) above the original temperature within the time listed below:

- Class "A-60" 60 minutes
- Class "A-0" 0 minutes

*v)* A test of a prototype bulkhead or deck to a recognized standard to ensure that it meets the above requirements for integrity and temperature rise may be required.

### 3.23 "B" Class Division

*"B" Class Divisions* are divisions formed by bulkheads, decks, ceilings, or linings which comply with the following:

*i)* They are to be so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test.

*ii)* They are to have an insulation value such that the average temperature of the unexposed side will not rise more than 139°C (282°F) above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C (437°F) above the original temperature within the time listed below.

- Class "B-0" 0 minutes

*iii)* They are to be constructed of approved non-combustible materials and all materials entering into the construction and erection of "B" Class divisions are to be non-combustible, with the exception that combustible veneers may be permitted provided they meet other requirements in this section

*iv)* A test of a prototype division to a recognized standard to ensure that it meets the above requirements for integrity and temperature rise may be required.

### 3.25 Continuous "B" Class Ceilings or Linings

*Continuous "B" Class Ceilings or Linings* are those "B" Class ceilings or linings which terminate only at "A" or "B" Class Divisions.

### 3.27 Steel Equivalent Material

A *Steel Equivalent Material* is a non-combustible material which, by itself or due to the insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (i.e., aluminum alloy with appropriate insulation).

### 3.29 Low Flame Spread Surface

A *Low Flame Spread Surface* is a surface that will adequately restrict the spread of flame, this being determined to the satisfaction of the Flag State or ABS by a recognized, established test procedure.

## 5 Main Vertical Zones

The hull, superstructure, and deckhouses are to be subdivided by "A-60" divisions into main vertical zones, each with the mean length on any deck generally not in excess of 48 m (157.50 ft) with a square area of deck not to exceed 1600 $m^2$ (17222 $ft^2$).

## 7 Protection of Accommodation Spaces, Service Spaces and Control Stations

### 7.1

Corridor bulkheads are to be "A" or "B" Class divisions extending from deck to deck. Where continuous "B" Class ceilings and/or linings are fitted on both sides of the bulkhead, the "B" Class bulkhead may terminate at the continuous ceiling or lining. Doors fitted in "B" Class divisions may have a louver in the lower half not exceeding 0.05 $m^2$ (78 $in^2$). As an equivalent, these doors may be undercut up to 25 mm (1 in.). Such openings or undercuttings are not to be provided in doors forming a stairway enclosure.

### 7.3

All doors and frames in such bulkheads are to be of non-combustible materials and are to be so constructed and erected as to provide substantial fire resistance, as to maintain the integrity of the division in which the doors are fitted.

### 7.5

The Machinery Spaces of Category A, High Risk Service Spaces, and Control Stations are to be isolated from adjacent Accommodation Spaces and each other by "A-60" Divisions.

### 7.7

The fire integrity of the deck between accommodation spaces is to be steel or equivalent. However, where a deck is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be of "A" Class integrity

### 7.9

The fire integrity of the divisions between the accommodation spaces and the machinery spaces of other than Category "A" is to be "A-0" Class.

## 9 Stairways & Elevators

### 9.1

Stairways which penetrate only a single deck are to be protected at least at one level by an "A" Class Division and self-closing door so as to limit the rapid spread of fire from one deck to another. Elevator trunks are to be protected by "A" Class divisions. Stairways are to be constructed of steel or equivalent material.

### 9.3

Stairways and elevator trunks which penetrate more than a single deck are to be surrounded by "A" Class divisions and protected by "A" Class self-closing doors at all levels. Self-closing doors are not to be fitted with hold-back hooks. However, hold-back arrangements incorporating remote release fittings of failsafe type may be used.

## 11 Non-Combustible Materials

### 11.1

Ceilings, linings, bulkheads and insulation except for insulation in refrigerated compartments are to be of non-combustible material. Vapor barriers and adhesives used in conjunction with the insulation, as well as insulation of pipe fittings for cold service systems need not be non-combustible, but they should be kept to a minimum and their exposed surfaces are to have resistance to propagation of flame.

### 11.3

Partial bulkheads or decks used to subdivide a space for utility or artistic treatment are also to be of non-combustible materials.

### 11.5

The framing, including grounds and the joint pieces of bulkheads, linings, ceilings and draft stops are to be of non-combustible materials.

### 11.7

Each accommodation space/public space on board vessels with no overnight accommodations is to be designed with a maximum fire load not to exceed 14.6 kg/m$^2$ (3 lbs/ft$^2$).

### 11.9

For those vessels designed with onboard overnight accommodations, the maximum fire load is not to exceed 48.8 kg/m$^2$ (10 lbs/ft$^2$). This is to provide for 36.6 kg/m$^2$ (7.5 lbs/ft$^2$) for combustible furniture and 12.2 kg/m$^2$ (2.5 lbs/ft$^2$) for personal effects.

## 13 Exposed Surfaces, Deck Coverings, and Paints, Varnishes and Other Finishes

### 13.1

The following surfaces are to have low flame-spread characteristics.

- All exposed surfaces in corridors and stairway enclosures, and of bulkheads, wall and ceiling linings in all accommodation and service spaces and control stations.

### 13.3

The bulkheads, linings and ceilings may have combustible veneers provided that the thickness of such veneers does not exceed 2 mm (0.08 in.) within any space other than corridors, stairway enclosures and control stations where the thickness is not to exceed 1.5 mm (0.06 in.). Note these veneers are to be included in the fire load calculations discussed above.

### 13.5

Paints, varnishes and other finishes used on exposed interior surfaces are not to be of a nature to offer an undue fire hazard and are not to be capable of producing excessive quantities of smoke or toxic fumes.

## 15 Details of Construction

In accommodation and service spaces, control stations, corridors and stairways:

*i)* Air spaces enclosed behind ceilings, paneling or linings are to be suitably divided by close fitting draught stops not more than 14 m apart.

*ii)* In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., are to be closed at each deck.

## 17 Ventilation

### 17.1

Ducts provided for ventilation of Machinery Spaces of Category A and Galleys are not to pass through Accommodation and Service Spaces or Control Stations. However, some relaxation from this requirement will be considered provided that:

*i)* The ducts are constructed of steel and insulated to "A-60" standards throughout the accommodations, with no openings in the duct work within the accommodation, service or control spaces.

OR

*ii)* The ducts are constructed of steel and fitted with an automatic fire damper close to the boundary penetrated and insulated to "A-60" standard from the Machinery Space of Category A and galleys to a point at least 5 m (16.4 ft) beyond the fire damper, with no openings in the duct work within the accommodation, service or control spaces.

### 17.3

Ventilation ducts in general are not to pass through main vertical zone divisions, however, where this is unavoidable, they are to be equipped with a fail-safe automatic closing fire damper which are also to be capable of being manually closed from each side of the division. In addition, fail-safe automatic closing fire dampers with manual operation from within the stairway enclosure (for stairs serving more than two decks) are to be fitted to all ventilation ducts, serving both the accommodation and service spaces passing through stairways, where the ducts pierce such enclosures. Ventilation ducts serving stairway enclosures are to serve no other spaces. Ventilation ducts are not to serve more than one main vertical zone.

### 17.5

Where they pass through the Accommodation Spaces or Spaces containing combustible materials, the exhaust ducts from galley ranges are to be constructed of "A" Class divisions. Each exhaust duct is to be fitted with:

*i)* A grease trap readily removable for cleaning

*ii)* A fire damper located in the lower end of the duct

*iii)* Arrangements, operable from within the galley, for shutting off the exhaust fans

*iv)* Fixed means for extinguishing a fire within the duct

*v)* And suitable hatches for inspection and cleaning.

### 17.7

The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the space being ventilated.

## 19 Miscellaneous Items

### 19.1

Where "A" or "B" divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for girders, beams or other structural members, arrangements are to be made to ensure that the fire resistance is not impaired.

### 19.3

Pipes penetrating "A" or "B" Class divisions are to be of approved materials having regard to the temperature such divisions are required to withstand.

### 19.5

In spaces where the penetration of oil products is possible, the surface of insulation is to be impervious to oil or oil vapors.

### 19.7

All waste receptacles are to be constructed of non-combustible materials with no openings in sides or bottoms.

## 21 Means of Escape

### 21.1

Stairways and ladders are to be arranged to provide ready means of escape to an area of safe refuge.

### 21.3

There are to be at least two means of escape from each main vertical zone and from each restricted space of 27.5 $m^2$ or more in enclosed area.

### 21.5

In general there are to be at least two means of escape from each Machinery Space of Category A. However, in ships of less than 1,000 tons gross tonnage one means of escape may be dispensed with, provided due regard is paid to the width and disposition of the space, and the number of persons normally employed.

### 21.7

The installation of dead end corridors of any length is not permitted.

### 21.9

Elevators are not to be considered as forming one of the required means of escape.

### 21.11

Windows or airport assemblies installed adjacent to weather deck egress routes are to have $^1/_4$ inch thick wire inserted glass mounted in substantial metal frames.

### 21.13

Stairways are to be sized in accordance with recognized national or international standards, but are to have a minimum tread width of 112 cm (44 in.).

## 23 Fire Control Plans

A fire control plan is to be permanently exhibited for the guidance of the vessel's officers as required by 4-4-1/25.19.

PART

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## CHAPTER 5 Equipment

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PART

# 3

# CHAPTER 5 Equipment

# SECTION 1 Passenger Vessels

## 1 Anchoring and Mooring Equipment

### 1.1 General

Passenger vessels, unless 3-5-1/1.3 is applicable, are to have at least one anchor and cable of sufficient weight and size to restrain the vessel during temporary mooring within a harbor or sheltered area while waiting berth or tide, etc., under the environmental conditions defined in 3-5-1/1.5.

Means are to be provided for heaving in the cable and for stopping the cable as it is being paid out.

The inboard end of the cable is to be secured to the hull by efficient means.

### 1.3 Berthed Passenger Vessels

The requirements for ground tackle may be waived for vessels not intended for temporary mooring as defined above in which case the vessel will be classed as **Berthed Passenger Vessel – River Service**.

### 1.5 Environmental Conditions

It is the designer's responsibility to select the environmental conditions suitable for the anticipated service. For the purpose of calculations required in 3-5-1/1.7, they are to be not less than the following:

- Wind 20.6 m/sec (40.0 knots)
- Current 0.50 m/sec (1.0 knot)
- Water Depth 6.1 m (20 ft)

Where a design is approved to a higher value, the approved environmental conditions will be entered in the *Record*.

### 1.7 Calculations and Data

Calculations for the drag force on the hull under the selected environmental condition and the resulting catenary tension are to be submitted.

The methodology for determining the holding capability of the anchor/cable combination under the specified water depth is also to be submitted together with the substantiating data.

### 1.9 Anchor Weight and Cable Size

Anchor weight and cable size are to be determined so that the following minimum factor of safety is attained.

- Drag force vs. holding power 1.4
- Catenary tension vs. breaking strength 2 for chain 5 for wire

## 3 Lifesaving Appliances

Each passenger vessel is to be provided with the following lifesaving appliances.

### 3.1 Life Jackets

Life jackets are to be provided for 105% of the total number of persons on board. A number of life jackets suitable for children equal to at least 10% of the total number of passengers on board are to be provided or such greater number as may be required to provide a life jacket for each child.

Each life jacket is to be provided with a light and whistle.

### 3.3 Life Buoys

Lifebuoys are to be provided in a quantity not less than that indicated below and placed in locations such that they are accessible from exposed locations.

| *Vessel Length, m (ft)* | | *Minimum Number of Lifebuoys* |
|---|---|---|
| *Over* | *Not Over* | |
| --- | 100 (328) | 8 |
| 100 (328) | 150 (492) | 10 |
| 150 (492) | 200 (656) | 12 |
| 200 (656) | --- | 14 |

Not less than one-half the total number of lifebuoys are to be provided with self-igniting lights. At least two of these are also to be provided with self-activating smoke signals. The lifebuoys provided with lights and smoke signals are to be equally distributed on both sides of the vessel.

At least one lifebuoy on each side of the vessel is to be provided with a buoyant lifeline at least 30.5 m (100 ft) in length. Those lifebuoys provided with lights and smoke signals are not to be fitted with lifelines.

### 3.5 Rescue Boats and Life Rafts

Each vessel is to be provided with a rescue boat and also sufficient number of life rafts to accommodate 125% of the total number of persons on board. Vessels carrying more than 150 persons are to be provided with two rescue boats.

The rescue boats are to be maintained and attached to the davits and be capable of being launched within five minutes.

### 3.7 Immersion Suits and Thermal Protective Aids

An immersion suit is to be provided for each person assigned to crew the rescue boat. Each rescue boat is to be provided with at least two thermal protective aids.

Immersion suits need not be carried if the vessel is constantly in operation in warm climates where, in the opinion of ABS, immersion suits are unnecessary.

### 3.9 Portable Radio Apparatus

A portable radio apparatus is to be provided to permit communication between the rescue boat(s) and the vessel and between the rescue boat(s) and other craft assisting in an emergency.

### 3.11 Guards and Rails

To prevent persons from falling, the unprotected perimeter of all floors and deck areas and openings are to be provided with guards, rails or other devices.

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CHAPTER 6 Testing, Trials and Surveys During Construction – Hull

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PART

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## CHAPTER 6 Testing, Trials and Surveys During Construction – Hull

## SECTION 1 Tank, Bulkhead and Rudder Tightness Testing *(2018)*

### 1 General

Testing to confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which form the watertight subdivisions[1] of ships is to be completed. Verification of the weathertightness of structures and shipboard outfitting is to be carried out. The tightness of all tanks and tight boundaries of new ships and those tanks and boundaries whose structural integrity is affected by major conversions or major repairs[2] is to be confirmed prior to the delivery of the ship or prior to the completion of the modification or repair as relevant.

Testing procedures of watertight compartments for ships built in compliance with SOLAS 1974 as amended are to be carried out in accordance with 3-6-1/3, unless:

*i)* The shipyard provides documentary evidence of the Owner's agreement to a request to the flag Administration for an exemption from the application of Chapter II-1, Regulation 11 of SOLAS 1974 as amended, or for an equivalency agreeing that the content of 3-6-1/5 is equivalent to Chapter II-1, Regulation 11 of SOLAS 1974 as amended; and

*ii)* The above-mentioned exemption/equivalency has been granted by the responsible flag Administration.

Testing procedures of watertight compartments are to be carried out in accordance with 3-6-1/5 for ships not built in compliance with SOLAS 1974 as amended and those ships built in compliance with SOLAS 1974 as amended for which:

*i)* The shipyard provides documentary evidence of the Owner's agreement to a request to the flag Administration for an exemption from the application of Chapter II-1, Regulation 11 of SOLAS 1974 as amended, or for an equivalency agreeing that the content of 3-7-1/5 is equivalent to Chapter II-1, Regulation 11 of SOLAS 1974 as amended; and

*ii)* The above-mentioned exemption/equivalency has been granted by the responsible flag Administration.

*Notes:*

1 Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

2 Major repair means a repair affecting structural integrity.

### 3 Testing Requirements for Ships Built in Compliance with SOLAS 1974 as Amended

#### 3.1 Application

All gravity tanks which are subjected to vapor pressure not greater than 0.7 bar (0.7 kgf/cm$^2$, 10 psi) and other boundaries required to be watertight or weathertight are to be tested in accordance with this Subsection and proven to be tight or structurally adequate as follows:

3.1.1

*Gravity Tanks* for their structural adequacy and tightness,

3.1.2

*Watertight Boundaries Other Than Tank Boundaries* for their watertightness, and

3.1.3

*Weathertight Boundaries* for their weathertightness.

For the testing of cargo containment systems of liquefied gas carriers, the requirements in 5C-8-4/20 of the *Steel Vessel Rules* will apply.

Testing of structures not listed in 3-6-1/Table 1 and 3-6-1/Table 2 is to be specially considered.

## 3.3 Test Types and Definitions

3.3.1

The following two types of tests are specified in this requirement.

*3.3.1(a) Structural Test.* A test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test.

*3.3.1(b) Leak Test.* A test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by Note 3 of 3-6-1/Table 1.

3.3.2

The definition of each test type is as follows:

| | |
|---|---|
| *Hydrostatic Test: (Leak and Structural)* | A test wherein a space is filled with a liquid to a specified head. |
| *Hydropneumatic Test: (Leak and Structural)* | A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air. |
| *Hose Test: (Leak)* | A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side. |
| *Air Test: (Leak)* | A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as *compressed air fillet weld tests* and *vacuum box tests*. |
| *Compressed Air Fillet Weld Test: (Leak)* | An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds. |
| *Vacuum Box Test: (Leak)* | A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks. |
| *Ultrasonic Test: (Leak)* | A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques. |
| *Penetration Test: (Leak)* | A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e., dye penetrant test). |

## 3.5 Test Procedures

### 3.5.1 General

Tests are to be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc., installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints. Specific test requirements are given in 3-6-1/3.5.4 and 3-6-1/Table 1. For the timing of application of coating and the provision of safe access to joints, see 3-6-1/3.5.5, 3-6-1/3.5.6, and 3-6-1/Table 3.

### 3.5.2 Structural Test Procedures

*3.5.2(a) Type and Time of Test.* Where a structural test is specified in 3-6-1/Table 1 or 3-6-1/Table 2, a hydrostatic test in accordance with 3-6-1/3.5.4(a) will be acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with 3-6-1/3.5.4(b) may be approved instead.

A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the vessel is afloat, provided the results of a leak test are confirmed to be satisfactory before the vessel is afloat.

*3.5.2(b) Testing Schedule for New Construction or Major Structural Conversion.*

*i)* Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship*, shall be tested for tightness and structural strength as indicated in 3-6-1/Table 1 and 3-6-1/Table 2.

*ii)* The tank boundaries are to be tested at least from one side. The tanks for structural test are to be selected so that all representative structural members are tested for the expected tension and compression.

*iii)* The watertight boundaries of spaces other than tanks for structural testing may be exempted, provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections. Structural testing may not be exempted and the requirements for structural testing of tanks in 3-6-1/3.5.2(b)i) to 3-6-1/3.5.2(b)ii) shall apply, for ballast holds, chain lockers and a representative cargo hold if intended for in-port ballasting.

*iv)* Tanks which do not form part of the watertight subdivision of the ship*, may be exempted from structural testing provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections.

** Note:* Watertight subdivision means the main transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

### 3.5.3 Leak Test Procedures

For the leak tests specified in 3-6-1/Table 1, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), or their combination, will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that 3-6-1/3.5.5, 3-6-1/3.5.6, and 3-6-1/3.5.7 are complied with. Hose tests will also be acceptable for such locations as specified in 3-6-1/Table 1, note 3, in accordance with 3-6-1/3.5.4(c).

The application of the leak test for each type of welded joint is specified in 3-6-1/Table 3.

Air tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. See also 3-6-1/3.5.5(a) for the application of final coatings and 3-6-1/3.5.6 for the safe access to joints and the summary in 3-6-1/Table 3.

### 3.5.4 Test Methods

*3.5.4(a) Hydrostatic Test.* Unless another liquid is approved, hydrostatic tests are to consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in 3-6-1/Table 1 or 3-6-1/Table 2. See also 3-6-1/3.5.7.

In cases where a tank is designed for cargo densities greater than sea water and testing is with fresh water or sea water, the testing pressure height is to simulate the actual loading for those greater cargo densities as far as practicable.

All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

*3.5.4(b) Hydropneumatic Test.* Hydropneumatic tests, where approved, are to be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable. The requirements and recommendations for tank air tests in 3-6-1/3.5.4(d) will also apply to hydropneumatic tests. See also 3-6-1/3.5.7.

All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

*3.5.4(c) Hose Test.* Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at 2 bar (2 kgf/cm$^2$, 30 psi) during the test. The nozzle is to have a minimum inside diameter of 12 mm (0.5 in.) and be at a perpendicular distance from the joint not exceeding 1.5 m (5 ft). The water jet is to impinge directly upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetration test or ultrasonic leak test or the equivalent.

*3.5.4(d) Tank Air Test.* All boundary welds, erection joints, and penetrations, including pipe connections, are to be examined in accordance with approved procedure and under a stabilized pressure differential above atmospheric pressure not less than 0.15 bar (0.15 kgf/cm$^2$, 2.2 psi) with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure is to be arranged. The cross sectional area of the U-tube is not to be less than that of the pipe supplying air to the tank. Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account the provisions in F5.1 and F7.4 of IACS Recommendation 140, "Recommendation for Safe Precautions during Survey and Testing of Pressurized Systems".

Other effective methods of air testing, including compressed air fillet weld testing or vacuum testing, may be considered in accordance with 3-6-1/3.5.4(i).

A double inspection is to be made of tested welds. The first is to be immediately upon applying the leak indication solution; the second is to be after approximately four or five minutes, without further application of leak indication solution, in order to detect those smaller leaks which may take time to appear.

*3.5.4(e) Compressed Air Fillet Weld Test.* In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least 0.15 bar (0.15 kgf/cm$^2$, 2.2 psi) can be verified at each end of all passages within the portion being tested.

For limited portions of the partial penetration or fillet welded joints forming tank boundaries, such as corners and section of the weld adjacent to the testing apparatus, the attending Surveyor may accept the use of Magnetic Particle Inspection or Dye Penetration examination as an alternative to fillet air testing.

Where a leaking test of partial penetration welding is required and the root face is sufficiently large, such as 6-8 mm (0.24-0.32 inch), the compressed air test is to be applied in the same manner as for a fillet weld.

*3.5.4(f) Vacuum Box Test.* A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of 0.20 bar (0.20 kgf/cm$^2$, 2.9 psi) – 0.26 bar (0.27 kgf/cm$^2$, 3.8 psi) inside the box.

*3.5.4(g) Ultrasonic Test.* An ultrasonic echo transmitter is to be arranged inside of a compartment and a receiver is to be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.

*3.5.4(h) Penetration Test.* A test of butt welds or other weld joints using the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

*3.5.4(i) Other Test.* Other methods of testing, except as provided in 3-6-1/5, may be considered upon submission of full particulars prior to the commencement of testing.

### 3.5.5 Application of Coating

*3.5.5(a) Final Coating.* For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints, provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

Surveyors reserve the right to require a leak test prior to the application of final coating over automatic erection butt welds.

For all other joints, the final coating is to be applied after the completion of the leak test of the joint. See also 3-6-1/Table 3.

*3.5.5(b) Temporary Coating.* Any temporary coating which may conceal defects or leaks is to be applied at the time as specified for the final coating [see 3-6-1/3.5.5(a)]. This requirement does not apply to shop primer.

### 3.5.6 Safe Access to Joints

For leak tests, safe access to all joints under examination is to be provided. See also 3-6-1/Table 3.

### 3.5.7 Hydrostatic or Hydropneumatic Tightness Testing

In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, examined boundaries must be dew-free, otherwise small leaks are not visible.

## TABLE 1
## Testing Requirements for Tanks and Boundaries *(2018)*

| | *Tank or Boundary to be Tested* | *Test Type* | *Test Head or Pressure* | *Remarks* |
|---|---|---|---|---|
| 1 | Double bottom tanks(4) | Leak & Structural (1) | The greater of<br>- top of the overflow,<br>- to 1.2 m (4 ft) above top of tank (2), or<br>- to bulkhead deck | |
| 2 | Double bottom voids(5) | Leak | See 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), as applicable | Including pump room double bottom and bunker tank protection double hull required by MARPOL Annex I |
| 3 | Double side tanks | Leak & Structural (1) | The greater of<br>- top of the overflow,<br>- to 1.2 m (4 ft) above top of tank (2), or<br>- to bulkhead deck | |
| 4 | Double side voids | Leak | See 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), as applicable | |
| 5 | Deep tanks other than those listed elsewhere in this table | Leak & Structural (1) | The greater of<br>- top of the overflow, or<br>- to 1.2 m (4 ft) above top of tank (2) | |
| 6 | Cargo oil tanks | Leak & Structural (1) | The greater of<br>- top of the overflow,<br>- to 1.2 m (4 ft) above top of tank (2), or<br>- to top of tank (2) plus setting of any pressure relief valve | |
| 7 | Ballast hold of bulk carriers | Leak & Structural (1) | Top of cargo hatch coaming | See item 16 for hatch covers. |
| 8 | Peak tanks | Leak & Structural (1) | The greater of<br>- top of the overflow, or<br>- to 1.2 m (4 ft) above top of tank (2) | After peak to be tested after installation of stern tube |
| 9 | .1 Fore peak spaces with equipment | Leak | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | |
| | .2 Fore peak voids | Leak | See 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), as applicable | |
| | .3 Aft peak spaces with equipment | Leak | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | |
| | .4 Aft peak voids | Leak | See 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), as applicable | After peak to be tested after installation of stern tube |
| 10 | Cofferdams | Leak | See 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), as applicable | |
| 11 | .1 Watertight bulkheads | Leak (8) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable (7) | |
| | .2 Superstructure end bulkheads | Leak | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | |
| | .3 Cable penetrations in watertight bulkheads | Hose | See 3-6-1/3.5.4(c) | |
| 12 | Watertight doors below freeboard or bulkhead deck | Leak (6, 7) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | See 3-2-9/9.11 of the *Steel Vessel Rules* for additional test at the manufacturer. |

## TABLE 1 (continued)
## Testing Requirements for Tanks and Boundaries *(2018)*

| | *Tank or Boundary to be Tested* | *Test Type* | *Test Head or Pressure* | *Remarks* |
|---|---|---|---|---|
| 13 | Double plate rudder blades | Leak | See 3-6-1/3.5.4(d) through 3-6-1/3.5.4(f), as applicable | |
| 14 | Shaft tunnels clear of deep tanks | Leak (3) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | |
| 15 | Shell doors | Leak (3) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | |
| 16 | Weathertight hatch covers and closing appliances | Leak (3, 7) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | Hatch covers closed by tarpaulins and battens excluded |
| 17 | Dual purpose tanks/dry cargo hatch covers | Leak (3, 7) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | In addition to structural test in item 6 or 7 |
| 18 | Chain lockers | Leak & Structural (1) | Top of chain pipe | |
| 19 | L.O. sump tanks and other similar tanks/spaces under main engine | Leak (9) | See 3-6-1/3.5.4(c) through 3-6-1/3.5.4(f), as applicable | |
| 20 | Ballast ducts | Leak & Structural (1) | The greater of<br>- ballast pump maximum pressure, or<br>- setting of any pressure relief valve | |
| 21 | Fuel Oil Tanks | Leak & Structural (1) | The greater of<br>- top of the overflow, or<br>- to 1.2 m (4 ft) above top of tank (2), or<br>- to top of tank (2) plus setting of any pressure relief valve, or<br>- to bulkhead deck | |

*Notes:*

1 *(2018)* Refer to 3-6-1/3.5.2(b).

2 Top of tank is the deck forming the top of the tank, excluding any hatchways.

3 *(2018) Hose Test* may also be considered as a medium of the test. See 3-6-1/3.3.2.

4 Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4

5 *(2016)* Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12A and Chapter 4, Part A, regulation 22, respectively.

6 Where water tightness of a watertight door has not confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.

7 *(2018)* As an alternative to the hose testing, other testing methods listed in 3-6-1/3.5.4(g) through 3-6-1/3.5.4(i) may be applicable subject to adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1. For watertight bulkheads (item 11.1) alternatives to the hose testing may only be used where a hose test is not practicable.

8 *(2018)* A "Leak and structural test", see 3-6-1/3.5.2(b), is to be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting is to be the maximum loading that will occur in-port as indicated in the loading manual.

9 *(2018)* Where L.O. sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they are to be tested as per the requirements of Item 5, Deep tanks other than those listed elsewhere in this table.

## TABLE 2
## Additional Testing Requirements for Vessels or Tanks of Special Service *(2018)*

| | *Type of Vessels or Tanks* | *Structures to be Tested* | *Type of Testing* | *Hydrostatic Testing Head* | *Remarks* |
|---|---|---|---|---|---|
| 1 | Liquefied Gas Carriers | Ballast or Fuel Oil Tanks adjacent to or between Cargo Tank Hold Spaces | Leak & Structural | The greater of<br>- the top of overflow, or<br>- to 1.2 m (4 ft) above under side of deck at side | See 5C-8-4/20 for testing requirements applicable to integral cargo tanks, independent cargo tanks and hull structure supporting membrane or semi-membrane cargo tanks. |
| 2 | Edible Liquid Tanks | Independent Tanks | Leak & Structural | The greater of<br>- the top of overflow, or<br>- to 0.9 m (3 ft) above top of tank (2) | |
| 3 | Chemical Carriers | Integral or Independent Tanks | Leak & Structural | The greater of<br>- 1.2 m (4 ft) above under side of deck at side, or<br>- to top of tank (2) plus setting of any pressure relief valve | Where a cargo tank is designed for the carriage of cargoes with specific gravities larger than 1.0, an appropriate additional head is to be considered. |

*Notes:*

1 *(2018)* See 3-6-1/3.5.2(b).

2 *(1 July 2013)* Top of tank is the deck forming the top of the tank, excluding any hatchways.

## TABLE 3
## Application of Leak Testing, Coating and Provision of Safe Access for Type of Welded Joints *(2016)*

| *Type of Welded Joints* | | *Leak Testing* | *Coating (1)* | | *Safe Access (2)* | |
|---|---|---|---|---|---|---|
| | | | *Before Leak Testing* | *After Leak Testing & Before Structural Test* | *Leak Testing* | *Structural Test* |
| Butt | Automatic | Not required | Allowed(3) | N/A | Not required | Not required |
| Butt | Manual or Semi-automatic(4) | Required | Not allowed | Allowed | Required | Not required |
| Fillet | Boundary including penetrations | Required | Not allowed | Allowed | Required | Not required |

*Notes:*

1 Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.

2 Temporary means of access for verification of the leak testing.

3 The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

4 *(2016)* Flux Core Arc Welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of the Rule and Surveyor required NDE testing show no significant defects.

# 5 Testing Requirements for Ships Not Built in Compliance with SOLAS 1974 as Amended

## 5.1

Testing procedures are to be carried out in accordance with the requirements of 3-6-1/3 in association with the following alternative procedures for 3-6-1/3.5.2(b) "Testing Schedule for New Construction or Major Structural Conversion" and alternative test requirements for 3-6-1/Table 1.

## 5.3

The tank boundaries are to be tested from at least one side. The tanks for structural test are to be selected so that all representative structural members are tested for the expected tension and compression.

## 5.5

Structural tests are to be carried out for at least one tank of a group of tanks having structural similarity (i.e., same design conditions, alike structural configurations with only minor localized differences determined to be acceptable by the attending Surveyor) on each vessel provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or to the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.

## 5.7

Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

## 5.9

Where the structural adequacy of the tanks of a vessel were verified by the structural testing required in 3-6-1/Table 1, subsequent vessels in the series (i.e., sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

*i)* Watertightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out.

*ii)* Structural testing is carried out for at least one tank of each type among all tanks of each sister vessel.

*iii)* Additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending Surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships, the provisions of 3-6-1/5.3 shall apply in lieu of 3-6-1/5.5.

## 5.11

Sister ships built (i.e., keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with 3-6-1/5.5 at the discretion of the Surveyor, provided that:

*i)* General workmanship has been maintained (i.e., there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, and shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the Surveyor).

*ii)* An NDT plan is implemented and evaluated by the Surveyor for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction are to be reviewed and agreed during the kick-off meeting. Structural fabrication is to be carried out in accordance with IACS Recommendation 47, "Shipbuilding and Repair Quality Standard", or a recognized fabrication standard to the satisfaction of the attending Surveyor prior to the commencement of fabrication/construction. The work is to be carried out in accordance with the Rules and under survey of the Surveyor.

PART
# 3

## CHAPTER 6 Testing, Trials and Surveys During Construction – Hull

## SECTION 2 Trials

### 1 Bilge System Trials

All elements of the bilge system are to be tested to demonstrate satisfactory pumping operation, including emergency suctions and all controls. Upon completion of the trials, the bilge strainers are to be opened, cleaned and closed up in good order.

### 3 Steering Trials

Refer to 4-2-3/1.19 and 4-2-3/3.33 for the technical details of the steering trials.

PART
# 3

# CHAPTER 6 Testing, Trials and Surveys During Construction – Hull

# SECTION 3 Surveys

## 1 Construction Welding and Fabrication *(1 July 2012)*

For surveys of hull construction welding and fabrication, refer to Chapter 4 of the ABS *Rules for Materials and Welding (Part 2)*, Section 3-2-6 of these Rules, and the ABS *Guide for Nondestructive Inspection of Hull Welds*.

## 3 Hull Castings and Forgings

For surveys in connection with the manufacture and testing of hull castings and forgings, refer to Chapter 1 of the ABS *Rules for Materials and Welding (Part 2)*.

## 5 Hull Piping *(1 July 2012)*

For surveys in connection with the manufacture and testing of hull piping, refer to Part 4, Chapter 3.

PART

# 4

# Vessel Systems and Machinery

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## CHAPTER 1 General

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PART

# 4

# CHAPTER 1 General

## SECTION 1 Classification of Machinery

### 1 General

The provisions of Part 1, "Conditions of Classification", are applicable to the classification of machinery.

#### 1.1 Gross Tonnage

For vessels in domestic service, "gross tonnage", as used in these Rules, is the national gross tonnage as specified by the country in which the vessel is to be registered. For vessels which are engaged in international voyages, gross tonnage is to be determined by the International Convention on Tonnage Measurement of Ships, 1969.

### 3 Certification of Machinery *(2003)*

#### 3.1 Basic Requirements

The Rules define, to varying degrees, the extent of evaluation required for products, machinery, equipment and their components based on the level of criticality of each of those items. There are three basic evaluation constituents:

- Design review; type/prototype testing, as applicable;
- Survey during construction and testing at the plant of manufacture; and
- Survey during installation onboard the vessel and at trials.

Where design review is required by the Rules, a letter will be issued by ABS upon satisfactory review of the plans to evidence the acceptance of the design. In addition to, or independent of, design review, ABS may require survey and testing of forgings, castings and component parts at the various manufacturers' plants, as well as survey and testing of the finished product. A certificate or report will be issued upon satisfactory completion of each survey to evidence acceptance of the forging, casting, component or finished product. Design review, survey and the issuance of reports or certificates constitute the certification of machinery.

Based on the intended service and application, some products do not require certification because they are not directly related to the scope of classification or because normal practices for their construction within the industry are considered adequate. Such products may be accepted based on the manufacturers' documentation on design and quality.

In general, surveys during installation onboard the vessel and at trials are required for all items of machinery. This is not considered a part of the product certification process. There may be instances, however, where letters or certificates issued for items of machinery contain conditions which must be verified during installation, tests or trials.

### 3.3 Type Approval Program

Products that can be consistently manufactured to the same design and specification may be Type Approved under the ABS Type Approval Program. The ABS Type Approval Program is a voluntary option for the demonstration of the compliance of a product with the Rules or other recognized standards. It may be applied for at the request of the designer or manufacturer. . The ABS Type Approval Program generally covers Product Type Approval (1-1-4/7.7.3 of the ABS *Rules for Conditions of Classification (Part 1)*), but is also applicable for a more expeditious procedure towards Unit-Certification, as specified in 1-1-4/7.7.2 of the above-referenced Part 1.

See the "ABS Type Approval Program" in Appendix 1-1-A3 of the ABS *Rules for Conditions of Classification (Part 1)*. The ABS *Type Approval Program* and the indicated references are available for download from the ABS website at http://www.eagle.org/absdownloads/index.cfm.

### 3.5 Non-mass Produced Machinery

Non-mass produced critical machinery, such as propulsion boilers, slow speed diesel engines, turbines, steering gears and similar critical items are to be individually unit certified in accordance with the procedure described in 4-1-1/3.1. However, consideration will be given to granting Type Approval to such machinery in the category of Recognized Quality System (RQS). The category of Product Quality Assurance (PQA) will not normally be available for all products, and such limitations will be indicated in 4-1-1/Table 1 through 4-1-1/Table 6 of the *Steel Vessel Rules*. In each instance where Type Approval is granted, in addition to quality assurance and quality control assessment of the manufacturing facilities, ABS will require some degree of product specific survey during manufacture.

### 3.7 Details of Certification of Some Representative Products

4-1-1/Table 1 through 4-1-1/Table 6 of the *Steel Vessel Rules* provide abbreviated certification requirements of representative machinery based on the basic requirements of the Rules for machinery. The tables also provide the applicability of the Type Approval Program for each of these machinery items.

For easy reference, the tables contain six product categories as follows:

- Prime movers
- Propulsion, maneuvering and mooring machinery
- Electrical and control equipment
- Fire safety equipment
- Boilers, pressure vessels, fired equipment
- Piping system components

## 5 Machinery Plans and Data

### 5.1 Details

Plans and data enumerated in 4-2-1/1, 4-2-2/1, 4-2-3/1.3, 4-2-3/3.3, 4-3-1/3, 4-3-7/5, 4-4-1/7 and 4-5-1/5, as applicable, for each vessel to be built under survey, are to be submitted and approved before proceeding with the work. See also 1-1-4/3 of the Supplement to the ABS *Rules for Conditions of Classification (Part 1)*. It is desired that the sizes, dimensions, welding and other details, make and size of standard approved appliances be shown on the plans as clearly and fully as possible. All welded construction is to meet the requirements of Chapter 4 of the ABS *Rules for Materials and Welding (Part 2)*.

### 5.3 Plans *(2011)*

Plans from the designers and shipbuilders should generally be submitted electronically to ABS. However, hard copies will also be accepted. All plan submissions originating from manufacturers are understood to be made with the cognizance of the shipbuilder. A fee may be charged for the review of plans for which there is no contract of classification.

## 7 Oil Fuel Unit

Oil fuel unit is any equipment, such as pumps, filters and heaters, used for the preparation and delivery of fuel oil to oil-fired boilers (including inert gas generators), internal-combustion engines or gas turbines at a pressure of more than 1.8 bar (1.8 kgf/cm$^2$, 26 psi).

## 9 Machinery Space Ventilation

Machinery spaces are to be ventilated so as to ensure that when machinery is operating at full power in all weather conditions, including heavy weather, an adequate supply of air is maintained for operation of the machinery and safety of the personnel.

## 11 Boilers and Pressure Vessels

Boilers, pressure vessels, fluid power cylinders and heat exchangers are to be designed, constructed, tested and installed in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*.

## 13 Turbines, Engines and Reduction Gears

All steam turbines, gas turbines and internal-combustion engines of 100 kW [135 horsepower (hp)] and over and associated reduction gears are to be constructed and installed in accordance with the applicable requirements of Part 4, Chapters 2 and 3 of the *Steel Vessel Rules*. Turbines and engines of less than 100 kW (135 hp) and associated gears are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

Internal-combustion engines are also to comply with the requirements in 4-1-1/15 and 4-1-1/17 as applicable.

## 15 Engine Installation Particulars

### 15.1 Tank Barges

Internal-combustion engines located on the weather deck are to be provided with ventilation metal hoods or with a well-ventilated metal housing of sufficient size to allow for proper operation and maintenance.

Where a housing is provided on vessels intended for carrying flammable or combustible liquids having a closed cup flash point at or below 60°C (140°F), the housing is to be fitted with a cofferdam as required by 3-2-1/19.1.2 and all openings in the housing are to be located more than 3 m (10 ft) from any tank, gas or vapor outlet.

### 15.3 Engine Exhausts on Tank Barges

On vessels intended for carrying flammable or combustible liquids having a closed cup flash point at or below 60°C (140°F) in bulk, the engine exhaust lines are to be fitted with spark arresters and are to be located more than 3 m (10 ft) from the nearest source of flammable vapor or gas. See 4-5-6/1.5.2. Exhaust piping is to be either insulated or water cooled.

## 17 Starting Arrangements for Propulsion Engines

### 17.1 Starting Air System

#### 17.1.1 Compressors

For vessels having main propulsion engines arranged for air starting, one or more air compressors are to be fitted capable of restoring the air capacity within 45 minutes after completion of the starting tests required in 4-1-1/17.1.2.

17.1.2 Containers *(2013)*

Vessels having internal-combustion engines arranged for air starting are to be provided with at least two starting-air reservoirs of approximately equal size. The total capacity of the starting-air reservoirs is to be sufficient to provide, without recharging the air reservoirs, at least the number of consecutive starts stated below. If other compressed air systems, such as control air, are supplied from starting-air reservoirs, the aggregate capacity of the air reservoirs is to be sufficient for continued operation of these systems after the air necessary for the required number of starts has been used.

*17.1.2(a) Diesel Propulsion.* The minimum number of consecutive starts (total) required to be provided from the starting-air reservoirs is to be based upon the arrangement of the engines and shafting systems as indicated in the following table:

| *Engine Type* | *Single Propeller Vessels* | | *Multiple Propeller Vessels* | |
|---|---|---|---|---|
| | *One engine coupled to shaft directly or through reduction gear* | *Two or more engines coupled to shaft through clutch and reduction gear* | *One engine coupled to each shaft directly or through reduction gear* | *Two or more engines coupled to each shaft through clutch and reduction gear* |
| Reversible | 12 | 16 | 16 | 16 |
| Non-reversible | 6 | 8 | 8 | 8 |

For arrangements of engines and shafting systems which differ from those indicated in the table, the capacity of the starting-air reservoirs will be specially considered based on an equivalent number of starts.

*17.1.2(b) Diesel-electric Propulsion.* The minimum number of consecutive starts required to be provided from the starting-air reservoirs is to be determined from the following equation:

$$S = 6 + G(G - 1)$$

where

$S$ = total number of consecutive starts

$G$ = number of engines necessary to maintain sufficient electrical load to permit vessel transit at full seagoing power and maneuvering. The value of $G$ need not exceed 3.

## 17.3 Starting Batteries

Storage batteries to be used for starting the main propulsion engines are to have sufficient capacity without recharging for starting the main engines as required in 4-1-1/17.1.2. See also 4-5-4/5.5.

## 17.5 Hydraulic Starting

Hydraulic oil accumulators for starting the main propulsion engines are to have sufficient capacity without recharging for starting the main engines as required in 4-1-1/17.1.2.

# 19 Trial

## 19.1 General

A final underway trial is to be made of all machinery, including the steering gear, to the satisfaction of the Surveyor.

## 19.3 Steering Gear

Trials for the steering gear are to be in accordance with 4-2-3/1.19 or 4-2-3/3.33.

### 19.5 Reduction Gears for Propulsion

Before final acceptance, the entire installation is to be operated in the presence of the Surveyor to demonstrate its ability to function satisfactorily under operating conditions and its freedom from harmful vibrations at speeds within the operating range.

For conventional propulsion gear units above 1120 kW (1500 HP), a record of gear-tooth contact is to be made at the trials. To facilitate the survey of extent and uniformity of gear-tooth contact, selected bands of pinion or gear teeth on each meshing are to be coated beforehand with copper or layout dye. See 7-6-2/1.1.2 of the ABS *Rules for Survey After Construction (Part 7)*.

The gear-tooth examination for conventional gear units 1120 kW (1500 HP) and below and all epicyclic gear units will be subject to special consideration. The gear unit manufacturer's recommendations will be considered.

## 21 Materials Containing Asbestos *(2011)*

Installation of materials which contain asbestos is prohibited.

## 23 Units

These Rules are written in two systems of units (i.e., MKS units and US customary units). Each system is to be used independently of the other system.

Unless indicated otherwise, the format of presentation in the Rules of the two systems of units are as follows:

MKS units (US customary units)

## 25 Ambient Temperature *(2008)*

The ambient temperature, as indicated in 4-1-1/Table 1, is to be considered in the selection and installation of machinery, equipment and appliances. For vessels of restricted or special service, the ambient temperature appropriate to the special nature is to be considered.

**TABLE 1**
**Ambient Temperatures for Unrestricted Service** *(2014)*

| **Air** | | |
|---|---|---|
| *Installations, Components* | *Location, Arrangement* (1, 2) | *Temperature Range (°C)* |
| Machinery and electrical installations | Enclosed Spaces – General | 0 to +45 |
| | Components mounted on machinery associated with high temperature | According to specific machinery and installation |
| | In spaces subject to higher temperature (details to be submitted) | According to the actual maximum ambient temperature |
| | In spaces with temperature lower than +45°C (details to be submitted) | According to the actual ambient temperature subject to minimum +40 |
| | Open Deck | –25 to +45 |
| **Water** | | |
| *Coolant* | | *Temperature (°C)* |
| Seawater | | +32 |

*Notes:*

1 *(2014)* Electronic equipment is to be suitable for operations up to 55°C.

2 *(2014)* For environmentally controlled spaces, see 4-5-1/19.3.

PART

# 4

## CHAPTER 2 Propulsion and Maneuvering Machinery

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PART

# 4

## CHAPTER 2 Propulsion and Maneuvering Machinery

## SECTION 1 Propulsion Shafting

### 1 General

Propellers and propulsion shafting for self-propelled vessels are to be designed, constructed and tested in accordance with the requirements of this Section. Before proceeding with the construction, prints of the propeller and shafting plans giving design data and material characteristics are to be submitted. The construction of propellers and shafts on vessels exhibiting special design features may be carried out in accordance with other applicable ABS Rules or Guides.

#### 1.1 Definitions *(2014)*

For the purposes of using shaft diameter formulas in this section, the following definitions apply.

##### 1.1.1 Tail Shaft

*Tail Shaft* is the part of the propulsion shaft aft of the forward end of the propeller end bearing.

##### 1.1.2 Stern Tube Shaft

*Stern Tube Shaft* or *Tube Shaft* is the part of the propulsion shaft passing through the stern tube from the forward end of the propeller end bearing to the in-board shaft seal.

##### 1.1.3 Line Shaft

*Line Shaft* is the part of the propulsion shaft in-board of the vessel.

##### 1.1.4 Thrust Shaft

*Thrust Shaft* is that part of the propulsion shaft which transmits thrust to the thrust bearing.

##### 1.1.5 Oil Distribution Shaft

*Oil Distribution Shaft* is a hollow propulsion shaft where the bore and radial holes are used for distribution of hydraulic oil in controllable pitch propeller installations.

### 3 Line Shaft, Tail Shaft, Tube Shaft and Thrust Shaft Diameters

For vessels 45.7 m (150 ft) in length and under, the shafting is to comply with the applicable requirements of the ABS *Rules for Building and Classing Steel Vessels Under 90 m (295 ft) in Length*. For vessels greater than 45.7 m (150 ft) in length, the least diameter of shafting is to be determined from the following equation:

$$D = \sqrt[3]{KH / R}$$

where

$D$ = diameter of shaft, mm (in.)

*K* = as defined in the table below:

| | *MKS Units* | *US Units* |
|---|---|---|
| Line shafts | $39.5 \times 10^6/(U + 16)$ | $3480/(U + 22.8)$ |
| Thrust shafts | $59.3 \times 10^6/(U + 16)$ | $5225/(U + 22.8)$ |
| Tail shafts | $1.314 \times 10^6$ | 81.24 |
| Tube shafts | $1.202 \times 10^6$ | 74.34 |

*H* = horsepower at rated speed

*R* = shaft revolutions per minute at rated speed

*U* = ultimate tensile strength of the shaft material, kg/mm$^2$ (ksi). For tensile strength greater than 80 kg/mm$^2$ (115 ksi), *U* equal to 80 kg/mm$^2$ (115 ksi) is to be used.

*Notes*

1 When a material other than Grade 2 steel forging is used for tail shafts, the Owners of the vessel are to be notified if weld repair of the shaft may be difficult. Material for shafting is to be tested in the presence of a Surveyor. In general, material with elongation less than 16% in 50 mm (2 in.) is not to be used for shafting, couplings or coupling bolts.

2 For dimension of coupling bolts, see 4-2-1/17.

3 The thickness of line shaft coupling flanges is not to be less than the minimum required diameter of the coupling bolts, and the fillet radius at the base of the flange is not to be less than one-eighth of the actual shaft diameter. For couplings other than flanged couplings integral with the shaft, the shaft diameter in way of fitted coupling members is not to be less than 1.1 times the minimum required line shaft diameter.

4 The thrust shaft diameter is to be determined at the bottom of the collar when it transmits torque.

5 When shafting is exposed to sea water, the diameter is to be increased by 2.5%.

## 5 Line Shaft Bearing Location

The location and spacing of line shaft bearings are to take into consideration the effect of these arrangements on the low-speed gear elements, and the natural frequency of the propulsion shafting.

## 7 Tail Shaft Inboard End

The inboard end of a tail shaft may be tapered at the coupling to not less than 1.09 times the minimum required line shaft diameter. Abrupt changes in shaft diameters at the coupling between tail shaft and line shaft are to be avoided. The thickness of the tail shaft coupling flange is not to be less than the minimum required diameter of the coupling bolts. The fillet radius at the base of the flange is not to be less than one-eighth of the shaft diameter. Special consideration will be given to fillets of multiple-radii design.

## 9 Tail Shaft Propeller-end Design

Tail shafts are to be provided with an accurate taper fit in the propeller hub, particular attention being given to the fit at the large end of the taper. Means are to be provided for sealing the shaft taper in way of the propeller assembly against saltwater in accordance with 4-2-2/13 as follows:

### 9.1 Propeller Forward End

Where exposed to saltwater, the propeller assembly is to be sealed at the forward end with a well-fitted soft-rubber packing ring and

### 9.3 Propeller Aft End

Where exposed to saltwater, a fairwater cap filled with suitable sealing material or equivalent sealing arrangement is to be provided at the aft end of the propeller.

### 9.5 Non-corrosive Non-pitting Alloys

For vessels under 45.7 m (150 ft) in length, the sealing in 4-2-1/9.1 and 4-2-1/9.3 is not required where the tail shaft is fabricated of corrosion resistant pitting-resistant alloy unless required by the manufacturer.

The key is to fit tightly in the keyway and be of sufficient size to transmit the full torque of the shaft, but it is not to extend into the liner counterbore on the forward side of the propeller hub. The forward end of the keyway is to be so cut in the shaft as to give a gradual rise from the bottom of the keyway to the surface of the shaft. Ample fillets are to be provided in the corners of the keyway and, in general, stress concentrations are to be reduced as far as practicable.

## 11 Propeller-End Bearings

### 11.1 Water-Lubricated Bearings

The length of the bearing next to and supporting the propeller is not to be less than four times the required tail shaft diameter, except that the length of metal bearings will be subject to special consideration.

### 11.3 Oil-Lubricated Bearings

The length of white-metal-lined, oil-lubricated propeller-end bearings fitted with an approved oil-seal gland is to be on the order of two times the required tail shaft diameter. Oil-lubricated cast-iron and bronze bearings will be subject to special consideration.

## 13 Tail Shaft Liners

### 13.1 Thickness at Bearings

#### 13.1.1 Bronze Liner *(2009)*

The thickness of bronze liners to be fitted to tail shafts or tube shafts is not to be less than that given by the following equation:

$$t = T/25 + 5.1 \text{ mm} \qquad t = T/25 + 0.2 \text{ in.}$$

where

$t$ = thickness of liner, in mm (in.)

$T$ = required diameter of tail shaft, in mm (in.)

#### 13.1.2 Stainless Steel Liner *(2009)*

The thickness of stainless steel liners to be fitted to tail shafts or tube shafts is not to be less than one-half that required for bronze liners or 6.5 mm (0.25 in.), whichever is greater.

### 13.3 Thickness Between Bearings

The thickness of a continuous bronze liner between bearings is to be not less than three-fourths of the thickness $t$ determined by the foregoing equation.

### 13.5 Continuous Fitted Liners

Continuous fitted liners are to be in one piece or, if made of two or more lengths, the joining of the separate pieces is to be done by an approved method of fusion through not less than two-thirds the thickness of the liner or by an approved rubber seal.

### 13.7 Fit Between Bearings

If the liner does not fit the shaft tightly between the bearing portions, the space between the shaft and liner is to be filled by pressure with an insoluble non-corrosive compound.

### 13.9 Material and Fit

Fitted liners are to be of a high-grade composition, bronze or other approved alloy, free from porosity and other defects, and are to prove tight under hydrostatic test of 1.0 bar (1 kgf/cm$^2$, 15 psi). All liners are to be carefully shrunk or forced upon the shaft by pressure and they are not to be secured by pins.

### 13.11 After-end Seal

Effective means are to be provided to prevent sea water having access to the shaft at the part between the after end of the liner and the propeller hub

### 13.13 Glass Reinforced Plastic Coating

Glass reinforced plastic coatings may be fitted on propulsion shafting when applied by an approved procedure to the satisfaction of the Surveyor. Such coatings are to consist of at least four plies of cross-woven glass tape impregnated with resin, or an equivalent process. In all cases where reinforced plastic coatings are employed, effective means are to be provided to prevent water having access to the shaft. Provisions are to be made for overlapping and adequately bonding the coating to fitted or clad liners.

### 13.15 Stainless Steel Cladding *(2009)*

Stainless steel cladding of shafts is to be carried out in accordance with an approved procedure. See Appendix 7-A-11, "Repair and Cladding of Shafts" of the *Rules for Survey After Construction (Part 7)*.

## 15 Hollow Shafts

The proportions of hollow shafts are to be such that their strength will be equivalent to that required by the equations for the corresponding solid shafts.

## 17 Coupling Bolts

The minimum diameter of the shaft coupling bolts is to be determined by the following equation:

$$d = 0.57\sqrt{\frac{D^3}{Nr}}$$

where

| | | |
|---|---|---|
| $d$ | = | diameter of bolts at joint, in mm (in.) |
| $D$ | = | required diameter of shaft, in mm (in.), as defined 4-2-1/3, using mechanical properties of coupling bolt material |
| $N$ | = | number of bolts fitted in one coupling |
| $r$ | = | radius of the pitch circle, in mm (in.) |

Coupling bolts are to be accurately fitted and where couplings are separate from the shaft, provision is to be made to resist the astern pull.

## 19 Circulating Currents *(2014)*

Where means are provided to prevent circulating currents from passing between the propeller, shaft and the hull, a warning notice plate is to be provided in a visible place cautioning against the removal of such protection.

PART

# 4

## CHAPTER 2 Propulsion and Maneuvering Machinery

## SECTION 2 Propellers

## 1 General

Propellers and propulsion shafting for self-propelled vessels are to be designed, constructed and tested in accordance with the requirements of this Section. Before proceeding with the construction, prints of the propeller and shafting plans giving design data and material characteristics are to be submitted. The construction of propellers and shafts on vessels exhibiting special design features may be carried out in accordance with other applicable ABS Rules or Guides.

## 3 Materials and Testing

### 3.1 Propeller Material

The material of the propellers is to be tested in the presence of and inspected by a Surveyor in accordance with the requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or to other requirements which have been approved by the Committee. The finished and assembled propellers are to be inspected by the Surveyor.

### 3.3 Stud Material

The material of the studs securing detachable blades to the hub is to be of Grade 2 steel or equally satisfactory material and is to be tested in the presence of and inspected by the Surveyor in accordance with the requirements of 2-3-7/7 of the ABS *Rules for Materials and Welding (Part 2)*.

## 5 Blade Design

### 5.1 Blade Thickness

Where the propeller blades are of conventional design, the thickness of the blades is not to be less than determined by the following equations:

#### 5.1.1 Fixed-Pitch Propellers

$$t_{0.25} = K_1\sqrt{\frac{AH}{CRN}} \pm \frac{1.72BK}{C} \quad \text{mm (in.)}$$

where

$K_1$ = 915 (41)

$A$ = $1.0 + (6.0/P_{0.70}) + 4.3P_{0.25}$

$B$ = $(4300wa/N)\,(R/100)^2\,(D/20)^3$

$C$ = $(1 + 1.5P_{0.25})\,(Wf - B)$

$t_{0.25}$ = required thickness at the one-quarter radius, in mm (in.)

$H$ = power at rated speed; kW (PS, hp) (1 PS = 735 W; 1 hp = 746 W)

$R$ = rpm at rated speed

$N$ = number of blades

$P_{0.25}$ = pitch at one-quarter radius divided by propeller diameter

$P_{0.7}$ = pitch at seven-tenths radius divided by propeller diameter, corresponding to the design ahead conditions

$W$ = expanded width of a cylindrical section at the 0.25 radius, in mm (in.)

$a$ = expanded blade area divided by the disc area

$D$ = propeller diameter, in m (ft)

$K$ = rake of propeller blade, in mm/m (in/ft), multiplied by $D/2$ (with forward rake, use minus sign in equation; with aft rake, use plus sign)

$f, w$ = material constants from the following table:

| *Type* | *Representative Propeller Materials [See Chapter 3 of the ABS* Rules for Materials and Welding (Part 2)*]* | *SI and MKS Units* | | *US Customary Units* | |
|---|---|---|---|---|---|
| | | *f* | *w* | *f* | *w* |
| 2 | Manganese bronze | 2.10 | 8.30 | 68 | 0.30 |
| 3 | Nickel-manganese bronze | 2.13 | 8.00 | 69 | 0.29 |
| 4 | Nickel-aluminum bronze | 2.62 | 7.50 | 85 | 0.27 |
| 5 | Mn-Ni-Al bronze | 2.37 | 7.50 | 77 | 0.27 |
| | Cast iron | 0.66 | 7.20 | 25 | 0.26 |
| | Cast steel | 2.10 | 8.30 | 68 | 0.30 |
| CF-3 | Austenitic stainless steel | 2.10 | 7.75 | 68 | 0.28 |

*Notes*

1 For propellers of unusual design, material, or application, the blade thickness will be specially considered.

2 For vessels below 30 m (100 ft) in length with multiple shafts, and all vessels below 20 m (65 ft) in length, consideration will be given to the acceptance of propeller designs on the basis of a review of the manufacturer's design parameters and guarantee of physical properties and suitability for the intended service.

5.1.2 Controllable-Pitch Propellers

$$t_{0.35} = K_2 \sqrt{\frac{AH}{CRN}} \pm \frac{1.09BK}{C} \quad \text{mm (in.)}$$

where

$K_2$ = 735 (32.8)

$A$ = $1.0 + (6.0/P_{0.7}) + 3P_{0.35}$

$B$ = $(4900wa/N)\,(R/100)^2\,(D/20)^3$

$C$ = $(1 + 0.6P_{0.35})\,(Wf - B)$

$t_{0.35}$ = required thickness at the 0.35 radius, in mm (in.)

$P_{0.35}$ = pitch at 0.35 radius divided by propeller diameter, corresponding to the design ahead conditions

$W$ = expanded width of a cylindrical section at the 0.35 radius, in mm (in.)

$H, R, N, P_{0.7}, a, D, K, f$ and $w$ are as defined in 4-2-2/5.1.1.

## 5.3 Blade-root Fillets

Fillets at the root of the blades are not to be considered in the determination of blade thickness.

### 5.5 Built-up Blades

The required blade section is not to be reduced in order to provide clearance for nuts. The face of the flange is to bear on that of the hub in all cases, but the clearance of the spigot in its counterbore or the edge of the flange in the recess is to be kept to a minimum.

### 5.7 Tip Thickness

The minimum blade thickness, $t_a$, at the tip is to be determined from the following equation where $D$ is the diameter of the propeller in m (ft):

$t_a = 6D$ mm $\qquad$ $t_a = 0.072D$ in.

### 5.9 Blade Thickness at Other Radii

The blade thickness at any radius is not to be less than given by a straight line relationship between the thickness found from 4-2-2/5.1 and the tip thickness $t_a$.

## 7 Studs

### 7.1 Stud Area

$s = 0.056 W t_{0.35}^2 f/rn$ mm$^2$ $\qquad$ $s = 0.0018 W t_{0.35}^2 f/rn$ in$^2$

where

$s$ = area of one stud at bottom of thread, in mm$^2$ (in$^2$)

$n$ = number of studs on driving side of blade

$r$ = radius of pitch circle of the studs, in mm (in)

$t_{0.35}$ = maximum thickness at the 0.25 or 0.35 radius, in mm (in.), from propeller drawing

$W$ and $f$ are as defined in 4-2-2/5.

### 7.3 Fit of Studs and Nuts

Studs are to be fitted tightly into the hub and provided with effective means for locking. The nuts are also to have a tight-fitting thread and be secured by stop screws or other effective locking devices.

## 9 Blade Flange and Mechanisms

The strength of the propeller blade flange and internal mechanisms of controllable-pitch propellers subjected to the forces from propulsion torque is to be at least 1.5 times that of the blade at design pitch conditions.

## 11 Key

The key is to have a true fit in the hub. For shape of keyway in shaft, see 4-2-1/9. Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for review.

## 13 Protection Against Corrosion

For vessels engaged primarily in saltwater service, the exposed steel of the shaft is to be protected from the action of the water by filling all spaces between cap, hub and shaft with a suitable material. The propeller assembly is to be sealed at the forward end with a well-fitted soft rubber packing ring. When the rubber ring seal is fitted in an external gland, the hub counterbore is to be filled with suitable material. Clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub, and the ring is to be sufficiently oversize to squeeze into the clearance space when the propeller is driven up on the shaft. Where necessary, a filler piece is to be fitted in the propeller hub keyway to provide a flat unbroken seating for the ring. The recess formed at the small end of the taper by the overhanging propeller hub is to be packed with red lead putty or rust preventive compound before the propeller nut is put on.

PART
# 4

## CHAPTER 2 Propulsion and Maneuvering Machinery

## SECTION 3 Steering Gears

## 1 Steering Gear Requirements for All Type of Vessels

### 1.1 General

All self-propelled vessels are to be provided with effective means for steering which is to be capable of putting the rudder from hard over to hard over. In general, power operated steering gears are to be designed to be capable of putting the rudder from 35 degrees on one side to 35 degrees on the other side with the vessel running ahead at the maximum continuous rated shaft RPM and at the design waterline.

Steering gears for passenger vessels which are over 100 gross tons or are intended to carry more than 150 passengers are to be designed, constructed and tested in accordance with 4-2-3/3. Steering gears for all other self-propelled vessels are to comply with the following.

### 1.3 Plans

Detailed plans and calculations of the steering arrangement are to be submitted for approval.

### 1.5 Power Gear Stops *(2010)*

Power gears are to be provided with arrangements, such as limit switches, for stopping the gear before the structural rudder stops or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the position of the gear itself, such as from the rudder stock, tiller, or ram, rather than by the control system.

### 1.7 Strength Requirements

Tillers, quadrants, yokes, steering chains, rods, and cables and all parts of steering gears subject to load from the rudder are to be of materials tested in accordance with the applicable requirements of Chapter 1 of the ABS *Rules for Materials and Welding (Part 2)*. In general, steering gears are to be so proportioned as to have a strength equivalent to that of the required upper rudder stock (see 3-2-4/23.5.1 or 3-2-5/25.5.1 as applicable. Parts in tension or subject to shock (impact) are not to be of cast iron.

### 1.9 Steering Chains

Steering chains and wire rope are to be of special quality and tested as required by Sections 2-2-1 and 2-2-2 of the ABS *Rules for Materials and Welding (Part 2)*, respectively.

### 1.11 Sheaves

Sheaves are to be of ample size, and so placed as to provide a fair lead to the quadrant and avoid acute angles. Parts subjected to shock are not to be of cast iron. For sheaves intended to be used with wire ropes, the radius of the grooves is to equal that of the wire rope plus 0.8 mm ($^1/_{32}$ in.) and the sheave diameter is to be determined on the basis of the wire rope flexibility. For 6 × 37 wire rope, the sheave diameters are to be not less than 18 times that of the wire rope. For wire rope of lesser flexibility, the sheave diameter is to be increased accordingly. Sheave diameters for chain are to be not less than 30 times the chain diameter.

### 1.13 Buffers

Steering gears other than hydraulic types are to be designed with suitable buffer arrangements to relieve the gear from shock from the rudder.

### 1.15 Hydraulic Piping for Steering Gears

A relief valve is to be provided for the protection of the hydraulic system. Pressure piping is to meet the requirements of Part 4, Chapter 3, except that the mill tests need not be witnessed by the Surveyor. After fabrication, the piping system or each piping component is to be subjected, in the presence of the Surveyor, to a hydrostatic test equal to 1.5 times the design working pressure. After installation in the vessel, the piping is to be tested under working conditions including a check of the relief valve operation.

### 1.17 Electrical Parts of Steering Gears

Electrical parts of steering gears are to meet the applicable requirements of Part 4, Chapter 5.

### 1.19 Trials

The steering gear is to be tested to demonstrate to the Surveyor's satisfaction that the requirements of these Rules have been met. Satisfactory performance is to be demonstrated under the following conditions.

#### 1.19.1 Towboats and Tugs

From 35 degrees on either side to 30 degrees on the other side in 20 seconds with vessel moored to a dock or the river bank and with the main propulsion engines operating at approximately the full load rack setting.

#### 1.19.2 Passenger Vessels and Other Self-propelled Vessels

From 35 degrees on either side to 30 degrees on the other side in not more than 28 seconds with the vessel running ahead at the maximum continuous rated shaft RPM. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated RPM. Where a test with the vessel running ahead at full speed is not practicable, the test for towboats and tugs in 4-2-3/1.19.1 may be used.

Consideration may be given to other means for proving the adequacy of the steering arrangements and power subject to the satisfaction of the attending Surveyor.

## 3 Steering Gears for Passenger Vessels Over 100 Gross Tons or Carrying More than 150 Passengers

### 3.1 General

All passenger vessels which are over 100 gross tons or are intended to carry more than 150 passengers are to be provided with an approved means of steering. All power-operated steering gears for such vessels are to be constructed to the satisfaction of and tested in the presence of the Surveyor as follows:

#### 3.1.1 Design

*i)* *Capability*. The steering gear is to be designed to be capable of:

- Putting the rudder from 35 degrees on one side to 35 degrees on the other side with the vessel running ahead at the maximum continuous rated shaft RPM and at the design waterline, and
- Meeting the performance requirements in accordance with 4-2-3/3.33.1. In this respect, any approval is to be understood as being subject to compliance with 4-2-3/3.33.1.

#### 3.1.2 Special Steering

Vessels having cycloidal, azimuthing or similar type propulsion systems in which the steering is effected by changing the direction of the propulsion thrust are to comply with the provisions in Section 4-3-5 of the *Steel Vessel Rules*.

#### 3.1.3 Single Failure *(1996)*

The steering gear system is to be designed so that after a single failure in its piping system, one of the power units or mechanical connections to the power units the defect can be isolated so that the integrity of the remaining part of the system will not be impaired and the steering capability can be maintained or speedily regained.

## 3.3 Plans

Detailed plans of the steering arrangement, including machinery, controls, instrumentation, power supplies, piping systems, and pressure cylinders are to be submitted for approval. See 4-1-1/5.3.

The rated torque of the unit is to be indicated in the data submitted for review.

## 3.5 Steering-gear Protection

The steering gear is to be protected from the weather. Steering gear compartments are to be readily accessible. Handrails and gratings or other non-slip surfaces are to be provided in way of steering gear machinery and controls.

## 3.7 Power-driven Steering Gear

The steering gear is to be power-operated if the required upper stock diameter is 120 mm (4.7 in.) or greater. Refer to 3-2-5/25.5.1.

## 3.9 Mechanical Components

All steering gear parts transmitting force to or from the rudder, such as tillers, quadrants, rams, pins, tie rods and keys are to be proportioned as to have strength equivalent to that of the upper rudder stock required by 3-2-5/25.5.1.

## 3.11 Power Units

### 3.11.1 Definitions

For purposes of the Rules, a steering gear power unit is:

*i)* *Electric Steering Gear.* An electric motor and its associated electrical equipment.

*ii)* *Electro-hydraulic Steering Gear.* An electric motor and its associated electrical equipment and connected pump or pumps.

*iii)* *Other Hydraulic Steering Gear.* A driving engine and connected pump or pumps.

### 3.11.2 Composition

The steering gear is to be comprised of two or more identical power units and is to be capable of operating the rudder as required by 4-2-3/3.33.1 while operating with one or more of the power units. Mechanical connections to the power unit are to be of substantial construction.

The steering gear is to be arranged so that a single failure in one of the power units or mechanical connections to the power units will not impair the integrity of the remaining part of the steering gear. See 4-2-3/3.1.3.

### 3.11.3 Testing

A prototype of each new design power unit pump is to be shop tested for a duration of not less than 100 hours. The testing is to be carried out in accordance with an approved agenda and is to include the following as a minimum:

*i)* The pump and stroke control (or directional control valve) is to be operated continuously from full flow and relief valve pressure in one direction through idle to full flow and relief valve pressure in the opposite direction.

*ii)* Pump suction conditions are to simulate lowest anticipated suction head. The power unit is to be checked for abnormal heating, excessive vibration, or other irregularities. Following the test, the power unit pump is to be disassembled and inspected in the presence of a Surveyor.

## 3.13 Mechanical Steering

Steel-wire rope, chain and other mechanical steering systems are to comply with 4-2-3/1.9, 4-2-3/1.11 and 4-2-3/1.13.

## 3.15 Material

### 3.15.1 General

All parts of steering gears transmitting a force to the rudder and pressure retaining components of hydraulic rudder actuators are to be of steel or other approved ductile material. The use of gray cast iron or other material having an elongation less than 12% in 50 mm (2 in.) is not acceptable.

### 3.15.2 Material Test Attendance *(2010)*

Except as modified below, materials for the parts and components mentioned in 4-2-3/3.15.1 are to be tested in the presence of the Surveyor in accordance with the requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)*. See also 4-2-3/3.23.2.

Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor. For upper rudder stock keys, see 3-2-5/25.1.

Material tests for forged, welded or seamless steel parts (including the internal components) of rudder actuators that are under 150 mm (6 in.) in internal diameter need not be carried out in the presence of the Surveyor. Such parts are to comply with the requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or such other appropriate material specifications as may be approved in connection with a particular design, and may be accepted on the basis of a review of mill certificates by the Surveyor.

## 3.17 Transfer

An effective means of rapid transfer between power units is to be provided. Such transfer arrangements are also to include the capability to initiate the transfer process manually (i.e., non-automatic) from the navigation bridge.

## 3.19 Power-gear Stops

Power gears are to be provided with stops in accordance with 4-2-3/1.5.

## 3.21 Rudder Actuators

### 3.21.1 General

Hydraulic cylinders and housings of vane-type steering gears are to meet the requirements of 4-2-3/3.15 for material and material tests, and also 2-4-2/1 of the ABS *Rules for Materials and Welding (Part 2)* for welding, 4-4-1A1/3.1 (Equation No. 2), 4-4-1A1/5, 4-4-1A1/7 of the *Steel Vessel Rules* for design, and 4-4-1A1/21 of the *Steel Vessel Rules* for hydrostatic tests. For cylinders, see also 4-3-4/1.11 of the *Steel Vessel Rules* for plans.

### 3.21.2 Non-duplicated Rudder Actuators

Regardless of extent of nondestructive testing, casting quality factor is not to exceed 0.85. See the last note of 4-4-1A1/Table 2 of the *Steel Vessel Rules*.

### 3.21.3 Oil Seals

Oil seals between non-moving parts forming part of the exterior pressure boundary are to be of the pressure seal type. Oil seals between moving parts forming the external pressure boundary are to be fitted in duplicate so that the failure of one seal does not render the actuator inoperative. Alternative seal arrangements will be considered where they are shown to be equivalent.

## 3.23 Piping Arrangement

### 3.23.1 General

Piping for hydraulic gears is to be arranged so that transfer between units can be readily effected. The arrangement is to be such that a single failure in one part of the piping will not impair the integrity of remaining parts of the system. See 4-2-3/3.1.3. Where necessary, arrangements for bleeding air from the hydraulic system are to be provided.

#### 3.23.2 Requirements

Piping systems are to meet the requirements of 4-3-8/1.3 through 4-3-8/1.15. The design pressure for steering gear system piping and components subject to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure to be expected in order to satisfy the operational conditions specified in 4-2-3/3.33.1.

#### 3.23.3 Valves *(1996)*

In general, valves are to comply with the requirements of 4-3-2/11. Isolating valves are to be fitted on the pipe connections to the rudder actuator. For vessels with non-duplicated rudder actuators, the isolating valves are to be directly mounted on the actuator.

#### 3.23.4 Relief Valves *(1996)*

Relief valves are to be provided for the protection of the hydraulic system. Each relief valve is to be capable of relieving not less than the full flow of all the pumps which can discharge through it increased by 10%. With this flow condition, the maximum pressure rise is not to exceed 10% of the relief valve setting. In this regard, consideration is to be given to the extreme expected ambient conditions in respect to oil viscosity.

The relief valve setting is to be at least 1.25 times the maximum working pressure to be expected in order to satisfy the operational conditions specified in 4-2-3/3.33.1 but is not to exceed the design pressure in 4-2-3/3.33.2.

#### 3.23.5 Filtration

A means is to be provided to maintain cleanliness of the hydraulic fluid.

#### 3.23.6 Storage Tank

A fixed storage tank having sufficient capacity to recharge the complete hydraulic power system including the power unit reservoirs is to be provided. The tank is to be permanently connected by piping in such a manner that the system can be readily recharged from a position within the steering gear compartment. The storage tank is to be provided with an approved level indicating system in accordance with 4-3-3/9.

#### 3.23.7 Testing

The following tests are to be performed in the presence of the Surveyor.

*3.23.7(a) Shop Tests (2008).* After fabrication, each component of the steering gear piping system, including the power units, hydraulic cylinders and piping, is to be hydrostatically tested at the plant of manufacture to 1.5 times the relief valve setting.

*3.23.7(b) Installation Test.* After installation in the vessel, the complete piping system, including power units, hydraulic cylinders and piping, is to be subjected to a hydrostatic test equal to 1.1 times the relief valve setting, including a check of the relief-valve operation.

### 3.25 Controls

#### 3.25.1 General *(1 July 2011)*

Control system is the equipment by which orders are transmitted from the navigation bridge to the power units. Control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables. For the purpose of these Rules, steering wheels or steering levers are not considered to be part of the control system.

There are to be two independent control systems provided, each of which can be operated from the navigation bridge. The independent control systems are to meet the following requirements.

*3.25.1(a) Redundancy.* These control systems are to be independent in all respects and are to provide on the navigation bridge all necessary apparatus and arrangements for the starting and stopping of steering gear motors and the rapid transfer of steering power and control between units.

The control cables and piping are to be separated throughout their length as widely as is practicable.

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated throughout their length as widely as is practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate. See 4-5-2/11.1 and 4-5-6/9.3.

*3.25.1(b) Local Steering Gear Control.* In addition to the steering gear control systems required above, local steering gear control is to be provided in the steering gear compartment. These controls if electric are to be supplied from the steering gear power circuit from a point within the steering gear compartment.

*3.25.1(c) Duplication.* All electric components of the steering gear control system are to be duplicated. This does not require duplication of a steering wheel or steering lever.

*3.25.1(d) Steering Mode Selector Switch.* If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

*3.25.1(e) Follow-up Amplifier.* In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, the follow-up amplifiers are to be protected selectively.

*3.25.1(f) Additional Control Systems.* Control circuits for additional control systems (e.g. steering lever or autopilot) are to be designed for all-pole disconnection.

*3.25.1(g) Feed-back Units and Limit Switches.* The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

*3.25.1(h) Hydraulic Control Components.* Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear, (e.g. solenoid valves, magnetic valves) are to be considered as part of the steering gear control system and shall be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

#### 3.25.2 Hydraulic Telemotor *(1 July 2011)*

When the control comprises a hydraulic telemotor, a second independent control system will not be required.

#### 3.25.3 Control System Disconnect *(1998)*

Means are to be provided in the steering gear compartment to disconnect the steering gear control system from the power circuit when local control is to be used. Such means for disconnecting are to be operable by one person without the need for tools. Additionally, if more than one steering station is provided, a selector switch is to disconnect completely all stations, except the one in use.

#### 3.25.4 Communications

A means of communication is to be provided in accordance with 4-5-6/9.7.

#### 3.25.5 Computer-based Systems *(1 July 2011)*

Steering control systems that are computer-based systems are to comply with Section 4-9-3 of the *Steel Vessel Rules* and are to be considered Category III.

## 3.27 Instrumentation and Alarms

The following instruments and alarms are to be provided. The audible and visual alarms required are to be of the self-monitoring type so that a circuit failure will cause an alarm condition and they are to have provisions for testing.

### 3.27.1 Rudder Position Indicator

The angular position of the rudder is to be indicated on the navigation bridge and in the steering gear compartment. The rudder angle indication is to be independent of the steering gear control system, and readily visible from the control position.

### 3.27.2 Power Failure

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a power failure to any one of the steering gear power units.

### 3.27.3 Motor Alarms *(2000)*

A visual and audible alarm is to be given on the navigation bridge to indicate an overload condition of the steering gear power unit motor. Where a three-phase supply is used a visual and audible alarm is to be supplied which will indicate failure of any one of the supply phases. The operation of this alarm is not to interrupt the circuit.

### 3.27.4 Control Power Failure

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate an electrical power failure in any steering gear control circuit, or remote control circuit.

### 3.27.5 Motor Running Indicators

Indicators for running indication of motors are to be installed on the navigation bridge and in the engine room control station.

### 3.27.6 Low Oil-level Alarm

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a low oil level in any power unit reservoir.

### 3.27.7 Hydraulic Lock *(2007)*

Where the arrangement is such that a single failure may cause hydraulic lock and loss of steering, an audible and visual hydraulic lock alarm which identifies the failed system or component is to be provided on the navigation bridge. The alarm is to be activated upon steering gear failure if:

- Position of the variable displacement pump control system does not correspond to the given order, or
- Incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected.

Alternatively, for follow-up control systems, an independent steering failure alarm complying with the following requirements may be provided in lieu of a hydraulic lock alarm:

*i)* The steering failure alarm system is to actuate an audible and visible alarm in the wheelhouse when the actual position of the rudder differs by more than 5 degrees from the rudder position ordered by the follow-up control systems for more than:

30 seconds for ordered rudder position changes of 70 degrees;

6.5 seconds for ordered rudder position changes of 5 degrees; and

The time period calculated by the following formula for ordered rudder positions changes between 5 degrees and 70 degrees:

$$t = (R/2.76) + 4.64$$

where:

$t$ = maximum time delay in seconds

$R$ = ordered rudder change in degrees

*ii)* The steering failure alarm system must be separate from, and independent of, each steering gear control system, except for input received from the steering wheel shaft.

*iii)* Each steering failure alarm system is to be supplied by a circuit that:

*a.* is independent of other steering gear system and steering alarm circuits.

*b.* is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and

*c.* has no overcurrent protection except short circuit protection.

3.27.8 Autopilot Override *(1999)*

Steering gear control systems capable of operation in the autopilot mode are to be provided with the means to automatically disengage the autopilot controls when an effort is made to manually steer the vessel from the main steering station at the navigation bridge. Additionally, an audible and visual alarm is to be provided at the navigation bridge in the event the override mechanism fails to respond within a preset period.

3.27.9 Loop Failures *(1 July 2011)*

A visual and audible alarm is to be given on the navigation bridge to indicate a loop failure.

*Note:* Monitoring is to be provided for short circuit, broken connections and earth faults for command and feedback loops. Monitoring for loop failures is not required, when a steering failure alarm system is provided. See 4-2-3/3.27.7i), ii) and iii).

3.27.10 Computer-based System Failures *(1 July 2011)*

For steering control systems that are computer-based systems, a visual and audible alarm is to be given on the navigation bridge to indicate a computer-based system failure.

*Note:* Monitoring is to be provided for data communication errors, computer hardware failures and software failure. See also Section 4-9-3 of the *Steel Vessel Rules*. Monitoring for computer-based system failures is not required, when a steering failure alarm system is provided. See 4-2-3/3.27.7i), ii) and iii).

## 3.29 Electrical Components *(1996)*

Electrical components of the steering gear are to meet the applicable requirements of Part 4, Chapter 5. The steering gear electrical circuit is to comply with 4-5-2/11.

## 3.31 Operating Instructions

Appropriate operating instructions with a block diagram showing the changeover procedures for steering gear control systems and steering gear power units are to be permanently displayed on the navigation bridge and in the steering gear compartment.

## 3.33 Trials

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of these Rules have been met. The trial is to include the operation of the following:

3.33.1 *(2017)*

The steering gear, including demonstration of the performance requirements as shown below with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions, steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either:

*i)* The rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition.

*ii)* The rudder load and torque at the specified trial loading condition have been predicted (based on the system pressure measurement) and extrapolated to the full load condition using the following method to predict the equivalent torque and actuator pressure at the deepest seagoing draft:

$$Q_F = Q_T\alpha$$

$$\alpha = 1.25\left(\frac{A_F}{A_T}\right)\left(\frac{V_F}{V_T}\right)^2$$

where

| | | |
|---|---|---|
| $\alpha$ | = | extrapolation factor |
| $Q_F$ | = | rudder stock moment for the deepest service draft and maximum service speed condition |
| $Q_T$ | = | rudder stock moment for the trial condition |
| $A_F$ | = | total immersed projected area of the movable part of the rudder in the deepest seagoing condition |
| $A_T$ | = | total immersed projected area of the movable part of the rudder in the trial condition |
| $V_F$ | = | contractual design speed of the vessel corresponding to the maximum continuous revolutions of the main engine at the deepest seagoing draft |
| $V_T$ | = | measured speed of the vessel (considering current) in the trial condition |

Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken as:

$$P_F = P_T\alpha$$

where

| | | |
|---|---|---|
| $P_F$ | = | estimated steering actuator hydraulic pressure in the deepest seagoing draft condition |
| $P_T$ | = | maximum measured actuator hydraulic pressure in the trial condition |

Where constant volume fixed displacement pumps are utilized, the requirements can be deemed satisfied if the estimated steering actuator hydraulic pressure at the deepest draft is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data should be supplied and interpreted to estimate the delivered flow rate that corresponds to the deepest seagoing draft in order to calculate the steering time and allow it to be compared to the required time.

Where $A_T$ is greater than $0.95A_F$, there is no need for extrapolation methods to be applied.

*iii)* Alternatively the designer or builder may use computational fluid dynamic (CFD) studies or experimental investigations to predict the rudder stock moment at the full sea going draft condition and service speed. These calculations or experimental investigations are to be to the satisfaction of ABS.

In any case for the main steering gear trial, the speed of the vessel corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

Satisfactory performance is to be demonstrated under the following conditions.

*3.33.1(a) Full Speed Trial.* From 35 degrees on either side to 30 degrees on the other side in not more than 28 seconds with the vessel running ahead at the maximum continuous rated shaft RPM. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated RPM. This test is to be met with one of the power units in reserve.

*3.33.1(b) Half Speed Trial.* From 15 degrees on either side to 15 degrees on the other side in not more than 60 seconds while running at one-half of the maximum ahead speed or 7 knots, whichever is the greater. This test is to be conducted with one of the power units in reserve. This test may be waived where the steering gear consists of two identical power units with each capable of meeting the requirements in 4-2-3/3.33.1 above.

Where three or more power units are provided, the test procedures are to be specially considered on basis of the specifically approved operating arrangements of the steering gear system.

3.33.2

The power units, including transfer between power units.

3.33.3

The emergency power supply required by 4-5-6/9.3.

3.33.4

The steering gear controls, including transfer of control, and local control.

3.33.5

The means of communications between the navigation bridge, engine room, and the steering gear compartment.

3.33.6

The alarms and indicators required by 4-2-3/3.27 (test may be done at dockside).

3.33.7

The storage and recharging system contained in 4-2-3/3.23.6 (test may be done at dockside).

3.33.8

The isolation and automatic starting provisions of 4-2-3/3.1.3 (test may be done at dockside).

PART

# 4

## CHAPTER 3 Pumps and Piping Systems

**CONTENTS**

PART

# 4

# CHAPTER 3 Pumps and Piping Systems

# SECTION 1 General

## 1 Construction and Installation

### 1.1 General Requirements

All vessels are to be provided with the necessary pumps and piping systems for safe and efficient operation in the service for which they are intended. Materials and workmanship are to be in accordance with good marine practice and to the satisfaction of the Surveyor. The arrangements and details are to comply with the following requirements.

### 1.3 Piping Groups *(2008)*

To distinguish between detail requirements for the various systems, the piping on shipboard is divided into two groups.

Group I, in general, includes all piping intended for working pressures or temperatures in various services, as follows:

| *Service* | *Pressure bar (kgf/cm$^2$, psi)* | *Temperature °C (°F)* |
|---|---|---|
| Vapor and Gas | over 10.3 (10.5, 150) | over 343 (650) |
| Water | over 15.5 (15.8, 225) | over 177 (350) |
| Lubricating Oil | over 15.5 (15.8, 225) | over 204 (400) |
| Fuel Oil | over 10.3 (10.5, 150) | over 66 (150) |
| Hydraulic Fluid | over 15.5 (15.8, 225) | over 204 (400) |

Group II includes all piping intended for working pressures and temperatures below those stipulated under Group I. Group II also includes cargo oil and tank-cleaning piping in cargo area on oil carriers and open-ended lines such as drains, overflows, engine exhausts, boiler escape pipes, and vents, regardless of the working pressures or temperatures.

## 3 Plans and Data to Be Submitted

### 3.1 Plans *(2011)*

Before proceeding with the work, diagrammatic plans are to be submitted, showing clearly the arrangement and details of the following. Plans should generally be submitted electronically to ABS. However, hard copies will also be accepted.

- General arrangement of pumps and piping
- Sanitary systems
- Bilge and ballast systems
- Vent, sounding and overflow pipes
- Fuel oil filling, transfer and service systems
- Lubricating oil systems
- Cargo oil pumping systems

- Hydraulic-power piping systems
- Essential raw-water and freshwater service systems
- Fire-main and fire extinguishing systems (See Part 4, Chapter 4)
- Steering-gear piping systems (See Section 4-2-3)
- Starting-air piping
- Exhaust piping for internal combustion engines and auxiliary boilers.

### 3.3 Data

The plans are to consist of a diagrammatic drawing of each system accompanied by lists of materials giving size, wall thickness, maximum working pressure and material of all pipes and the type, size, pressure rating and material of valves and fittings.

## 5 Material Tests and Inspection

### 5.1 Specifications and Purchase Orders

The appropriate material to be used for the various pipes, valves and fittings is indicated in Section 4-3-2, except that tests of material for valves and fittings need not be witnessed by the Surveyors. Where electric welding is used, the requirements of Chapter 4 of the ABS *Rules for Materials and Welding (Part 2)* are also applicable. Copies in duplicate of the purchase orders for material requiring test and inspection at the mills or place of manufacture are to be forwarded to ABS for the information of the Surveyors.

### 5.3 Special Materials

If it is desired to use special alloys or other materials not covered by the Rules, the use of such materials will be specially considered for approval.

## 7 General Installation Details

### 7.1 Protection

Pipes, valves and operating rods are to be effectively secured and adequately protected from mechanical damage. These protective arrangements are to be fitted so that they may be removed to enable examination of the pipes, valves and operating rods.

### 7.3 Pipes Near Switchboards

The leading of pipes in the vicinity of switchboards is to be avoided as far as possible. When such leads are necessary, care is to be taken to fit no flanges or joints over or near the switchboards unless provision is made to prevent any leakage from damaging the equipment.

### 7.5 Expansion or Contraction Stresses *(2004)*

Ample provision is to be made to take care of expansion or contraction stresses in pipes due to temperature changes or working of the hull. Suitable provisions include, but are not limited to, piping bends, elbows, offsets, changes in direction of the pipe routing or expansion joints. Slip joints of an approved type may be used in systems and locations where possible leakage will not be hazardous.

Where expansion joints are used, the following requirements apply:

- *Pipe support.* Adjoining pipes are to be suitably supported so that the expansion joints do not carry any significant pipe weight.
- *Alignment.* Expansion joints are not to be used to make up for piping misalignment errors. Misalignment of an expansion joint reduces the rated movements and can induce severe stresses into the joint material, thus causing reduced service life.
- *Anchoring.* Expansion joints are to be installed as close as possible to an anchor point. Where an anchoring system is not used, control rods may be installed on the expansion joint to prevent excessive movements from occurring due to pressure thrust of the line.

- *Mechanical damage.* Where necessary, expansion joints are to be protected against mechanical damage.
- *Accessible location.* Expansion joints are to be installed in accessible locations to permit regular inspection and/or periodic servicing.
- *Mating flange.* Mating flanges are to be clean and usually of the flat-faced type. When attaching beaded-end flange expansion joints to raised face flanges, the use of a ring gasket is permitted. Rubber expansion joints with beaded-end flange are not to be installed next to wafer-type check or butterfly valves. Serious damage to the rubber flange bead can result due to lack of flange surface and/or bolt connection.

## 7.7 Molded Expansion Joints *(2004)*

Molded expansion joints may be Type Approved. See 1-1-A3/1 of the ABS *Rules for Conditions of Classification (Part 1)*.

### 7.7.1 Circulating Water Systems

Molded expansion fittings of reinforced rubber or other suitable materials may be used in circulating water piping systems in machinery spaces. Such fittings are to be oil-resistant. The maximum working pressure is not to be greater than 25% of the hydrostatic bursting pressure of the fitting as determined by a prototype test. Manufacturer's name and the month and year of manufacture are to be embossed or otherwise permanently marked on the outside edge of one of the flanges or other easily examined area of all flexible expansion joints intended for use in seawater piping systems over 150 mm (6 in.). Plans of the molded or built-up flexible expansion joints in seawater piping systems over 150 mm (6 in.), including details of the internal reinforcement arrangements, are to be submitted for approval.

### 7.7.2 Oil Systems

Where molded expansion joints of composite construction utilizing metallic material, such as steel or stainless steel or equivalent material, with rubberized coatings inside and/or outside or similar arrangements are proposed for use in oil piping systems (fuel, lubricating, or hydraulic oil), the following requirements apply:

*7.7.2(a)* Expansion joint ratings for temperature, pressure, movements and selection of materials are to be suitable for the intended service.

*7.7.2(b)* The maximum allowable working pressure of the system is not to be greater than 25% of the hydrostatic bursting pressure determined by a burst test of a prototype expansion joint. Results of the burst test are to be submitted.

*7.7.2(c)* The expansion joints are to pass the fire-resistant test specified in 4-3-1/7.7.3, below.

*7.7.2(d)* The expansion joints are to be permanently marked with the manufacturer's name and the month and year of manufacture.

### 7.7.3 Fire-Resistant Test

In order for a molded expansion joint of composite construction utilizing metallic material, as referenced in 4-3-1/7.7.2, to be considered fire-resistant, a prototype of the molded expansion joint is to be subjected to a fire test for at least 30 minutes at a temperature of not less than 800°C (1472°F) while water at the maximum service pressure is circulated inside. The temperature of the water at the outlets is not to be less than 80°C (176°F) during the test. The tested molded expansion joint is to be complete with end fittings and no leakage is to be recorded during or after the test. In lieu of maximum service pressure, the fire test may be conducted with the circulating water at a pressure of at least 5 bar (5.1 kgf/cm$^2$, 72.5 lb/in$^2$), and with a subsequent pressure test to twice the design pressure.

## 7.9 Bulkhead, Deck or Tank Top Penetrations *(2013)*

### 7.9.1 Watertight Integrity

Where it is necessary for pipes to penetrate watertight bulkheads, decks or tank tops, the penetrations are to be made by methods which will maintain the watertight integrity. For this purpose, bolted connections are to have bolts threaded into the plating from one side; through bolts are not to be used. Welded connections are either to be welded on both sides or to have full penetration welds from one side.

### 7.9.2 Firetight Integrity

Where pipes penetrate bulkheads, decks or tank-tops which are required to be firetight or smoketight, the penetrations are to be made by approved methods which will maintain the same degree of firetight or smoketight integrity.

## 7.11 Relief Valves

All systems which may be exposed to pressures greater than that for which they are designed are to be safeguarded by suitable relief valves or the equivalent. Pressure containers such as evaporators, heaters, etc., which may be isolated from a protective device in the line are to have such devices either directly on the shell or between the shell and the isolation valve.

### 7.11.1 Exceptions

In pumping systems such as oil piping and fire main, where relief valves are ordinarily required at the pump, such valves need not be fitted when the system is served only by centrifugal pumps so designed that the pressure delivered cannot exceed that for which the piping is designed.

## 7.13 Common Overboard Discharge

In general, various types of systems which discharge overboard are not to be interconnected without special approval; that is, closed pumping systems, deck scuppers, soil lines or sanitary drains are not to have a common overboard discharge.

## 7.15 Plastic Piping *(1997)*

Where permitted, plastic piping is to be generally confined to one watertight compartment. Where systems are connected to the sea, the valve and its connection to the shell are to be metallic. Penetrations of watertight bulkheads or decks are to be in accordance with 4-3-2/7.5.5 and 4-3-2/7.5.6.

## 7.17 Standard Thicknesses

Pipe thicknesses referred to as standard or extra heavy are the equivalent of American National Standards Institute Schedule 40 and Schedule 80 pipe up to a maximum wall thickness of 9.5 mm (0.375 in.) and 12.5 mm (0.5 in.), respectively.

## 7.19 Instruments

### 7.19.1 Temperature

Thermometers and other temperature sensing devices registering through pressure boundaries are to be provided with instrument wells to allow for instrument removal without impairing the integrity of the pressurized system. Fuel oil tanks, except cargo tanks, are to be provided with similar protection.

### 7.19.2 Pressure

Pressure sensing devices are to be provided with valve arrangements to allow for instrument isolation and removal without impairing the pressurized system's integrity.

### 7.21 Hose *(1996)*

Hose assemblies may be installed between two points where flexibility is required but are not to be subject to torsional deflection (twisting) under normal operating conditions. In general, hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery. Burst pressure of the hose is not to be less than four times the relief valve setting.

Where the use of non-metallic hose is permitted, the hose materials are to be suitable for the intended service. Hoses for oil service are to be fire resistant and reinforced with wire braid or other suitable material.

In order for a non-metallic flexible hose to be considered fire-resistant, a prototype of the hose is to be subjected to a fire test for at least 30 minutes at a temperature of not less than 800°C (1472°F) while water at the maximum service pressure is circulated inside. The temperature of the water at the outlets is not to be less than 80°C (176°F) during the test. The tested hose is to be complete with end fittings and no leakage is to be recorded during or after the test. As an alternative, the fire test may be conducted with the circulating water at a pressure of at least 5 bar (5.1 kgf/cm$^2$, 72.5 psi) and a subsequent pressure test to twice the design pressure.

A hose is to be complete with factory assembled end fittings or factory supplied end fittings installed in accordance with manufacturer's procedures. The use of non-metallic hoses which are not provided with factory assembled end fittings will be considered for non-combustible and non-toxic, Group II piping systems under 5.2 bar (5.3 kgf/cm$^2$, 75 psi) in pipe sizes up to 114.3 mm O.D. (4 in. NPS). Such hoses are to be located in accessible locations and secured by means of at least two stainless-steel hose clamps at each end. Such clamps are to be at least 12 cm (0.5 in.) wide and are not to be dependent on spring tension to remain fastened.

PART

# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 2 Piping, Valves and Fittings

### 1 General

The piping details determined in accordance with 4-3-2/5 through 4-3-2/17 are to be based on the maximum working pressure and temperature to which they may be exposed in service under normal sustained operating conditions. Installations intended for maximum temperatures in excess of 343°C (650°F) will be subject to special consideration.

The following requirements for valves, fittings and flanges are based upon standards of the American National Standards Institute. However, the suitability and application of those manufactured in accordance with other recognized standards will be considered.

### 3 Pressure Tests

#### 3.1 General

In addition to the testing and inspection of materials, as required in Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)*, the following tests on the fabricated piping are to be witnessed by the Surveyor after bending and the attachment of flanges.

#### 3.3 Fuel Oil Suction and Transfer Lines

Transfer systems and fuel oil suction lines are to be tested before installation to 3.4 bar (3.5 kgf/cm$^2$, 50 psi).

#### 3.5 Cargo Oil Piping

After installation, cargo oil piping systems are to be tested to 1.5 times the design pressure.

#### 3.7 Hydraulic Power Piping

After fabrication, the hydraulic power piping system or each piping component is to be tested to 1.5 times the design pressure. For steering gear piping tests, see 4-2-3/1.15 or 4-2-3/3.23, as applicable.

#### 3.9 All Piping

After installation, all piping is to be tested under working conditions.

### 5 Metallic Pipes

#### 5.1 Test and Inspection of Group I Piping

Pipes intended for use in Group I piping systems are to be tested in the presence of and inspected by the Surveyor in accordance with Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or such other appropriate material specification as may be approved in connection with a particular design.

## 5.3 Steel Pipe

### 5.3.1 Seamless Pipe

Seamless drawn steel pipe may be used for all purposes.

### 5.3.2 Welded Pipe

Electric-resistance-welded steel pipe may be used for temperatures up to 343°C (650°F).

Consideration will be given to the use of electric-resistance-welded (ERW) pipe for use above 343°C (650°F) where the material is shown to be suitable for the intended service (i.e., in a non-corrosive environment where the design temperature is below the lowest graphitization temperature specified for the material, etc.). Furnace butt-welded pipe up to and including 115 mm O.D. (4 in. NPS) may be used for Group II piping for temperatures up to 232°C (450°F), but is not to be used for flammable or combustible fluids.

## 5.5 Copper Pipe

Seamless drawn and welded copper pipe, unless otherwise prohibited, may be used for all purposes where the temperature does not exceed 208°C (406°F).

## 5.7 Brass Pipe

Seamless drawn brass pipe, unless otherwise prohibited, may be used where the temperature does not exceed 208°C (406°F).

## 5.9 Plastic Pipe *(1997)*

Plastic pipe complying with the applicable requirements in 4-3-2/7 may be used where permitted by 4-3-2/Table 2.

## 5.11 Working Pressure and Thickness of Metallic Pipe

The maximum allowable working pressure and the minimum thickness of pipes are to be determined by the following equations, with due consideration being given to the reduction in thickness at the outer radius of bent pipes:

$$W = \frac{KS(t - C)}{D - M(t - C)} \qquad\qquad t = \frac{WD}{KS + MW} + C$$

where

| | | |
|---|---|---|
| $W$ | = | maximum allowable working pressure, in bar (kgf/cm$^2$, psi). See Note 1. |
| $t$ | = | minimum thickness of pipe, in mm (in.). See Note 5. |
| $K$ | = | 20 (200, 2) |
| $D$ | = | actual external diameter of pipe, in mm (in.) |
| $S$ | = | maximum allowable fiber stress, in N/mm$^2$ (kgf/mm$^2$, psi) from 4-3-2/Table 1. See Note 2. |
| $M$ | = | factor from 4-3-2/Table 1 |
| $C$ | = | allowance for threading, grooving or mechanical strength |

- 1.65 mm (0.065 in.) for plain-end steel or wrought-iron pipe or tubing up to 115 mm O.D. (4 in. NPS). See Note 3.
- 0.00 mm (0.000 in.) for plain-end steel or wrought-iron pipe or tubing up to 115 mm O.D. (4 in. NPS) used for hydraulic piping systems. See Note 3.
- 0.00 mm (0.000 in.) for plain-end steel or wrought-iron pipe or tubing 115 mm O.D. (4 in. NPS) and larger. See Note 3.

- 1.27 mm (0.05 in.) for all threaded pipe 17 mm O.D. ($^3/_8$ in. NPS) and smaller
- Depth of thread, *h*, for all threaded pipe over 17 mm O.D. ($^3/_8$ in. NPS). See Note 4.
- Depth of groove for grooved pipe
- 0.00 mm (0.000 in.) for plain-end nonferrous pipe or tubing. See Note 3.

*Notes:*

1 The value of *W* used in the equations is to be not less than 8.6 bar (8.8 kgf/cm$^2$, 125 psi), except that for suction and other low-pressure piping of nonferrous material, the actual working pressure may be applied if a suitable addendum is provided against erosion and outside damage. However, in no case is the value of *W* to be less than 3.4 bar (3.5 kgf/cm$^2$, 50 psi) for use in the equations.

2 Values of *S* for other materials are not to exceed the stress permitted by ASME B31.1 Code for Pressure Piping, Power Piping.

3 Plain-end pipe or tubing includes those joined by any method in which the wall thickness is not reduced.

4 The depth of thread, *h*, may be determined by the equation $h = 0.8/n$ where *n* is the number of threads per inch, or in metric units by the equation $h = 0.8n$ where *n* is the number of mm per thread.

5 If pipe is ordered by its nominal wall thickness, the manufacturing tolerance on wall thickness is to be taken into account.

## TABLE 1
## Allowable Stress Values *S* for Steel Piping N/mm$^2$ (kgf/mm$^2$, psi)

| *Part 2, Chapter 3, Section 12/Paragraph No. and (Grade) Nominal Composition* | *Tensile Strength* | *Service Temperature—Degrees C (F)* | | | |
|---|---|---|---|---|---|
| | | *–29°C (–20°F) to 343°C (650°F)* | *372°C (700°F)* | *399°C (750°F)* | *427°C (800°F)* |
| | | $M = 0.8$ | $M = 0.8$ | $M = 0.8$ | $M = 0.8$ |
| 2-3-12/5.1 (Gr. 1)<br>Elec. res. Carbon Steel | 310<br>(31.5, 45000) | 46.9<br>(4.78, 6800) | 46.6<br>(4.75, 6500) | | |
| 2-3-12/5.1 (Gr. 2)<br>Elec. res. Carbon Steel | 330<br>(33.7, 48000) | 70.3<br>(7.17, 10200) | 68.3<br>(6.96, 9900) | 62.8<br>(6.40, 9100) | 53.1<br>(5.41, 7700) |
| Seamless Carbon Steel | 330<br>(33.7, 48000) | 82.8<br>(8.44, 12000) | 80.6<br>(8.22, 11700) | 73.7<br>(7.52, 10700) | 62.1<br>(6.33, 9000) |
| 2-3-12/5.1 (Gr. 3)<br>Elec. res. Carbon Steel | 415<br>(42, 60000) | 88.3<br>(9.0, 12800) | 84.1<br>(8.58, 12200) | 75.8<br>(7.73, 11000) | 63.4<br>(6.47, 9200) |
| Seamless Carbon Steel | 415<br>(42, 60000) | 103.5<br>(10.55, 15000) | 99.2<br>(10.12, 14400) | 89.6<br>(9.14, 13000) | 74.4<br>(7.59, 10800) |
| 2-3-12/5.3 (Gr. 4)<br>Carbon Steel | 330<br>(33.7, 48000) | 82.8<br>(8.44, 12000) | 80.7<br>(8.23, 11700) | 73.7<br>(7.52, 10700) | 62.1<br>(6.33, 9000) |
| 2-3-12/5.3 (Gr. 5)<br>Carbon Steel | 415<br>(42, 60000) | 103.5<br>(10.55, 15000) | 99.2<br>(10.12, 14400) | 89.6<br>(9.14, 13000) | 74.4<br>(7.59, 10800) |

*Notes:*

1 Intermediate values of *S* may be determined by interpolation.

2 For grades of piping other than those given in 4-3-2/Table 1, *S* values are not to exceed those permitted by ASTM B31.1 Code for Pressure Piping. See 4-3-2/5.11.

3 Consideration is to be given to the possibility of graphite formation in carbon steel at temperatures above 425°C (800°F).

# 7 Plastic Pipes *(1997)*

## 7.1 General *(2015)*

Pipes and piping components made of thermoplastic or thermosetting plastic materials with or without reinforcement may be used in piping systems referred to in 4-3-2/Table 2 subject to compliance with the following requirements. For the purpose of these Rules, "plastic" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as polyvinyl chloride (PVC) and fiber reinforced plastics (FRP). Plastic includes synthetic rubber and materials of similar thermo/mechanical properties.

## 7.3 Plans and Data to be Submitted *(2007)*

Rigid plastic pipes are to be in accordance with a recognized national or international standard acceptable to ABS. Specification for the plastic pipe, including thermal and mechanical properties and chemical resistance, is to be submitted for review together with the spacing of the pipe supports.

The following information for the plastic pipes, fittings and joints is to be submitted for approval.

### 7.3.1 General Information

*i)* Pipe and fitting dimensions

*ii)* Maximum internal and external working pressure

*iii)* Working temperature range

*iv)* Intended services and installation locations

*v)* Level of fire endurance

*vi)* Electrically conductive

*vii)* Intended fluids

*viii)* Limits on flow rates

*ix)* Serviceable life

*x)* Installation instructions

*xi)* Details of marking

### 7.3.2 Drawings and Supporting Documentation

*i)* Certificates and reports for relevant tests previously carried out

*ii)* Details of relevant standards

*iii)* All relevant design drawings, catalogues, data sheets, calculations and functional descriptions

*iv)* Fully detailed sectional assembly drawings showing pipe, fittings and pipe connections.

### 7.3.3 Materials

*i)* Resin type

*ii)* Catalyst and accelerator types and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed

*iii)* A statement of all reinforcements employed where the reference number does not identify the mass per unit area or the tex number of a roving used in a filament winding process, these are to be detailed

*iv)* Full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate

*v)* Cure/post-cure conditions. The cure and post-cure temperatures and times employ for given resin/reinforcement ratio

*vi)* Winding angle and orientation.

## 7.5 Design

### 7.5.1 Internal Pressure

A pipe is to be designed for an internal pressure not less than the design pressure of the system in which it will be used. The maximum internal pressure, $P_{int}$, for a pipe is to be the lesser of the following:

$$P_{int} = \frac{P_{sth}}{4} \qquad\qquad P_{int} = \frac{P_{lth}}{2.5}$$

where

$P_{sth}$ = short-term hydrostatic test failure pressure

$P_{lth}$ = long-term hydrostatic test failure pressure (> 100,000 hours)

The hydrostatic tests are to be carried out under the following standard conditions:

- Atmospheric pressure = 1 bar (1 kgf/cm$^2$, 14.5 psi)
- Relative humidity = 30%
- Fluid temperature = 25°C (77°F)

The hydrostatic test failure pressure may be verified experimentally or determined by a combination of testing and calculation methods which are to be submitted to ABS for approval.

### 7.5.2 External Pressure

External pressure is to be considered for any installation which may be subject to vacuum conditions inside the pipe or a head of liquid on the outside of the pipe. A pipe is to be designed for an external pressure not less than the sum of the pressure imposed by the maximum potential head of liquid outside the pipe plus full vacuum, 1 bar (1 kgf/cm$^2$, 14.5 psi), inside the pipe. The maximum external pressure for a pipe is to be determined by dividing the collapse test pressure by a safety factor of 3.

The collapse test pressure may be verified experimentally or determined by a combination of testing and calculation methods which are to be submitted to ABS for approval.

### 7.5.3 Axial Strength

*7.5.3(a)* The sum of the longitudinal stresses due to pressure, weight and other dynamic and sustained loads is not to exceed the allowable stress in the longitudinal direction. Forces due to thermal expansion, contraction and external loads, where applicable, are to be considered when determining longitudinal stresses in the system.

*7.5.3(b)* In the case of fiber reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed one-half of the nominal circumferential stress derived from the maximum internal pressure determined according to 4-3-2/7.5.1, unless the allowable longitudinal stress is verified experimentally or by a combination of testing and calculation methods.

### 7.5.4 Temperature *(2007)*

The maximum allowable working temperature of a pipe is to be in accordance with the manufacturer's recommendations, but in each case, it is to be at least 20°C (36°F) lower than the minimum heat distortion temperature of the pipe material determined according to ISO 75 method A or equivalent. The minimum heat distortion temperature is not to be less than 80°C (176°F). This minimum heat distortion temperature requirement is not applicable to pipes and pipe components made of thermoplastic materials, such as polyethylene (PE), polypropylene (PP), polybutylene (PB) and intended for non-essential services.

Where low temperature services are considered, special attention is to be given with respect to material properties.

### 7.5.5 Impact Resistance

Plastic pipes and joints are to have a minimum resistance to impact in accordance with a recognized national or international standard such as ASTM D2444 or equivalent. After the impact resistance is tested, the specimen is to be subjected to hydrostatic pressure equal to 2.5 times the design pressure for at least one hour.

7.5.6 Fire Endurance *(2015)*

4-3-2/Table 2 specifies fire endurance requirements for pipes based upon system and location. Pipes and their associated fittings whose functions or integrity are essential to the safety of the vessel are to meet the indicated fire endurance requirements which are described below.

*i)* *Level 1* will ensure the integrity of the system during a full scale hydrocarbon fire and is particularly applicable to systems where loss of integrity may cause outflow of flammable liquids and worsen the fire situation. Piping having passed the fire endurance test specified in 4-3-2/7.13 for a duration of a minimum of one hour without loss of integrity in the dry condition is considered to meet Level 1 fire endurance standard (L1).

Level 1W – Piping systems similar to Level 1 systems except these systems do not carry flammable fluid or any gas and a maximum 5% flow loss in the system after exposure is acceptable. The flow loss must be taken into account when dimensioning the system.

*ii)* *Level 2* intends to ensure the availability of systems essential to the safe operation of the vessel, after a fire of short duration, allowing the system to be restored after the fire has been extinguished. Piping having passed the fire endurance test specified in 4-3-2/7.13 for a duration of a minimum of 30 minutes without loss of integrity in the dry condition is considered to meet Level 2 fire endurance standard (L2).

Level 2W – Piping systems similar to Level 2 systems except a maximum 5% flow loss in the system after exposure is acceptable. The flow loss must be taken into account when dimensioning the system.

*iii)* *Level 3* is considered to provide the fire endurance necessary for a water filled piping system to survive a local fire of short duration. The system's functions are capable of being restored after the fire has been extinguished. Piping having passed the fire endurance test specified in 4-3-2/7.15 for a duration of a minimum of 30 minutes without loss of integrity in the wet condition is considered to meet Level 3 fire endurance standard (L3).

Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance standards required, the following requirements apply.

*i)* Pipes are generally to be delivered from the manufacturer with the protective coating applied, with on-site application limited to that necessary for installation purposes (i.e., joints). See 4-3-2/7.7.7 regarding the application of the fire protection coating on joints.

*ii)* The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come in contact with the piping.

*iii)* In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations and elasticity are to be taken into account.

*iv)* The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

*v)* *(2007)* Random samples of pipe are to be tested to determine the adhesion qualities of the coating to the pipe.

7.5.7 Flame Spread

All pipes, except those fitted on open decks and within tanks, cofferdams, void spaces, pipe tunnels and ducts, are to have low flame spread characteristics. The test procedures in IMO Resolution A.653(16) *Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling, and Deck Finish Materials*, modified for pipes as indicated in 4-3-2/7.17, are to be used for determining the flame spread characteristics. Piping materials giving average values for all of the surface flammability criteria not exceeding the values listed in Resolution A.653(16) (surface flammability criteria of bulkhead, wall and ceiling linings) are considered to meet the requirements for low flame spread.

Alternatively, flame spread testing in accordance with ASTM D635 may be used in lieu of the IMO flame spread test, provided such test is acceptable to the Administration.

#### 7.5.8 Electrical Conductivity

*7.5.8(a)* Piping conveying fluids with a conductivity less than 1000 pico siemens per meter are to be electrically conductive.

*7.5.8(b)* Regardless of the fluid being conveyed, plastic pipes are to be electrically conductive if the piping passes through a hazardous area.

*7.5.8(c)* Where electrically conductive pipe is required, the resistance per unit length of the pipes and fittings is not to exceed $1 \times 10^5$ Ohm/m ($3 \times 10^4$ Ohm/ft). See also 4-3-2/7.7.4.

*7.5.8(d)* If the pipes and fittings are not homogeneously conductive, the conductive layers are to be protected against the possibility of spark damage to the pipe wall.

#### 7.5.9 Marking *(2007)*

Plastic pipes and other components are to be permanently marked with identification in accordance with a recognized standard. Identification is to include pressure ratings, the design standard that the pipe or fitting is manufactured in accordance with, the material with which the pipe or fitting is made and the date of fabrication.

### 7.7 Installation of Plastic Pipes

#### 7.7.1 Supports

*7.7.1(a) (2015)* Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria. Support spacing is not to be greater than the pipe manufacturer's recommended spacing. The selection and spacing of pipe supports are to take into account pipe dimensions, length of the piping, mechanical and physical properties of the pipe material, mass of pipe and contained fluid, external pressure, operating temperature, thermal expansion effects, loads due to external forces, thrust forces, water hammer and vibrations to which the system may be subjected. Combinations of these loads are to be checked.

*7.7.1(b)* Each support is to evenly distribute the load of the pipe and its contents over the full width of the support. Measures are to be taken to minimize wear of the pipes where they contact the supports.

*7.7.1(c)* Heavy components in the piping system, such as valves and expansion joints, are to be independently supported.

*7.7.1(d)* The supports are to allow for relative movement between the pipes and the vessel's structure, having due regard for the difference in the coefficients of thermal expansion and deformations of the vessel's hull and its structure.

*7.7.1(e)* When calculating the thermal expansion, the system working temperature and the temperature at which assembling is performed are to be taken into account.

#### 7.7.2 External Loads

When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowances are to include at least the force exerted by a load (person) of 980 N (100 kgf, 220 lbf) at mid-span on any pipe more than 100 mm (4 in.) nominal diameter.

Pipes are to be protected from mechanical damage where necessary.

#### 7.7.3 Plastic Pipe Connections

*7.7.3(a)* The strength of fittings and joints is not to be less than that of the piping they connect.

*7.7.3(b)* Pipes may be joined using adhesive-bonded, welded, flanged or other joints.

*7.7.3(c)* Tightening of flanged or mechanically coupled joints is to be performed in accordance with manufacturer's instructions.

*7.7.3(d)* Adhesives, when used for joint assembly, are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

Joining techniques are to be in accordance with manufacturer's installation guidelines. Personnel performing these tasks are to be qualified to the satisfaction of ABS, and each bonding procedure is to be qualified before shipboard piping installation commences. Requirements for joint bonding procedures are in 4-3-2/7.11.

#### 7.7.4 Electrical Conductivity

Where electrically conductive pipe is required by 4-3-2/7.5.8, installation of the pipe is to be in accordance with the following:

*7.7.4(a)* The resistance to earth (ground) from any point in the system is not to exceed 1 meg-ohm. The resistance is to be checked in the presence of the Surveyor.

*7.7.4(b)* Where used, earthing wires or bonding straps are to be accessible for inspection. The Surveyor is to verify that they are in visible locations.

#### 7.7.5 Shell Connections

Where plastic pipes are permitted in systems connected to the shell of the vessel, the valves and the pipe connection to the shell are to be metallic. The side shell valves are to be arranged for remote control from outside the space in which the valves are located. For further details of the shell valve installation, their connections and material, refer to 4-3-2/19.

#### 7.7.6 Bulkhead and Deck Penetrations

*7.7.6(a)* The integrity of watertight bulkheads and decks is to be maintained where plastic pipes pass through them.

*7.7.6(b)* Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that the fire endurance is not impaired. These arrangements are to be tested in accordance with IMO Resolution A 754 (18), Recommendation on Fire Resistance Tests for "A", "B" and "F" Class Divisions, as amended.

*7.7.6(c)* If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause inflow of liquid from a tank, a metallic shut-off valve operable from above the bulkhead deck is to be fitted at the bulkhead or deck.

#### 7.7.7 Application of Fire Protection Coatings

Fire protection coatings are to be applied on the joints, where necessary for meeting the required fire endurance criteria in 4-3-2/7.5.6, after performing hydrostatic pressure tests of the piping system (see 4-3-2/7.19). The fire protection coatings are to be applied in accordance with the manufacturer's recommendations, using a procedure approved in each particular case.

### 7.9 Manufacturing of Plastic Pipes *(1 July 2009)*

The manufacturer is to have a quality system and be certified in accordance with 1-1-A3/5.3 and 1-1-A3/5.5 of the ABS *Rules for Conditions of Classification (Part 1)* or ISO 9001 (or equivalent). The quality system is to consist of elements necessary to ensure that pipes and components are produced with consistent and uniform mechanical and physical properties in accordance with recognized standards including testing to demonstrate the compliance of plastic pipes, fittings and joints with 4-3-2/7.5.1 through 4-3-2/7.5.8 and 4-3-2/7.19, as applicable.

Where the manufacturer does not have a certified quality system in accordance with 1-1-A3/5.3 and 1-1-A3/5.5 of the ABS *Rules for Conditions of Classification (Part 1)* or ISO 9001 (or equivalent), the tests in 4-3-2/7.5.1 through 4-3-2/7.5.8 and 4-3-2/7.19, as applicable, will be required using samples from each batch of pipes being supplied for use aboard the vessel and are to be carried out in the presence of the Surveyor.

Each length of pipe and each fitting is to be tested at the manufacturer's production facility to a hydrostatic pressure not less than 1.5 times the maximum allowable internal pressure of the pipe in 4-3-2/7.5.1. Alternatively, for pipes and fittings not employing hand layup techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognized national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

Depending upon the intended application, ABS reserves the right to require the hydrostatic pressure testing of each pipe and/or fitting.

If the facility does not have a certified quality system in accordance with 1-1-A3/5.3 and 1-1-A3/5.5 of the *Rules for Conditions of Classification (Part 1)* or ISO 9001 (or equivalent), then the production testing must be witnessed by the Surveyor.

The manufacturer is to provide documentation certifying that all piping and piping components supplied are in compliance with the requirements of 4-3-2/7.

## 7.11 Plastic Pipe Bonding Procedure Qualification

### 7.11.1 Procedure Qualification Requirements

*7.11.1(a)* To qualify joint bonding procedures, the tests and examinations specified herein are to be successfully completed. The procedure for making bonds is to include the following:

*i)* Materials used

*ii)* Tools and fixtures

*iii)* Environmental requirements

*iv)* Joint preparation requirements

*v)* Cure temperature

*vi)* Dimensional requirements and tolerances

*vii)* Test acceptance criteria for the completed assembly

*7.11.1(b)* Any change in the bonding procedure which will affect the physical and mechanical properties of the joint will require the procedure to be requalified.

### 7.11.2 Procedure Qualification Testing

*7.11.2(a)* A test assembly is to be fabricated in accordance with the procedure to be qualified and it is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint. When the test assembly has been cured, it is to be subjected to a hydrostatic test pressure at a safety factor of 2.5 times the design pressure of the test assembly for not less than one hour. No leakage or separation of joints is to be allowed. The test is to be conducted so that the joint is loaded in both the longitudinal and circumferential direction.

*7.11.2(b)* Selection of the pipes used for the test assembly is to be in accordance with the following:

*i)* When the largest size to be joined is 200 mm (8 in.) nominal outside diameter or smaller, the test assembly is to be the largest pipe size to be joined.

*ii)* When the largest size to be joined is greater than 200 mm (8 in.) nominal outside diameter, the size of the test assembly is to be either 200 mm (8 in.) or 25% of the largest piping size to be joined, whichever is greater.

*7.11.2(c)* When conducting performance qualifications, each bonder and each bonding operator are to make up test assemblies, the size and number of which are to be as required above.

## 7.13 Tests by the Manufacturer – Fire Endurance Testing of Plastic Piping in the Dry Condition (For Level 1 and Level 2)

### 7.13.1 Test Method

*7.13.1(a)* The specimen is to be subjected to a furnace test with fast temperature increase similar to that likely to occur in a fully developed liquid hydrocarbon fire. The time/temperature is to be as follows:

| | | |
|---|---|---|
| At the end of 5 minutes | 945°C | (1733°F) |
| At the end of 10 minutes | 1033°C | (1891°F) |
| At the end of 15 minutes | 1071°C | (1960°F) |
| At the end of 30 minutes | 1098°C | (2008°F) |
| At the end of 60 minutes | 1100°C | (2012°F) |

*7.13.1(b)* The accuracy of the furnace control is to be as follows:

*i)* During the first 10 minutes of the test, variation in the area under the curve of mean furnace temperature is to be within ±15% of the area under the standard curve.

*ii)* During the first 30 minutes of the test, variation in the area under the curve of mean furnace temperature is to be within ±10% of the area under the standard curve.

*iii)* For any period after the first 30 minutes of the test, variation in the area under the curve of mean furnace temperature is to be within ±5% of the area under the standard curve.

*iv)* At any time after the first 10 minutes of the test, the difference in the mean furnace temperature from the standard curve is to be within ±100°C (±180°F).

*7.13.1(c)* The locations where the temperatures are measured, the number of temperature measurements and the measurement techniques are to be approved by ABS.

7.13.2 Test Specimen

*7.13.2(a)* The test specimen is to be prepared with the joints and fittings intended for use in the proposed application.

*7.13.2(b)* The number of specimens is to be sufficient to test typical joints and fittings including joints between non-metal and metal pipes and metal fittings to be used.

*7.13.2(c)* The ends of the specimen are to be closed. One of the ends is to allow pressurized nitrogen to be connected. The pipe ends and closures may be outside the furnace.

*7.13.2(d)* The general orientation of the specimen is to be horizontal and it is to be supported by one fixed support with the remaining supports allowing free movement. The free length between supports is not to be less than 8 times the pipe diameter.

*7.13.2(e)* Most materials will require a thermal insulation to pass this test. The test procedure is to include the insulation and its covering.

*7.13.2(f)* If the insulation contains or is liable to absorb moisture, the specimen is not to be tested until the insulation has reached an air dry-condition, defined as equilibrium with an ambient atmosphere of 50% relative humidity at 20 ± 5°C (68 ± 9°F). Accelerated conditioning is permissible, provided the method does not alter the properties of the component material. Special samples are to be used for moisture content determination and conditioned with the test specimen. These samples are to be so constructed as to represent the loss of water vapor from the specimen having similar thickness and exposed faces.

7.13.3 Test Condition

A nitrogen pressure inside the test specimen is to be maintained automatically at 0.7 ± 0.1 bar (0.7 ± 0.1 kgf/cm$^2$, 10 ± 1.5 psi) during the test. Means are to be provided to record the pressure inside the pipe and the nitrogen flow into and out of the specimen in order to indicate leakage.

7.13.4 Acceptance Criteria

*7.13.4(a)* During the test, no nitrogen leakage from the sample is to occur.

*7.13.4(b) (2015)* After termination of the furnace test, the test specimen together with fire protective coating, if any, is to be allowed to cool in still air to ambient temperature and then tested to the maximum allowable pressure of the pipes, as defined in 4-3-2/7.5.1 and 4-3-2/7.5.2. The pressure is to be held for a minimum of 15 minutes. Pipes without leakage qualify as Level 1 or 2 depending on the test duration. Pipes with negligible leakage (i.e., not exceeding 5% flow loss) qualify as Level 1W or Level 2W depending on the test duration. Where practicable, the hydrostatic test is to be conducted on bare pipe (i.e., coverings and insulation removed) so that any leakage will be apparent.

*7.13.4(c)* Alternative test methods and/or test procedures considered to be at least equivalent, including open pit testing method, may be accepted in cases where the pipes are too large for the test furnace.

## 7.15 Test by Manufacturer – Fire Endurance Testing of Water-filled Plastic Piping (For Level 3)

### 7.15.1 Test Method

*7.15.1(a)* A propane multiple burner test with a fast temperature increase is to be used.

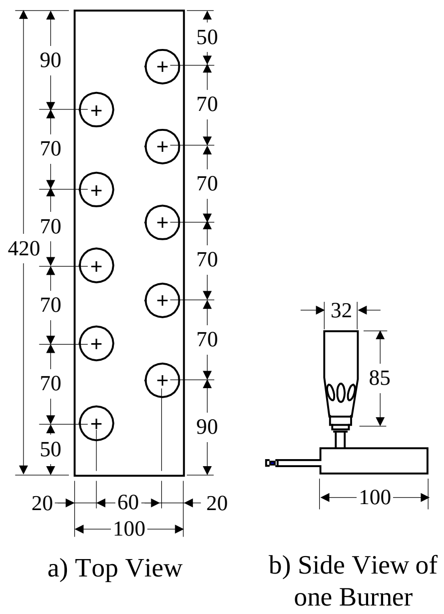
*7.15.1(b)* For piping up to and including 152 mm (6 in.) O.D., the fire source is to consist of two rows of five burners, as shown in 4-3-2/Figure 1. A constant heat flux averaging 113.6 kW/$m^2$ (36,000 BTU/hr-$ft^2$) ± 10% is to be maintained 12.5 ± 1 cm (5 ± 0.4 in.) above the centerline of the burner array. This flux corresponds to a pre-mix flame of propane with a fuel flow rate of 5 kg/hr (11 lb/hr) for a total heat release of 65 kW (3700 BTU/min.). The gas consumption is to be measured with an accuracy of at least ±3% in order to maintain a constant heat flux. Propane with a minimum purity of 95% is to be used.

*7.15.1(c)* For piping greater than 152 mm (6 in.) O.D., one additional row of burners is to be included for each 51 mm (2 in.) increase in pipe diameter. A constant heat flux averaging 113.6 kW/$m^2$ (36,000 BTU/hr-$ft^2$) ±10% is still to be maintained at the 12.5 ± 1 cm (5 ± 0.4 in.) height above the centerline of the burner array. The fuel flow is to be increased as required to maintain the designated heat flux.

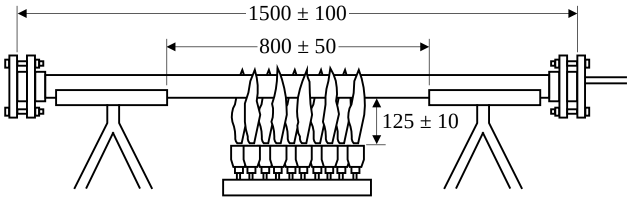
*7.15.1(d)* The burners are to be type "Sievert No. 2942" or equivalent which produces an air mixed flame. The inner diameter of the burner heads is to be 29 mm (1.14 in.). See 4-3-2/Figure 1. The burner heads are to be mounted in the same plane and supplied with gas from a manifold. If necessary, each burner is to be equipped with a valve in order to adjust the flame height.

*7.15.1(e)* The height of the burner stand is also to be adjustable. It is to be mounted centrally below the test pipe with the rows of burners parallel to the pipe's axis. The distance between the burner heads and the pipe is to be maintained at 12.5 ± 1 cm (5 ± 0.4 in.) during the test. The free length of the pipe between its supports is to be 0.8 ± 0.05 m (31.5 ± 2 in.). See 4-3-2/Figure 2.

**FIGURE 1**
**Fire Endurance Test Burner Assembly**



## FIGURE 2
## Fire Endurance Test Stand with Mounted Sample




### 7.15.2 Test Specimen

*7.15.2(a)* Each pipe is to have a length of approximately 1.5 m (5 ft).

*7.15.2(b)* The test pipe is to be prepared with permanent joints and fittings intended to be used. Only valves and straight joints versus elbows and bends are to be tested as the adhesive in the joint is the primary point of failure.

*7.15.2(c)* The number of pipe specimens is to be sufficient to test all typical joints and fittings.

*7.15.2(d)* The ends of each pipe specimen are to be closed. One of the ends is to allow pressurized water to be connected.

*7.15.2(e)* If the insulation contains or is liable to absorb moisture, the specimen is not to be tested until the insulation has reached an air dry-condition, defined as equilibrium with an ambient atmosphere of 50% relative humidity at 20 ± 5°C (68 ± 9°F). Accelerated conditioning is permissible, provided the method does not alter the properties of the component material. Special samples are to be used for moisture content determination and conditioned with the test specimen. These samples are to be so constructed as to represent the loss of water vapor from the specimen having similar thickness and exposed faces.

*7.15.2(f)* The pipe samples are to rest freely in a horizontal position on two V-shaped supports. The friction between pipe and supports is to be minimized. The supports may consist of two stands, as shown in 4-3-2/Figure 2.

*7.15.2(g)* A relief valve is to be connected to one of the end closures of each specimen.

### 7.15.3 Test Conditions

*7.15.3(a)* The test is to be carried out in a sheltered test site in order to prevent any draft influencing the test.

*7.15.3(b)* Each pipe specimen is to be completely filled with deaerated water to exclude air bubbles.

*7.15.3(c)* The water temperature is not to be less than 15°C (59°F) at the start and is to be measured continuously during the test. The water is to be stagnant and the pressure maintained at 3 ± 0.5 bar (3.1 ± 0.5 kgf/cm$^2$, 43.5 ± 7.25 psi) during the test.

### 7.15.4 Acceptance Criteria

*7.15.4(a)* During the test, no leakage from the sample(s) is to occur except that slight weeping through the pipe wall may be accepted.

*7.15.4(b)* After termination of the burner test, the test specimen together with fire protective coating, if any, is to be allowed to cool to ambient temperature and then tested to the maximum allowable pressure of the pipes, as defined in 4-3-2/7.5.1 and 4-3-2/7.5.2. The pressure is to be held for a minimum of 15 minutes without significant leakage [i.e., not exceeding 0.2 1/min. (0.05 gpm)]. Where practicable, the hydrostatic test is to be conducted on bare pipe (i.e., coverings and insulation removed) so that any leakage will be apparent.

## 7.17 Tests by Manufacturer – Flame Spread

### 7.17.1 Test Method

Flame spread of plastic piping is to be determined by IMO Resolution A.653(16) entitled, "Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling, and Deck Finish Materials" with the following modifications.

*7.17.1(a)* Tests are to be made for each pipe material and size.

*7.17.1(b)* The test sample is to be fabricated by cutting pipes lengthwise into individual sections and then assembling the sections into a test sample as representative as possible of a flat surface. A test sample is to consist of at least two sections. The test sample is to be at least 800 ± 5 mm (31.5 ± 0.2 in.) long. All cuts are to be made normal to the pipe wall.

*7.17.1(c)* The number of sections that must be assembled together to form a test sample is to be that which corresponds to the nearest integral number of sections which makes up a test sample with an equivalent linearized surface width between 155 mm (6 in.) and 180 mm (7 in.). The surface width is defined as the measured sum of the outer circumference of the assembled pipe sections that are exposed to the flux from the radiant panel.

*7.17.1(d)* The assembled test sample is to have no gaps between individual sections.

*7.17.1(e)* The assembled test sample is to be constructed in such a way that the edges of two adjacent sections coincide with the centerline of the test holder.

*7.17.1(f)* The individual test sections are to be attached to the backing calcium silicate board using wire (No. 18 recommended) inserted at 50 mm (2 in.) intervals through the board and tightened by twisting at the back.

*7.17.1(g)* The individual pipe sections are to be mounted so that the highest point of the exposed surface is in the same plane as the exposed flat surface of a normal surface.

*7.17.1(h)* The space between the concave unexposed surface of the test sample and the surface of the calcium silicate backing board is to be left void.

*7.17.1(i)* The void space between the top of the exposed test surface and the bottom edge of the sample holder frame is to be filled with a high temperature insulating wool if the width of the pipe segments extend under the side edges of the sample holding frame.

## 7.19 Testing By Manufacturer – General *(2007)*

Testing is to demonstrate the compliance of plastic pipes, fittings and joints for which approval, in accordance with 4-3-2/7, is requested. These tests are to be in compliance with the requirements of relevant standards as per 4-3-2/Table 3 and 4-3-2/Table 4.

## 7.21 Testing Onboard After Installation

Piping systems are to be subjected to a hydrostatic test pressure of not less than 1.5 times the design pressure to the satisfaction of the Surveyor.

For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be conducted to the satisfaction of the Surveyor.

## TABLE 2
## Fire Endurance Requirements Matrix for Plastic Pipes *(2015)*

| | *PIPING SYSTEMS* | *LOCATION* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | I | J | K |
| CARGO (Flammable cargoes with flash point ≤ 60°C (140°F) | | | | | | | | | | | | |
| 1 | Cargo lines | NA | NA | L1 | NA | NA | 0 | NA | 0 (10) | 0 | NA | L1 (2) |
| 2 | Crude oil washing lines | NA | NA | L1 | NA | NA | 0 | NA | 0 (10) | 0 | NA | L1 (2) |
| 3 | Vent lines | NA | NA | NA | NA | NA | 0 | NA | 0 (10) | 0 | NA | X |
| INERT GAS | | | | | | | | | | | | |
| 4 | Water seal effluent line | NA | NA | 0 (1) | NA | NA | 0 (1) | 0 (1) | 0 (1) | 0 (1) | NA | 0 |
| 5 | Scrubber effluent line | 0 (1) | 0 (1) | NA | NA | NA | NA | NA | NA | 0 (1) | NA | 0 |
| 6 | Main line | 0 | 0 | L1 | NA | NA | NA | NA | NA | 0 | NA | L1 (6) |
| 7 | Distribution lines | NA | NA | L1 | NA | NA | 0 | NA | NA | 0 | NA | L1 (2) |
| FLAMMABLE LIQUIDS (flash point > 60°C (140°F) | | | | | | | | | | | | |
| 8 | Cargo lines | X | X | L1 | X | X | NA (3) | 0 | 0 (10) | 0 | NA | L1 |
| 9 | Fuel oil | X | X | L1 | X | X | NA (3) | 0 | 0 | 0 | L1 | L1 |
| 10 | Lubricating oil | X | X | L1 | X | X | NA | NA | NA | 0 | L1 | L1 |
| 11 | Hydraulic oil | X | X | L1 | X | X | 0 | 0 | 0 | 0 | L1 | L1 |
| SEA WATER (See Note 1) | | | | | | | | | | | | |
| 12 | Bilge main and branches | L1 (7) | L1 (7) | L1 | X | X | NA | 0 | 0 | 0 | NA | L1 |
| 13 | Fire main and water spray | L1 | L1 | L1 | X | NA | NA | NA | 0 | 0 | X | L1 |
| 14 | Foam system | L1W | L1W | L1W | NA | NA | NA | NA | NA | 0 | L1W | L1W |
| 15 | Sprinkler system | L1W | L1W | L3 | X | NA | NA | NA | 0 | 0 | L3 | L3 |
| 16 | Ballast | L3 | L3 | L3 | L3 | X | 0 (10) | 0 | 0 | 0 | L2W | L2W |
| 17 | Cooling water, essential services | L3 | L3 | NA | NA | NA | NA | NA | 0 | 0 | NA | L2W |
| 18 | Tank cleaning services, fixed machines | NA | NA | L3 | NA | NA | 0 | NA | 0 | 0 | NA | L3 (2) |
| 19 | Non-essential systems | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 | 0 | 0 | 0 |
| FRESH WATER | | | | | | | | | | | | |
| 20 | Cooling water, essential services | L3 | L3 | NA | NA | NA | NA | 0 | 0 | 0 | L3 | L3 |
| 21 | Condensate return | L3 | L3 | L3 | 0 | 0 | NA | NA | NA | 0 | 0 | 0 |
| 22 | Non-essential systems | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 | 0 | 0 | 0 |
| SANITARY/DRAINS/SCUPPERS | | | | | | | | | | | | |
| 23 | Deck drains (internal) | L1W (4) | L1W (4) | NA | L1W (4) | 0 | NA | 0 | 0 | 0 | 0 | 0 |
| 24 | Sanitary drains (internal) | 0 | 0 | NA | 0 | 0 | NA | 0 | 0 | 0 | 0 | 0 |
| 25 | Scuppers and discharges (overboard) | 0 (1,8) | 0 (1,8) | 0 (1,8) | 0 (1,8) | 0 (1,8) | 0 | 0 | 0 | 0 | 0 (1,8) | 0 |
| VENTS/SOUNDING | | | | | | | | | | | | |
| 26 | Water tanks/dry spaces | 0 | 0 | 0 | 0 | 0 | 0 (10) | 0 | 0 | 0 | 0 | 0 |
| 27 | Oil tanks (flashpoint > 60°C (140°F)) | X | X | X | X | X | X[3] | 0 | 0 (10) | 0 | X | X |
| MISCELLANEOUS | | | | | | | | | | | | |
| 28 | Control air | L1 (5) | L1 (5) | L1 (5) | L1 (5) | L1 (5) | NA | 0 | 0 | 0 | L1 (5) | L1 (5) |
| 29 | Service air (non-essential) | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 | 0 | 0 | 0 |
| 30 | Brine | 0 | 0 | NA | 0 | 0 | NA | NA | NA | 0 | 0 | 0 |
| 31 | Auxiliary low pressure steam (pressure ≤ 7 bar (7 kgf/$cm^2$, 100 psi)) | L2W | L2W | 0 (9) | 0 (9) | 0 (9) | 0 | 0 | 0 | 0 | 0 (9) | 0 (9) |

*Locations*

- A Category A machinery spaces
- B Other machinery spaces
- C Cargo pump rooms
- D Ro/Ro cargo holds
- E Other dry cargo holds
- F Cargo tanks
- G Fuel oil tanks
- H Ballast water tanks
- I Cofferdams, void spaces, pipe tunnels and ducts
- J Accommodation, service and control spaces
- K Open decks

*Abbreviations*

- L1 Fire endurance test in dry conditions, 60 minutes, in accordance with 4-3-2/7.13
- L2 Fire endurance test in dry conditions, 30 minutes, in accordance with 4-3-2/7.13
- L3 Fire endurance test in wet conditions, 30 minutes, in accordance with 4-3-2/7.15
- 0 No fire endurance test required
- NA Not applicable
- X Metallic materials having a melting point greater than 925°C (1700°F)

## TABLE 2 (continued)
## Fire Endurance Requirements Matrix for Plastic Pipes *(2015)*

*Notes:*

1. Where non-metallic piping is used, remotely controlled valves are to be provided at the vessel's side. These valves are to be controlled from outside the space.
2. Remote closing valves are to be provided at the cargo tanks.
3. When cargo tanks contain flammable liquids with a flash point greater than 60°C (140°F), "0" may replace "NA" or "X".
4. *(2015)* For drains serving only the space concerned, "0" may replace "L1W".
5. When controlling functions are not required by statutory requirements, "0" may replace "L1".
6. For pipe between machinery space and deck water seal, "0" may replace "L1".
7. For passenger vessels, "X" is to replace "L1".
8. For essential services such as fuel oil tank heating and ship's whistle, "X" is to replace "0".

## TABLE 3
## Standards for Plastic Pipes – Typical Requirements for All Systems *(2007)*

| | *Test* | *Typical Standard* | *Notes* |
|---|---|---|---|
| 1 | Internal pressure [(1)] | 4-3-2/7.5.1<br>ASTM D 1599,<br>ASTM D 2992<br>ISO 15493 or equivalent | Top, Middle, Bottom (of each pressure range)<br>Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections. |
| 2 | External pressure [(1)] | 4-3-2/7.5.2<br>ISO 15493 or equivalent | As above, for straight pipes only. |
| 3 | Axial strength [(1)] | 4-3-2/7.5.3 | As above. |
| 4 | Load deformation | ASTM D 2412 or equivalent | Top, Middle, Bottom (of each pressure range) |
| 5 | Temperature limitations [(1)] | 4-3-2/7.5.4<br>ISO 75 Method A GRP piping system:<br>HDT test on each type of resin acc. to ISO 75 method A.<br>Thermoplastic piping systems:<br>ISO 75 Method AISO 306 Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)<br>VICAT test according to ISO 2507<br>Polyesters with an HDT below 80°C should not be used. | Each type of resin |
| 6 | Impact resistance [(1)] | 4-3-2/7.5.5<br>ISO 9854: 1994, ISO 9653: 1991 ISO 15493<br>ASTM D 2444, or equivalent | Representative sample of each type of construction |
| 7 | Ageing | Manufacturer's standard<br>ISO 9142:1990 | Each type of construction |
| 8 | Fatigue | Manufacturer’s standard or service experience. | Each type of construction |
| 9 | Fluid absorption | ISO 8361:1991 | |
| 10 | Material compatibility [(2)] | ASTM C581<br>Manufacturer’s standard | |

*Notes:*

1. Where the manufacturer does not have a certified quality system, test to be witnessed by the Surveyor. See 4-3-2/7.9.
2. If applicable.

## TABLE 4
## Standards for Plastic Pipes – Additional Requirements Depending on Service and/or Location of Piping *(2007)*

| | *Test* | *Typical Standard* | *Notes* |
|---|---|---|---|
| 1 | Fire endurance (1,2) | 4-3-2/7.13 | Representative samples of each type of construction and type of pipe connection. |
| 2 | Flame spread (1,2) | 4-3-2/7.17 | Representative samples of each type of construction. |
| 3 | Smoke generation (2) | IMO Fire Test Procedures Code | Representative samples of each type of construction. |
| 4 | Toxicity (2) | IMO Fire Test Procedures Code | Representative samples of each type of construction. |
| 5 | Electrical conductivity (1,2) | 4-3-2/7.5.8<br>ASTM F1173-95 or ASTM<br>D 257, NS 6126/ 11.2 or equivalent | Representative samples of each type of construction |

*Notes:*

1 Where the manufacturer does not have a certified quality system, test to be witnessed by the Surveyor. See 4-3-2/7.9.

2 If applicable.

*Note:* Test items 1, 2 and 5 in 4-3-2/Table 4 are optional. However, if not carried out, the range of approved applications for the pipes will be limited accordingly (see 4-3-2/Table 2).

# 9 Material of Valves and Fittings

## 9.1 General

The physical characteristics of such material are to be in accordance with the applicable requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or other such appropriate material specifications as may be approved in connection with a particular design for the stresses and temperatures to which they may be exposed. Manufacturers are to make physical tests of each melt and, upon request, are to submit the results of such tests to ABS.

## 9.3 Forged or Cast Steel

In any system, forged or cast steel may be used in the construction of valves and fittings for all pressures and temperatures.

## 9.5 Cast Iron

For temperatures not exceeding 232°C (450°F), cast iron of the physical characteristics specified in Section 2-3-6 of the ABS *Rules for Materials and Welding (Part 2)* may be used in the construction of valves and fittings, except as noted in 4-3-2/19.1.2, 4-3-2/19.7 and 4-3-4/1.7.1.

## 9.7 Ductile (Nodular) Iron

Nodular-iron applications for valves and fittings will be specially considered where the temperature does not exceed 343°C (650°F).

## 9.9 Nonferrous

Brass or bronze having the physical characteristics as specified in Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* may be used in the construction of valves and fittings intended for temperatures up to 208°C (406°F). For temperatures greater than 208°C (406°F) but not in excess of 288°C (550°F), high-temperature bronze is to be used and the chemical and physical characteristics are to be submitted for approval.

Valves, fittings and flanges of nonferrous material may be attached to nonferrous pipe by an approved soldering method. For pressures up to 6.9 bar (7 kgf/cm$^2$, 100 psi) and temperatures not exceeding 93°C (200°F), ordinary solder may be used, but for higher pressures and temperatures, the method and the quality of solder to be used will be considered for each case.

### 9.11 Plastic Compounds *(1997)*

Rigid plastic compounds for valves and fittings in plastic piping systems are to be in accordance with the applicable requirements in 4-3-2/7. The design pressure and temperature together with the physical characteristics of the material are to be submitted in all cases.

## 11 Valves

### 11.1 General

#### 11.1.1 Standard Valves

Valves constructed and tested in accordance with a recognized standard may be used, subject to compliance with 4-3-2/11.5.

#### 11.1.2 Non-Standard Valves

All other valves not certified by the manufacturer as being in accordance with a recognized standard may be accepted based on evidence verifying their suitability for the intended service. Acceptable evidence includes testing or analysis demonstrating adequacy including both structural and material capability aspects. Drawings of such valves showing details of construction and materials are to be submitted for review, as well as the basis for valve pressure rating, such as design calculations or appropriate burst test data.

### 11.3 Construction

All valves are to close with a right hand (clockwise) motion of the handwheel when facing the end of the stem and are to be either of the rising-stem type or fitted with an indicator to show whether the valve is open or closed.

All valves of Group I piping systems having nominal diameters exceeding 50 mm (2 in.) are to have bolted, pressure seal or breech lock bonnets and flanged or welding ends. Welding ends are to be the butt weld type, except that socket weld ends may be used for valves having nominal diameters of 80 mm (3 in.) or less, up to and including 39.2 bar (40.0 kgf/cm$^2$) pressure rating class (ASME 600 Class), and for valves having nominal diameters of 65 mm (2.5 in.) or less, up to and including 98.1 bar (100 kgf/cm$^2$) pressure rating class (ASME 1500 Class).

All cast iron valves are to have bolted bonnets or are to be of the union bonnet type. For cast iron valves of the union bonnet type, the bonnet ring is to be of steel, bronze or malleable iron.

Stems, discs or disc faces, seats and other wearing parts of valves are to be of corrosion-resistant materials suitable for the intended service.

Valves are to be designed for the maximum pressure to which they will be subjected. The design pressure is to be at least 3.4 bar (3.5 kgf/cm$^2$, 50 psi). Valves used in open systems, such as vent and drain lines, and valves mounted on atmospheric tanks which are not part of the tank suction or discharge piping(for example, level gauge and drain cocks) may be designed for a pressure below 3.4 bar (3.5 kg/cm$^2$, 50 psi), subject to the requirements of 4-3-2/11.1. Large fabricated ballast manifolds which connect lines exceeding 200 mm (8 in.) nominal pipe size may be specially considered when the maximum pressure to which they will be subjected does not exceed 1.7 bar (1.75 kgf/cm$^2$, 25 psi).

All valves for Group I piping systems and valves intended for use in steam or oil lines are to be constructed so that the stem is positively restrained from being screwed out of the body (bonnet). Plug valves, butterfly valves and valves employing resilient material will be subject to special consideration. Valve operating systems for all valves which cannot be manually operated are to be submitted for approval.

### 11.5 Hydrostatic Test and Identification

All valves are to be subjected by the manufacturer to a hydrostatic test at a pressure equal to that stipulated by the American National Standards Institute or other recognized standard. They are to bear the trademark of the manufacturer legibly stamped or cast on the exterior of the valve and the primary pressure rating at which the manufacturer identifies the valve as meeting the requirements of the standards.

## 13 Pipe Fittings

### 13.1 General

All fittings in Group I piping are to have flanged or welded ends in sizes over 89 mm O.D. (3 in. NPS). Screwed fittings may be used in Group I piping systems, provided the temperature does not exceed 496°C (925°F) and the pressure does not exceed the maximum pressure indicated below for the pipe size.

| *Pipe Size mm O.D. (in. NPS)* | *Maximum Pressure bar (kgf/cm$^2$, psi)* |
|---|---|
| Above 89 (3) | Not permitted in Group I piping service |
| Above 60 (2) through 89 (3) | 27.6 (28.10, 400) |
| Above 33 (1) through 60 (2) | 41.4 (42.20, 600) |
| Above 27 (0.75) through 33 (1) | 82.8 (84.40, 1200) |
| 27 (0.75) and smaller | 103 (105.50, 1500) |

Flared, flareless and compression fittings may be used for tube sizes not exceeding 60 mm O.D. (2 in. NPS) in Group I piping. In Group II piping, screwed fittings, flared, flareless and compression tube fittings will be accepted without size limitations. Flared fittings are to be used for flammable fluid systems, except that both flared and flareless fittings of the non-bite type may be used when the tubing system is of steel or nickel-copper or copper-nickel alloys. Only flared fittings are to be used when tubing for flammable fluid systems is of copper or copper-zinc alloys.

### 13.3 Hydrostatic Test and Identification

All fittings are to be subjected by the manufacturer to a hydrostatic test at a pressure equal to that stipulated by the American National Standards Institute or other recognized standard. They are to bear the trademark of the manufacturer legibly stamped or cast on the exterior of the fitting and also the primary pressure rating at which the manufacturer guarantees the fitting to meet the requirements of the standards.

### 13.5 Nonstandard Fittings

Fittings which are not certified by the manufacturer as being in accordance with a recognized standard will be subject to special consideration. Plans showing details of construction and calculations or test results establishing the basis for the fitting's pressure rating are to be submitted for review.

## 15 Welded Nonstandard Valves and Fittings

Non-standard steel valves and fittings fabricated by means of fusion welding are to also comply with the requirements of Chapter 4 of the ABS *Rules for Materials and Welding (Part 2)*. However, after a manufacturer's procedure in the fabrication of equipment of this kind has been demonstrated by tests to the satisfaction of an ABS Surveyor, subsequent tests on the product need not be witnessed, but the manufacturer's guarantee that the Rules are complied with will be accepted as to other valves and fittings which conform to standards of the American National Standards Institute or other recognized standards.

# 17 Flanges

## 17.1 General *(1996)*

Flanges are to be designed and fabricated in accordance with a recognized national or international standard. Slip-on flanges from flat plate may be substituted for hubbed slip-on flanges in Group II piping systems.

## 17.3 Group I Piping Flanges

In Group I piping, flanges may be attached to the pipes by any of the following methods appropriate for the material involved:

### 17.3.1 Steel Pipe

Over 60 mm O.D. (2 in. NPS) steel pipes are to be expanded into steel flanges, or they may be screwed into the flanges and seal-welded. They may in all cases be attached by fusion welding in compliance with the requirements of 2-4-2/9 of the ABS *Rules for Materials and Welding (Part 2)*. Smaller pipes may be screwed without seal-welding, but in steam and oil lines are, in addition, to be expanded into the flanges in order to ensure uniformly tight threads.

### 17.3.2 Nonferrous Pipe

In Group I, nonferrous pipes are to be brazed to composition metallic or steel flanges, and in sizes of 60 mm O.D. (2 in. NPS) and under, they may be screwed.

## 17.5 Group II Piping Flanges

Similar attachments are also to be used in Group II piping. However, modifications are permitted for welded flanges, as noted in 2-4-2/9.5 and 2-4-2/9.7 of the ABS *Rules for Materials and Welding (Part 2)*, and screwed flanges of suitable material may be used in all sizes.

# 19 Sea Chests, Sea Valve and Overboard Discharge Connections

## 19.1 General

### 19.1.1 Installation *(2006)*

Sea chests, sea valves and overboard discharge connections bolted to the shell plating are to have the bolt heads countersunk on the outside and the bolts threaded through the plating. Where a reinforcing ring of sufficient thickness is welded to the inside of the shell, studs may be used.

Threaded connections outboard of the shell valves are not considered an acceptable method of connection pipe to the shell.

### 19.1.2 Valve Connections to Shell

The wall thickness of the piping fitted between the sea chest and the valve or the shell and the valve is generally to be extra heavy. However, the thickness of the pipe need not be greater than the thickness of the shell plating. Cast iron is not to be used for any connection to the shell nor for any valve attached to such connections if located below the main deck. The use of nodular iron (also known as ductile iron or spheroidal-graphite iron) will be accepted provided the material has an elongation not less than 12% in 50 mm (2 in.). Wafer type valves are not to be used for connections to the vessel's shell unless specially approved.

### 19.1.3 Valves Required *(2006)*

Positive closing valves are to be fitted in pump overboard discharges.

Materials readily rendered ineffective by heat are not to be used for connection to the shell where the failure of the material in the event of a fire would give rise to danger of flooding.

### 19.3 Sea Chests

#### 19.3.1 Location

The locations of sea chests are to be such as to minimize the probability of blanking off the suction and arranged so that the valves may be operated from the floors or gratings. Power-operated sea valves are to be arranged for manual operation in the event of a failure of the power supply.

#### 19.3.2 Strainer Plates

Sea chests are to be fitted with strainer plates at the vessel's side. The strainers are to have a clear area of at least 1.5 times the area of the sea valves. Efficient means are to be provided for clearing the strainers.

### 19.5 Scuppers

Scuppers of sufficient number and size are to be fitted in all decks and are to be so placed as to provide effective drainage. Those leading from the weather portions of decks are to be led overboard, and those leading from spaces below the main deck are to be led to the bilges, but may be led overboard if fitted with efficient and accessible means for preventing water from passing inboard. Scuppers are to be made of steel, bronze or other approved ductile material. Ordinary cast iron or similar materials are not to be used.

### 19.7 Sanitary Discharges

Sanitary discharges led through the vessel's sides are to be fitted with efficient and accessible means for preventing water from passing inboard when the inboard open end is located below the main deck. Neither the ship shell valve nor its connection to the shell is to be made of cast iron. The use of nodular iron (also known as ductile iron or spheroidal-graphite iron) will be accepted provided the material has an elongation not less than 12% in 50 mm (2 in.).

## 21 Cooler Installations External to the Hull

### 21.1 General

Unless their omission is permitted by 4-3-2/21.3 or 4-3-2/21.5, positive closing valves are to be fitted at the locations where the pipes exit and re-enter the shell.

The inlet and discharge connections of external cooler installations are to be in accordance with 4-3-2/19.1.2 except that wafer type valves will be acceptable.

### 21.3 Integral Keel Cooler Installations

The positive closing valves required by 4-3-2/21.1 need not be provided if the keel (skin) cooler installation is integral with the hull. To be considered integral with the hull, the installation is to be constructed such that channels are welded to the hull with the hull structure forming part of the channel, the channel material is to be at least the same thickness and quality as that required for the hull and the forward end of the cooler is to be faired to the hull with a slope of not greater than 4 to 1.

If positive closing valves are not required at the shell, all flexible hoses or joints are to be positioned above the deepest load waterline or be provided with an isolation valve.

### 21.5 Non-integral Keel Cooler Installations *(2006)*

Where non-integral keel coolers are used, if the shell penetrations are not fully welded, the penetration is to be encased in a watertight enclosure.

Non-integral cooler installations which are fully recessed into the hull and provided with adequate protection may be accepted without the shell valve provided all inboard piping is extra heavy and any non-metallic flexible hose is above the deepest waterline which is to be indicated on the plan.

Non-integral keel coolers are to be suitably protected against damage from debris and grounding by recessing the unit into the hull or by the placement of protective guards.

PART
# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 3 Bilge and Ballast Systems and Tanks

## 1 Bilge and Ballast Systems for Self-propelled Vessels

### 1.1 General

A satisfactory pumping plant is to be provided in all vessels capable of pumping from and draining any compartment. For this purpose, wing suctions will often be necessary, except in narrow compartments. Arrangements are to be made whereby water in the compartment will drain to the suction pipes. Efficient means are to be provided for draining water from all tank tops and other watertight flats. Peak tanks may be drained by ejectors or hand pumps. Bilge systems for passenger vessels greater than 100 gross tons are also to comply with 4-3-3/3.

### 1.3 Pumps

All vessels 20 m (65 ft) in length or greater are to be provided with two power-driven bilge pumps, one of which may be attached to the propulsion unit. Vessels below 20 m (65 ft) are to be provided with one power-driven bilge pump, which may be an attached unit, and one suitable hand pump.

Power-driven bilge pump capacity is to be in accordance with the following:

| *Vessel Length* | *Minimum Capacity per Pump* |
|---|---|
| Below 20 m (65 ft) | 5.5 $m^3$/hr (25 gpm) |
| 20 m (65 ft) or greater | 11.0 $m^3$/hr (50 gpm) |

### 1.5 Bilge and Ballast Piping

#### 1.5.1 General

The arrangement of the bilge and ballast pumping systems is to be such as to prevent the possibility of water or oil passing into the cargo and machinery spaces, or from one compartment to another, whether from the sea, water ballast or oil tanks. The bilge and ballast mains are to have separate control valves at the pumps.

#### 1.5.2 Installation

Bilge or ballast pipes passing through compartments intended for the carriage of oil are to be of either steel or wrought iron.

Where bilge or ballast pipes pass through tanks, efficient means are to be provided to prevent the flooding of the holds in the event of a pipe breaking or joint leaking in the tanks. Such means may consist of an oil-tight or watertight tunnel, or making the lines of extra-heavy steel pipe, properly installed, to take care of expansion and having all joints within the tank welded or extra-heavy flanged joints. The number of flanged joints is to be kept to a minimum. When a tunnel is not employed and the line runs through a deep tank, bilge pipes are to have non-return valves fitted at the open ends.

#### 1.5.3 Manifolds, Cocks and Valves

All manifolds, cocks and valves in connection with the bilge pumping arrangement are to be in positions which are accessible at all times under ordinary circumstances. All valves in the machinery space controlling the bilge suctions from the various compartments are to be of the stop-check type. If valves are fitted at the open ends of pipes, they are to be of the non-return type.

#### 1.5.4 Strainers

Bilge lines in machinery spaces are to be fitted with strainers easily accessible from the floor plates and are to have straight tail pipes to the bilges. The ends of bilge lines in other compartments are to be fitted with suitable strainers having an open area of not less than three times the area of the suction pipe. In addition, strainers are to be fitted in accessible positions between the bilge manifolds and the pumps. The number and sizes of suctions in the machinery spaces are subject to special consideration.

#### 1.5.5 Size of Bilge Suctions

The least internal diameter of bilge suction pipes is to be that of the nearest commercial size within 6 mm (0.25 in.) of the diameter determined by the following equations:

*1.5.5(a) Main Line.* For the diameter of main bilge line suctions and direct bilge suctions to the pumps:

$$d = 25 + 1.68\sqrt{L(B+D)} \quad \text{mm} \qquad\qquad d = 1 + \sqrt{L(B+D)/2500} \quad \text{in.}$$

*1.5.5(b) Branch Lines.* For the equivalent diameter of the combined branch suctions to a compartment:

$$d = 25 + 2.16\sqrt{c(B+D)} \quad \text{mm} \qquad\qquad d = 1 + \sqrt{c(B+D)/1500} \quad \text{in.}$$

where

| | | |
|---|---|---|
| $d$ | = | internal diameter of pipe, in mm (in) |
| $L$ | = | length of vessel, as defined in 3-1-1/3, in m (ft) |
| $B$ | = | breadth of vessel, as defined in 3-1-1/5, in m (ft) |
| $c$ | = | length of compartment, in m (ft) |
| $D$ | = | molded depth, as defined in 3-1-1/7, in m (ft), |

*1.5.5(c) Main Line Reduction.* Where engine room bilge pumps are fitted primarily for drainage within the engine room, $L$ may be reduced by the combined length of the cargo tanks or cargo holds. In such cases, the cross sectional area of the bilge main is not to be less than twice the required cross sectional area of the engine room branch lines.

*1.5.5(d) Size Limits.* No main or branch suction piping is to be less than 38 mm (1.5 in.) nor need be more than 63 mm (2.5 in.) internal diameter.

#### 1.5.6 Bilge Common-main *(2005)*

The diameter of each common-main bilge line may be determined by the equation for bilge branches given in 4-3-3/1.5.5(b) using the combined compartment length upstream of the point where the diameter is being determined. In case of double hull construction with full depth wing tanks served by a ballast system, where the beam of the vessel is not representative of the breadth of the compartment, $B$ may be appropriately modified to the breath of the compartment. However, no common-main bilge pipe needs to be more than the diameter for the bilge main given in 4-3-3/1.5.5(a).

## 3 Bilge Systems for Self-propelled Passenger Vessels

### 3.1 General

Passenger vessels greater than 100 gross tons are to be provided with bilge systems complying with 4-3-3/1 in addition to the following.

## 3.3 Bilge Piping System

### 3.3.1 General

The bilge pumping system is to be capable of operation under all practicable conditions after a casualty whether the vessel is upright or listed. For this purpose wing suctions are to generally be fitted except in narrow compartments at the end of the vessel where one suction may be sufficient. In compartments of unusual form, additional suctions may be required. Arrangements are to be made whereby water in the compartment may find its way to the suction pipes. Where the provision of drainage may for particular compartments be undesirable, the provision of drainage to that compartment will be specially considered if calculations show that the survival capability of the vessel will not be impaired by flooding of the compartment.

### 3.3.2 Spindles

The spindles of the sea inlet and direct suction valves are to extend well above the engine room platform.

### 3.3.3 Bilge Suctions

All bilge suction piping up to the connection to the pumps is to be independent of other piping.

### 3.3.4 Direct Bilge Suction *(2006)*

One of the required independently-driven bilge pumps (see 4-3-3/3.5.1) is to be fitted with a suction led directly from the propulsion machinery space bilge to the suction main of the pump, so arranged that it can be operated independently of the bilge system. The size of this line is not to be less than that determined by 4-3-3/1.5.5(a). The direct bilge suction is to be controlled by a stop-check valve.

If a watertight bulkhead separates the propulsion machinery space into compartments, such direct bilge suction is to be fitted from each compartment, unless the pumps available for bilge service are distributed throughout these compartments. In such a case, at least one pump with a direct suction is to be fitted in each compartment.

### 3.3.5 Manifolds, Cocks and Valves

Manifolds, cocks and valves in connection with the bilge pumping system are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment; in addition, damage to a pump or its pipe connecting to the bilge main outboard of a line drawn at one-fifth of the breadth of the vessel is not to put the bilge system out of action. If there is only one system of pipes common to all the pumps, the necessary valves for controlling the bilge suctions are to be capable of being operated from above the bulkhead deck. If an emergency bilge pumping system is fitted, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding condition as specified in 4-3-3/3.3.1. In that case, only the valves necessary for the operation of the emergency system need be capable of being operated from above the main deck.

All cocks and valves referred to above which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and are to be provided with means to indicate whether they are open or closed.

## 3.5 Bilge Pumps

### 3.5.1 Number of Pumps

At least two power pumps are to be fitted and connected to the bilge main, one of which may be driven by the propulsion machinery.

### 3.5.2 Location

Where practicable, the power bilge pumps are to be placed in separate watertight compartments and so arranged or situated that these compartments will not be flooded by the same damage. If the main propulsion machinery, auxiliary machinery and boilers are in two or more watertight compartments, the pumps available for bilge service are to be distributed as far as is possible throughout these compartments.

#### 3.5.3 Arrangement

With the exception of additional pumps which may be provided for the forepeak compartments only, each required bilge pump is to be so arranged as to draw water from any space required to be drained.

#### 3.5.4 Capacity

The required capacity $Q$ of each bilge pump is to be determined from the following equation:

$$Q = \frac{5.66d^2}{1000} \quad m^3/hr \qquad\qquad Q = 16.1d^2 \quad gpm$$

where

$d$ = internal diameter of main bilge line suction, in mm (in.), required by 4-3-3/1.5.5(a) or 4-3-3/1.5.5(c)

In no case shall the capacity of each required bilge pump be less than 11.4 $m^3$/hr (50 gpm).

# 5 Bilge Systems for Barges

## 5.1 Unmanned Barges

Where barges are fitted with below deck machinery spaces or where fixed piping systems are led through void spaces, a satisfactory means is to be provided capable of pumping from and draining such spaces. This means may be by use of suitable hand pumps through fixed bilge piping arrangements or by means of portable pumps stored onboard the barge. Alternate arrangements will be considered in case of barges where special conditions prevail.

## 5.3 Manned Barges

Barges having facilities for 36 persons or more are to be provided with a fixed power operated bilge system capable of pumping from and draining any compartment below the freeboard or bulkhead deck. At least two power driven bilge pumps are to be provided and each pump is to have a capacity of not less than 11.4 $m^3$/hour (50 gpm). Bilge main and branch section sizes are to comply with 4-3-3/1.5.5.

For barges having facilities for less than 36 persons, at least two (2) hand pumps of suitable capacity may be substituted for the power pumps in the bilge main.

# 7 Vent, Sounding and Overflow Pipes

## 7.1 General

In all vessels, the structural arrangement in double-bottom and other tanks is to be such as to permit the free passage of air and gases from all parts of the tanks to the vent pipes. Tanks having a comparatively small surface, such as fuel oil settling tanks, need be fitted with only one vent pipe, while tanks having a comparatively large surface are to be fitted with at least two vent pipes, one of which is to be located at the highest part of the tank. Vent pipes are to be arranged to provide adequate drainage under normal conditions. All vent and overflow pipes on the open deck are to terminate by way of return bends.

## 7.3 Size

The diameter of each vent pipe is not to be less than 38 mm (1.5 in.) I.D. for freshwater tanks, 51 mm (2 in.) I.D. for water-ballast tanks and 63 mm (2.5 in.) I.D. for oil tanks unless specially approved otherwise. Where tanks are to be filled by pump pressure, the aggregate area of the vents in the tank is to be at least 125% of the effective area of the filling line, except that when overflows are fitted, the area of the overflow is to be at least 125% of the effective area of the filling line and the vents need not exceed the above minimum sizes. Notwithstanding the above, the pump capacity and pressure head are to be considered in the sizing of vents, and overflows.

### 7.5 Termination *(2007)*

Vents for all tanks, double bottoms and other compartments which extend to the shell of the vessel are to be led to above the bulkhead deck. In addition, vents for ballast tanks and fuel oil tanks are to be led to the weather. Vents for other tanks not adjacent to the shell of the vessel may terminate within the machinery space but are to be located so as to preclude the possibility of overflowing on electrical equipment.

Vent outlets on fuel oil tanks are to be fitted with corrosion resistant flame screens having a clear area through the mesh of not less than the required area of the vent pipe and are to be located where the possibility of ignition of gases issuing from the vent outlets is remote. Either a single screen of corrosion-resistant wire of at least 12 by 12 meshes per lineal cm (30 by 30 mesh per lineal inch), or two screens of at least 8 by 8 meshes per lineal cm (20 by 20 mesh per lineal inch) spaced not less than 13 mm (0.5 inch) nor more than 38 mm (1.5 inch) apart are acceptable.

*Note:* Mesh count is defined as a number of openings in a lineal cm (inch) counted from the center of any wire to the center of a parallel wire.

## 9 Sounding

### 9.1 General

All compartments which are not readily accessible are to be fitted with a suitable means of sounding. For such compartments and for tanks integral with the shell of the vessel, sounding pipes are to be provided where any portion of the compartment or tank boundary is located below the deepest waterline. Supplemental means of sounding may be provided for these spaces.

### 9.3 Sounding Pipes

Sounding pipes are not to be less than 38 mm (1.5 in.) inside diameter. They are to be led as straight as possible from the lowest part of the tank or compartment to the bulkhead deck or to a position which is always accessible. If sounding pipes terminate below the freeboard deck, they are to be provided with means for closing in the following manner:

#### 9.3.1 Oil Tanks

Quick-acting, self-closing gate valves are required.

#### 9.3.2 Other Tanks

A screw cap secured to the pipe with a chain or a gate valve is required.

Provision is to be made to prevent damaging the vessel's plating by the striking of the sounding rod. In general, sounding pipes are not to pass through bilge wells, but if this is not practicable, the pipe is to be at least extra-heavy in the bilge well.

### 9.5 Gauge Glasses

Tanks may be fitted with gauge glasses, provided the gauge glasses are fitted with a valve at each end and adequately protected from mechanical damage.

Tanks containing flammable or combustible fluids are to be fitted with gauge glasses of the flat type having self-closing valves at each end. For hydraulic oil tanks, cylindrical gauge glasses with approved self-closing valves at each end will be acceptable provided such spaces do not contain oil fired boilers, oil fuel units, internal combustion engines, generators, major electrical equipment or piping having a surface temperature in excess of 220°C (428°F).

Tanks integral with the shell which are located below the deepest water line may be fitted with gauge glasses provided they are of the flat glass type having self-closing valves at each end.

PART

# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 4 Fuel Oil and Lubricating Oil Systems and Tanks

### 1 Fuel Oil Transfer, Filling and Service Systems

#### 1.1 General

The fuel oil pumping arrangements are to be distinct from the other pumping systems as far as practicable, and the means provided for preventing dangerous interconnection in service are to be thoroughly effective.

#### 1.3 Pipes in Oil Tanks

Oil pipes and other pipes, where passing through oil tanks, are to be of wrought iron or steel, except that other materials may be considered where it is demonstrated that the material is suitable for the intended service. All packing is to be of a composition not affected by oil. See 4-3-3/1.5.2.

#### 1.5 Control Valves or Cocks

Valves or cocks controlling the various suctions are to be located close to the bulkhead where the suctions enter the machinery spaces and, wherever practicable, directly over the gutterway in way of fuel oil storage and day tanks. Pumps, strainers, etc., requiring occasional examination are to have drip pans.

#### 1.7 Valves on Oil Tanks

##### 1.7.1 General

Where pipe lines emanate from oil tanks at such a level that they will be subjected to a static head of oil from the tank, they are to be fitted with positive closing valves located at the tank or where the pipeline enters the machinery space. If the valves are installed on the outside of the tank, they are to be steel, bronze or other approved ductile material which has elongation not less than 12% in 50 mm (2 in.). Where fitted on tanks having a capacity of 500 liters (132 gals) or greater, these valves are to have arrangements for closing at the valve and from a readily accessible and safe location outside of the compartment in which the valve is located. If the valve is located within the tank, they may be of cast iron and arranged for remote control only, but additional valves for local control are to be located in the machinery space.

##### 1.7.2 Valve Operators *(2016)*

The valves required above may be remotely operated by reach rods or by electric, hydraulic, or pneumatic means. The source of power to operate these values is to be located outside of the space in which the valves are located. The positioning of the valve by either the local or remote means is not to interfere with the ability of the other means to close the valve. This remote means of closure is to override all other means of valve control. The use of electric, hydraulic or pneumatic system to keep the valve in the open position is not acceptable. Materials readily rendered ineffective by heat are not to be used within the space in the construction of the valves or the closure mechanism, unless adequately protected to ensure effective closure facility in the event of fire. If electric cables are utilized, they are to be fire resistant meeting the requirements of IEC 60331 (see 4-5-4/13.1.3) or an equivalent recognized standard. Hydraulic systems are to be in accordance with 4-3-8/1 for both Class I and II piping systems. For a pneumatic system, the air supply may be from a source from within the space provided a separate receiver complying with the following is located outside the space.

*i)* Sufficient capacity to close all connected valves twice

*ii)* Fitted with low air pressure alarm

*iii)* Air supply line is fitted with a non-return valve adjacent to the receiver

1.7.3 Filling Lines

Where independent filling lines are fitted, they are to enter at or near the top of the tank. If this is impractical, they are to be fitted with non-return valves at the tank.

### 1.9 Overflows and Drains

The oil tank overflows and drains from oil tanks and from drip pans may be led to a waste oil tank. The tank is to be fitted with a vent to the weather, a sounding pipe, and a method of removing the contents. Non-return valves are to be fitted in drain lines entering the drain tanks except where backflow would not present a hazard.

### 1.11 Fuel Oil Purifiers *(1997)*

Where fuel oil purifiers for heated oil are installed, the arrangement is to be in accordance with 4-4-1/21.

### 1.13 Fuel Oil Injection System

Strainers are to be provided in the suction line of the fuel oil injection pump. For main propulsion engines, the arrangement is to be such that the strainers may be cleaned without interrupting the fuel supply to the engine. For auxiliary engines the arrangement is to be such that the strainers may be cleaned without undue interruption of power necessary for propulsion. Multiple auxiliary engines, each fitted with a separate strainer and arranged such that changeover to a standby unit can be accomplished without loss of propulsion capability, will be acceptable for this purpose.

Where strainers are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a strainer under pressure being opened inadvertently. Strainers are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Valves or cocks with drain pipes led to a safe location are to be used for this purpose. Strainers are to be so arranged that in the event of leakage oil cannot be sprayed onto the exhaust manifold or surfaces with temperatures in excess of 220°C (428°F).

Cut-out valves are to be located at the service tanks and be so arranged as to be operable from a readily accessible location and, where considered necessary, from outside the engine hatch. The injection line is to be of seamless drawn pipe and fittings are to be extra heavy. The material used may be either steel or non-ferrous as approved in connection with the design.

## 3 Lubricating Oil System

### 3.1 General

Lubricating oil piping is to be entirely separated from other piping systems. Where oil coolers are provided, the sea suctions are to be arranged to minimize the probability of blanking off the cooling water.

### 3.3 Oil Filters

Oil filters are to be provided on all engines. In the case of main propulsion engines which are equipped with full flow type filters, the arrangement is to be such that the filters may be cleaned without interrupting the oil supply. For auxiliary engines the arrangement is to be such that the filters may be cleaned without undue interruption of power necessary for propulsion. Multiple auxiliary engines, each fitted with a separate filter and arranged such that changeover to a standby unit may be accomplished without loss of propulsion capability, will be acceptable for this purpose. Cartridge type filters with spring load bypass (relief valves) to ensure continuous oil supply will be specially considered for both main and auxiliary engines. In either instance, the arrangement of the valving or bypass is to be such as to avoid release of debris into the lubricating oil system upon activation of the relieving mechanism or opening of the bypass line.

Where filters are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a filter under pressure being opened inadvertently. Filters are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Valves or cocks with drain pipes led to a safe location are to be used for this purpose. Filters are to be so arranged that in the event of leakage oil cannot be sprayed onto the exhaust manifold or surfaces with temperatures in excess of 220°C (428°F).

### 3.5 Protective Features

Where forced lubrication is used, an alarm is to be fitted to warn of low oil pressure.

PART
# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 5 Internal Combustion Engine Systems

### 1 Cooling Water System

#### 1.1 General

Means are to be provided to ascertain the temperature of the circulating water at the return from each engine and to indicate that the proper circulation is being maintained. Drain cocks are to be provided at the lowest point of all jackets and a relief valve is to be fitted in the main line to the jackets to prevent excessive pressure unless the pumps are of the centrifugal type so designed that the pressure delivered cannot exceed that for which the piping is designed.

#### 1.3 Sea Suctions

At least two independent sea suctions are to be provided for supplying water to the engine jackets or to the heat exchangers. The sea suctions are to be located so as to minimize the possibility of blanking off the cooling water.

#### 1.5 Direct Cooling System

Where raw water is used for cooling the engine, unless other equivalent arrangements are specially approved, suitable strainers are to be fitted between the sea valves and the pump suctions. The strainers are to be either of the duplex type or otherwise so arranged that they can be cleaned without interrupting the cooling water supply.

### 3 Exhaust Piping

The exhaust pipes are to be water jacketed or effectively insulated. Exhaust pipes of several engines are not to be connected together but are to be run separately to the atmosphere unless arranged to prevent the return of gases to an idle engine. Exhaust lines which are led overboard near the waterline are to be protected against the possibility of water finding its way inboard. Boiler uptakes and engine exhaust lines are not to be connected except when specially approved as in cases where the boilers are arranged to utilize the waste heat from the engines.

PART
# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 6 Cargo Systems

### 1 Vessels Carrying Oil in Bulk Having a Flashpoint of 60°C (140°F) or Less

Vessels classed as **Oil Carrier** or **Oil Barge** are to meet the following requirements for the cargo handling equipment, including pumps, piping and venting.

#### 1.1 Cargo Pumps

1.1.1 Construction

Cargo pumps are to be so designed as to minimize the danger of sparking.

1.1.2 Installation

Care is to be taken to prevent leaks at the stuffing box. Where the shafts pass through gastight bulkheads, flexible couplings are to be provided in shafts between the pumps and prime movers. Stuffing boxes are to be fitted at the bulkheads.

Pumps installed in cargo pump rooms and driven by shafts passing through pump room bulkheads, including cargo pumps, ballast pumps and stripping pumps, are to be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. Excessive temperature is to activate an audible and visual alarm at the cargo control room or pump control station.

1.1.3 Relief Valve and Bypass

A relief valve of suitable type is to be installed in the discharge of each pump, except as noted in 4-3-1/7, and piped back into the suction. A bypass is to be provided around the pump for use when loading through the suction piping.

1.1.4 Pressure Gauges

One pressure gauge for each pump is to be located at the pump discharge. Where the pumps are operated by engines or motors external to the pump room, additional gauges are to be provided which are visible from the operating station.

#### 1.3 Cargo Piping Systems

1.3.1 General

Cargo piping systems are to be entirely separate from all other piping systems and are not to pass through fuel oil tanks nor spaces containing machinery where sources of vapor ignition are normally present. Cargo loading pipes are to be led as low as practical in the cargo tank. See also 4-3-2/3 and 4-3-1/7.

1.3.2 Suctions

Where water suctions are provided for ballasting, tank cleaning or other purposes, means of isolating the pumps from the sea chest is to be provided. The means of isolation is to be either a blank flange or a removable spool piece. A shut-off valve is to be fitted on each side of the blank flange or spool piece. As an alternative, the means of isolation may be two valves located inboard of the sea chest, one of which is to be capable of being locked in the closed position. Means are to be provided for detecting leakage past these valves.

#### 1.3.3 Operating Rod Stuffing Boxes

Stuffing boxes are to be fitted where operating rods from cargo valves pass through gastight structural parts.

### 1.5 Other Piping Systems

#### 1.5.1 Pump Room and Cofferdam Bilge Systems *(2009)*

Provision is to be made for removing drainage from the pump room bilges and adjacent cofferdams. A separate bilge pump, eductor or bilge suction from a cargo pump or cargo stripping pump may be provided for this purpose. The pump is not to be located in, nor is the piping to pass through, spaces containing machinery where sources of vapor ignition are normally present. Where a bilge suction is provided from a cargo or stripping pump, a stop-check valve is to be fitted in the bilge suction branch. An additional stop valve is to be fitted when the bilge suction branch is arranged so that it may be subjected to a head of oil from the filling line. Pump room bilge suction and discharge valves and bilge-pump controls are to be operable from in the pump room, unless Flag Administrations have a specific requirement for remote operation, either from an accessible position outside the pump room or from the pump room casing above the freeboard deck. High levels of liquid in the pump room's bilge are to activate an audible and visible alarm in the cargo control room and on the navigation bridge.

#### 1.5.2 Piping Through Cargo Tanks

Where the arrangement of the vessel is such as to necessitate the passing through the cargo tanks of piping other than that necessary for the handling or heating of the cargo or for fire protection, the piping systems will be subject to special consideration.

### 1.7 Venting Systems

#### 1.7.1 General

Each cargo tank is to be fitted with a pressure-vacuum relief valve, or a vent pipe is to be led from each tank into a common header. In the latter case, the header is to be led to a reasonable height above the deck and is to be fitted with a flame arrester or pressure-vacuum relief valve at the outlet to the atmosphere. Means are to be provided to prevent any tank from being subjected to excessive pressure during any phase of the cargo handling process.

The diameter of the vent pipes is not to be less that 63 mm (2.5 in.) I.D. When it is intended that the tanks are to be loaded with closed ullage hatches, the vent pipes are to be sized for 125% of the maximum loading rate to prevent the pressure in any cargo tank from exceeding the design pressure. Vent outlets for cargo loading, discharging and ballasting are to be located not less than 3 m (10 ft) measured horizontally from deck machinery and equipment which may constitute an ignition hazard.

#### 1.7.2 Cargo Oil With Flash Point Above 27°C (80°F)

Where a vessel is intended only for the carriage of combustible liquids having a flash point above 27°C (80°F), a venting system consisting of individual return-bend vents fitted with flame screens may be fitted in lieu of that described in 4-3-6/1.7.1.

#### 1.7.3 Inert Gas System

When tank vessels are equipped with a system whereby inert gas is continuously maintained in the tanks for fire prevention, such a system is to be in accordance with 4-3-6/1.9 and the venting arrangements subject to special consideration.

#### 1.7.4 Cofferdams

In general, cofferdams (see 3-2-1/19.1.2) are to be provided with return bend vents fitted with wire gauze flame screens or pressure-vacuum relief valves.

## 1.9 Inert Gas System Requirements

Where fitted, the inert gas system is to comply with the following:

### 1.9.1 Pressure

The systems are to be so designed that the maximum pressure which can be exerted on the tanks does not exceed 0.24 kgf/cm$^2$ (3.5 psi).

### 1.9.2 Blower Isolating Valves

Shut-off valves are to be fitted on both suction and discharge connections for each blower.

### 1.9.3 Demister

Demisters or equivalent devices are to be provided to minimize carryover of water from the scrubber and the deck water seal.

### 1.9.4 Gas Regulating Valve

The gas regulating valve is to be arranged to close automatically when any of the following additional conditions apply:

- Loss of water pressure to deck seal(s).
- Loss of control power.

### 1.9.5 Blowers

When two blowers are provided, the total required capacity of the inert gas system is preferably to be divided equally between the two blowers and in no case is one blower to have a capacity less than $^1/_3$ of the total capacity required.

### 1.9.6 Fire Protection

The compartment in which any oil-fired, inert gas generator is situated is to meet the requirements of 4-4-1/19.

### 1.9.7 Venting

Arrangements are to be made to vent the inert gas from oil-fired inert gas generators to the atmosphere when the inert gas produced is off-specification (e.g., during starting-up or in the event of equipment failure).

### 1.9.8 Fuel Oil Shutdown

Automatic shutdown of the fuel oil supply to inert gas generators is to be arranged on predetermined limits being reached in respect of low water pressure or low water flow rate to the cooling and scrubbing arrangement and in respect of high gas temperature.

### 1.9.9 Scrubber Cooling Pump

A minimum of two pumps are to be provided for inert gas scrubber cooling, one of which is to be dedicated for this service. Pumps, other than the required dedicated pump, may be used for other services such as bilge, ballast or general service.

## 1.11 Cargo Vapor Emission Control Systems

Cargo vapor emission control systems, where provided, are to be in accordance with 5C-1-7/21 of the *Steel Vessel Rules*.

## 3 Cargo-handling Systems

### 3.1 General

All vessels and barges are to be provided with cargo handling systems for safe and efficient operation in the service for which they are intended. The construction and installation of the cargo handling systems and associated auxiliary systems are to be in accordance with the applicable parts of Part 4, Chapter 3, and are also to comply with the detailed requirements as specified below for the particular type of cargo.

### 3.3 Dangerous Chemicals

The cargo handling system for vessels and barges carrying dangerous chemical cargoes are to be in accordance with Section 4-3-7.

### 3.5 Liquefied Gases

Cargo-handling systems for refrigerated liquefied gases at a service temperature below –18°C (0°F) and near atmospheric pressure are to be in accordance with Sections 4-3-7 and Chapter 4 of the ABS *Rules for Materials and Welding (Part 2)*.

### 3.7 Pressurized Gases

Cargo-handling systems for loading and discharging pressurized cargo will be specially considered upon submittal of the details of the arrangements.

### 3.9 Cargo Oil Piping

Cargo oil piping is to be in accordance with 4-3-6/1.3.

### 3.11 Noncombustible Liquids

When a vessel is intended solely for carrying liquid cargo which is neither flammable nor combustible, the arrangements of the cargo and venting systems will be given special consideration in each case. See also Section 4-3-7.

PART

# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 7 Cargo Transfer Systems for Dangerous Chemical Cargoes

### 1 General

All vessels intended for the carriage of dangerous chemicals in bulk are to be provided with the necessary cargo transfer systems for safe operation. The construction and installation of the cargo transfer system and associated auxiliary systems are to be in accordance with the requirements contained in Part 151 of Subchapter O of Chapter 1 Title 46 Code of Federal Regulations, or other recognized standards as indicated in 3-2-3/3, and are also to comply with the applicable requirements of Part 4, Chapter 3 and the following additional requirements. Cargo transfer systems for refrigerated cargoes will be subject to special consideration and are to be designed and constructed to be in general compliance with the applicable requirements of Part 4, Chapter 3.

Cargo pressure vessels are to be designed and constructed in accordance with the requirements of Part 4, Chapter 4 of the *Steel Vessel Rules* and the applicable sections of Part 151 of Subchapter O of Chapter I Title 46 Code of Federal Regulations.

### 3 Cargo Piping Classification

#### 3.1 Cargo Piping for Barge Type I

Cargo piping for Barge Type I is to be designed and fabricated as Group I piping for all service temperatures or pressures, except where otherwise indicated in Table 151.05 of Part 151 of Subchapter O of Chapter I Title 46 CFR.

#### 3.3 Cargo Piping for Barge Types II and III

Cargo piping for Barge Types II and III may be designed and fabricated as either Group I or Group II piping as limited by service temperatures or pressures under 4-3-1/1.3.

### 5 Plans and Data to be Submitted *(2011)*

Plans and specifications covering the entire cargo handling installation together with all machinery, equipment, piping and electrical devices and systems are to be submitted before proceeding with the work. Plans should generally be submitted electronically to ABS. However, hard copies will also be accepted. The plans and specifications are to include:

- General arrangement of pumps and piping
- Diagram of cargo piping (liquid and vapor) including lists and details of special valves and fittings
- Diagram of venting system including calculations of relief valve capacities
- Arrangement of liquid level gauging devices
- Arrangement of temperature measuring devices
- Details of all electrical apparatus, if fitted, together with schematic wiring diagrams
- Arrangement for electric bonding

- Details of refrigerating or heating plant when fitted
- Details of fire extinguishing system when fitted
- Methods for cargo handling
- List of cargoes intended to be carried including vapor pressure at 46°C (115°F) or 41°C (105°F) if the cargo tanks are insulated

# 7 Materials

## 7.1 General

The materials for pumps, pipes, valves, fittings, gaskets and other components coming in contact with the product are to be suitable for the intended service. Material specifications including the chemical composition and mechanical properties are to be submitted. Materials entering into the fabrication of Group I cargo piping are to be tested and inspected by the Surveyors and are to comply with the requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or such other appropriate material specifications as may be approved in connection with a particular design. The tests of material for pumps, valves, fittings and for Group II piping need not be witnessed by the Surveyors. Valves and pipe fittings are to comply with the requirements of 4-3-2/11 and 4-3-2/13. Where welding is used, the requirements of Chapter 4 of the ABS *Rules for Materials and Welding (Part 2)* are also applicable.

## 7.3 Service Temperature Below –18°C (0°F)

Where the service temperature is below –18°C (0°F) the cargo handling system materials are to be in general compliance with the applicable requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)*.

# 9 Venting

All tanks intended for dangerous chemical cargoes are to be provided with one of the three venting systems as listed in 4-3-7/9.1 through 4-3-7/9.5. 46 CFR Table 151.05 referred to in 4-3-7/3.1 specifies the type of systems appropriate to the particular cargo. Safety-relief venting applies to compressed or liquefied gas.

Cargo vapor emission control systems, where provided, are to be in accordance with 5C-1-7/21 of the *Steel Vessel Rules* in addition to the applicable requirements of the Rules.

## 9.1 Open Venting

Where this system is specified, the requirements elsewhere in these Rules, including 4-3-3/7, are to be complied with. Due consideration is to be given to 4-3-7/9.3.3 where applicable.

## 9.3 Pressure-Vacuum Venting

### 9.3.1 System Design

The system is to be sized, allowing for flame screens if fitted, to permit loading at the design rate without exceeding the pressure setting used in determining the scantlings in accordance with 3-2-1/17.

### 9.3.2 Vent Line Capacity

The capacity of branch vents, vent headers or risers will depend upon the number of cargo tanks connected to such branch, header or vent riser as provided for in the following table.

| *Number of Cargo Tanks* | *Percent of Total Value Discharge* |
|---|---|
| l or 2 | 100 |
| 3 | 90 |
| 4 | 80 |
| 5 | 70 |
| 6 or more | 60 |

9.3.3 Condensation

Chemicals whose vapors condense or deposit as solids in vent openings will be subject to special consideration. In general, tanks carrying such products are to be fitted with vents having an aggregate area at least twice the area of the filling line and safe means are to be provided for inspecting the venting systems and clearing any accumulation or product deposits in the vent openings.

### 9.5 Safety-Relief Venting

Each tank intended for dangerous chemicals for which this system is specified in 46 CFR Table 151.05 is to have one or more safety-relief valves in accordance with 4-3-7/11.

## 11 Safety-Relief Valves

### 11.1 Capacity

The safety-relief valves are to have sufficient capacity to relieve either the vapors formed by heat transfer into the cargo tanks plus the vapors displaced by the maximum loading rate, or the vapors formed by fire as calculated by the following equation, whichever is larger. In no case is a safety-relief valve to be less than 100 mm (4 in.) diameter.

$$Q = 5.66 \times 10^6 \frac{FA^{0.82}}{LC}\sqrt{\frac{ZT}{M}} \quad \text{m}^3\text{/hr}$$

$$Q = 633{,}000 \frac{FA^{0.82}}{LC}\sqrt{\frac{ZT}{M}} \quad \text{ft}^3\text{/hr}$$

where

$Q$ = minimum required rate of discharge of air at standard conditions 0°C and 1 atm (60°F and 14.7 psia), in m$^3$/hour (ft$^3$/minute)

$F$ = fire exposure factor

= 1.0 except when an approved fireproofing of recommended thickness of a metal screen is used, then $F$ = 0.5. Special consideration may be given to a reduction in $F$ when considering the thermal conductance of the insulation on a cargo tank and its stability under fire exposure

= 0.2 for non-pressure container type tanks in holds

= 0.1 for non-pressure type tanks in holds which are inerted at all times

$M$ = molecular weight of the cargo

$T$ = temperature of the gas at relieving conditions, degrees Kelvin, K = 273 + temperature in degrees C (degrees Rankine, R = 460 + temperature in degrees F)

$A$ = total area of cargo container less the bottom surface area, in m$^2$ (ft$^2$)

= $\pi DU$ for cylindrical tank with hemispherical heads

= $D(U + 0.3D)$ for cylindrical tanks with torispherically- (spherically-) dished or semi-ellipsoidal heads

= $\pi D^2$ for torispherical (spherical) tanks]

$D$ = outside diameter of the tank, in m (ft)

$U$ = external overall length of the tank, in m (ft)

$C$ = constant based on the relation of the specific heats with values given in 4-3-7/Table 1

$k$ = ratio of specific heats ($k = C_p/C_v$)

*Note:* If $k$ is not known, use $C$ = 315.

$L$ = latent heat of the material being vaporized at relieving conditions, in calorie/gram (BTU/pound)

$Z$ = compressibility factor of gas at relieving conditions (if not known, use $Z$ = 1.0)

### 11.3 Certification

Certified copies of the valve manufacturer's capacity tests for the relief valves, or other data establishing the relieving capacity, are to be submitted.

### 11.5 Installation

Safety-relief valves are to be attached to the tank near the highest point of the vapor space. Shutoff valves are not to be installed between the tanks and safety-relief valves, except manifolds for mounting multiple safety-relief valves may be fitted with interlocking shutoff valves so arranged at all times as to permit the required discharge capacity through the open safety-relief valves.

### 11.7 Tests

Each safety-relief valve is to be tested in the presence of the Surveyor before being placed in service. The relief valves are to be lifted from their seats by pressure in the presence of a Surveyor to verify that each relief valve is set to discharge at a pressure not in excess of the tank design pressure.

## 13 Pressure Vessels

Pressure vessels carrying liquefied gases under pressure need not be fitted with tank level gauges where contact with the gas would be hazardous. Such gases are to be loaded in accordance with methods recommended by the gas manufacturer and usually involve charging weighed amounts of a liquefied gas into a cargo tank until the allowable total weight of a gas cargo has been loaded into a given tank at controlling pressure and temperature. A pressure gauge is to be fitted at each cargo tank during the loading and unloading of the contents of each tank intended for the carriage of compressed gases. For pressure vessel type tanks, each automatic float, continuous reading tape or similar gauge not mounted directly on the tank or dome is to be fitted with a shutoff device located as close to the tank as practicable.

## 15 Cargo Transfer

### 15.1 General

Cargo unloading arrangements will be influenced by the nature of the cargo and whether carried in vented gravity tanks or in pressurized tanks. Cargo pumps may be used for discharging most cargoes. Gravity, vapor or gas pressurization, inert gas, or water displacement may be considered for certain cargoes provided construction of the tank structure is suitable for pressures produced during displacement discharge.

### 15.3 Cargo Pumps

Cargo pumps are to be preferably of the vertical submerged type fabricated of materials suitable for the intended service. The shaft is to be fitted with an effective seal to preclude leakage of the cargo.

### 15.5 Pump Wells

Where vertical submerged cargo pumps are installed in cylindrical pump wells located within the cargo tanks, the arrangement is to be such that the pump wells can be isolated from the cargo to permit the flooding of the wells with water or suitable liquid for the safe removal of cargo pumps for maintenance purposes. The pump wells may be located external to the cargo tanks, provided they are placed as close to the centerline and are as far from the bottom and ends of the barge as is practicable. External pump wells are to be designed and constructed to withstand the maximum pressures which would be expected in service.

### 15.7 Pump Prime Movers

Cargo pump prime movers are to be located preferably in the open and fitted with well-ventilated hoods for protection from the weather. See also 4-1-1/15.3.

## 15.9 Pressure Gauges

A pressure gauge is to be installed at each pump discharge. Additionally, where the pressure gauge is not visible from the pump control station, a pressure display is to be fitted at such station.

## 15.11 Independent Tank Connections

Cargo piping is to enter the cargo tanks above the weather deck or at the top of the tanks. Bottom entry of cargo piping into independent gravity and pressure tanks in association with externally fitted pump wells will be subject to special consideration.

## 15.13 Piping, Valves and Fittings

Group I and Group II piping are to be of seamless or electric-resistance-welded steel or alloy, compatible with the range of products to be handled. The minimum thickness of Group I carbon steel piping is to be as follows:

- Less than 100 mm (4 in.) I.D. Schedule 80
- 100 mm (4 in.) I.D. and over Schedule 40

Group II piping is to be at least standard thickness.

### 15.13.1 Design of Piping

All piping system components are to have a pressure rating at operating temperature not less than the maximum pressure to which the system may be subjected. Component materials are to be compatible with the type of cargo carried and subjected to the requirements of 3-2-3/5 and 4-3-7/1. Piping which is not protected by a relief valve, or which can be isolated from its relief valve, is to be designed for the greatest of the following:

*i)* The maximum vapor pressure at 46°C (115°F)

*ii)* The maximum allowable working pressure of the cargo tank

*iii)* The pressure of the associated pump or compressor relief valve

*iv)* The total discharge head of the associated pump or compressor where a discharge relief valve is not used.

### 15.13.2 Valves and Fittings

Valves and fittings in piping systems are to be steel or alloy compatible with the range of products to be handled and are not to be less than ANSI 150 Class or equivalent. Consideration will be given to the acceptance of nodular iron, malleable iron, and non-ferrous valves and fittings when used in accordance with a recognized standard, provided the material has an elongation not less than 12%.

### 15.13.3 Low Temperature Piping

Low temperature piping systems are to be in accordance with the applicable requirements of Chapter 3 of the ABS *Rules for Materials and Welding (Part 2).*

## 15.15 Piping Flexibility Arrangements

Piping is to be provided with adequate support to take the weight of the piping of valves and fittings and, where subject to a wide temperature range, provision is to be made for expansion and contraction either by means of pipe bends, loops, offsets or individually approved bellows-type expansion joints. Slip joints are not to be used.

## 15.17 Pipe Joints

Piping is to be joined with butt welds wherever practicable and flanged joints kept to a minimum. Socket and slip-on welded connections may be used for sizes 50 mm (2 in.) and smaller. Threaded joints may be used on accessory lines for sizes 25 mm (1 in.) and smaller properly valved off from the cargo lines. Where threaded joints are used, they are to be visible and accessible for inspection under all service conditions. If the threaded joints are seal welded they need not be exposed. There are to be no threaded connections to cargo tanks.

### 15.19 Cargo Filling Lines in Tanks

Cargo filling lines are to have their discharge openings near the bottom of the tanks except in special cargo handling arrangements where cargo filling drop lines would not be practicable.

### 15.21 Spillage Containment

Drip pans or other suitable containment are to be provided where cargo leakage or spillage from the piping system may occur and arranged to prevent leakage being washed into any waterway during cargo loading and unloading.

### 15.23 Electrical Bonding

Where flammable cargoes are carried and the tanks or piping are separated from the vessel's structure by thermal insulation or nonmetallic chocking or lining material in way of supports, provision is to be made for electrically bonding both the piping and the tanks. All gasketed pipe joints are to be electrically bonded. Tanks or piping permanently connected to the hull by metallic bolting will be considered as being electrically bonded.

## 17 Protective Housing

Where practicable, connections to cargo pressure tanks are to be protected against mechanical damage preferably by grouping the necessary fill, discharge, liquid and vapor shutoff valves and safety-relief valves in the smallest practicable space and enclosing them in a suitable protective metal housing.

## 19 Electrical

For electrical requirements, refer to 4-5-6/7.

## 21 Fire Extinguishing

Requirements for fire extinguishing systems and equipment are in 4-4-1/23.

## 23 Salvaging Connections

Where salvaging connections are fitted between the cargo pump wells to permit removal of water from the buoyancy spaces in an emergency, two valves are to be fitted between the cargo pump well and such unwatering systems. One of these valves is to be capable of being locked in the closed position.

## TABLE 1
## Values of $C$ for Use in Calculating Safety-Relief Valve Capacity

| *Constant* | | *Constant* | | *Constant* | |
|---|---|---|---|---|---|
| *k* | *C* | *k* | *C* | *k* | *C* |
| 1.00 | 315 | 1.40 | 356 | 1.80 | 357 |
| 1.02 | 318 | 1.42 | 358 | 1.82 | 388 |
| 1.04 | 320 | 1.44 | 359 | 1.84 | 390 |
| 1.06 | 322 | 1.46 | 361 | 1.86 | 391 |
| 1.08 | 324 | 1.48 | 363 | 1.88 | 392 |
| 1.10 | 327 | 1.50 | 364 | 1.90 | 394 |
| 1.12 | 329 | 1.52 | 366 | 1.92 | 395 |
| 1.14 | 331 | 1.54 | 368 | 1.94 | 397 |
| 1.16 | 333 | 1.56 | 369 | 1.96 | 398 |
| 1.18 | 335 | 1.58 | 371 | 1.98 | 399 |
| 1.20 | 337 | 1.60 | 372 | 2.00 | 400 |
| 1.22 | 339 | 1.62 | 374 | 2.02 | 401 |
| 1.24 | 341 | 1.64 | 376 | 2.20 | 412 |
| 1.26 | 343 | 1.66 | 377 | | |
| 1.28 | 345 | 1.68 | 379 | | |
| 1.30 | 347 | 1.70 | 380 | | |
| 1.32 | 349 | 1.72 | 382 | | |
| 1.34 | 351 | 1.74 | 383 | | |
| 1.36 | 352 | 1.76 | 384 | | |
| 1.38 | 354 | 1.78 | 386 | | |

PART

# 4

## CHAPTER 3 Pumps and Piping Systems

## SECTION 8 Other Piping Systems and Tanks

## 1 Hydraulic Piping

### 1.1 Arrangements

The arrangements for Group I hydraulic piping systems are to be in accordance with the requirements of this Section except that hydraulic systems which form part of a unit which is independently manufactured and assembled and which does not form part of the vessel's piping system are not covered by this Section. Plans showing clearly the arrangements and details are to be submitted for review.

### 1.3 Valves

#### 1.3.1 General

In general, valves are to comply with the requirements of 4-3-2/11.

#### 1.3.2 Relief Valves

Relief valves are to be provided for the protection of the hydraulic system. Each relief valve is to be capable of relieving not less than full pump flow with a maximum pressure rise of not more than 10% of the relief valve setting.

### 1.5 Piping

Piping is to meet the requirements of 4-3-1/5 and 4-3-2/5 except that mill tests need not be witnessed by the Surveyor. In such cases, mill certificates are to be provided.

### 1.7 Pipe Fittings

Fittings and flanges are to meet the requirements of 4-3-2/13 and 4-3-2/15 except as follows:

#### 1.7.1 Non-standard Fittings

Fittings which are not constructed to a recognized standard will be subject to special consideration. Plans showing details of construction, material and design calculations or test results are to be submitted for review.

#### 1.7.2 Split Flanges

Split flanges are not to be used in steering gear systems. The use of split flanges for all other applications will be specially considered.

#### 1.7.3 Straight-thread, O-ring Connections

Straight-thread, O-ring type connections may be used for connections to equipment such as pumps, valves, cylinders, accumulators, gauges and hoses. Such connections are not to be used for joining sections of pipe.

#### 1.7.4 Tapered-threaded Connections

Tapered-threaded connections up to and including 89 mm O.D. (3 in. NPS) may be used without limitations for connections to equipment such as pumps, valves, cylinders, accumulators, gauges and hoses. Tapered-threaded connections are not to be used in steering gear systems, controllable pitch propeller systems and other systems associated with propulsion or propulsion control, except where permitted by 4-3-2/13. Such connections are not to be used for joining sections of pipe except where permitted by 4-3-2/13.

### 1.9 Hose

Hose assemblies are to be in accordance with 4-3-1/7.21.

### 1.11 Accumulators

Accumulators are to meet the requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*. Each accumulator which may be isolated is to be protected by suitable relief valves. Where a gas charging system is used, a relief valve is to be provided on the gas side of the accumulator.

### 1.13 Fluid Power Cylinders

Fluid power cylinders are to meet the requirements of 4-6-7/3.5.5 of the *Steel Vessel Rules*.

### 1.15 Design Pressure

The pressure used for determining the strength and design of piping and components is not to be less than the relief valve setting.

### 1.17 Segregation of High Pressure Hydraulic Units in Machinery Spaces

Hydraulic units with working pressures above 15.5 bar (15.8 kgf/cm$^2$, 225 psi) installed within machinery spaces are to be placed in separate room or rooms or shielded as necessary to prevent any oil or oil mist that may escape under pressure from coming into contact with surfaces with temperatures in excess of 220°C (428°F), electrical equipment or other sources of ignition. For the purposes of this requirement, a hydraulic unit includes the power pack and all components of the hydraulic piping system.

## 3 Liquefied Petroleum Gases

Where liquid petroleum gases are used in the galley, the cylinders and piping are to be kept in the open as far as practicable. The installation is to comply with 46 CFR Subpart 58.16.

## 5 Ship Service Ammonia System *(1996)*

### 5.1 Compartmentation

Ammonia handling machinery is to be installed in a dedicated compartment with at least two access doors. The doors are to be of the self-closing, gastight type with no hold-back arrangements.

### 5.3 Safety Measures

The following safety measures are to be provided for compartments containing ammonia handling machinery, including process vessels.

*i)* An independent mechanical negative ventilation system capable of providing at least 30 air changes per hour based on the gross volume of the space

*ii)* A sprinkler system with control outside of the compartment

*iii)* A fixed ammonia detector system with alarm inside and outside of the compartment

*iv)* Water screen devices operable from outside of the compartment, for all access doors.

*v)* An independent bilge system located within these compartments

### 5.5 Ammonia Piping

Ammonia piping is not to pass through accommodation spaces.

PART

# 4

## CHAPTER 4 Fire Extinguishing Systems and Equipment

### CONTENTS

PART

# 4

# CHAPTER 4 Fire Extinguishing Systems

# SECTION 1 All Vessels

## 1 General

All vessels are to be provided with fire extinguishing systems and fire protection equipment as outlined in this Section.

## 3 Governmental Authority

Attention is directed to the appropriate governmental authority in each case, as there may be additional requirements depending on the size, type and intended service of the vessel, as well as other particulars and details. Consideration will be given to fire extinguishing systems which comply with the published requirements of the governmental authority in which the vessel is to be registered.

## 5 Fire Safety Measures

Passenger vessels are to comply with the applicable requirements of Section 3-4-1.

## 7 Plans and Data

### 7.1 Plans *(2011)*

Before proceeding with the work, the following plans are to be submitted together with supporting data and particulars as applicable. Plans should generally be submitted electronically to ABS. However, hard copies will also be accepted. See also 4-1-1/5.

- Arrangement and details of fire main systems
- Foam smothering systems
- Fire control pans
- Fixed fire extinguishing systems
- Fire detection systems
- Other fire extinguishing equipment and appliances
- *(2010)* The most severe service condition for the operation of the emergency fire pump (e.g., lightest draft as shown in Trim and Stability Booklet, etc.)
- *(2010)* Calculations and pump data demonstrating that the emergency fire pump system can meet the operational requirements specified in 4-4-1/9 with the proposed pump location and piping arrangements (e.g., adequate suction lift, discharge pressure, capacity, etc.) at the most severe service condition

### 7.3 Data

The number and capacity of fire pumps is to be submitted as well as a list of the fire protection equipment to be provided.

# 9 Fire Pumps

## 9.1 Number of Pumps

### 9.1.1 General

All self-propelled vessels, other than passenger vessels, are to be provided with at least one fire pump. For vessels over 20 m (65 ft) in length, the pump is to be power-driven. For vessels 20 m (65 ft) in length and under, the pump may be hand-operated.

### 9.1.2 Passenger Vessels

Passenger vessels are to be provided with at least two independently-power-driven fire pumps. One of these pumps is to be dedicated for fire-fighting duties and available for such duties at all times. The arrangements of the pumps, sea suctions and sources of power are to be such as to ensure that if a fire or casualty in any one space could put all the pumps out of action, an alternative means of providing water for fire-fighting purposes is to be provided. This alternative means is to be from a fixed independently-driven, power-operated fire pump which has its source of power and sea connection located outside the machinery space. The emergency fire pump is to have a capacity not less than 25 $m^3$/hr (110 gpm) and is to be capable of simultaneously delivering 12 m (40 ft) jet throw from any two adjacent hydrants located in accordance with 4-4-1/13.1.

## 9.3 Type and Capacity

### 9.3.1 Power-driven Pumps

Sanitary, ballast, bilge or general-service pumps may be accepted as fire pumps. Each pump is to be capable of providing a full supply of water to the fire hoses whereby at least two powerful streams can be rapidly and simultaneously directed into any part of the vessel. Each power-driven pump is to be capable of producing the two streams of water with the throw at any nozzle being at least 12 m (40 ft). For passenger vessels, the fire pumps required by 4-4-1/9.1.2 are to be capable of delivering for fire-fighting purposes at a pressure of at least 3.1 kgf/$cm^2$ (44 psi) a quantity of water not less than two-thirds the quantity required to be dealt with by the bilge pumps when employed for bilge pumping. See 4-3-3/3.5.4.

### 9.3.2 Hand-operated Pumps

Each hand pump is to have a capacity of at least 1.1 $m^3$/hr (5 gpm) and is to be equipped with suction and discharge hoses suitable for use in fire-fighting. The hand pump may also serve as a bilge pump.

## 9.5 Relief Valves

Relief valves are to be provided in connection with all power-driven fire pumps unless it can be shown that the arrangements are such as to prevent excessive pressure in any part of the fire main system.

# 11 Fire Mains

## 11.1 Size

All vessels for which power-driven fire pumps are required are to be fitted with a fire main system, including fire main, hydrants, hoses and nozzles. The diameter of the fire main is to be sufficient to ensure an adequate supply of water for the simultaneous operation of at least the two fire hoses required in 4-4-1/9.3.1.

## 11.3 Cocks or Valves

Cocks or valves are to be fitted in such positions on the pipes that any of the fire hoses may be removed while the fire pumps are operating.

## 11.5 Materials *(1997)*

Materials readily rendered ineffective by heat are not to be used for fire mains unless adequately protected. In order to be considered not “readily rendered ineffective by heat”, a component is to be certified as having passed an applicable recognized fire test, or the material is to have a melting temperature higher than the test temperature specified in an applicable fire test.

## 13 Hydrants, Hoses and Nozzles

### 13.1 Hydrants *(1997)*

#### 13.1.1 General

The number and position of the hydrants is to be such that at least two streams of water, not emanating from the same hydrant, may be directed to any part of the vessel. One of these streams is to be from a single length of hose not more than 23 m (75 ft) long for 38 mm (1.5 in.) diameter hose or 15 m (50 ft) long for 63 mm (2.5 in.) diameter hose.

The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. In vessels where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged, as far as practicable, to avoid risk of damage by such cargo.

Materials readily rendered ineffective by heat are not to be used for hydrants. See 4-4-1/11.5.

#### 13.1.2 Passenger Vessels

The requirement in 4-4-1/13.1.1 is to be met for any part of the vessel normally accessible to the passengers or crew while the vessel is being navigated and any part of the cargo space when empty, any ro-ro space or any special category space in which latter case the two jets will reach any part of such space, each from a single length of hose. Furthermore, such hydrants are to be positioned near the accesses to the protected spaces.

In the accommodation, service and machinery spaces, the number and position of the hydrants are to be such that the above requirements may be complied with when all watertight doors and all doors in main vertical zone bulkheads are closed.

### 13.3 Hoses *(1997)*

The number of fire hoses to be provided, each complete with couplings and nozzles, is to be one for each 30 m (100 ft) length of the vessel and one spare. This number does not include any hoses required in any machinery space. For passenger vessels, a hose is to be provided for each hydrant and in interior locations in vessels carrying more than 36 passengers, fire hoses are to be connected to the hydrants at all times.

Fire hoses are to be of approved material. The minimum hose diameter for all vessels over 20 m (65 ft) in length is to be not less than 38 mm (1.5 in.) diameter. For vessels 20 m (65 ft) and under, 19 mm (0.75 in.) diameter hose may be used. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. The maximum length of hose is not to exceed 23 m (75 ft).

Each hose is to be provided with a nozzle and necessary couplings. Unless there is provided one hose and nozzle for each hydrant in the vessel, there is to be complete interchangeability of hose couplings and nozzles. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the water-service hydrants of connections.

### 13.5 Nozzles *(1997)*

#### 13.5.1 General

The minimum internal diameter of hose nozzles is not to be less than 16 mm ($^{5}/_{8}$ in.), except as indicated in 4-4-1/13.5.2 or 4-4-1/13.5.3. Nozzles for hoses attached to hydrants in the machinery spaces are to be suitable for spraying water on oil, or alternatively dual-purpose nozzles. Fire hose nozzles of plastic type material, such as polycarbonate may be accepted subject to review of their capacity and serviceability as marine use fire hose nozzles.

#### 13.5.2 Vessels 100 Gross Tons and Under

The minimum internal diameter of nozzles may be 8 mm ($^{5}/_{16}$ in.). For vessels under 20 m (65 ft) in length, garden type nozzles may be used.

13.5.3 Passenger Vessels

Standard nozzle sizes are to be 12 mm (0.5 in.), 16 mm (0.625 in.) and 19 mm (0.75 in.), or as near thereto as possible. For accommodation and service spaces, a nozzle size greater than 12 mm (0.5 in.) need not be used. For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets at the referenced pressures in 4-4-1/9.3 from the smallest pump. However, a nozzle size greater than 19 mm (0.75 in.) need not be used.

## 15 Portable Extinguishers

For all self-propelled vessels and all barges having facilities for 36 persons or more, portable extinguishers are to be provided in the quantities and locations indicated in 4-4-1/Tables 1 and 2.

## 17 Shutdowns and Closures

### 17.1 Ventilation Fans and Openings *(2009)*

Means are to be provided for stopping ventilating fans serving machinery and cargo spaces, and for closing all doorways, ventilators and other openings to such spaces. These means are to be capable of being manually operated from outside of such spaces in the event of a fire. See 4-5-2/17.1.1.

### 17.3 Other Auxiliaries *(2009)*

Machinery driving forced- and induced-draft fans, oil-fuel transfer pumps, oil-fuel unit pumps and other similar fuel pumps, fired equipment such as an incinerator, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers) are to be fitted with remote shutdowns situated outside of the spaces concerned so that they may be stopped in the event of a fire arising in the space. This need not apply to oily water separators. See 4-5-2/17.1.2.

In addition to the remote shutdowns required above, a means to shut down the equipment is to be provided within the space itself.

## 19 Fixed Fire Extinguishing Systems for Machinery Spaces

### 19.1 Provision

An approved fixed fire extinguishing system is to be provided for spaces containing any of the following:

*i)* Boiler, heater or incinerator of the oil-fired type

*ii)* Oil-fuel unit used for the preparation and delivery of fuel oil to oil-fired boilers (including incinerators and inert gas generators), internal-combustion engines or gas turbines at a pressure of more than 1.8 kgf/cm$^2$, 26 psi).

*iii)* Internal-combustion engines where the aggregate total power output exceeds 375 kW (500 HP) and the vessels gross tonnage exceeds 500.

Paint lockers and flammable liquid lockers with a deck area of 4 m$^2$ (43 ft$^2$) or greater are also to be fitted with a fixed fire extinguishing system.

### 19.3 Carbon Dioxide Systems *(2017)*

Where a fixed carbon dioxide fire-extinguishing system is installed, the system is to comply with the following requirements:

19.3.1 Cylinders

Containers for the storage of fire-extinguishing medium and associated pressure components are to be designed in accordance with Part 4, Chapter 4 of the *Steel Vessel Rules*. Means are to be provided for the crew to safely check the quantity of medium in the containers.

19.3.2 Storage

*19.3.2(a) General (2018).* The cylinders are to be located outside the protected space in a room which is situated in a safe and readily accessible location. The storage room is to be gastight and effectively ventilated. The ventilation system is to be independent of the protected space. Any entrance to the storage room shall be independent of the protected space. The access doors to the storage space are to open outwards.

Where space limitations do not permit the storage of extinguishing medium bottles in a separate space, the arrangements are to be in accordance with the following:

*i)* The door between the storage location and the protected space is to be self-closing with no hold-back arrangements.

*ii)* The space where cylinders are stored is to be adequately ventilated by a system which is independent of the protected space.

*iii)* Means are to be provided to prevent unauthorized release of gas, such as containment behind a break glass.

*iv)* There is to be provision to vent the bottles to the atmosphere in order to prevent a hazard to personnel occupying the storage area.

Where the $CO_2$ system discharge piping is also used for the sample extraction smoke detection system piping, see Chapter 10 of the International Code for Fire Safety Systems (FSS Code), as amended), for the location of the indicating unit.

*19.3.2(b) Cargo Spaces (1 July 2007).* Fire-extinguishing media protecting the cargo holds (see 4-4-1/23.1) may be stored in a room located forward of the cargo holds, but aft of the collision bulkhead, provided that both the local manual release mechanism and remote control(s) for the release of the media are fitted, and the latter is of robust construction or so protected as to remain operable in case of fire in the protected spaces. The remote controls are to be placed in the accommodation area in order to facilitate their ready accessibility by the crew. The capability to release different quantities of fire-extinguishing media into different cargo holds so protected is to be included in the remote release arrangement.

19.3.3 Alarm *(2017)*

Means are to be provided for automatically giving audible warning of the release of fire-extinguishing medium into any space to which personnel normally have access. The audible alarms are to be located so as to be audible throughout the protected space with all machinery operating, and the alarms are to be distinguished from other audible alarms by adjustment of sound pressure or sound patterns. The alarm is to operate for at least a 20-second period before the gas is released.

19.3.4 Controls *(2017)*

Precautions are to be made to prevent the inadvertent release of $CO_2$ into spaces which are required, to be provided with means to automatically give an audible warning of the release of fire extinguishing medium. For this purpose, the following arrangements are to be complied with for carbon dioxide systems for the protection of ro-ro spaces, container holds equipped with integral reefer containers, spaces accessible by doors or hatches, and other spaces in which personnel normally work or to which they have access:

*i)* Two separate controls are to be provided at each release location for releasing $CO_2$ into a protected space and to ensure the activation of the alarm. One control is to be used for opening the valve of the piping which conveys the gas into the protected space and a second control is to be used to discharge the gas from its storage containers. Positive means are to be provided so the controls can only be operated in that order.

*ii)* The two controls are to be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box is to be in a break-glass type enclosure conspicuously located adjacent to the box.

*iii)* Systems are to be designed so that opening of the door to a $CO_2$ release mechanism will not cause an inadvertent blackout condition in machinery spaces.

Means are to be provided to close all openings which may admit air to, or allow gas to escape from, a protected space. See 4-4-1/17.

#### 19.3.5 Gas Quantity *(2002)*

For machinery spaces, the quantity of carbon dioxide carried is to be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

*i)* 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casing; or

*ii)* 35% of the gross volume of the largest machinery space protected, including the casing; provided that the above mentioned percentages may be reduced to 35% and 30%, respectively, for cargo vessels of less than 2000 gross tonnage; provided also that if two or more machinery spaces are not entirely separate they are to be considered as forming one space.

For cargo spaces, the quantity of carbon dioxide available is to be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space so protected in the vessel.

For the purpose of these requirements, the volume of free carbon dioxide is to be calculated at 0.56 $m^3$/kg (9 $ft^3$/lb).

An additional quantity of fire-extinguishing medium is to be provided where the volume of free air contained in the air receivers in any space is such that it would seriously affect the efficiency of the fixed fire-extinguishing system if released into the space in the event of a fire.

Where the quantity of extinguishing medium is required to protect more than one space, the amount of medium available need not be more than the largest quantity required to protect the largest space.

#### 19.3.6 Gas Distribution System *(2017)*

The fixed piping system is to be such that 85% of the gas can be discharged into the space within two minutes. The piping within the space is to be proportioned to give proper distribution to the outlets. The number, type and location of discharge outlets are to be such as to give uniform distribution throughout the space.

For container and general cargo spaces (primarily intended to carry a variety of cargoes separately secured or packed) the fixed piping system is to be such that at least two thirds of the gas can be discharged into the space within 10 min. For solid bulk cargo spaces the fixed piping system is to be such that at least two thirds of the gas can be discharged into the space within 20 min. The system controls are to be arranged to allow one third, two thirds or the entire quantity of gas to be discharged based on the loading condition of the hold.

### 19.4 Clean Agent Fire Extinguishing Systems *(2017)*

Fixed gas fire-extinguishing systems equivalent to those specified in 4-4-1/19.1 through 4-4-1/19.3 are to be submitted for approval, based on the guidelines specified in the IMO MSC/Circ. 848 as amended by MSC/Circ. 1267 and this subsection.

Fire extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons are prohibited. The use of a fire-extinguishing medium, which either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons, is not permitted.

#### 19.4.1 Fire Suppression Agent

The agent is to be recognized as a fire extinguishing medium by NFPA Standard 2001 or other recognized national standard. The minimum extinguishing concentration for net volume total flooding of the protected space at the lowest expected operating temperature, but not greater than 0°C (32°F), is to be determined by an acceptable cup burner test. The minimum design concentration is to be at least 30% above the minimum extinguishing concentration and is to be verified by full-scale test (see 4-4-1/19.4.2).

The fire extinguishing agent is to be acceptable for use in occupied spaces by U.S. EPA or other recognized national organization. The concentrations for cardiac sensitization NOAEL (No Observed Adverse Effect Level), LOAEL (Lowest Observed Adverse Effect Level) and ALC (Approximate Lethal Concentration) are to be submitted.

#### 19.4.2 Fire Tests

The system is to pass the fire tests in the Appendix of the IMO MSC/Circ. 848 as amended by MSC/Circ. 1267. The testing is to include the system components.

The system is to pass an additional fire test (number 1 in the Appendix of MSC/Circ. 848) with the agent storage cylinder at the lowest expected operating temperature, but not greater than 0°C (32°F).

#### 19.4.3 System Components

The system is to be suitable for use in a marine environment. Major components (valves, nozzles, etc.) are to be made of brass or stainless steel, piping is to be corrosion resistant (stainless steel or galvanized) and the material is to have a melting point of not less than 927°C (1700°F).

The system and its components are to be designed, manufactured and installed in accordance with recognized national standards.

Containers and associated pressure components are to be designed based upon an ambient temperature of 55°C (131°F).

Minimum wall thickness for distribution piping is to be in accordance with 4-3-2/5.11.

#### 19.4.4 System Installation

*19.5.4(a) Storage.* As far as practicable, the fire suppression agent is to be stored outside the protected space in a dedicated storeroom. The storeroom is to be in accordance with 4-4-1/19.3.2(a), except that when mechanical ventilation is provided, the location of the exhaust duct (suction) is dependent on the density of the agent relative to air.

When allowed by the flag Administration, the fire suppression agent may be stored inside the protected space. In addition to the related instructions from the Flag Administration, the installation is to be in accordance with paragraph 11 of IMO MSC/Circ. 848 as amended by MSC/Circ. 1267.

In the case of new installation in existing units, the storage of the fire suppression agent within a low fire risk space with a net volume at least two (2) times greater than the net volume of the protected space may be specially considered, based on the type of agent and the possible hazards for the personnel within the space.

*19.5.4(b) Alarm.* An audible and visual predischarge alarm in accordance with 4-4-1/19.3.3 and paragraph 6 of IMO MSC/Circ. 848 as amended by MSC/Circ. 1267 is to be provided.

*19.5.4(c) Controls.* Except as otherwise permitted herein two independent manual control arrangements are to be provided, one of them being positioned at the storage location and the other in a readily accessible position outside of the protected space.

Automatic actuation is not permitted when the protected space is normally manned or interferes with the safety navigation of the vessel. If the protected space is normally unmanned and may be entered occasionally for brief periods such as for repairs**,** ~~or~~ maintenance or other purpose, automatic actuation may be allowed in addition to manual actuation, provided that the following conditions are met:

*i)* The egress from the protected space is horizontal. Exit doors from the spaces are to be outward-swinging self-closing doors (i.e., opening in the direction of escape routes) which can be opened from the inside, including when the doors are locked from the outside.

*ii)* Notices that the space is protected by an automatic activation system are prominently posted at the entrance to the space.

*iii)* A switch is provided near the entrance to disable the automatic release feature of the system.

The switch is to have an indicator of its status such as red pilot light to indicate when the switch is activated (automatic release feature disabled). A sign is to be posted near the switch indicating that the automatic release feature is to be disabled when the space is occupied and that the automatic actuation is to be enabled when leaving the space. The sign is to also indicate that the manual release of the system remains enabled and the space is to be vacated immediately when the release alarm sounds.

*iv)* When the automatic release feature is disabled, all other controls, alarms, etc., are to remain activated.

*v)* An indicator at the control console is provided to indicate when the automatic release feature has been disabled.

*vi)* The medium release warning alarm is to operate for the length of time needed to evacuate the space, but in no case less than 30 seconds for space exceeding 6000 $ft^3$ (170 $m^3$) and 20 seconds for spaces 6000 $ft^3$ (170 $m^3$) or less before the medium is released.

*vii)* The automatic release of a clean agent fire extinguishing system is to be approved by the vessel's flag Administration.

*19.5.4(d) Nozzles.* The nozzle type, maximum nozzle spacing, maximum height and minimum nozzle pressure are to be within the limits to provide fire extinction as tested and verified in the appropriate fire test (see 4-4-1/19.4.2).

### 19.5 Foam *(2012)*

Where a fixed high expansion foam system is installed, the system is to comply with the provisions of 4-7-3/5.1 of the *Steel Vessel Rules*.

### 19.7 Fixed Water Spraying Systems *(2012)*

Where a fixed pressure water-spraying fire-extinguishing system or an equivalent water-mist fire-extinguishing system is installed, the system is to comply with the provisions of 4-7-3/7 of the *Steel Vessel Rules*.

The installed total bilge pump capacity of the vessel is to be sufficient to evacuate 1.5 times the maximum water flow of the system.

## 21 Segregation of Fuel Oil Purifiers *(1997)*

Fuel oil purifiers for heated oil are to be placed in a separate room or rooms, enclosed by steel bulkheads extending from deck-to-deck and provided with self-closing doors. In addition, the room(s) is to be provided with the following (see also 4-4-1/17):

*i)* Independent mechanical ventilation or a ventilation arrangement which can be isolated from the machinery space ventilation

*ii)* Fire detection system

*iii)* Fixed fire extinguishing system capable of activation from outside the room. The extinguishing system is to be separate for the room but may be part of the main fire extinguishing system for the machinery space.

*iv)* Means of closing ventilation openings from a position close to where the fire extinguishing system is activated.

If it is impracticable to locate the fuel oil purifiers in a separate room, special consideration will be given in regard to location, containment of possible leakage, shielding and ventilation. In such cases, a local fixed fire extinguishing system is to be provided and arranged to be activated automatically, where permitted, or manually from the machinery control position or from another suitable location. If automatic release is provided, additional manual release is also to be arranged.

## 23 Protection of Cargo Spaces

### 23.1 Cargo Vessels of 2000 Gross Tons and Over

Except otherwise indicated in these Rules, cargo spaces of cargo vessels of 2,000 gross tons and above are to be provided with approved fixed fire extinguishing systems.

### 23.3 Fixed Fire-Extinguishing Systems

Fixed fire-extinguishing systems for cargo spaces and pump room of tankers, liquefied gas and special product carriers will be specially considered. Where the cargo area or pump room of a vessel intended to carry chemicals is fitted with a fixed system, care is to be taken to ensure that the extinguishing medium is compatible with the cargoes being carried.

### 23.5 Fire Protection on Chemical Barges

Chemical barges are to comply with the requirements of Part 151 Subchapter O of Chapter I Title 46 CFR. Where Table 151.05 of 46 CFR indicates that fire protection is required, portable fire extinguishers are to be provided in accordance with 4-4-1/Tables 1 and 2 of these Rules.

## 25 Additional Requirements for Vessels Intended to Carry Passengers

### 25.1 Fixed Fire Detection and Fire Alarm Systems, Automatic Sprinkler, Fire Detection and Fire Alarm System

#### 25.1.1 Vessels Carrying 36 Passengers or Less

There is to be installed throughout each separate vertical or horizontal fire zone, in all accommodation and service spaces, and where it is considered necessary, also in control stations (except such spaces which afford no substantial fire risk, such as void spaces, sanitary spaces, etc.) either:

*i)* A fixed fire detection and fire alarm system of an approved type and complying with the requirements of 4-4-1/25.1.4 and so installed and arranged as to detect the presence of fire in such spaces; or

*ii)* An automatic sprinkler, fire detection and fire alarm system of an approved type and complying with the requirements of 4-4-1/25.1.5 and so installed and arranged as to protect such spaces and, in addition, a fixed fire detection and fire alarm of an approved type complying with the requirements of 4-4-1/25.1.4 so installed and arranged as to provide smoke detection in corridors, stairways and escape routes within accommodation spaces.

#### 25.1.2 Vessels Carrying More than 36 Passengers

An automatic sprinkler, fire detection and fire alarm system of an approved type and complying with the requirements of 4-4-1/25.1.5 is to be installed and arranged to protect all service spaces, control stations and accommodation spaces, including corridors and stairways. As an alternative, control stations where water may cause damage to essential equipment may be fitted with an approved fire extinguishing system of another type.

In addition to the automatic sprinkler, fire detection and fire alarm system, a fixed fire detection and fire alarm system of an approved type and complying with 4-4-1/25.1.4 is to be installed and arranged to provide smoke detection in service spaces, control stations and accommodation spaces, including corridors and stairways. Smoke detectors need not be fitted in private bathrooms and galleys.

#### 25.1.3 Control Station for Fire Detection Alarms

The fire detection alarms for the systems required by 4-4-1/25.1.2 are to be centralized in a continuously manned central control station. In addition, the controls for remote closing of the fire doors and shutting down the ventilation fans are to be centralized in the same location. The ventilation fans are to be capable of reactivation by the crew at this control station.

The control panels at the central control station are to be capable of indicating the positions of the fire doors (open or closed) and the status of the detectors, alarms, fans (stopped or running). The control panel is to be continuously powered and is to be provided with an automatic changeover to standby power upon loss of normal power supply. Power for the control panel is to be supplied by the main source of electrical power and the emergency source of electrical power.

The control panel is to be designed on the fail-safe principle; an open detector circuit is to cause an alarm condition.

25.1.4 Fixed Fire Detection and Fire Alarm Systems

Where a fixed fire detection and fire alarm system is required, it is to be in accordance with the following:

*25.1.4(a) General*. Detectors and manually operated call points are to be grouped into sections. A section of detectors is not to service spaces on both sides of the vessel nor on more than one deck, and it is not to be situated in more than one main vertical zone except that if it can be demonstrated that the protection of the vessel against fire will not be reduced, such an arrangement may be accepted.

*25.1.4(b) Alarm.* The activation of any detector or manually operated call points is to initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within two minutes, an audible alarm is to be automatically sounded throughout the crew accommodation and service spaces, control stations and propulsion machinery spaces. This alarm sounder system need not be an integral part of the detection system.

*25.1.4(c) Control Panel.* The control panel is to be located on the navigation bridge or in the main fire control station.

*25.1.4(d) Indicating Units.* Indicating units are to denote the section in which a detector or manually operated call point has operated. At least one unit is to be so located that it is easily accessible to responsible members of the crew at all times when underway or in port except when the vessel is out of service. One indicating unit is to be located on the navigation bridge if the control panel is located in the main fire control station.

Clear information is to be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

25.1.5 Automatic Sprinkler, Fire Detection and Fire Alarm Systems

Following are the requirements for automatic sprinkler, fire detection and fire alarm systems required for vessels over 30.5 m (100 ft). Vessels of 30.5 m (100 ft) and under will be subject to special consideration.

*25.1.5(a) General.* Any required automatic sprinkler, fire detection and fire alarm system is to be capable of immediate operation at all times without requiring action by the crew to set it in operation. It is to be of the wet type, but small exposed sections may be of the dry type where determined that this is a necessary precaution. Any parts of the system which may be subject to freezing temperatures in service are to be suitably protected against freezing. The system is to be kept charged at the necessary pressure and is to have provision for a continuous supply of water.

*25.1.5(b) Alarm.* Each section of sprinklers is to include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems are to indicate any fault in the system upon its occurrence.

*25.1.5(c) Indicating Units.* Indicating units are to give an indication of fire and its location in any space served by the system and are to be centralized on the navigation bridge or in the in the main fire control station, which is to be manned or equipped so as to ensure that any alarm from the system is immediately received by a responsible member of the crew.

A list or plan is to be displayed at each indicating unit showing the spaces covered and the locations of the zone in respect of each section. Suitable instruction for testing and maintenance is to be available.

*25.1.5(d) Sprinklers.* Sprinklers are to be grouped into separate sections. A section of sprinklers is not to serve more than two decks nor be situated in more than one main vertical zone except that if it can be demonstrated that the protection of the vessel against fire will not be reduced, such an arrangement may be accepted.

The sprinklers are to be resistant to corrosion by marine atmosphere. In accommodation and service spaces, the sprinklers are to come into operation within the temperature range of 68 to 79°C (154 to 174°F), except that in locations such as drying rooms, where high ambient temperatures might be expected, the operating temperature may be increased no more than 30°C (54°F) above the maximum deck head temperature.

Sprinklers are to be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 l/m$^2$ (0.12 gal/ft$^2$) per minute over the nominal areas covered by the sprinklers.

*25.1.5(e) Isolation Valves.* Each section of sprinklers is to be capable of being isolated by one stop valve only. The stop valve in each section is to be readily accessible and its location is to be clearly and permanently indicated. Means are to be provided to prevent the operation of stop valves by unauthorized persons.

*25.1.5(f) Pressure Indication.* A gauge indicating the pressure in the system is to be provided at each section stop valve and at a central location.

*25.1.5(g) Pressure Tank.* A pressure tank is to be provided and contain a standing charge of freshwater equivalent to the amount of water that would be discharged in one minute by the pump referred to in item 4-4-1/25.1.5(h). The volume of the pressure tank is to be at least twice that of the required charge of freshwater. Arrangements are to such that the air pressure in the tank after the standing charge of water has been used will not be less than the working pressure of the sprinkler plus the pressure exerted by a head of water measured from the bottom of the tank to the highest sprinkler in the system. Suitable means of replenishing the air under pressure and of replenishing the freshwater charge in the tank are to be provided. A glass gauge is to be provided to indicate the correct level of water in the tank.

Means are to be provided to prevent the passage of sea water into the tank.

*25.1.5(h) Pump and Piping System.* An independent-power pump is to be provided solely for the purpose of automatically continuing the discharge of water from the sprinklers. The pump is to be brought into action automatically upon pressure drop in the system before the standing freshwater charge in the pressure tank is completely exhausted.

The pump and piping system are to be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous output of water sufficient for the simultaneous coverage of a minimum area of 280 m$^2$ (3014 ft$^2$) at the application rate required in item 4-4-1/25.1.5(d).

*25.1.5(i) Test Valve.* The pump is to have fitted on the delivery side a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe is to be adequate to permit the release of the required pump output while maintaining the pressure in the system required in item 4-4-1/25.1.5(h).

*25.1.5(j) Water Supply.* The water inlet to the pump is to be so arranged that when the vessel is afloat, it will not be necessary to shut off the supply of water to the pump for any purpose other than inspection or repair of the pump.

## 25.3 Special Category Spaces

Special category spaces as defined in 3-4-1/3.7 are to comply with the following:

### 25.3.1 Fixed Fire Extinguishing System

Each special category space is to be fitted with an approved fixed pressure water spraying system for manual operation which will protect all parts of any deck and vehicle platform in such space. Suitable provisions are to be provided to drain or pump out water that may accumulate due to operation of the water spraying system. The use of any other fixed fire extinguishing system that has been shown by full scale test in conditions simulating a flowing petrol fire in a special category space to be not less effective in controlling fires likely to occur in such a space will be specially considered.

### 25.3.2 Fire Detection and Alarm System

*i)* An approved fixed fire detection and alarm system complying with 4-4-1/25.1.4 is to be provided. The fixed fire detection system is to be capable of rapidly detecting the onset of fire. The spacing and location of detectors is to be tested to the satisfaction of ABS taking into account the effects of ventilation and other relevant factors.

*ii)* Manually operated call points are to be provided throughout the special category spaces and one is to be placed close to each exit from such spaces.

#### 25.3.3 Fire Extinguishing Equipment

The following equipment is to be provided in each special category space.

*25.3.3(a) Fog Applicator.* At least three water fog applicators.

*25.3.3(b) Foam Applicator (1 July 2009).* One portable applicator unit complying with the following:

*i) Specification.* A portable foam applicator unit is to consist of a foam nozzle/branch pipe, either of a self-inducing type or in combination with a separate inductor, capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l (5.3 US gal) of foam concentrate and at least one spare tank of foam concentrate of the same capacity.

*ii) System performance*

*a)* The nozzle/branch pipe and inductor is to be capable of producing effective foam suitable for extinguishing an oil fire, at a foam solution flow rate of at least 200 l/min (52.8 gpm) at the nominal pressure in the fire main.

*b)* The foam concentrate shall be approved by ABS based on guidelines in the Guidelines for the Performance and Testing Criteria and Surveys of Low-expansion Foam Concentrates for Fixed Fire-extinguishing Systems (MSC/Circ.582/Corr.1).

*c)* The values of the foam expansion and drainage time of the foam produced by the portable foam applicator unit is not to differ more than ±10% of that determined in 4-4-1/25.3.3(b)ii)a).

*d)* The portable foam applicator unit is to be designed to withstand clogging, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on ships.

*25.3.3(c) Portable Fire Extinguishers.* Portable fire extinguishers suitable for fighting oil fires are to be provided at each vehicle deck level in all spaces where vehicles are carried. Extinguishers are to be located not more than 20 m (65 ft) apart, on both sides of the vessel including at least one extinguisher located at each cargo space access.

### 25.5 Cargo Spaces, Other than Special Category Spaces, Intended for the Carriage of Motor Vehicles with Fuel in their Tanks

All cargo spaces (other than special category spaces) containing vehicles with fuel in their tanks are to comply with the following:

#### 25.5.1 Fixed Fire Detection System

An approved fixed fire detection and alarm system complying with 4-4-1/25.1.4 or an approved sample smoke detection system is to be provided. The design and arrangements of this system are to be considered in conjunction with the ventilation requirements.

#### 25.5.2 Fixed Fire Extinguishing System

An approved fixed gas fire extinguishing system complying with 4-4-1/19.3 is to be provided, except that the quantity of gas available is to be at least sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest such cargo space which is capable of being sealed, and the arrangements are to be such as to ensure that at least two-thirds of the gas required for the relevant spaces is introduced within 10 minutes. A fixed high-expansion foam system may be fitted provided it gives equivalent protection. As an alternative, a system meeting the requirements of 4-4-1/25.3.1 may be fitted.

#### 25.5.3 Fire Extinguishing Equipment

Portable fire extinguishers are to be provided as required in 4-4-1/25.3.3(c).

## 25.7 Other Cargo Spaces

For vessels of 1,000 gross tons and above, cargo spaces not covered under 4-4-1/25.3 or 4-4-1/25.5 are to be protected by a fixed gas fire extinguishing system complying with 4-4-1/19.3 or by a fixed high expansion foam fire extinguishing system which gives equivalent protection.

## 25.9 Special Arrangements in Machinery Spaces

### 25.9.1 Remote Controls

The controls as required in 4-4-1/17 and the controls for any required fire-extinguishing system are to be situated at one control position or grouped in as few positions as possible. Such positions are to have a safe access from the open deck.

### 25.9.2 Fuel Oil Tanks

Free standing fuel oil tanks are not permitted in defined machinery spaces.

### 25.9.3 Sounding Pipes

In addition to 4-3-3/9, other means of ascertaining the amount of fuel oil in any fuel oil tank will be considered if such means do not require penetration below the tank top and providing their failure or overfilling of the tanks will not permit release of fuel oil.

### 25.9.4 Doors in Machinery Spaces

Doors, other than power-operated sliding watertight doors, are to have positive closure in case of fire. Such doors are to have power-operated closing arrangements or self-closing doors capable of closing against an opposing inclination of 3.5 degrees which may have a fail-safe hook back arrangement. The closing arrangements are to be operable locally and from the central control station. See also 3-3-1/19.

### 25.9.5 Nozzles

In vessels carrying more than 36 passengers, each machinery space for which a fixed fire extinguishing system is required by 4-4-1/19.1 is to be provided with at least two suitable water fog applicators.

## 25.11 Alarm Systems

An approved manual alarm system complying with the requirements of the Administration or a separate alarm system independent of the vessel's fire alarm system is to be installed in all areas, other than the main machinery spaces, which are normally accessible to the passengers or crew.

## 25.13 General or Special Fire Alarm

A special fire alarm, operated from the navigation bridge or fire control station, is to be fitted to summon the crew. This alarm may be part of the vessel's general alarm system but is to be capable of being sounded independently of the alarm to the passenger spaces.

## 25.15 Public Address System

A public address system or other effective means of communication is to be provided throughout the accommodation and service spaces and control stations and open decks.

## 25.17 Portable Communication Equipment

For vessels carrying more than 36 passengers, a sufficient number of two-way portable radio telephone apparatus are to be available onboard for each member of the fire patrol.

## 25.19 Fire Control Plans

A fire control plan is to be permanently exhibited for the guidance of the vessel's officers. Fire control plans are to be general arrangement plans showing for each deck provision, location, controls and particulars, as applicable, of fixed fire detection, alarm and extinguishing systems, portable fire-fighting equipment and appliances, controls of fuel oil pumps and valves and ventilation system shut-downs, fan control positions and closing of openings. They are also Class divisions, the sections enclosed by "B" Class divisions, means of access to different compartments, decks, etc., and the identification numbers of ventilating fan serving each section.

## TABLE 1
## Classification of Portable and Semi-portable Extinguishers *(1 July 2009)*

Fire extinguishers are designated by type as follows: A, for fires in combustible materials such as wood; B, for fires in flammable liquids and greases; C, for fires in electrical equipment.

Fire extinguishers are designated by size where II is the smallest and size V is the largest. Size II is hand portable extinguishers and sizes III, IV, and V are semi-portable extinguishers.

| *Classification* | | *Soda-Acid and Water liters (US gallons)* | *Foam liters (US gallons)* | *Carbon Dioxide kg (lb)* | *Dry Chemical kg (lb)* |
|---|---|---|---|---|---|
| *Type* | *Size* | | | | |
| A | II | 9 (2.5) | 9 (2.5) | — | 5 (11) (1) |
| B | II | — | 9 (2.5) | 5 (11) | 5 (11) |
| B | III | — | 45 (12) | 15.8 (35) | 9 (20) |
| B | IV | — | 76 (20) | 22.5 (50) | 13.5 (30) |
| B | V | — | 152 (40) | 45 (100) (2) | 22.5 (50) (2) |
| C | II | — | — | 5 (11) | 5 (11) |

*Notes:*

1 Must be specifically approved as Type A, B, C extinguisher

2 For outside use, double the amount to be carried.

## TABLE 2
## Portable and Semi-portable Extinguisher Locations

| *Space* | *Classification* | *Quantity and Location (5)* |
|---|---|---|
| **Safety Areas** | | |
| Communicating corridors | A-II or B-II | 1 in each main corridor not more than 23 m (75 ft) apart. (May be located in stairways.) See Note 1 |
| **Service Spaces** | | |
| Galleys | B-II or C-II | 1 for each 230 $m^2$ (2500 $ft^2$) or fraction thereof for hazards involved. |
| Paint or lamp rooms | B-II | 1 outside the space in vicinity of exit. |
| **Machinery Spaces** | | |
| Oil-fired boilers: Spaces containing oil-fired boilers, or their fuel oil units | B-II<br>and B-IV | 1 required<br>1 required |
| Internal combustion or gas turbine propulsion machinery spaces | B-II<br>and B-III | 1 for each 746 kW (1000 hp), but not less than 2 nor more than 6. See Note 2.<br>1 required. See Notes 2 and 3. |
| Electric motors or generators of the open type | C-II | 1 for each motor or generator unit. |
| Auxiliary spaces containing internal combustion or gas turbine units | B-II | 1 required in vicinity of exit. |
| Auxiliary spaces emergency generators | C-II | 1 required in vicinity of exit. |
| **Cargo Areas** | | |
| Pump rooms | B-II | 1 required in vicinity of exit. See Note 4 |
| Cargo tank areas | B-II<br>and B-V | 2 required. See Notes 5 and 7.<br>1 required. See Notes 4, 6 and 7. |

## TABLE 2 (continued)
## Portable and Semi-portable Extinguishers

*Notes:*

1 In general, portable extinguishers in which the medium is stored under pressure are not to be stored in passenger or crew accommodations.

2 If oil burning auxiliary boiler fitted in space, the B-IV previously required for the protection of the boiler may be substituted. Not required where a fixed carbon dioxide system is installed.

3 Not required on vessels of less than 300 gross tons if fuel has a flash point higher than 43°C (110°F).

4 Not required if fixed system installed.

5 If no cargo pump on barge, only one B-II required.

6 Not required for barges less than 100 gross tons.

7 Where foam is used it is to be compatible with cargoes being carried.

PART

# 4

## CHAPTER 5 Electrical Installations

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PART

# 4

## CHAPTER 5 Electrical Installations

## SECTION 1 General

### 1 Applications

The requirements contained in this Section are applicable to vessels having an aggregate electrical generating capacity of 75 kW or greater. For electrical installations of generating capacity of less than 75 kW, the requirements contained in the ABS *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length* may be considered. The use of machinery and equipment designed in accordance with the standards of the National Electrical Manufacturer Association (NEMA) will be acceptable on vessels intended primarily for operation in fresh water. Electrical installations in machinery spaces containing gasoline engines will be the subject of special considerations.

### 3 Definitions

The following definitions apply for the purpose of this Section.

#### 3.1 Cascade Protection *(2014)*

The application of protective devices in which the device nearest to the source of power has short-circuit ratings equal to or in excess of the maximum prospective short-circuit current, while devices in succeeding steps further from the source have lower short-circuit ratings.

#### 3.3 Earth *(2014)*

A large conducting body, such as the metal hull of the ship, used as an arbitrary zero of potential.

#### 3.5 Earthed Distribution System

A system in which one pole of a single phase system or the neutral point of a three phase system is earthed, but the earthing connection does not normally carry current.

#### 3.7 Essential Services *(2004)*

Essential services are those considered necessary for:

- Continuous operation to maintain propulsion and steering (primary essential services);
- Non-continuous operation to maintain propulsion and steering and a minimum level of safety for the vessel’s navigation and systems, including safety for dangerous cargoes to be carried (secondary essential services); and
- Emergency services as described in 4-5-2/5 (each service is either primary essential or secondary essential depending upon its nature).

Examples of primary essential services and secondary essential services are as listed in 4-5-1/Table 4 and 4-5-1/Table 5, respectively.

### 3.9 Explosion-proof (Flameproof) Equipment

Explosion-proof equipment is equipment:

3.9.1

Having an enclosure capable of:

*i)* Withstanding an explosion within it of a specified flammable gas or vapor, and

*ii)* Preventing the ignition of the specified flammable gas or vapor in the atmosphere surrounding the enclosure by sparks, flashes or explosions of the gas or vapor within, and

3.9.2 *(2016)*

Operates at such an external temperature that a surrounding flammable atmosphere will not be ignited. Where explosion-proof equipment is required by these Rules, equipment certified as being flameproof, as defined in IEC Publication 60079 series or other recognized standard may be accepted.

### 3.11 Hazardous Area (Hazardous Location)

An area where flammable or explosive vapor, gas, or dust may normally be expected to accumulate.

### 3.13 High Voltage *(2014)*

*High Voltage* in these Rules refers to voltages above 1000 V up to and including 15 kV AC.

### 3.15 Hull-return System

A system in which insulated conductors are provided for connection to one pole or phase of the supply, the hull of the vessel or other permanently earthed structure being used for effecting connections to the other pole or phase.

### 3.17 Increased Safety

Type of protection applied to electrical apparatus that does not produce arcs or sparks in normal service, in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arc and sparks. See IEC Publication 60079-7.

### 3.19 Inhomogeneous Field *(2014)*

An electric field which does not have a constant voltage gradient between electrodes.

### 3.21 Intrinsically-safe

A circuit or part of a circuit is intrinsically safe when any spark or any thermal effect produced in the test conditions prescribed in a recognized standard (such as IEC Publication 60079-11) is incapable of causing ignition of the prescribed explosive gas atmosphere.

3.21.1 Category "ia" *(2016)*

Apparatus which is incapable of causing ignition in normal operation, or with a single fault, or with any combination of two faults applied, with the following safety factors:

| | |
|---|---|
| In normal operation: | 1.5 |
| With one fault: | 1.5 |
| With two faults: | 1.0 |

Above safety factors are applied to the current, voltage, or their combination, as specified in 5.2 of IEC Publication 60079-11.

### 3.23 Low Voltage *(2016)*

*Low Voltage* in these Rules refers to voltages up to and including 1000 V AC and 1500 V DC.

### 3.25 Minimum Comfortable Condition of Habitability *(2014)*

A condition in which at least services such as cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water are adequately provided.

### 3.27 Nominal Voltage *(2014)*

*Nominal Voltage ($U_n$)* – The nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240 V, 480/277 V, 600 V). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

$U_o$ (as relates to cable voltage rating) – The rated power frequency voltage between conductor and earth or metallic screen for which the cable is designed.

### 3.29 Non-periodic Duty Rating

A rating at which the machine is operated continuously or intermittently with varying load and speed within the permissible operating range. The load and speed variations include the overloads applied frequently, which may greatly exceed the full load rating of the machine.

### 3.31 Non-sparking Fan

A fan consisting of a combination of impeller and housing which are unlikely to produce sparks by static electricity or by entry of foreign objects in both normal and abnormal conditions.

### 3.33 Overvoltage Category *(2014)*

*Overvoltage Category* (of a circuit or within an electrical system) – Conventional number based on limiting the values of prospective transient overvoltages occurring in a circuit and depending on the means employed to influence the overvoltages.

### 3.35 Overvoltage Withstand Test *(2014)*

*Overvoltage Withstand Test* (layer test) **–** Test intended to verify the power-frequency withstand strength along the winding under test and between its phase (strength between turns and between layers in the windings).

### 3.37 Periodic Duty Rating

A rating at which the machine is operated repeatedly on a cycle of sequential loading with starting, electric braking, no-load running, rest and de-energized periods, where applicable. The time for the duration of operating cycle (duty cycle) is to be 10 minutes and the ratio (i.e., cyclic duration factor) between the period of loading (including starting and electric braking) and the duty cycle is to be one of the values of 15%, 25%, 40% or 60%.

### 3.39 Pollution Degree *(2014)*

*Pollution Degree* (of environmental conditions) **–** A conventional number based on the amount of conductive or hygroscopic dust, ionized gas or salt, and on the relative humidity and its frequency of occurrence resulting in hygroscopic absorption or condensation of moisture leading to reduction in dielectric strength and/or surface resistivity of the insulating materials of devices and components.

### 3.41 Portable Apparatus

Portable apparatus is any apparatus served by a flexible cord.

### 3.43 Pressurized Equipment *(1997)*

Equipment having an enclosure in which positive pressure is maintained to prevent against the ingress of external atmosphere and complying with the requirements in 4-5-3/11.3.3.

### 3.45 Semi-enclosed Space

A space limited by decks and/or bulkheads in such a manner that the natural conditions of ventilation in the space are notably different from those obtained on open deck.

### 3.47 Separate Circuit

A circuit which is independently protected by a circuit protection device at the final sub-circuit and is dedicated to a single load.

### 3.49 Short Circuit

A short circuit is an abnormal connection through a negligible impedance, whether made accidentally or intentionally, between two points of different potential in a circuit.

### 3.51 Short-time Rating

A rating at which the machine is operated for a limited period, which is less than that required to reach the steady temperature condition, followed by a rest and de-energized period of sufficient duration to re-establish the machine temperature within 2°C (3.6°F) of the coolant.

## 5 Plans and Data to Be Submitted

See 4-5-2/1, 4-5-3/1, 4-5-4/1 and 4-5-5/5.1.2.

## 7 Standard Distribution System *(2014)*

The following are recognized as standard systems of distribution. Distribution systems differing from these will be specially considered.

- Two-wire direct current
- Three-wire direct current
- Two-wire single-phase alternating current
- Three-wire three-phase alternating current*
- Four-wire three-phase alternating current with solidly earthed neutral but not with hull return

* *Note:* Three-wire single-phase AC may be used in conjunction with this system for lighting.

## 9 Voltage and Frequency Variations *(2008)*

Electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of being operated satisfactorily under the normally occurring variations in voltage and frequency. Unless otherwise stated in national or international standards, the variations from the rated value may be taken from the 4-5-1/Table 1. Any special system, such as electronic circuits, which cannot operate satisfactorily within the limit shown in 4-5-1/Table 1, is not to be supplied directly from the system but by alternative means, such as through a stabilized supply.

For generators, see 4-5-4/3.17.1, 4-5-4/3.19.1, and 4-5-4/3.21.2.

## 11 Inclination

Machines and apparatus are to operate satisfactorily under all conditions with the vessel at the following inclinations from the normal:

- Transversely: 15 degrees
- Rolling: Up to 22.5 degrees
- Longitudinally: 10 degrees, or for vessels of length exceeding 150 m (490 ft), 5 degrees

## 13 Materials

All electrical equipment is to be constructed of durable and flame-retardant materials. Materials are to be resistant to corrosion, moisture, high and low temperatures, and are to have other qualities necessary to prevent deterioration in the ambient conditions that the equipment may be expected to encounter.

## 15 Insulation Material

For the purposes of these requirements, insulating material is designated as follows.

### 15.1 Class A Insulation

Materials or combinations of materials such as cotton, silk and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 105°C (221°F).

### 15.3 Class B Insulation

Materials or combinations of materials such as mica, glass fiber, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 130°C (266°F).

### 15.5 Class E Insulation

Materials or combinations of materials which by experience or accepted tests can be shown to be capable of operation at 120°C (248°F) (materials possessing a degree of thermal stability allowing them to be operated at a temperature 15°C (27°F) higher than Class A materials).

### 15.7 Class F Insulation

Materials or combinations of materials such as mica, glass fiber, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 155°C (311°F).

### 15.9 Class H Insulation

Materials or combinations of materials such as silicone elastomer, mica, glass fiber, etc., with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 180°C (356°F).

### 15.11 Insulation for Temperature Above 180°C (356°F)

Materials or combination of materials which by experience or accepted tests can be shown to be capable of satisfactory operation at temperature over 180°C (356°F) will also be considered. Supporting background experience or report of tests conducted in accordance with a recognized standard ascertaining their suitability for the intended application and temperature operation are to be submitted for review.

## 17 Degree of Protection for Enclosure *(2014)*

The designation to indicate the degree of protection consists of the characteristic letters "IP" followed by two numerals (the "characteristic numerals") indicating conformity with conditions stated in 4-5-1/Table 2 and 4-5-1/Table 3. The test and inspection for determining the degree of protection may be carried out in accordance with IEC Publication 60529 by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. The type of enclosure required for protection of equipment is to be suitable for the intended location. See 4-5-3/3.1.1 for selection of a protective enclosure for electrical equipment based on location condition. Equipment in compliance with recognized national standards will also be considered. For high voltage equipment see 4-5-5/Table 1.

# 19 Temperature Ratings

## 19.1 General *(2014)*

For purposes of rating of equipment a maximum ambient air temperature of 45°C (113°F) is to be assumed.

Where ambient temperatures in excess of 45°C (113°F) are expected the rating of equipment is to be based on the actual maximum ambient air temperature.

The use of lower ambient temperatures may be considered provided the total rated temperature of the equipment is not exceeded and where the lower values can be demonstrated. The use of a value for ambient temperature less than 40°C (104°F) is only permitted in spaces that are environmentally controlled.

## 19.3 Reduced Ambient Temperature *(2005)*

### 19.3.1 Environmentally Controlled Spaces

Where electrical equipment is installed within environmentally-controlled spaces, the ambient temperature for which the equipment is to be rated may be reduced from 40°C and maintained at a value not less than 35°C, provided:

*i)* The equipment is not to be used for emergency services.

*ii)* Temperature control is achieved by at least two independent cooling systems so arranged that in the event of loss of one cooling system for any reason, the remaining system(s) is capable of satisfactorily maintaining the design temperature. The cooling equipment is to be rated for a 40°C ambient temperature.

*iii)* The equipment is to be able to initially start to work safely at a 40°C ambient temperature until such a time that the lesser ambient temperature may be achieved.

*iv)* Audible and visual alarms are provided, at a continually-manned control station, to indicate any malfunction of the cooling systems.

### 19.3.2 Rating of Cables

In accepting a lesser ambient temperature than 40°C, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

### 19.3.3 Ambient Temperature Control Equipment

The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as a secondary essential service, in accordance with 4-5-1/3.7, and the capability of cooling is to be witnessed by the Surveyor at sea trial.

# 21 Clearances and Creepage Distances

The distances between live parts of different potential and between live parts and the case or other earthed metal, whether across surfaces or in air, are to be adequate for working voltage having regard to the nature of the insulating material and the conditions of service. See 4-5-4/7.11.6 and 4-5-5/1.1.3 for additional requirements for switchboard and high voltage systems.

## 23 Service Trial

### 23.1 Electrical Installation for Ship Services

All auxiliary apparatus is to be tried under working conditions. Each generator is to be run for a time sufficient to show satisfactory operation, and parallel operation with all possible combinations is to be demonstrated. Each auxiliary motor necessary to the operation of the vessel is to be run for a time sufficient to show satisfactory performance at such load as can readily be obtained. All main switches and circuit breakers are to be operated, but not necessarily at full load. The operation of the lighting system, heaters, etc., is to be satisfactorily demonstrated. The entire installation is to operate to the satisfaction of the Surveyor, and the drop in voltage on any part of the installation is not to exceed 6%. See 4-5-3/5.1.3.

### 23.3 Communication Facilities

Satisfactory operation of the interior communications system required by 4-5-6/9.7 is to be demonstrated to the Surveyor during sea trials. Particular attention is to be given to demonstrating that the voice communication systems required by 4-5-6/9.7 provide the capability of carrying on a conversation while the vessel is being navigated.

**TABLE 1**
**Voltage and Frequency Variations [See 4-5-1/9]** *(2008)*

| *Voltage and Frequency Variations for AC Distribution Systems* | | |
|---|---|---|
| *Quantity in Operation* | *Permanent Variation* | *Transient Variation (Recovery Time)* |
| Frequency | ±5% | ±10% (5 s) |
| Voltage | +6%, –10% | ±20% (1.5 s) |

| *Voltage Variations for DC Distribution Systems (such as systems supplied by DC generators or rectifiers)* | |
|---|---|
| *Parameters* | *Variations* |
| Voltage tolerance (continuous) | ±10% |
| Voltage cyclic variation deviation | 5% |
| Voltage ripple (AC r.m.s over steady DC voltage) | 10% |

| *Voltage Variations for Battery Systems* | |
|---|---|
| *Type of System* | *Variations* |
| Components connected to the battery during charging (see Note) | +30%, –25% |
| Components not connected to the battery during charging | +20%, –25% |

*Note:* Different voltage variations as determined by the charging/discharging characteristics, including the ripple voltage from the charging device, may be considered.

## TABLE 2
## Degree of Protection of Electrical Equipment (First IP Numeral)

| *First IP Numeral* | *Short Description* | *Definition* |
|---|---|---|
| 0 | Non-protected | No special protection |
| 1 | Protected against solid objects greater than 50 mm (2 in.) | A large surface of the body, such as a hand (but no protection against deliberate access). Solid object exceeding 50 mm (2 in.) in diameter. |
| 2 | Protected against solid objects greater than 12 mm (0.5 in.) | Fingers or similar objects not exceeding 80 mm (3.15 in.) in length. Solid objects exceeding 12 mm (0.5 in.) in diameter. |
| 3 | Protected against solid objects greater than 2.5 mm (0.1 in.) | Tools, wires, etc. of diameter or thickness greater than 2.5 mm (0.1 in.). Solid objects exceeding 2.5 mm (0.1 in.) in diameter |
| 4 | Protected against solid objects greater than 1 mm (0.04 in.) | Wires or strips of thickness greater than 1 mm (0.04 in.). Solid objects exceeding 1 mm (0.04 in.) in diameter. |
| 5 | Dust protected | Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment |
| 6 | Dust-tight | No ingress of dust |

*[Designation]*

The degree of protection is designated as shown in the following examples:

When it is required to indicate the degree of protection by only one characteristic numeral which shows either degree of protection against foreign bodies and electrical shock or against liquid, the omitted numeral is to be replaced by the letter X.

*Examples:*

1 IP56 The first characteristic numeral of “5”

The second characteristic numeral of “6”.

2 IPX5 Degree of protection against only liquid.

3 IP2X Degree of protection against only foreign bodies and electrical shock.

## TABLE 3
## Degree of Protection of Electrical Equipment (Second IP Numeral) *(2016)*

| *Second IP Numeral* | *Short Description* | *Definition* |
|---|---|---|
| 0 | Non-protected | No special protection. |
| 1 | Protected against dripping water | Dripping water (vertically falling drops) is to have no harmful effect. |
| 2 | Protected against dripping water when tilted up to 15° | Vertically dripping water is to have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position. |
| 3 | Protected against spraying water | Water falling as spray at an angle up to 60° from the vertical is to have no harmful effect. |
| 4 | Protected against splashing water | Water splashed against the enclosure from any direction is to have no harmful effect. |
| 5 | Protected against water jets | Water projected by a nozzle against the enclosure from any direction is to have no harmful effect. |
| 6 | Protected against heavy seas | Water from heavy seas or water projected in powerful jets is not to enter the enclosure in harmful quantities. |
| 7 | Protected against the effects of immersion | Ingress of water in a harmful quantity is not to be possible when the enclosure is immersed in water under defined conditions of pressure and time. |
| 8 | Protected against submersion | The equipment is suitable for continuous submersion in water under conditions which are to be specified by the manufacturer.<br>*Note:* Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter, but only in such a manner that it produces no harmful effects. |
| 9 *(2016)* | Protected against high pressure and temperature water jets | Water projected at high pressure and high temperature against the enclosure from any direction shall not have harmful effects |

See Designation & examples in 4-5-1/Table 2.

## TABLE 4
## Primary Essential Services *(2010)*

| | |
|---|---|
| (a) | Steering gears |
| (b) | Pumps for controllable pitch propellers |
| (c) | *(2010)* Scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines, turbines and shafting necessary for propulsion |
| (d) | Ventilation necessary to maintain propulsion |
| (e) | Forced draft fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine vessels, and also for auxiliary boilers on vessels where steam is used for equipment supplying primary essential services |
| (f) | Oil burning installations for steam plants on steam turbine vessels and for auxiliary boilers where steam is used for equipment supplying primary essential services |
| (g) | *(2010)* Low duty gas compressor and other boil-off gas treatment facilities supporting boil-off gas usage as fuel to main propulsion or electric power generation machinery. |
| (h) | Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps, etc. |
| (i) | Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps |
| (j) | Electric generators and associated power sources supplying primary essential equipment |
| (k) | Hydraulic pumps supplying primary essential equipment |
| (l) | Viscosity control equipment for heavy fuel oil |
| (m) | Control, monitoring and safety devices/systems of equipment for primary essential services. |

## TABLE 5
## Secondary Essential Services *(2010)*

| | |
|---|---|
| (a) | Windlass |
| (b) | Fuel oil transfer pumps and fuel oil treatment equipment |
| (c) | Lubrication oil transfer pumps and lubrication oil treatment equipment |
| (d) | Pre-heaters for heavy fuel oil |
| (e) | Starting air and control air compressors |
| (f) | Bilge, ballast and heeling pumps |
| (g) | Fire pumps and other fire extinguishing medium pumps |
| (h) | Ventilating fans for engine and boiler rooms |
| (i) | Services considered necessary to maintain dangerous spaces in a safe condition |
| (j) | *(2010)* Re-liquefaction plant on liquefied gas carriers |
| (k) | Navigation lights, aids and signals |
| (l) | Internal communication equipment required by 4-5-6/9.7 for passenger vessels |
| (m) | Fire detection and alarm system |
| (n) | Lighting system |
| (o) | Electrical equipment for watertight and fire-tight closing appliances |
| (p) | Electric generators and associated power sources supplying secondary essential equipment |
| (q) | Hydraulic pumps supplying secondary essential equipment |
| (r) | Control, monitoring and safety systems for cargo containment systems |
| (s) | Control, monitoring and safety devices/systems of equipment for secondary essential services. |
| (t) | *(2005)* Ambient temperature control equipment required by 4-5-1/19.3 |
| (u) | *(2010)* Watertight Doors (see 3-3-1/21 and 3-3-1/23 for passenger vessels) |

PART

# 4

# CHAPTER 5 Electrical Installations

# SECTION 2 Shipboard Systems

## 1 Plans and Data to be Submitted

### 1.1 Wiring

#### 1.1.1 Systems

One line diagrams for the following electrical systems are to be submitted for review.

- Power Supply and Distribution
- Lighting including Navigation Light
- Steering Gear Control
- Intrinsically-safe Equipment
- Inert Gas Control, Monitoring, and Alarm
- Internal Communication (for passenger vessels)
- General Emergency Alarm (for passenger vessels)
- Fire Detection and Alarm (for passenger vessels)
- Emergency Generator Starting (for passenger vessels)

#### 1.1.2 Data for Wiring Systems

The one line diagrams are to show the circuit designation, type and size of cables, cable grouping and banking, trip setting and rating of the circuit protection devices, the location of electrical equipment accompanied by list of components, complete feeder list, rated load current for each branch circuit. The one line diagram for power supply and distribution systems is to indicate the following component details.

*Note:* For vessels having a length of 61 m (200 ft) and over, a voltage drop calculation for the longest run of each cable size is to be included.

- Generator: kW rating, voltage, rated current, frequency, number of phases, power factor
- Batteries: type, voltage, capacity, conductor protection (when required)
- Motors: kW rating, remote stops (when required)
- Transformers: kVA rating, rated voltage and current on primary and secondary side, connection method

The one line diagram for power supply and distribution systems is also to include a list of sequential start of motors and equipment having emergency tripping or preferential tripping features.

### 1.3 Short-circuit Data *(2016)*

In order to establish that the protective devices on the main and emergency switchboards have sufficient short-circuit breaking and making capacities, data are to be submitted giving the maximum calculated short-circuit current in symmetrical rms and asymmetrical peak values available at the main bus bars together with the maximum allowable breaking and making capacities of the protective device. Similar calculations are to be made at other points in the distribution system, where necessary, to determine the adequacy of the interrupting capacities of the protective devices.

Reference may be made to IEC Publication 61363-1 Electrical Installations of Ships and Mobile and Fixed Offshore Units – Part 1: Procedures for Calculating Short-Circuit Currents in Three-Phase A.C.

### 1.5 Protective Device Coordination

A protective device coordination study is to be submitted for review. This protective device coordination study is to consist of an organized time-current study of all of the protective devices in series from the utilization equipment to the source for all circuit protection devices having different setting or time-current characteristics for long-time delay tripping, short-time delay tripping and instantaneous tripping, where applicable. Where an over-current relay is provided in series and adjacent to the circuit protection device, the operating and time-current characteristics of the relay are to be considered for coordination. See 4-5-2/9.1.5.

### 1.7 Load Analysis *(2002)*

An electric-plant load analysis is to be submitted for review. The electric-plant (including high voltage ship service transformers or converters, where applicable per 4-5-2/3.5) load analysis is to cover all operating conditions of the vessel, such as normal voyage, cargo handling (loading/unloading), harbor in/out and emergency operations.

## 3 Main Source of Power

### 3.1 Propulsion

The power for the propulsion equipment may be derived from a single generator.

### 3.3 Ship's Service

All vessels using electricity for auxiliary power or light are to be provided with at least two sources of power. The aggregate capacity of the power sources is to be sufficient to carry the necessary load under normal running operation with one power source in reserve.

### 3.5 Main Transformers

Where transformers are an essential part of the propulsion or ship’s service supply, the system is to be arranged so that the necessary load under normal running operation will be maintained.

## 5 Emergency Source of Power

### 5.1 Non-passenger Vessels

An emergency source of power to supply emergency lighting for at least three hours is to be provided on self-propelled vessels regardless of the total generator capacity. The emergency lighting power source may be any one of the following:

*i)* Automatic connected or manually controlled storage batteries:

*ii)* An automatically or manually started generator; or

*iii)* Relay-controlled, battery-operated lanterns.

### 5.3 Passenger Vessels

For related requirements for passenger vessels, see 4-5-6/9.1.

# 7 Distribution System

## 7.1 Ship Service Distribution System

### 7.1.1 General

Current-carrying parts with potential to earth are to be protected against accidental contact.

For recognized standard distribution systems, see 4-5-1/7. Separate feeders are to be provided for essential and emergency services.

### 7.1.2 Method of Distribution

The output of the ship's service generators may be supplied to the current consumers by way of either branch system, meshed network system or ring main system. The cables of a ring main or other looped circuit (e.g., interconnecting section boards in a continuous circuit) are to be formed of conductors having sufficient current-carrying and short-circuit capacity for any possible load and supply configuration.

### 7.1.3 Through-feed Arrangements

The size of feeder conductors is to be uniform for the total length, but may be reduced beyond any intermediate section board and distribution board, provided that the reduced size section of the feeder is protected by an overload device.

### 7.1.4 Motor Control Center *(2006)*

Feeder cables from the main switchboard or any section board to the motor control centers are to have a continuous current-carrying capacity not less than 100% of the sum of the nameplate ratings of all of the motors supplied. Feeder cables of lesser current capacity are permitted, where the design is such that connected consumers are not operated simultaneously, under any operating mode.

### 7.1.5 Motor Branch Circuit

A separate circuit is to be provided for each fixed motor having a full-load current rating of 6 amperes or more, and the conductors are to have a carrying capacity of not less than 100% of the motor full-load current rating. No branch circuit is to have conductors less than 1.5 $mm^2$ wire (16 AWG). Circuit-disconnecting devices are to be provided for each motor branch circuit and to be in accordance with 4-5-3/3.13.2 and 4-5-4/7.17.2.

### 7.1.6 Ventilation System

Ventilation fans for cargo space are to have feeders separate from those for accommodations. See also 4-5-2/17.1.1, 4-5-3/3.7.3, 4-5-6/1.9.1 and 4-5-6/5.3.

### 7.1.7 Heating Appliances

Each heater is to be connected to a separate final subcircuit. However, a group of up to ten heaters whose total current does not exceed 16 A may be connected to a single final subcircuit.

### 7.1.8 Circuits for Bunker or Cargo Space

All lighting and power circuits terminating in a bunker or cargo space are to be provided with a multiple pole switch outside of the space for disconnecting such circuits.

## 7.3 Hull Return System

### 7.3.1 General

*7.3.1(a) All Vessels.* The hull return system is not to be used for any purpose in a tanker, or for power, heating or lighting in other type of vessels, except that the following systems may be used for all types of vessels.

*i)* Impressed current cathodic protective systems;

*ii)* Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any hazardous areas; or

*iii)* Insulation level monitoring devices, provided the circulation current does not exceed 30 mA under all possible conditions.

Current-carrying parts with potential to earth are to be protected against accidental contact.

*7.3.1(b) Tankers.* In addition to the above, also see 4-5-6/1.3.

### 7.3.2 Final Subcircuits and Earth Wires

Where the hull return system is used, all final subcircuits (i.e., all circuits fitted after the last protective device) are to consist of two insulated wires, the hull return being achieved by connecting to the hull one of the bus bars of the distribution board from which they originate. The earth wires are to be in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation.

## 7.5 Earthed Distribution Systems

System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts. Means of disconnection is to be provided in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance. In distribution systems with neutral earthed or for generators intended to be run with neutrals interconnected, the machines are to be designed to avoid circulating currents exceeding the prescribed value. Transformer neutral is not to be earthed unless all corresponding generator neutrals are disconnected from the system (e.g., during shore supply). See 4-5-3/7.5.2 and 4-5-6/1.3 for tankers.

## 7.7 External or Shore Power Supply Connection

### 7.7.1 General

Where arrangements are made for the supply of electricity from a source on shore or other external source, a termination point is to be provided on the vessel for the reception of the flexible cable from the external source. Fixed cables of adequate rating are to be provided between the termination point and the main or emergency switchboard. Means for disconnecting the external or shore power supply are to be provided at the receiving switchboard. See 4-5-2/9.11 for the protection of external or shore power supply circuit.

### 7.7.2 Earthing Terminal

An earth terminal is to be provided for connecting the hull to an external earth.

### 7.7.3 Indicators

The external supply connection or shore connection is to be provided with a pilot lamp and a voltmeter (and frequency meter for AC) at main or emergency switchboard to show energized status of the cable.

### 7.7.4 Polarity or Phase Sequence

Means are to be provided for checking the polarity (for DC) or the phase sequence (for three-phase AC) of the incoming supply in relation to the vessel's system.

#### 7.7.5 Information Plate

An information plate is to be provided at or near the connection box giving full information on the system of supply and the nominal voltage (and frequency if AC) of the vessel's system and the recommended procedure for carrying out the connection.

#### 7.7.6 Securing of Trailing Cable

Provision is to be made for securing the trailing cable to a framework to absorb stress on the electrical terminals by catenary tension of the cable.

### 7.9 Harmonics *(1 July 2017)*

The total harmonic distortion (THD) in the voltage waveform in the distribution systems is not to exceed 8% and any single order harmonics not to exceed 5%. Other higher values may be accepted provided the distribution equipment and consumers are designed to operate at the higher limits. This relaxation on THD limits is to be documented (harmonic distortion calculation report) and made available on board as a reference for the Surveyor at each periodical survey. Where higher values of harmonic distortion are expected, any other possible effects, such as additional heat losses in machines, network resonances, errors in control and monitoring systems are to be considered. See also 4-6-2/9.18 and 4-6-2/9.19.

## 9 Circuit Protection System

### 9.1 System Design

#### 9.1.1 General *(1998)*

Electrical installations are to be protected against accidental overload and short circuit, except

*i)* As permitted by 4-5-2/11.3,

*ii)* Where it is impracticable to do so, such as engine starting battery circuit, and

*iii)* Where by design, the installation is incapable of developing overload, in which case it may be protected against short circuit only.

The protection is to be by automatic protective devices for:

*i)* Continued supply to remaining essential circuits in the event of a fault, and

*ii)* Minimizing the possibility of damage to the system and fire.

Three-phase, three-wire alternating current circuits are to be protected by a triple-pole circuit breaker with three overload trips or by a triple-pole switch with a fuse in each phase. All branch circuits are to be protected at distribution boards only, and any reduction in conductor sizes is to be protected. Dual-voltage systems having an earthed neutral are not to have fuses in the neutral conductor, but a circuit breaker which simultaneously opens all conductors may be installed, when desired. In no case is the dual-voltage system to extend beyond the last distribution board.

#### 9.1.2 Protection Against Short-circuit

*9.1.2(a) Protective Devices.* Protection against short-circuit is to be provided for each non-earthed conductor by means of circuit breakers or fuses.

*9.1.2(b) Rated Short-circuit Breaking Capacity.* The rated short-circuit breaking capacity of every protective device is not to be less than the maximum available fault current at that point. For alternating current (AC), the rated short-circuit breaking capacity is not to be less than the root mean square (rms) value of the AC component of the prospective short-circuit current at the point of application. The circuit breaker is to be able to break any current having an AC component not exceeding its rated breaking capacity, whatever the inherent direct current (DC) component may be at the beginning of the interruption.

*9.1.2(c) Rated Short-circuit Making Capacity.* The rated short-circuit making capacity of every switching device is to be adequate for maximum peak value of the prospective short-circuit current at the point of installation. The circuit breaker is to be able to make the current corresponding to its making capacity without opening within a time corresponding to the maximum time delay required.

#### 9.1.3 Protection Against Overload

*9.1.3(a) Circuit Breakers.* Circuit breakers or other mechanical switching devices for overload protection are to have a tripping characteristic (overload-trip time) adequate for the overload capacity of all elements in the system to be protected and for any discrimination requirements.

*9.1.3(b) Fuses.* A fuse of greater than 320 amperes is not to be used for overload protection.

*9.1.3(c) Rating (2005).* Fuse ratings and rating (or settings, if adjustable) of time-delay trip elements of circuit breakers are not to exceed the rated current capacity of the conductor to be protected as listed in 4-5-4/Table 10, except as otherwise permitted for generator, motor and transformer circuit protection in 4-5-2/9.3, 4-5-2/9.13 and 4-5-2/9.15. If the standard ratings or settings of overload devices do not correspond to the rating or the setting allowed for conductors, the next higher standard rating or setting may be used, provided that it does not exceed 150% of the allowable current carrying capacity of the conductor, where permitted by the Standard to which the feeder cables have been constructed. Except as otherwise permitted for motor and transformer branch-circuit protection, adjustable-trip circuit breakers of the time-delay or instantaneous type are to be set to operate at not more than 150% of the rated capacity of the conductor to be protected.

*9.1.3(d) Indication.* The rating or setting of the overload protective device for each circuit is to be permanently indicated at the location of the protective device.

#### 9.1.4 Back-up Protection *(2011)*

*9.1.4(a) Back-up Fuse Arrangements.* Circuit breakers having breaking and/or making capacities less than the prospective short-circuit current at the point of application will be permitted, provided that such circuit breakers are backed-up by fuses which have sufficient short-circuit capacity for that application. The fuse is to be specifically designed for back-up combinations with the circuit breaker, and the maximum fault rating for the combination is to be provided.

*9.1.4(b) Cascade Protection.* Cascade protection may be permitted, subject to special consideration. Such special consideration is not intended for new construction vessels, however may be granted when modifications are performed to existing vessels. The cascade protection is to be arranged such that the combination of circuit protective devices has sufficient short-circuit breaking capacity at the point of application [see 4-5-2/9.1.2(b)]. All circuit protective devices are to comply with the requirements for making capacity [see 4-5-2/9.1.2(c)]. Cascade protection is not to be used for circuits of primary essential services. Where cascade protection is used for circuits of secondary essential services, such services are to be duplicated, provided with means of automatic transfer and the automatic transfer is to alarm at a manned location. Cascade protection may be used for circuits of non-essential services.

#### 9.1.5 Coordinated Tripping

Coordinated tripping is to be provided between generator, bus tie, bus feeder and feeder protective devices. See also 4-5-2/9.3.2 and 4-5-2/9.7.1. Except for cascade system (backup protection) in 4-5-2/9.1.4, the coordinated tripping is also to be provided between feeder and branch-circuit protective devices for essential services. Continuity of service to essential circuits under short-circuit conditions is to be achieved by discrimination of the protective devices, as follows:

*9.1.5(a)* The tripping characteristics of protective devices in series is to be coordinated.

*9.1.5(b)* Only the protective device nearest to the fault is to open the circuit, except for the cascade system (backup protection), as specified in 4-5-2/9.1.4(a).

*9.1.5(c)* The protective devices are to be capable of carrying, without opening, a current not less than the short-circuit current at the point of application for a time corresponding to the opening of the breaker, increased by the time delay required for discrimination.

## 9.3 Protection for Generators

### 9.3.1 General

Generators of less than 25 kW not arranged for parallel operation may be protected by fuses. Any generators arranged for parallel operation and all generators of 25 kW and over are to be protected by a trip-free circuit breaker whose trip settings are not to exceed the thermal withstand capacity of the generator. The long-time over-current protection is not to exceed 15% above either the full-load rating of continuous rated machines or the overload rating of special-rated machines. The shutting down of the prime mover is to cause the tripping of the ship service generator circuit breaker.

### 9.3.2 Trip Setting for Coordination *(2008)*

The instantaneous and short-time over-current trips of the generators are to be set at the lowest values of current and time which will coordinate with the trip settings of feeder circuit breakers. See also 4-5-2/9.1.5, 4-5-2/9.5.1, and 4-5-2/9.5.2(a).

### 9.3.3 Load-shedding Arrangements *(2004)*

*9.3.3(a) Provision for Load Shedding Arrangements.* In order to safeguard continuity of the electrical power supply, automatic load-shedding arrangements or other equivalent arrangements are to be provided:

*i)* Where only one generating set is normally used to supply power for propulsion and steering of the vessel, and a possibility exists that due to the switching on of additional loads, whether manually or automatically initiated, the total load exceeds the rated generator capacity of the running generator, or

*ii)* Where electrical power is normally supplied by more than one generator set simultaneously in parallel operation for propulsion and steering of the vessel, upon the failure of one of the parallel running generators, the total connected load exceeds the total capacity of the remaining generator(s).

*9.3.3(b) Services not Allowed for Shedding.* Automatic load-shedding arrangements or other equivalent arrangements are not to automatically disconnect the following services. See 4-5-1/3.7 for the definition of essential services.

*i)* Primary essential services that, when disconnected, will cause immediate disruption to propulsion and maneuvering of the vessel,

*ii)* Emergency services as listed in 4-5-2/5, and

*iii)* Secondary essential services that, when disconnected, will:

- cause immediate disruption of systems required for safety and navigation of the vessel, such as:

  Lighting systems,

  Navigation lights, aids and signals,

  Internal communication systems required by 4-5-6/9.7, etc.

- prevent services necessary for safety from being immediately reconnected when the power supply is restored to its normal operating conditions, such as:

  Fire pumps, and other fire extinguishing medium pumps,

  Bilge pumps,

  Ventilation fans for engine and boiler rooms

### 9.3.4 Emergency Generator

The emergency generator is also to comply with 4-5-2/9.1, 4-5-2/9.3, 4-5-2/9.5 and 4-5-2/9.7, where applicable. See also 4-5-6/9.1 for passenger vessels.

## 9.5 Protection for Alternating-current (AC) Generators

### 9.5.1 Short-time Delay Trip *(2008)*

Short-time delay trips are to be provided with circuit breakers for AC generators. See also 4-5-2/9.3.2. The current setting of the short time delay trip is to be less than the steady state short-circuit current of the generator.

For generators with a capacity of less than 200 kW having prime movers such as diesel engines or gas turbines which operate independently of the electrical system, consideration may be given to omission of short-time delay trips if instantaneous trips and long time overcurrent protection (see 4-5-2/9.3.1) are provided. When the short time delay trips are omitted, the thermal withstand capacity of the generator is to be greater than the steady state short-circuit current of the generator, until activation of the tripping system.

### 9.5.2 Parallel Operation

Where AC generators are arranged for parallel operation with other AC generators, the following protective devices are to be provided.

*9.5.2(a) Instantaneous Trip (2016).* Instantaneous trips are to be installed and set in excess of the maximum short-circuit contribution of the individual generator where three or more generators are arranged for parallel operation. Alternative suitable protection, such as generator differential protection, which will trip the generator circuit breaker in the event of a fault in the generator or in the supply cable between the generator and its circuit breaker, would also be acceptable. See also 4-5-2/9.3.2.

*9.5.2(b) Reverse Power Protection (2006).* A time-delayed reverse active power protection or other devices which provide adequate protection is to be provided. The setting of protective devices is to be in the range of 8% to 15% of the rated power for diesel engines. A setting of less than 8% of the rated power of diesel engines may be allowed with a suitable time delay recommended by the diesel engine manufacturer**.** A fall of 50% in the applied voltage is not to render the reverse power protection inoperative, although it may alter the setting to open the breaker within the above range.

*9.5.2(c) Undervoltage Protection.* Means are to be provided to prevent the generator circuit breaker from closing if the generator is not generating and to open the same when the generator voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation is to be instantaneous when preventing closure of the breaker, but is to be delayed for discrimination purposes when tripping a breaker.

## 9.7 Protection for Direct Current (DC) Generators

### 9.7.1 Instantaneous Trip

DC generator circuit breakers are to be provided with an instantaneous trip set below the generator maximum short-circuit current and are to coordinate with the trip settings of feeder circuit breakers supplied by the generator.

### 9.7.2 Parallel Operation

*9.7.2(a) Reverse Current Protection.* DC generators arranged for parallel operation with other DC generators or with an accumulator battery are to be provided with instantaneous or short-time delayed reverse current protection. The setting of the protection devices is to be within the power range specified by 4-5-2/9.5.2(a). When an equalizer connection is provided, the reverse current device is to be connected on the pole opposite to the equalizer connection where the series compound winding for the generator is connected. Reverse current protection is to be adequate to deal effectively with reverse current conditions emanating from the distribution system (e.g., electric driven cargo winches).

*9.7.2(b) Generator Ammeter Shunts.* Generator ammeter shunts are to be so located that the ammeters indicate total generator current.

*9.7.2(c) Undervoltage Protection.* Requirements for AC generator in 4-5-2/9.5.2(c) are also applicable to DC generator.

## 9.9 Protection for Accumulator Batteries

Accumulator (storage) batteries, other than engine starting batteries, are to be protected against overload and short circuits by devices placed as near as practicable to the batteries, but outside of the battery rooms, lockers or boxes, except that the emergency batteries supplying essential services are to have short circuit protection only. Fuses may be used for the protection of emergency lighting storage batteries instead of circuit breakers up to and including 320 amperes rating. The charging equipment, except converters, for all batteries with a voltage of more than 20% of the line voltage is to be provided with reverse current protection.

## 9.11 Protection for External or Shore Power Supply

### 9.11.1 General

Where arrangements are made for the supply of electricity from a source on shore or other external source, permanently fixed cables from the external supply or shore connection box to the main or emergency switchboard are to be protected by fuses or circuit breakers located at the connection box.

### 9.11.2 Interlocking Arrangement

Where the generator is not arranged for parallel operation with the external or shore power supply, an interlocking arrangement is to be provided for the circuit breakers or disconnecting devices between the generator and the external or shore power supply in order to safeguard from connecting unlike power sources to the same bus.

## 9.13 Protection for Motor Branch Circuits

### 9.13.1 General

Trip elements of circuit breaker for starting and for short-circuit protection are to be in accordance with 4-5-2/9.13.2 or 4-5-2/9.13.3, except that circuit breakers having only instantaneous trips may be provided as part of the motor control center. Where circuit breakers having only instantaneous trips are provided, the motor running protective device is to open all conductors, and the motor controller is to be capable of opening the circuit without damage to itself resulting from a current up to the setting of the circuit breaker. Circuit-disconnecting devices are to be provided for each motor branch circuit and to be in accordance with 4-5-3/3.13.2 and 4-5-4/7.17.2.

### 9.13.2 Direct-current Motor Branch Circuits

The maximum fuse rating or the setting of the time-delay trip element is to be 150% of the full-load rating of the motor served. If that rating or setting is not available, the next higher available rating or setting may be used.

### 9.13.3 Alternating-current Motor Branch Circuits

The maximum fuse rating or setting of the trip element is to be the value stated below. If that rating or setting is not available, the next higher available rating or setting may be used.

| *Type of Motor* | *Rating or Setting in % Motor Full-load Current* |
|---|---|
| Squirrel-cage and Synchronous Full-voltage, Reactor or Resistor-starting | 250 |
| Autotransformer Starting | 200 |
| Wound Rotor | 150 |

When fuses are used to protect polyphase motor circuits, they are to be arranged to protect against single-phasing.

The setting of magnetic instantaneous trips for short-circuit protection only is to exceed the transient current inrush of the motor, and to be the standard value nearest to, but not less than, 10 times full-load motor current.

#### 9.13.4 Motor Running Protection *(2005)*

Running protection is to be provided for all motors having a power rating exceeding 0.5 kW, except that such protection is not to be provided for steering gear motors (see 4-5-2/11.3). The running protection is to be set between 100% and 125% of the motor rated current.

For athwartship thrusters having only instantaneous trips, a motor overload alarm in the wheelhouse is acceptable in lieu of the motor running protection.

#### 9.13.5 Undervoltage Protection and Undervoltage Release *(2011)*

Undervoltage protection is to be provided for motors having power rating exceeding 0.5 kW (0.7 hp) to prevent undesired restarting upon restoration of the normal voltage, after a stoppage due to a low voltage condition or voltage failure condition.

Undervoltage release is to be provided for the following motors unless the automatic restart upon restoration of the normal voltage will cause hazardous conditions:

*i)* Primary essential services (see 4-5-1/Table 4).

*ii)* Only those secondary essential services (see 4-5-1/Table 5) necessary for safety, such as:

- Fire pumps and other fire extinguishing medium pumps.
- Ventilating fans for engine and boiler rooms where they may prevent the normal operation of the propulsion machinery (See Note 1 below)

Special attention is to be paid to the starting currents due to a group of motors with undervoltage release controllers being restarted automatically upon restoration of the normal voltage. Means such as sequential starting is to be provided to limit excessive starting current, where necessary.

*Note 1:* Undervoltage protection is to be provided for ventilation fans for engine and boiler room, which are supplied by an emergency source of power for the purpose of removing smoke from the space after a fire has been extinguished.

### 9.15 Protection for Transformer Circuits

#### 9.15.1 Setting of Overcurrent Device

Each power and lighting transformer feeder is to be protected by an overcurrent device rated or set at a value not more than 125% of rated primary current. When a transformer is provided with an overcurrent device in the secondary circuit rated or set at not more than 125% of rated secondary current, the feeder overcurrent device may be rated or set at a value less than 250% of the rated primary current.

#### 9.15.2 Parallel Operation *(2006)*

When the transformers are arranged for parallel operation, means are to be provided to disconnect the transformer from the secondary circuit. Where power can be fed into secondary windings, short-circuit protection (i.e., short-time delay trips) is to be provided in the secondary connections. In addition, when the disconnecting device in primary side of the transformer is opened due to any reason (e.g., the short-circuit protection, overload protection, or manual operation for opening), the disconnecting device in the secondary side of the transformer is to be arranged to open the circuit automatically.

### 9.17 Protection for Meters, Pilot Lamps and Control Circuits

Indicating and measuring devices are to be protected by means of fuses or current limiting devices. For devices such as voltage regulators where interruption of the circuit may have serious consequences, fuses are not to be used. If fuses are not used, means are to be provided to prevent fire in the unprotected part of installation. Fuses are to be placed as near as possible to the tapping from the supply.

## 9.18 Harmonic Distortion for Ship Electrical Distribution System including Harmonic Filters *(1 July 2017)*

### 9.18.1 Monitoring

Where the electrical distribution system on board a ship includes harmonic filters, such ships are to be fitted with facilities to continuously monitor the levels of harmonic distortion experienced on the main bus bar as well as alert the crew should the level of harmonic distortion exceed the acceptable limits. Where the engine room is provided with automation systems, this reading is to be logged electronically, otherwise it is to be recorded in the engine log book for future inspection by the Surveyor. However, harmonic filters installed for single application frequency drives such as pump motors may be excluded from the requirements of this section.

### 9.18.2 Measurement

As a minimum, harmonic distortion levels of main bus bar on board such existing ships are to be measured annually under seagoing conditions as close to the periodical machinery survey as possible so as to give a clear representation of the condition of the entire plant to the Surveyor. Harmonic distortion readings are to be carried out when the greatest amount of distortion is indicated by the measuring equipment. An entry showing which equipment was running and/or filters in service is to be recorded in the log so this can be replicated for the next periodical survey. Harmonic distortion levels are also to be measured following any modification to the ship's electrical distribution system or associated consumers by suitably trained ship's personnel or from a qualified outside source. Records of all the above measurements are to be made available to the surveyor at each periodical survey in accordance with the ABS *Rules for Survey After Construction (Part 7)*.

### 9.18.3 Validation of Calculated Harmonic

Where the electrical distribution system on board a ship includes harmonic filters, the system integrator of the distribution system is to show, by calculation, the effect of a failure of a harmonic filter on the level of harmonic distortion experienced.

The system integrator of the distribution system is to provide the ship owner with guidance documenting permitted modes of operation of the electrical distribution system while maintaining harmonic distortion levels within acceptable limits during normal operation as well as following the failure of any combination of harmonic filters.

The calculation results and validity of the guidance provided are to be verified by the Surveyor during sea trials.

### 9.18.4 Filter Protection Alarm

Arrangements are to be provided to alert the crew in the event of activation of the protection of a harmonic filter circuit.

A harmonic filter is to be arranged as a three-phase unit with individual protection of each phase. The activation of the protection arrangement in a single phase is to result in automatic disconnection of the complete filter. Additionally, there is to be installed a current unbalance detection system independent of the overcurrent protection alerting the crew in case of current unbalance.

Consideration is to be given to additional protection for the individual capacitor element as (e.g., relief valve or overpressure disconnector) in order to protect against damage from rupturing. This consideration is to take into account the type of capacitors used.

## 9.19 Protection of Harmonic Filter Circuits *(1 July 2017)*

Notwithstanding the requirements of 4-5-2/9.18 above, harmonic filters circuits shall be protected against overload and short-circuit. An alarm is to be initiated in a continuously manned location in the event of an activation of overload or short-circuit protection.

In cases where multiple harmonic filter circuits are used in series or in parallel, current imbalance between the different filter circuits is to be continuously monitored. The total rms current into each phase of a passive harmonic filter circuit is also to be monitored. Detection of a current imbalance shall be alarmed in a continuously manned location. If the current imbalance exceeds the ratings of the individual filter circuit components, the appropriate circuits shall automatically trip and be prevented from interacting with other parts of the electrical network.

Harmonic filters that contain capacitors are to have means of monitoring and of providing advance warning of capacitor(s) deterioration. Harmonic filters containing oil filled capacitors are to be provided with suitable means of monitoring oil temperature or capacitor internal pressure. Refer to 4-5-2/9.5 for additional requirements. Detection of capacitor(s) deterioration shall be alarmed locally at the equipment and in a continuously manned location. Power to the harmonic filter circuit containing the deteriorated capacitor(s) shall be automatically disconnected and the capacitor discharged safely upon detection of deterioration.

In cases where provisions for automatic/manual switching and/or disconnection of harmonic filter circuits are provided, there are to be provisions to prevent transient voltages in the system and to automatically discharge the capacitors in the harmonic filter circuits before they can be put back on-line.

Capacitors used in harmonic filters/capacitor banks are to be prevented from producing a leading system power factor which could potentially lead to generator(s) becoming self-excited. In cases where a leading power factor condition approaches the point of the generator(s) becoming self-excited, the appropriate capacitive circuits shall be automatically disconnected and prevented from interacting with the rest of the electrical network.

## 11 System for Steering Gear

### 11.1 Power Supply Feeder *(1 July 2016)*

Each electric or electro-hydraulic steering gear is to be served by at least two exclusive circuits fed directly from the main switchboard. However, one of the circuits may be supplied through the emergency switchboard.

For vessels fitted with alternative propulsion and steering arrangements, such as azimuthing propulsors, where the propulsion power exceeds 2,500 kW per thruster unit, see 4-3-5/5.12.3 of the *Steel Vessel Rules*.

An auxiliary electric or electro-hydraulic steering gear associated with a main electric or electro-hydraulic steering gear may be connected to one of the circuits supplying this main steering gear. The circuits supplying an electric or electro-hydraulic steering gear are to have adequate rating for supplying all motors, control system and instrumentation which are normally connected to them and operated simultaneously. The circuits are to be separated throughout their length as widely as is practicable.

### 11.3 Protection for Steering Gear Circuit

#### 11.3.1 Short Circuit Protection

Each steering gear feeder is to be provided with short-circuit protection which is to be located at the main or emergency switchboard. Long term overcurrent protection is not to be provided for steering gear motors.

*11.3.1(a) Direct Current (DC) Motors.* For DC motors, the feeder circuit breaker is to be set to trip instantaneously at not less than 300% and not more than 375% of the rated full-load current of the steering-gear motor, except that the feeder circuit breaker on the emergency switchboard may be set to trip at not less than 200%.

*11.3.1(b) Alternating Current (AC) Motors.* For AC motors, the protection against excess current, including starting current, if provided, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

*11.3.1(c) Fuses as Motor-feeder Protection.* The use of fuses instead of circuit breakers for steering gear motor feeder short-circuit protection is not permitted.

*11.3.1(d) Overload Indicator (1999).* Means are to be provided in the engine room for visually indicating an overload condition of the steering gear motor. The operation of the overload device is not to interrupt the circuit.

*11.3.1(e) Power Failure (1999).* Visual and audible alarms are to be provided in the wheelhouse and in the engine room to automatically indicate the opening of the short circuit protection device.

#### 11.3.2 Undervoltage Release

Power unit motor controllers and other automatic motor controllers are to be fitted with undervoltage release.

### 11.5 Controls, Instrumentation, and Alarms *(1999)*

For passenger vessels over 100 GT or carrying more than 150 passengers, see 4-2-3/3.25 and 4-2-3/3.27.

## 13 Lighting and Navigation Light Systems

### 13.1 Lighting System

#### 13.1.1 Main Lighting System

A main electric lighting system is to provide illumination throughout those parts of the vessel normally accessible to and used by passengers or crew. It is to be supplied from the main source of electrical power.

#### 13.1.2 System Arrangement

*13.1.2(a) Main Lighting System.* The arrangement of the main electric lighting system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard will not render the emergency electric lighting system required by 4-5-2/5.1 or 4-5-6/9.1.2(b) inoperative.

*13.1.2(b) Emergency Lighting System.* The arrangement of the emergency electric lighting system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electric lighting system required by 4-5-2/13.1.1 inoperative.

#### 13.1.3 Lighting Circuits

*13.1.3(a) Machinery Space and Accommodation Spaces (2006).* In spaces such as:

- Public spaces
- Category A machinery spaces
- Galleys
- Corridors
- Stairways leading to boat-decks, including stairtowers and escape trunks

there is to be more than one final sub-circuit for lighting, one of which may be supplied from the emergency switchboard in such a way that failure of any one circuit does not leave these spaces in darkness.

*13.1.3(b) Cargo Spaces.* Fixed lighting circuits in cargo spaces are to be controlled by multipole-linked switches situated outside of the cargo spaces. Means are to be provided on the multipole linked switches to indicate the live status of circuits.

#### 13.1.4 Protection for Lighting Circuits

Lighting circuits are to be protected against overload and short-circuit. Overload protective devices are to be rated or set at not more than 30 amperes. The connected load is not to exceed the lesser of the rated current carrying capacity of the conductor or 80% of the overload protective device rating or setting. The control switches are to be rated for the load controlled.

#### 13.1.5 Low-voltage Systems, 0-50 Volts

Where a low-voltage system is used for lighting, standard lamp sockets and receptacles are preferably to be used, and no circuit is to be fitted with more than 8 lamp sockets or receptacles. Each branch lighting circuit is to be wired with not less than 3.3 $mm^2$ (12 AWG) and is to be protected by fuses of no greater capacity than 20 amperes, except that special circuits supplying appliances are to have receptacles of 20-ampere rating and are to be wired with not less than 5.27 $mm^2$ (10 AWG). Where a low-voltage, low-amperage system is used, such as for interior communication, no electrical connection is to be made to a standard voltage system unless specially approved.

### 13.3 Navigation Light System *(2017)*

The following requirements are applicable to all vessels but may be modified for small vessels.

#### 13.3.1 Feeder

Navigation lights (mast head, side and stern lights) are to be fed by their own exclusive distribution board located on the bridge. The distribution board is to be supplied from the main as well as from the emergency source of power (see 4-5-2/5.3.2). A means to transfer the power source is to be fitted on the bridge.

#### 13.3.2 Branch Circuit

Each navigation light is to have its own branch circuit, and each branch circuit is to be fitted with a protective device.

#### 13.3.3 Duplicate Lamp

Each navigation light is to be fitted with duplicate lamps.

#### 13.3.4 Control and Indication Panel

A control and indication panel for the navigation lights is to be provided on the navigation bridge. The panel is to be fitted with the following functions:

*i)* A means to disconnect each navigation light.

*ii)* An indicator for each navigation light.

*iii)* Automatic visual and audible warning in the event of failure of a navigation light. If a visual signal device is connected in series with the navigation light, the failure of this device is not to cause the extinction of the navigation light. The audible device is to be connected to a separate power supply so that the audible alarm may still be activated in the event of power or circuit failure to the navigation lights.

### 13.5 Emergency and Interior-communication Switchboard

Emergency and interior-communication switchboards, when fitted, are to comply with the applicable parts of 4-5-4/7 and attention is directed to the requirements of the governmental authority whose flag the vessel flies.

## 15 Refrigerated Space Alarm

Fan and diffuser rooms serving subfreezing compartments are to be provided with a device capable of activating an audible and visual alarm in a manned control center and operable from within the latter space for the protection of personnel.

## 17 Fire Protection Systems

### 17.1 Emergency Stop

#### 17.1.1 Ventilation System *(2013)*

*17.1.1(a) General.* All electrical ventilation systems are to be provided with means for stopping the motors in case of fire or other emergency. These requirements do not apply to closed re-circulating systems within a single space. See also 4-5-6/1.9.1(b), 4-5-6/5.3.6 and 4-4-1/17.

*17.1.1(b) Propulsion Machinery Space Ventilation.* Machinery-space ventilation is to be provided with means for stopping the ventilation fans. The means for stopping the power ventilation serving machinery spaces is to be entirely separate from the means for stopping the ventilation of spaces in 4-5-2/17.1.1(c) and 4-5-2/17.1.1(d).

*17.1.1(c) Machinery Spaces other than Propulsion Machinery Spaces.* Power ventilation systems serving these spaces are to be fitted with means for stopping the ventilation fan motors in the event of fire. The means for stopping the power ventilation serving these spaces is to be entirely separate from the means for stopping the ventilation of spaces in 4-5-2/17.1.1(b) and 4-5-2/17.1.1(d). See 4-4-1/17.1.

*17.1.1(d) Accommodation Spaces, Service Spaces, Control Stations and Other Spaces.* A control station for all other power ventilation systems is to be located in a centralized fire-fighting location or navigation bridge, or in an accessible position leading to, but outside of, the space ventilated.

#### 17.1.2 Other Auxiliaries *(2009)*

See 4-4-1/17 for emergency tripping and emergency stop for other auxiliaries, such as forced and induced draft fans, fuel oil units, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers).

### 17.3 Fire Detection and Alarm System

See 4-4-1/25.

PART

# 4

# CHAPTER 5 Electrical Installations

# SECTION 3 Shipboard Installation

## 1 Plans and Data to be Submitted

### 1.1 Booklet of Standard Details *(2014)*

A booklet of the standard wiring practices and details, including such items as cable supports, earthing details, bulkhead and deck penetrations, cable joints and sealing, cable splicing, watertight and explosion-proof connections to equipment, earthing and bonding connections, etc., as applicable, is to be submitted.

For high voltage systems see installation requirements given in 4-5-5/1.9.3.

For high voltage cables the minimum cable bending radii and securing arrangements, taking the relevant recommendations of the cable manufacturer into consideration, are to be included. Cable tray segregation (HV to HV and HV to LV arrangements) are also to be included.

### 1.3 Arrangement of Electrical Equipment

A general arrangement plan showing the location of at least the following electrical equipment is to be submitted for review.

- Generator, Essential Motor and Transformer
- Battery
- Switchboard, Battery Charger and Motor Controller
- Emergency Lighting Fixture
- General Emergency Alarm Device and Alarm Actuator (for passenger vessels)
- Detector, Manual Call Point and Alarm Panel for Fire Detection and Alarm System (for passenger vessels)
- Certified-safe Type Equipment

Where cable splices or cable junction boxes are provided, locations of the splices and cable junction boxes together with the information of their services are also to be submitted for review.

### 1.5 Electrical Equipment in Hazardous Areas

A plan showing hazardous areas is to be submitted for review together with the following:

- A list/booklet of intended electrical equipment in the indicated hazardous areas, including a description of the equipment, applicable degree of protection and ratings. See 4-5-3/11.3.
- For intrinsically-safe systems, also wiring plans, installation instructions with any restrictions imposed by the certification agency.
- Detail of installation for echo sounder, speed log and impressed current cathodic protection system where located in these areas.

When the selection of the equipment has been finalized, a list/booklet identifying all equipment in the hazardous areas, their method of protection (flameproof, intrinsically safe, etc.), rating (flammable gas group and temperature class), manufacturer's name, model number and evidence of certification is to be submitted for review. A copy of this list/booklet is to be maintained onboard for future reference. See 4-5-3/11.1.4.

### 1.7 Maintenance Schedule of Batteries *(2008)*

Maintenance Schedule of batteries for essential and emergency services. See 4-5-3/3.7.5.

## 3 Equipment Installation and Arrangement

### 3.1 General Consideration

#### 3.1.1 Equipment Location *(2006)*

*3.1.1(a) General.* Electrical equipment is to be so placed or protected as to minimize the probability of mechanical injury or damage from the accumulation of dust, oil vapors, steam or dripping liquids. Equipment liable to generate arc is to be ventilated or placed in a compartment ventilated to avoid accumulation of flammable gases, acid fumes and oil vapors. See 4-5-3/Table 1 for the required degree of protection for various locations.

*3.1.1(b) Equipment in Areas Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces (2014).* Electrical and electronic equipment within areas affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing Systems are to be suitable for use in the affected area. See 4-5-3/Figure 1. Where enclosures have a degree of protection lower than IP44, evidence of suitability for use in these areas is to be submitted to ABS taking into account:

*i)* The actual Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing system being used and its installation arrangements, and

*ii)* The equipment design and layout (e.g., position of inlet ventilation openings, filters, baffles, etc.) to prevent or restrict the ingress of water mist/spray into the equipment. The cooling airflow for the equipment is to be maintained.

*Note:*

Additional precautions may be required to be taken with respect to:

a. Tracking as the result of water entering the equipment

b. Potential damage as the result of residual salts from sea water systems

c. High voltage installations

d. Personnel protection against electric shock

Equipment may require maintenance after being subjected to water mist/spray.

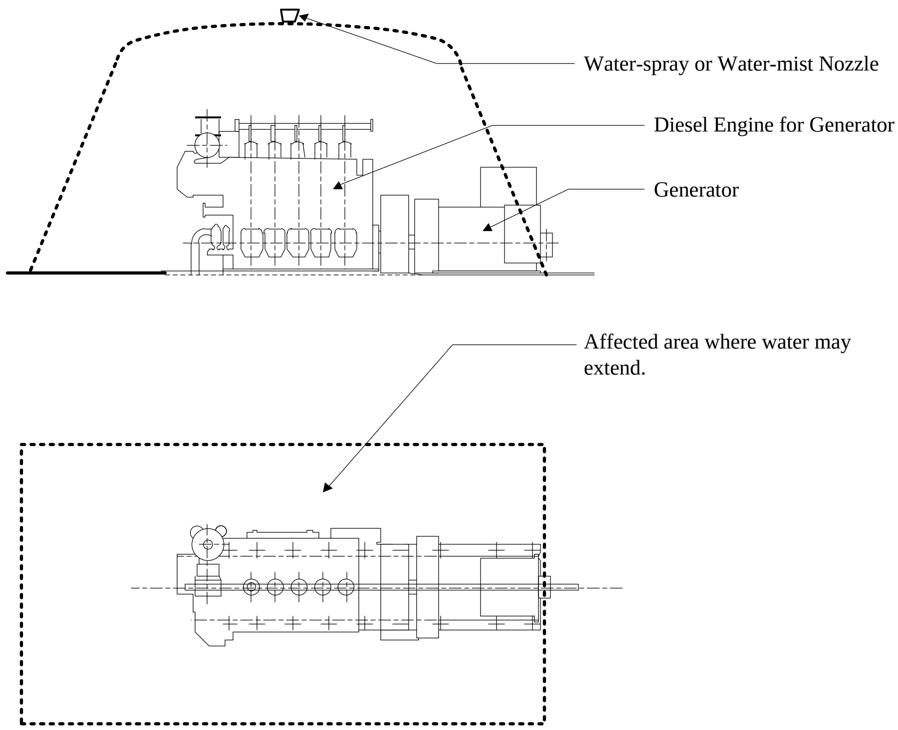
#### 3.1.2 Protection from Bilge Water

All generators, motors and electric couplings are to be so arranged that they cannot be damaged by bilge water; and, if necessary, a watertight coaming is to be provided to form a well around the base of such equipment with provision for removing water from the well.

#### 3.1.3 Accessibility

The design and arrangement of electrical apparatus is to provide accessibility to parts requiring inspection or adjustment. Armature and field coils, rotors and revolving fields are to be removable and where air ducts are used, there are to be means of access.

## FIGURE 1
## Example of Area Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces *(2014)*




### 3.3 Generators

All generators are to be located with their shafts in a fore-and-aft direction on the vessel and are to operate satisfactorily in accordance with the inclination requirements of 4-5-1/11. Where it is not practicable to mount the generators with the armature shafts in the fore-and-aft direction, their lubrication will require special consideration. Provision is to be made to prevent oil or oil vapor from passing into the machine windings.

### 3.5 Ship Service Motors

#### 3.5.1 General

Motors for use in the machinery space above the floor plate or spaces where subject to mechanical injury or dripping of oil or water are to have an enclosure of at least IP22 protection, in accordance with 4-5-3/Table 1. However, where they are protected by drip covers, they may have an enclosure of a lower protection grade than IP22. The motors having a protection enclosure of IP22 or lower are to be installed at a location high enough to avoid bilge water. Motors below the level of the floor plates are to have an enclosure of at least IP44 protection. Where motors intended for service at sea are not mounted with the rotor shafts in the fore-and-aft direction, the type of bearing and lubrication will require special consideration.

#### 3.5.2 Pump Motors

Motors for operating plunger and close-coupled pumps are to have the driving end entirely enclosed or designed to prevent leakage from entering the motor.

#### 3.5.3 Motors on Weather Decks

Motors for use on weather decks are to have an enclosure of at least IP56 protection or are to be enclosed in watertight housings.

#### 3.5.4 Motors Below Decks

Motors below decks are to be installed at a location as dry as practicable and away from steam, water and oil piping.

## 3.7 Accumulator Batteries

### 3.7.1 General

The following requirements are applicable to permanently installed power, control and monitoring storage batteries of acid or alkaline types. Batteries are to be so arranged that the trays are accessible and provided with not less than 254 mm (10 in.) headroom. Where a relief valve is provided for discharging excessive gas due to overcharge, arrangements are to be made for releasing the gas to the weather deck away from any source of ignition.

### 3.7.2 Battery Installation and Arrangements

*3.7.2(a) Large Batteries (2016).* Large storage batteries, those connected to a charging device with an output of more than 2 kW, are to be installed in a room assigned to the battery only, but may be installed in a deck locker if such a room is not available. No electrical equipment is to be installed in the battery rooms unless essential for the operational purposes and certified safe for battery room atmosphere. Electrical equipment installed in battery rooms may be any of the types indicated in 4-5-3/11.1.1 and is to be IEC Publication 60079-20-1 group IIC class T1.

*3.7.2(b) Moderate-size Batteries.* Batteries of moderate size, those connected to a charging device with a power output of 0.2 kW up to and including 2 kW, may be installed in the battery room or may be installed in battery lockers or deck boxes in the emergency generator room, machinery space or other suitable location. Cranking batteries are to be located as closely as possible to the engine or engines served.

*3.7.2(c) Small Batteries.* Small batteries are to be installed in a battery box and may be located as desired, except they are not to be located in sleeping quarters unless hermetically sealed.

*3.7.2(d) Low-hydrogen-emission Battery Installations (1999).* A low-hydrogen-emission battery installation with a battery charger having a charging rate of a large or moderate battery size installation may be treated as a moderate or small battery installation, respectively, if the following are met:

*i)* Calculations under the worst case charging conditions are submitted that demonstrate that the low-hydrogen-emission battery installation does not emit more hydrogen under similar charging conditions than a bank of standard lead acid batteries supplied by a 2 kW charger for a moderate battery installation or 0.2 kW charger for a small battery installation, and

*ii)* A warning notice is placed to notify maintenance personnel that additional batteries are not to be installed, and batteries are only to be replaced by other batteries of the same or lower hydrogen emission rate.

*3.7.2(e) Battery Trays.* Trays for batteries are to be chocked with wood strips or equivalent to prevent movement, and each tray is to be fitted with nonabsorbent insulating supports on the bottom and with similar spacer blocks at the sides or with equivalent provision to secure air-circulation space all around each tray.

*3.7.2(f) Identification of Battery Types.* Lead-acid batteries and alkaline batteries, when placed in the same battery compartment, are to be effectively identified as to type and segregated.

### 3.7.3 Ventilation

*3.7.3(a) Battery Rooms.* Battery rooms are to be ventilated to avoid accumulation of flammable gas. Natural ventilation may be employed if ducts are run directly from the top of the battery room to the open air above.

If natural ventilation is impractical, mechanical exhaust ventilation is to be provided with fan intake at the top of the room. Fans are to be of non-sparking construction in accordance with 4-5-3/11.7 and capable of completely changing the air in the battery room in not more than two minutes. Alternatively, a lesser ventilation rate may be considered, provided that satisfactory calculations are submitted substantiating that adequate ventilation is available to maintain the flammable gases within the battery room to a level below the lower explosive limit (L.E.L.) at the maximum battery charging current. Where the ventilation rate is based on low hydrogen emission type batteries, a warning notice to this effect is to be provided in a visible place in the battery room. Openings for air inlet are to be provided near the floor.

*3.7.3(b) Battery Lockers.* Battery lockers are to be ventilated, if practicable, similarly to battery rooms by a duct led from the top of the locker to the open air or to an exhaust ventilation duct. Louvers or equivalent are to be provided near the bottom for entrance of air.

*3.7.3(c) Deck Boxes.* Deck boxes are to be provided with a duct from the top of the box, terminating in a goose neck, mushroom head or equivalent to prevent entrance of water. Holes for air inlet are to be provided on at least two opposite sides of the box. The entire deck box, including openings for ventilation, is to be weathertight to prevent entrance of spray or rain.

*3.7.3(d) Small Battery Boxes.* Boxes for small batteries require no ventilation other than openings near the top to permit escape of gas.

### 3.7.4 Protection from Corrosion

The interiors of battery rooms, including the structural parts and shelves therein, as well as ventilation inlets and outlets are to be painted with corrosion-resistant paint. Shelves in battery rooms or lockers for acid batteries are to have a watertight lining of sheet lead not less than 1.6 mm ($^1/_{16}$ in.) on all sides. For alkaline batteries, the shelves are to be similarly lined with steel not less than 0.8 mm ($^1/_{32}$ in.) thick. Alternatively, a battery room may be fitted with a watertight lead pan, steel for alkaline batteries, over the entire deck, carried up not less than 152 mm (6 in.) on all sides. Deck boxes are to be lined in accordance with the above alternative method. Boxes for small batteries are to be lined to a depth of 76 mm (3 in.), consistent with the methods described above.

### 3.7.5 Maintenance of Batteries *(2008)*

*3.7.5(a) Maintenance Schedule of Batteries (1 July 2016).* Where batteries are fitted for use for essential and emergency services, a maintenance schedule of such batteries is to be provided and maintained.

The schedule is to include all batteries used for essential and emergency services, including system batteries installed in battery rooms, battery lockers and deck boxes as well as batteries installed within vendor supplied equipment. Examples of batteries included with equipment are:

- Computer equipment and programmable logic controllers (PLC) used in computer based systems and programmable electronic systems, when used for essential or emergency services.
- Navigation equipment, such as the equipment required by SOLAS, Chapter V, Regulation 19.

The schedule is to be submitted for review, during their plan approval or the new building survey, and is to include at least the following information regarding the batteries.

- Type and manufacturer's type designation.
- Voltage and ampere-hour rating.
- Location.
- Equipment and/or system(s) served.
- Maintenance/replacement cycle dates.
- Date(s) of last maintenance and/or replacement.
- For replacement batteries in storage, the date of manufacture and shelf life (See Note below)

*Note:* Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

*3.7.5(b) Procedure of maintenance.* Procedures are to be put in place to show that, where batteries are replaced, they are to be of an equivalent performance type. Details of the schedule, procedures, and the maintenance records are to be included in the ship's safety management system and integrated into the ship's operational maintenance routine, as appropriate, which are to be verified by the Surveyor.

#### 3.7.6 Replacement of Batteries *(2008)*

Where a vented type battery (See Note 1) replaces a valve-regulated, sealed type battery (See Note 2), the requirements in 4-5-3/3.7.2 and 4-5-3/3.7.3 are to be complied with on the basis of the charging capacity.

*Notes:*

1 A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.

2 A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

### 3.9 Switchboard

Switchboards are to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel. Switchboards are to be located in a dry place so as to provide a clear working space of at least 914 mm (36 in.) at the front of the switchboard and a clearance of at least 610 mm (24 in.) at the rear which may be reduced to 457 mm (18 in.) in way of stiffeners or frames, except that for switchboards which are enclosed at the rear and are fully serviceable from the front, clearance at the rear will not be required unless necessary for cooling. Switchboards are to be secured to a solid foundation. They are to be self-supported or be braced to the bulkhead or the deck above. In case the last method is used, means of bracing is to be flexible to allow deflection of the deck without buckling the assembly structure.

### 3.11 Distribution Boards

#### 3.11.1 Location and Protection *(2004)*

Distribution boards are to be located in accessible positions and not in such space as bunkers, storerooms, cargo holds or compartments allotted alternately to passengers or cargo. Distribution boards may be located behind panels/linings within accommodation spaces, including stairway enclosures, without the need to categorize the space to a fire integrity standard, provided no provision is made for storage. Distribution boards are to have approved noncombustible, non-hygroscopic enclosures. Metal enclosures and all exposed metal parts in nonmetallic enclosures are to be earthed to the vessel's structure. All cases are to be of adequate mechanical strength.

#### 3.11.2 Switchboard-type Distribution Boards

Distribution boards of the switchboard type, unless installed in machinery spaces or in compartments assigned exclusively to electric equipment and accessible only to authorized personnel, are to be completely enclosed or protected against accidental contact and unauthorized operation.

#### 3.11.3 Safety-type Panels *(1998)*

If the method of operation demands the handling of switches by persons unfamiliar with electrical equipment, the distribution board is to be of the safety type. This type of distribution board is to be used for controlling branch lighting circuits. Dead front type panels are to be used where voltage to earth is in excess of 50 volts DC or 50 volts AC rms between conductors.

### 3.13 Motor Controllers and Control Centers

#### 3.13.1 Location and Installation

Motor control centers are to be located in a dry place. Clear working space is to be provided around motor control centers to enable doors to be fully opened and equipment removed for maintenance and replacement. Motor control centers are to be secured to a solid foundation, be self-supported or be braced to the bulkhead.

#### 3.13.2 Disconnecting Arrangements

*3.13.2(a) Device.* Means are to be provided for disconnecting the motor and controller from all supply conductors, except that a manually operated switch or circuit breaker may serve as both controller and disconnecting means (see 4-5-4/7.17.2).

*3.13.2(b) Location (1998).* The disconnecting device may be in the same enclosure with the controller or may be in a separate enclosure, and is to be externally operated. Except for remotely controlled fire extinguishing purpose motors, the branch-circuit switch or circuit breaker on the power-distribution board or switchboard may serve as the disconnect device if in the same compartment with the controller.

*3.13.2(c) Locking Means (1998).* If the disconnecting device is not within sight of both motor and controller, or if it is more than 15.25 m (50 ft) from either, it is to be arranged for locking in the open position. For remotely controlled fire extinguishing purpose motors, the locking means are to be provided at the feeder circuit breaker for such motors.

*3.13.2(d) Identification Plate.* The disconnect switch, if not adjacent to the controller, is to be provided with an identification plate.

*3.13.2(e) Open and Close Indications.* The disconnect device is to indicate by a position of the handle, or otherwise, whether it is open or closed.

3.13.3 Indicating-light Circuits

Where indicating-light circuits are employed, their potential is to be limited to 150 volts if the opening of the foregoing disconnecting devices does not de-energize the indicating circuit.

## 3.15 Resistors for Control Apparatus

The resistor is to be protected against corrosion either by rust-proofing or embedding in a protective material. Resistors are to be located in well-ventilated compartments and are to be mounted with ample clearances, about 305 mm (12 in.), to prevent excessive heating of adjacent vessel's structure or dangerous overheating of unprotected combustible material. The arrangement of the electrical equipment and wiring located within these spaces is to be such as to prevent their exposure to ambient temperatures in excess of that for which they have been designed.

## 3.17 Lighting Fixtures

Lighting fixtures are to be so arranged as to prevent temperature rises which could damage the cables and wiring, and to prevent surrounding material from becoming excessively hot.

## 3.19 Heating Equipment

Electric radiators, if used, are to be fixed in position and be so constructed as to reduce fire risks to a minimum. Electric radiators of the exposed-element type are not to be used.

## 3.21 Magnetic Compasses

Precautions are to be taken in connection with apparatus and wiring in the vicinity of the magnetic compass to prevent disturbance of the needle from external magnetic fields.

## 3.23 Portable Equipment and Outlets

Portable equipment are not to be used in cargo oil pump rooms or other hazardous areas nor are portable lights to be used for berth lights in passenger accommodations or crew's quarters.

## 3.25 Receptacles and Plugs of Different Ratings *(2015)*

Receptacles and plugs of different electrical ratings are not to be interchangeable. In cases where it is necessary to use 230 volt portable equipment, the receptacles for their attachment are to be of a type which will not permit attaching 115 volt equipment.

# 5 Cable Installation

## 5.1 General Considerations

### 5.1.1 Continuity of Cabling

Electric cables are to be installed in continuous lengths between terminations at equipment or in cable junction boxes. See 4-5-3/5.33. However, approved splices will be permitted at interfaces of new construction modules, when necessary to extend existing circuits for a vessel undergoing repair or alteration, and in certain cases to provide for cables of exceptional length (See 4-5-3/5.29).

### 5.1.2 Choice of Cables

The rated operating temperature of the insulating material is to be at least 10°C (18°F) higher than the maximum ambient temperature likely to exist or to be produced in the space where the cable is installed.

### 5.1.3 Cable Voltage Drop for New Installation

The cross-sectional area of conductors are to be so determined that the drop in voltage from the main or emergency switchboard bus-bars to any and every point of the installation when the conductors are carrying the maximum current under normal steady conditions of service will not exceed 6% of the nominal voltage. For supplies from batteries with a voltage not exceeding 55 V, this figure may be increased to 10%.

The above values are applicable under normal steady conditions. Under special conditions of short duration, such as motor starting, higher voltage drops may be accepted, provided the installation is capable of withstanding the effects of these higher voltage drops.

### 5.1.4 Restricted Location of Cabling *(2015)*

Cables and wiring are to be installed and supported in such a manner as to avoid chafing or other damage. Cables are to be located with a view to avoiding, as far as practicable, spaces where excessive heat and gases may be encountered, also spaces where they may be exposed to damage, such as exposed sides of deckhouses. Cables are not to be installed in the bilge or tanktop area unless protected from bilge water. Cables are not to be installed in water tanks, oil tanks, cargo tanks, ballast tanks or any liquid tanks except to supply equipment and instrumentations specifically designed for such locations and whose functions require it to be installed in the tank. See also 4-5-6/1.7.3 for cables used for echo sounder, speed log and impressed current cathodic protection system in hazardous area.

### 5.1.5 Means of Drainage from Cable Enclosures

Where cables are installed in a cable draw box and horizontal pipes or the equivalent used for cable protection, means of drainage are to be provided.

### 5.1.6 High Voltage Cables

Cables serving systems above 1 kV are not to be bunched with cables serving systems of 1 kV and below.

### 5.1.7 Paint on Cables *(2006)*

Where paint or any other coating is systematically and intentionally applied on the electric cables, it is to be established that the mechanical and fire performance properties of the cable are not adversely affected.

In this regard:

*i)* Fire retardant property is to be confirmed to be in compliance with 4-5-4/13.1.2.

*ii)* It is to be confirmed that the paint and the solvent used will not cause damages to the cable sheath (e.g., cracking).

Overspray on cables or painted exterior cables are not subject to the requirements of this section.

5.1.8 Cable Installation above High Voltage Switchgear and Control-gear *(2006)*

Where a pressure relief flap is provided for high voltage switchgear and high voltage control-gear, the cables are not to be installed near and above this equipment in order to prevent the damage of cables from the flare/flame released from the relief flap upon occurrence of short circuit in this equipment.

5.1.9 Ultra Violet (UV) Light Protection for Wiring Insulation within Fluorescent Light Fixtures *(2014)*

Where the supply cable's outer sheathing or covering is removed once the cable enters a fluorescent light fixture to facilitate routing and/or connection, the insulation on the individual conductors is to be protected against the possible detrimental effects of UV light exposure by one of the following:

*i)* The insulation is to be manufactured with additives that protect the insulation from UV light damage and a test report is to be submitted to ABS.

*ii)* Adequate shielding arrangements are to be provided inside the fixture for the entire length of the exposed insulation within the fixture.

*iii)* UV protective sleeves are to be installed on the full length of the exposed conductors inside the fixture during the installation.

5.1.10 Protection of Cables in Tanks *(2015)*

Where cables are installed in liquid tanks, the following arrangements are to be complied with:

*i)* Cables are to be installed in steel pipes with at least extra-heavy wall thickness with all joints welded and with corrosion-resistant coating.

*ii)* Cable gland with gastight packing is to be provided for the cable at both ends of the cable conduit pipe

*iii)* Cable inside of the vertical cable conduit pipe is to be suitably supported (e.g., by sand-filling or by strapping to a support-wire). Alternatively, the cable inside of the vertical conduit pipe may be accepted without provided support if the mechanical strength of the cable is sufficient to prevent cable damage due to the cable weight within the conduit pipe under continuous mechanical load. Supporting documentation is to be submitted to verify the mechanical strength of the cable with respect to the cable weight inside of the conduit.

## 5.3 Insulation Resistance for New Installation

Each power and each light circuit is to have an insulation resistance between conductors and between each conductor and earth of not less than the following values.

| | |
|---|---|
| Up to 5 amperes load | 2 meg ohms |
| 10 amperes load | 1 meg ohm |
| 25 amperes load | 400,000 ohms |
| 50 amperes load | 250,000 ohms |
| 100 amperes load | 100,000 ohms |
| 200 amperes load | 50,000 ohms |
| Over 200 amperes load | 25,000 ohms |

If the above values are not obtained, any or all appliances connected to the circuit may be disconnected for this test.

## 5.5 Protection for Electric-magnetic Induction

5.5.1 Multiple Conductor Cables

All phase conductors of alternating-current cables are to be contained within the same sheath in order to avoid overheating due to induction by use of multiple conductor cables.

5.5.2 Single Conductor Cables *(1999)*

AC installations are to be carried out, as far as possible, in twin or multi-conductor cables. However, when it is necessary to use single conductor cables in circuits rated in excess of 20 A, the following arrangements are to be complied with:

*5.5.2(a)* Cables are supported on non-fragile insulators;

*5.5.2(b)* There are to be no magnetic materials between cables of a group; and

*5.5.2(c)* *(1999)* Where single conductor cables are run in bunches, each group of cables is to comprise 360 electrical degrees. To this end, in three-phase circuits, single conductor cable runs of 30 m (100 ft) or longer and having a cross-sectional area of 185 $mm^2$ (365,005 circ. mils) or more are to be transposed throughout the length at intervals not exceeding 15 m (50 ft) in order to equalize to some degree the impedance of the three phase circuits. Alternatively, such cables may be installed in trefoil formation.

See 4-5-4/13.1.5 for armor.

5.5.3 Non-shielded Signal Cables

Except for fiber optic cables, non-shielded signal cables for automation and control systems essential for the safe operation of the vessel which may be affected by electromagnetic interference are not to be run in the same bunch with power or lighting cables.

## 5.7 Joints and Sealing

Cables not having a moisture-resistant insulation are to be sealed against the admission of moisture by methods such as taping in combination with insulating compound or sealing devices. Cables are to be installed in such a manner that stresses on the cable are not transmitted to the conductors. Terminations and joints in all conductors are to be so made as to retain the original electrical, flame retarding and, where necessary, fire resisting properties of the cable. Terminal boxes are to be secured in place and the moisture-resistant jacket is to extend through the cable clamp. Enclosures for outlets, switches and similar fittings are to be flame and moisture-resistant and of adequate mechanical strength and rigidity to protect the contents and to prevent distortion under all likely conditions of service. See also 4-5-3/5.17.1 and 4-5-3/5.29

## 5.9 Support, Fixing and Bending

5.9.1 Support and Fixing *(1999)*

*5.9.1(a)* Where cables are fixed by means of clips, saddles or straps, they are to have a surface area so large and shaped such that the cables remain tight without their coverings being damaged. Metal clips may be screwed directly to deck or bulkhead, except on watertight bulkheads.

*5.9.1(b)* The distances between supports are to be suitably chosen according to the type of cable and the probability of vibration, and are not to exceed 400 mm (16 in.); for a horizontal cable run where the cables are laid on cable supports in the form of tray plates, separate support brackets or hanger ladders, the spacing between the fixing points may be up to 900 mm (36 in.), provided that there are supports with maximum spacing, as specified above. This exemption does not apply to cable runs along weather decks when the cable run is arranged so that the cables can be subjected to forces by water washing over the deck.

*Note:* When designing a cable support system for single-core cables, consideration is also to be given to the effects of electrodynamic forces developing on the occurrence of a short-circuit.

The above-given distances between cable supports are not necessarily adequate for these cables. Further, other recognized standards for cable support and fixing will be considered.

*5.9.1(c)* The supports and the corresponding accessories are to be robust and are to be of corrosion-resistant material or suitably treated before erection to resist corrosion.

*5.9.1(d)* Cable clips or straps made from an approved material other than metal (such as polyamide, PVC) may be used.

*5.9.1(e)* When cables are fixed by means of clips or straps, referred to in Item 4-5-3/5.9.1(d) above, and these cables are not laid on top of horizontal cable trays or cable supports, suitable metal cable clips or saddles are to be added at regular distances not exceeding 2 m (6.5 ft) in order to prevent the release of cables during a fire. This also applies to the fixing of non-metallic conduits or pipes.

*Note:* Item 4-5-3/5.9.1(e) does not necessarily apply in the case of cable runs with only one or a few cables with small diameters for the connection of a lighting fitting, alarm transducer, etc.

*5.9.1(f)* *(2004)* Non-metallic clips, saddles or straps are to be flame retardant in accordance with IEC Publication 60092-101.

### 5.9.2 Bending Radius

For bending radius requirements, see 4-5-3/Table 2.

### 5.9.3 Plastic Cable Trays and Protective Casings *(2004)*

*5.9.3(a)* *Installations (2008).* Cable trays and protective casings made of plastic materials are to be supplemented by metallic fixing and straps such that, in the event of a fire, they and the cables affixed are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route. See 4-5-3/5.9.1(e). Cable trays and protective casings made of plastic materials are to be flame retardant (see Appendix 4-8-4A1 of the *Steel Vessel Rules*). Where plastic cable trays and protective casings are used on open deck, they are additionally to be protected against UV light by such as anti-UV coating or equivalent.

*Note:* "Plastic" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fiber reinforced plastics (FRP). "Protective casing" means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

*5.9.3(b)* *Safe Working Load (2008).* The load on the cable trays and protective casings is to be within the Safe Working Load (SWL). The support spacing is to be not greater than the manufacturer's recommendation nor in excess of the spacing at the SWL test (see Appendix 4-8-4A1 of the *Steel Vessel Rules)*. In general, the spacing is not to exceed 2 meters.

*Note:* The selection and spacing of cable tray and protective casing supports are to take into account:

- Dimensions of the cable trays and the protective casings;
- Mechanical and physical properties of their material;
- Mass of the cable trays/protective casings;
- Loads due to weight of cables, external forces, thrust forces and vibrations;
- Maximum accelerations to which the system may be subjected;
- Combination of loads.

*5.9.3(c)* *Cable Occupation Ratio in Protective Casing.* The sum of the total cross-sectional area of all cables on the basis of their external diameter is not to exceed 40% of the internal cross-sectional area of the protective casing. This does not apply to a single cable in a protective casing.

*5.9.3(d)* *Hazardous Areas (2008).* Cable trays and protective casings passing through hazardous areas are to be electrically conductive (see Appendix 4-8-4A1 of the *Steel Vessel Rules).*

*5.9.3(e)* *Type Testing (2008).* Cable trays and protective casings made of plastic materials are to be and type tested in accordance with Appendix 4-8-4A1 of the *Steel Vessel Rules*. Alternate test procedures for impact resistance test, safe working load test, flame retardant test, smoke and toxicity tests and/or resistivity test from an international or national standard may be considered instead of the test specified in Appendix 4-8-4A1 of the *Steel Vessel Rules*. The type test reports are to be submitted for review.

## 5.11 Cable Run in Bunches

### 5.11.1 Reduction of Current Rating

Where cables which may be expected to operate simultaneously are laid close together in a cable bunch in such a way that there is an absence of free air circulation around them, the following reduction factor is to be applied to the current rating obtained from 4-5-4/Table 10:

| *Number of Cables in One Bunch* | *Reduction Factor* |
|---|---|
| one to six | 1.0 |
| seven to twelve | 0.85 |

Bunches of more than twelve cables will be subject to special consideration based on the type and service of the various cables in the bunch.

### 5.11.2 Clearance and Segregation

A clearance is to be maintained between any two cable bunches of at least the diameter of the largest cable in either bunch. Otherwise, for the purpose of determining the number of cables in the bunch, the total number of cables on both sides of the clearance will be used.

### 5.11.3 Cable of Lower Conductor Temperature

The current rating of each cable in a bunch is to be determined based on the lowest conductor temperature rating of any cable in the bunch.

## 5.13 Deck and Bulkhead Penetrations *(1 July 2013)*

### 5.13.1 General

Where cables pass through watertight, firetight, or smoke-tight bulkheads or decks, the penetrations are to be made through the use of approved stuffing tubes, transit devices or pourable materials installed in accordance with manufacturer's installation procedures to maintain the watertight integrity or fire-rating of the bulkheads or decks. These devices or pourable materials are not to damage the cable physically or through chemical action or through heat build-up, and are to be examined and tested as specified in 3-6-1/Table 1 and 4-5-3/5.13.4.

Where cable conduit pipe or equivalent is carried through decks or bulkheads, arrangements are to be made to maintain the integrity of the water or gas tightness of the structure.

### 5.13.2 Non-watertight Penetrations

When cables pass through non-watertight bulkheads where the bearing surface is less than 6.4 mm (0.25 in.), the holes are to be fitted with bushings having rounded edges and a bearing surface for the cable of at least 6.4 mm (0.25 in.) in length. Where cables pass through deck beams or similar structural parts, all burrs are to be removed in way of the holes and care is to be taken to eliminate sharp edges.

### 5.13.3 Collision Bulkhead

Cables are not to pass through a collision bulkhead.

### 5.13.4 Watertight and Fire-rated Deck and Bulkhead Cable Penetrations

During installation of deck and bulkhead watertight and fire-rated cable penetrations, the attending Surveyor is to confirm that the installer is familiar with and has access to the manufacturer's installation procedures for stuffing tubes, transit devices or pourable materials.

After installation, all watertight and fire-rated cable penetrations are to be visually examined. Watertight cable penetrations are to be tested as required by 3-6-1/Table 1.

## 5.15 Mechanical Protection

### 5.15.1 Metallic Armor

Electric cables installed in locations liable to damage during normal operation of the vessel are to be provided with braided, metallic armor and be otherwise suitably protected from mechanical injury, as appropriate for the location. See also 4-5-3/11.1.3 for cables in hazardous areas.

### 5.15.2 Conduit Pipe or Structural Shapes

Where cables are installed in locations in way of cargo ports, hatches, tank tops, open decks subject to seas, and where passing through decks, they are to be protected by substantial metal shields, structural shapes, pipe or other equivalent means. All such coverings are to be of sufficient strength to provide effective protection to the cables. When expansion bends are fitted, they are to be accessible for maintenance. Where cables are installed in metal piping or in a metal conduit system, such piping and systems are to be earthed and are to be mechanically and electrically continuous across all joints.

## 5.17 Emergency and Essential Feeders

### 5.17.1 Location *(2013)*

As far as practicable, cables and wiring for emergency and essential services are not to pass through high fire risk areas (see 4-5-6/9.13). For Emergency Fire Pumps, see requirements in 4-5-3/5.17.2.

These cables and wiring are to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

In those cases when it is not possible for the cables and wiring to be routed clear of high fire risk areas, the methods applicable to passenger vessels in 4-5-6/9.15 may be considered.

### 5.17.2 Electrical Cables for the Emergency Fire Pump *(1 July 2009)*

The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their sources of power and prime movers. They are to be of a fire resistant type, in accordance with 4-5-4/13.1.3, where they pass through other high fire risk areas.

### 5.17.3 Requirements by the Governmental Authority

Attention is directed to the requirements of the governmental authority of the country whose flag the vessel flies for the installation of emergency circuits required in various types of vessels.

## 5.19 Mineral Insulated Cables

At all points where mineral-insulated metal-sheathed cable terminates, an approved seal is to be provided immediately after stripping to prevent entrance of moisture into the mineral insulation. In addition, the conductors extending beyond the sheath are to be insulated with an approved insulating material. When mineral-insulated cable is connected to boxes or equipment, the fittings are to be approved for the conditions of service. The connections are to be in accordance with the manufacturer's installation recommendation.

## 5.21 Fiber Optic Cables

The installation of fiber optic cables is to be in accordance with the manufacturer's recommendations to prevent sharp bends where the fiber optic cables enter the equipment enclosure. Consideration is to be given to the use of angled stuffing tubes. The cables are to be installed so as to avoid abrading, crushing, twisting, kinking or pulling around sharp edges.

## 5.23 Battery Room

Where cables enter battery rooms, the holes are to be bushed, as required for watertight bulkheads in 4-5-3/5.13. All connections within battery rooms are to be resistant to the electrolyte. Cables are to be sealed to resist the entrance of electrolyte by spray or creepage. The size of the connecting cable is to be based on current-carrying capacities given in 4-5-4/Table 10 and the starting rate of charge or maximum discharge rate, whichever is the greater, is to be taken into consideration in determining the cable size.

### 5.25 Paneling and Dome Fixtures

Cables may be installed behind paneling, provided all connections are accessible and the location of concealed connection boxes is indicated. Where a cable strip molding is used for cable installation on the incombustible paneling, it is to be of incombustible material. Dome fixtures are to be installed so that they are vented or they are to be fitted with fire-resistant material in such a manner as to protect the insulated wiring leading to the lamps and any exposed woodwork from excessive temperature.

### 5.27 Sheathing and Structural Insulation

Cables may be installed behind sheathing, but they are not to be installed behind nor imbedded in structural insulation. They are to pass through such insulation at right angles and are to be protected by a continuous pipe with a stuffing tube at one end. For deck penetrations, this stuffing tube is to be at the upper end of the pipe and for bulkhead penetrations, it is to be on the uninsulated side of the bulkhead. For refrigerated-space insulation, the pipe is to be of phenolic or similar heat-insulating material joined to the bulkhead stuffing tube, or a section of such material is to be inserted between the bulkhead stuffing tube and the metallic pipe.

### 5.29 Splicing of Electrical Cables

#### 5.29.1 Basis of Approval

Replacement insulation is to be fire-resistant and is to be equivalent in electrical and thermal properties to the original insulation. The replacement jacket is to be at least equivalent to the original impervious sheath and is to assure a watertight splice. Splices are to be made using an approved splice kit which contains the following:

- Connector of correct size and number
- Replacement insulation
- Replacement jacket
- Instructions for use

In addition, prior to approval of a splicing kit, it will be required that completed splices be tested for fire resistance, watertightness, dielectric strength, etc., to the satisfaction of the Surveyor. This requirement may be modified for splice kits which have had such tests conducted and reported on by an independent agency acceptable to ABS.

#### 5.29.2 Installation

All splices are to be made after the cable is in place and are to be accessible for inspection. The conductor splice is to be made using a pressure type butt connector by use of a one-cycle compression tool. See 4-5-3/11.1.3 for splices in hazardous area.

#### 5.29.3 Protection

Splices may be located in protected enclosures or in open wireways. Armored cables having splices will not be required to have the armor replaced, provided that the remaining armor has been earthed in compliance with 4-5-3/7.9 or provided that the armor is made electrically continuous. Splices are to be so located such that stresses (as from the weight of the cable) are not carried by the splice.

### 5.31 Splicing of Fiber Optic Cables

Splicing of fiber optic cables is to be made by means of approved mechanical or fusion methods.

### 5.33 Cable Junction Box

Except for propulsion cables, junction boxes may be used in the installation of electric cables aboard the vessel, provided the plans required by 4-5-3/1.3 for junction boxes are submitted and the following requirements are complied with.

5.33.1

The design and construction of the junction boxes are to comply with 4-5-4/11.7 as well as 4-5-3/5.33.2, below.

5.33.2

The junction boxes are to be suitable for the environment in which they are installed (i.e., explosion-proof in hazardous areas, watertight or weathertight on deck, etc.).

5.33.3 *(1998)*

Separate* junction boxes are to be used for feeders and circuits of each of the following rated voltage levels:

* A physical barrier may be used in lieu of two separate junction boxes for circuits having rated voltage levels corresponding to those in 4-5-3/5.33.3(a) and 4-5-3/5.33.3(b).

*5.33.3(a)* Rated voltage levels not exceeding those specified in 4-5-3/7.1i).

*5.33.3(b)* Rated voltage levels exceeding those in 4-5-3/5.33.3(a) up to and including 1 kV. A physical barrier is to be used within the junction box to separate distribution systems of different rated voltages, such as 480 V, 600 V and 750 V.

*5.33.3(c)* Rated voltage levels exceeding 1 kV. Separate junction boxes are to be used for each of the rated voltage levels exceeding 1 kV.

Each junction box and the compartment in the junction box separated by a physical barrier are to be appropriately identified as regards the rated voltage of the feeders and circuits that it contains.

5.33.4

The junction boxes for emergency feeders and circuits are to be separate from those used for normal ship service feeders and circuits.

5.33.5

Cables are to be supported, as necessary, within junction boxes so as not to put stress (as from the weight of the cable) on the cable contact mountings. The connections are to be provided with locking type connections.

In addition to the above, the applicable requirements in 4-5-3/5 and 4-5-4/13 regarding cable installation and application details are to be complied with.

# 7 Earthing

## 7.1 General

Exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live are to be earthed unless the machines or equipment are:

*i)* *(1998)* supplied at a voltage not exceeding 50 volts DC or 50 volts AC rms between conductors; auto-transformers are not to be used for the purpose of achieving this voltage; or

*ii)* Supplied at a voltage not exceeding 250 volts AC rms by safety isolating transformers supplying only one consuming device; or

*iii)* Constructed in accordance with the principle of double insulation.

## 7.3 Permanent Equipment

The metal frames or cases of all permanently installed generators, motors, controllers, instruments and similar equipment are to be permanently earthed through a metallic contact with the vessel’s structure. Alternatively, they are to be connected to the hull by a separate conductor, in accordance with 4-5-3/7.5. Where outlets, switches and similar fittings are of non-metallic construction, all exposed metal parts are to be earthed.

### 7.5 Connections

#### 7.5.1 General

All earthing conductors are to be of copper or other corrosion-resistant material and are to be protected against damage. The nominal cross-sectional area of every copper earthing conductor is to be not less than that required by 4-5-3/Table 3.

#### 7.5.2 Earthed Distribution System

Earthing conductors in an earthed distribution system are to comply with 4-5-3/7.5.1, except that the earthing conductor in line C4 of 4-5-3/Table 3 is to be *A*/2.

#### 7.5.3 Connection to Hull Structure

All connections of an earth-continuity conductor or earthing lead to the vessel's structure are to be made in an accessible position and be secured by a screw of brass or other corrosion-resistant material having a cross-sectional area equivalent to the earth-continuity conductor or earthing lead, but not less than 4 mm (0.16 in.) in diameter. The earth connection screw is to be used for this purpose only.

### 7.7 Portable Cords *(1998)*

Receptacle outlets operating at 50 volts DC or 50 volts AC rms or more are to have an earthing pole.

### 7.9 Cable Metallic Covering

All metal sheaths, armor of cable and mineral-insulated, metal-sheathed cable are to be electrically continuous and are to be earthed to the metal hull at each end of the run, except that final sub-circuits may be earthed at the supply end only. All metallic coverings of power and lighting cables passing through hazardous areas or connected to equipment in such an area are to be earthed at least at each end.

### 7.11 Lightning Earth Conductors

Each wooden mast or topmast is to be fitted with lightning earth conductors. They need not be fitted to steel masts.

## 9 Installation in Cargo Hold for Dry Bulk Cargoes

### 9.1 Equipment

The installation of electrical equipment in cargo holds for dry bulk cargoes is to be limited to only that which is absolutely necessary. Where electrical equipment must be installed in such spaces, it is to be protected from mechanical damage. All electrical equipment in cargo holds or spaces through which cargo passes is to have an IP55 enclosure, as defined in 4-5-1/17.

### 9.3 Self-unloading Controls and Alarms

#### 9.3.1 General

Where vessels are equipped with self-unloading systems, controls are to be provided for the safe operation of the self-unloading system. These controls are to be clearly marked to show their functions. Energizing the power unit at a location other than the cargo control station is not to set the gear in motion.

#### 9.3.2 Monitors

As appropriate, monitoring is to indicate the system operational status (operating or not operating), availability of power, overload alarm, air pressure, hydraulic pressure, electrical power or current, motor running and motor overload and brake mechanism engagement.

#### 9.3.3 Emergency Shutdowns

Remote emergency shutdowns of power units for self-unloading equipment are to be provided outside of the power unit space so that they may be stopped in the event of fire or other emergency. Where remote controls are provided for cargo gear operation, means for the local emergency shutdowns are to be provided.

# 11 Equipment and Installation in Hazardous Areas

## 11.1 General Considerations

### 11.1.1 General *(2015)*

Electrical equipment and wiring are not to be installed in hazardous areas unless essential for operational purposes. Generally electrical equipment certified for use in hazardous areas in accordance with the IEC 60079 series is considered suitable for use in temperatures –20°C to 40°C (–4°F to 104°F). Account is to be taken of the temperature at the point of installation when selecting electrical equipment for installation in hazardous areas.

*11.1.1(a) Electrical Equipment Types (2016).* Only electrical equipment of the following types, complying with IEC Publication 60079 series or other recognized standards, is to be considered for installation in hazardous areas.

- Intrinsically safe type (Ex i)
- Flameproof (explosion-proof) type (Ex d)
- Increased safety type (Ex e)
- Pressurized or purged type (Ex p)

Consideration is to be given to the flammability group and the temperature class of the equipment for suitability for the intended hazardous area, see IEC Publication 60079-20.

*11.1.1(b) Fans.* Fans used for the ventilation of the hazardous areas are to be of non-sparking construction in accordance with 4-5-3/11.7.

### 11.1.2 Lighting Circuits *(2002)*

All switches and protective devices for lighting fixtures in hazardous areas are to interrupt all poles or phases and are to be located in a non-hazardous area. However, a switch may be located in a hazardous area if the switch is of a certified safe type for the hazardous location in which it is to be installed. On solidly grounded distribution systems, the switches need not open the grounded conductor. The switches and protective devices for lighting fixtures are to be suitably labeled for identification purposes.

### 11.1.3 Cables Installation *(2006)*

Cables in hazardous areas are to be armored or mineral-insulated metal-sheathed, except for cables of intrinsically-safe circuits subject to the requirements of 4-5-3/5.15. Where cables pass through hazardous area boundaries, they are to be run through gastight fittings. No splices are allowed in hazardous areas, except in intrinsically-safe circuits.

### 11.1.4 Permanent Warning Plates

Permanent warning plates are to be installed in the vicinity of hazardous areas in which electrical equipment is installed, such as the pump room, to advise personnel carrying out maintenance, repair or surveys of the availability of the booklet/list of equipment in hazardous areas referenced in 4-5-3/1.5, if required for their use.

## 11.3 Certified-safe Type and Pressurized Equipment and Systems

### 11.3.1 Installation Approval

Electrical equipment in hazardous areas is to be of a type suitable for such locations. Where permitted by the Rules, electrical equipment of a certified safe type, such as explosion-proof type and intrinsically-safe electrical instruments, circuitry and devices, will be approved for installation, provided such equipment has been type-tested and certified by a competent independent testing laboratory as explosion-proof or intrinsically-safe and provided that there is no departure in the production equipment from the design so tested and approved.

11.3.2 Intrinsically-safe System *(2005)*

*11.3.2(a) Installation of Cables and Wiring.* Installations with intrinsically safe circuits are to be erected in such a way that their intrinsic safety is not adversely affected by external electric or magnetic fields under normal operating condition and any fault conditions, such as a single-phase short circuit or earth fault in non-intrinsically safe circuits, etc.

*11.3.2(b) Separation and Mechanical Protection.* The installation of the cables is to be arranged as follows:

*i)* Cables in both hazardous and non-hazardous areas are to meet one of the following requirements:

- Intrinsically safe circuit cables are to be installed a minimum of 50 mm (2 in.) from all non-intrinsically safe circuit cables, or
- Intrinsically safe circuit cables are to be so placed as to protect against the risk of mechanical damage by use of a mechanical barrier, or
- Intrinsically safe or non-intrinsically safe circuit cables are to be armored, metal sheathed or screened.

*ii)* Conductors of intrinsically safe circuits and non-intrinsically safe circuits are not to be carried in the same cable.

*iii)* Cables of intrinsically safe circuits and non-intrinsically safe circuits are not to be in the same bundle, duct or conduit pipe.

*iv)* Each unused core in a multi-core cable is to be adequately insulated from earth and from each other at both ends by the use of suitable terminations.

*11.3.2(c) Sub-compartment.* When intrinsically safe components are located by necessity within enclosures that contain non-intrinsically safe systems, such as control consoles and motor starters, such components are to be effectively isolated in a sub-compartment by earthed metallic or nonmetallic insulating barriers having a cover or panel secured by bolts, locks, Allen-screws, or other approved methods. The intrinsic safety in the sub-compartment is not to be adversely affected by external electric or magnetic fields under normal operating condition and any fault conditions in non-intrinsically safe circuits.

*11.3.2(d) Termination Arrangements.* Where it is impracticable to arrange the terminals of intrinsically safe circuit in the sub-compartment, they are to be separated from those for non-intrinsically safe circuits by either of the following methods. Other National or International recognized Standards will also be accepted.

*i)* When separation is accomplished by distance, then the clearance between terminals is to be at least 50 mm, or

*ii)* When separation is accomplished by use of an insulating partition or earthed metal partition, the partitions are to extend to within 1.5 mm of the walls of the enclosure, or alternatively provide a minimum measurement of 50 mm between the terminals when taken in any direction around the partition.

*11.3.2(e) Identification Plate.* The terminals and sub-compartment for intrinsically safe circuit and components are to have a nameplate indicating that the equipment within is intrinsically safe and that unauthorized modification or repairs are prohibited.

*11.3.2(f) Replacement.* Unless specifically approved, replacement equipment for intrinsically-safe circuits is to be identical to the original equipment.

#### 11.3.3 Pressurized Equipment

Pressurized equipment is to consist of separately ventilated enclosures supplied with positive-pressure ventilation from a closed-loop system or from a source outside the hazardous areas, and provision is to be made such that the equipment cannot be energized until the enclosure has been purged with a minimum of ten air changes and required pressure is obtained. Ventilating pipes are to have a minimum wall thickness of 3 mm (0.12 in. or 11 gage). In the case of loss of pressurization, power is to be automatically removed from the equipment, unless this would result in a condition more hazardous than that created by failure to de-energize the equipment. In this case, in lieu of removal of power, an audible and visual alarm is to be provided at a normally manned control station.

Pressurized equipment in compliance with IEC Publication 60079-2, NFPA 496 or other recognized standard will also be acceptable.

### 11.5 Paint Stores

#### 11.5.1 General *(2016)*

Electrical equipment in paint stores and in ventilation ducts serving such spaces as permitted in 4-5-3/11.1.1 is to comply with the requirements for group IIB class T3 in IEC Publication 60079-20-1.

The following type of equipment will be acceptable for such spaces.

*i)* Intrinsically-safe defined by 4-5-1/3.21

*ii)* Explosion-proof defined by 4-5-1/3.9

*iii)* Pressurized defined by 4-5-1/3.43

*iv)* Increased safety defined by 4-5-1/3.17

*v)* Other equipment with special protection recognized as safe for use in explosive gas atmospheres by a national or other appropriate authority.

#### 11.5.2 Open Area Near Ventilation Openings

In the areas on open deck within 1 m (3.3 ft) of the ventilation inlet or within 1 m (3.3 ft) (if natural) or 3 m (10 ft) (if mechanical) of the exhaust outlet, electrical equipment and cables, where permitted by 4-5-3/11.1.1, are to be in accordance with 4-5-3/11.1.2, 4-5-3/11.1.3 and 4-5-3/11.3.1.

#### 11.5.3 Enclosed Access Spaces

The enclosed spaces giving access to the paint store may be considered as non-hazardous, provided that:

*i)* The door to the paint store is gastight with self-closing devices without holding back arrangements,

*ii)* The paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area, and

*iii)* Warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

### 11.7 Non-sparking Fans

#### 11.7.1 Design Criteria

*11.7.1(a) Air Gap.* The air gap between the impeller and the casing is to be not less than 10% of the shaft diameter in way of the impeller bearing, but not less than 2 mm (0.08 in.). It need not be more than 13 mm (0.5 in.).

*11.7.1(b) Protection Screen.* Protection screens of not more than 13 mm (0.5 in.) square mesh are to be fitted in the inlet and outlet of ventilation openings on the open deck to prevent the entrance of an object into the fan casing.

11.7.2 Materials

*11.7.2(a) Impeller and its Housing.* Except as indicated in 4-5-3/11.7.2(c) below, the impeller and the housing in way of the impeller are to be made of alloys which are recognized as being spark proof by appropriate test.

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

*11.7.2(c) Acceptable Combination of Materials.* Tests referred to in 4-5-3/11.7.2(a) above are not required for fans having the following combinations:

*i)* Impellers and/or housings of nonmetallic material, due regard being paid to the elimination of static electricity;

*ii)* Impellers and housings of non-ferrous materials;

*iii)* Impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller;

*iv)* Any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm (0.5 in.) tip design clearance.

*11.7.2(d) Unacceptable Combination of Materials.* The following impellers and housings are considered as sparking-producing and are not permitted:

*i)* Impellers of an aluminum alloy or magnesium alloy and a ferrous housing, regardless of tip clearance;

*ii)* Housing made of an aluminum alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance;

*iii)* Any combination of ferrous impeller and housing with less than 13 mm (0.5 in.) design tip clearance.

11.7.3 Type Test *(2007)*

Type tests on the finished product are to be carried out using an acceptable national or international standard. Such type test reports are to be made available when requested by the Surveyor.

## TABLE 1
## Minimum Degree of Protection [See 4-5-3/3.1.1] *(2018)*
### (For high voltage equipment, see 4-5-5/Table 1)

| *Example of Location* | *Condition of Location* | *Switchboards, Distribution Boards, Motor Control Centers & Controllers (See 4-5-3/3.9 to 4-5-3/3.13)* | *Generators (See 4-5-3/3.3)* | *Motors (See 4-5-3/3.5)* | *Transformers, Converters* | *Lighting Fixtures (See 4-5-3/3.17)* | *Heating Appliances (See 4-5-3/3.19)* | *Accessories* [(3)] |
|---|---|---|---|---|---|---|---|---|
| Dry accommodation space | Danger of touching live parts only | IP20 | - | IP20 | IP20 | IP20 | IP20 | IP20 |
| Dry control rooms [(4)] *(1999)* | | IP20 | - | IP20 | IP20 | IP20 | IP20 | IP20 |
| Control rooms *(1999)* | Danger of dripping liquid and/or moderate mechanical damage | IP22 | - | IP22 | IP22 | IP22 | IP22 | IP22 |
| Machinery spaces above floor plates [(5)] | | IP22 | IP22 | IP22 | IP22 | IP22 | IP22 | IP44 |
| Steering gear rooms | | IP22 | IP22 | IP22 | IP22 | IP22 | IP22 | IP44 |
| Refrigerating machinery rooms | | IP22 | - | IP22 | IP22 | IP22 | IP22 | IP44 |
| Emergency machinery rooms | | IP22 | IP22 | IP22 | IP22 | IP22 | IP22 | IP44 |
| General store rooms | | IP22 | - | IP22 | IP22 | IP22 | IP22 | IP22 |
| Pantries | | IP22 | - | IP22 | IP22 | IP22 | IP22 | IP44 |
| Provision rooms | | IP22 | - | IP22 | IP22 | IP22 | IP22 | IP22 |
| Bathrooms and Showers | Increased danger of liquid and/or mechanical damage | - | - | - | - | IP34 | IP44 | IP55 |
| Machinery spaces below floor plates | | - | - | IP44 | - | IP34 | IP44 | IP55 [(2)] |
| Closed fuel oil or lubricating oil separator rooms | | IP44 | - | IP44 | - | IP34 | IP44 | IP55 [(2)] |
| Ballast pump rooms | Increased danger of liquid and mechanical damage | IP44 | - | IP44 | IP44 | IP34 | IP44 | IP55 |
| Refrigerated rooms | | - | - | IP44 | - | IP34 | IP44 | IP55 |
| Galleys and Laundries | | IP44 | - | IP44 | IP44 | IP34 | IP44 | IP44 [(6)] |
| Shaft or pipe tunnels in double bottom | Danger of liquid spray presence of cargo dust, serious mechanical damage, and/or aggressive fumes | IP55 | - | IP55 | IP55 | IP55 | IP55 | IP56 |
| Holds for general cargo | | - | - | - | - | IP55 | - | IP55 |
| Open decks | Exposure to heavy seas | IP56 | - | IP56 | - | IP55 | IP56 | IP56 |
| Bilge wells | Exposure to submersion | - | - | - | - | IPX8 | - | IPX8 |

*Notes*

1. Empty spaces shown with "-" indicate installation of electrical equipment is not recommended.
2. *(2018)* Socket outlets are not to be installed in machinery spaces below the floor plates, enclosed fuel and lubricating oil separator rooms. Plugs and sockets that are present in a hazardous area are to be certified for use in the particular zone.
3. "Accessories" include switches, detectors, junction boxes, etc. Accessories which are acceptable for use in hazardous areas are limited by the condition of the areas. Specific requirements are given in the Rules. See 4-5-3/3.23.
4. *(1999)* For the purpose of this Table, the wheelhouse may be categorized as a "dry control room" and consequently, the installation of IP20 equipment would suffice therein, provided that: (a) the equipment is located as to preclude being exposed to steam or dripping/spraying liquids emanating from pipe flanges, valves, ventilation ducts and outlets, etc., installed in its vicinity, and (b) the equipment is placed to preclude the possibility of being exposed to sea or rain.
5. *(2006)* See 4-5-3/3.1.1(b) where the equipment is located within areas protected by local fixed pressure water-spraying or water-mist fire extinguishing system and its adjacent areas.
6. *(2014)* Socket outlets in galleys and laundries are to maintain their protection against splashed water when not in use.

## TABLE 2
## Minimum Bending Radii of Cables [See 4-5-3/5.9.2] *(1999)*

| *Cable Construction* | | *Overall Diameter, D* | *Minimum Internal Bending Radius* |
|---|---|---|---|
| *Insulation* | *Outer Covering* | | |
| Thermoplastic or thermosetting with circular copper conductor | Unarmored or unbraided | $D \leq 25$ mm (1 in.) | 4 *D* |
| | | $D > 25$ mm (1 in.) | 6 *D* |
| | Metal braid screened or armored | Any | 6 *D* |
| | Metal wire or metal-tape armored or metal-sheathed | Any | 6 *D* |
| | Composite polyester/metal laminate tape screened units or collective tape screening | Any | 8 *D* |
| Thermoplastic or thermosetting with shaped copper conductor | Any | Any | 8 *D* |
| Mineral | Hard metal-sheathed | Any | 6 *D* |

## TABLE 3
## Size of Earth-continuity Conductors and Earthing Connections [See 4-5-3/7.5] *(2003)*

| *Type of Earthing Connection* | | *Cross-sectional Area, A, of Associated Current Carrying Conductor* | *Minimum Cross-sectional Area of Copper Earthing Connection* |
|---|---|---|---|
| Earth-continuity conductor in flexible cable or flexible cord | A1 | $A \leq 16$ mm$^2$ | $A$ |
| | A2 | 16 mm$^2$ $< A \leq 32$ mm$^2$ | 16 mm$^2$ |
| | A3 | $A > 32$ mm$^2$ | $A/2$ |
| Earth-continuity conductor incorporated in fixed cable | For cables having an insulated earth-continuity conductor | | |
| | B1a | $A \leq 1.5$ mm$^2$ | 1.5 mm$^2$ |
| | B1b | 1.5 mm$^2$ $< A \leq 16$ mm$^2$ | $A$ |
| | B1c | 16 mm$^2$ $< A \leq 32$ mm$^2$ | 16 mm$^2$ |
| | B1d | $A > 32$ mm$^2$ | $A/2$ |
| | For cables with bare earth wire in direct contact with the lead sheath | | |
| | B2a | $A \leq 2.5$ mm$^2$ | 1 mm$^2$ |
| | B2b | 2.5 mm$^2$ $< A \leq 6$ mm$^2$ | 1.5 mm$^2$ |
| Separate fixed earthing conductor | C1a | $A \leq 3$ mm$^2$ | Stranded earthing connection:<br>1.5 mm$^2$ for $A \leq 1.5$ mm$^2$<br>$A$ for $A > 1.5$ mm$^2$ |
| | C1b | | Unstranded earthing connection:<br>3 mm$^2$ |
| | C2 | 3 mm$^2$ $< A \leq 6$ mm$^2$ | 3 mm$^2$ |
| | C3 | 6 mm$^2$ $< A \leq 125$ mm$^2$ | $A/2$ |
| | C4 | $A > 125$ mm$^2$ | 64 mm$^2$ (see Note 1) |

*Notes:*

1 *(2003)* For earthed distribution systems, the size of earthing conductor is not to be less than $A$/2.

2 Conversion Table for mm$^2$ to circular mils:

| *mm$^2$* | *circ. mils* | | *mm$^2$* | *circ. mils* | | *mm$^2$* | *circ. mils* | | *mm$^2$* | *circ. mils* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,973 | | 2.5 | 4,933 | | 6 | 11,841 | | 70 | 138,147 |
| 1.5 | 2,960 | | 4 | 7,894 | | 16 | 31,576 | | 120 | 236,823 |

PART

# 4

# CHAPTER 5 Electrical Installations

# SECTION 4 Machinery and Equipment

## 1 Plans and Data to Be Submitted *(2010)*

### 1.1 Rotating Machines of 100 kW and Over

For rotating machines of 100 kW and over intended for essential services (primary and secondary) or for services indicated in 4-5-4/Table 11, drawings showing the following particulars are to be submitted: assembly, seating arrangements, terminal arrangements, shafts, coupling, coupling bolts, stator and rotor details together with data for complete rating, class of insulation, designed ambient temperature, temperature rise, degree of protection for enclosures, weights and speeds for rotating parts. Plans to be submitted for generator prime movers are given in 4-2-3/1.5, 4-2-4/1.5 and 4-2-1/1.9 of the *Steel Vessel Rules*.

### 1.3 Switchboards, Distribution Boards, Controllers, etc.

For switchboards, distribution boards, battery charger units, uninterruptible power system (UPS) units, motor control centers, and motor controllers intended for essential services (primary and secondary) or for services indicated in 4-5-4/Table 11, drawings showing arrangements and details, front view, and installation arrangements are to be submitted for review together with data for protective device rating and setting, type of internal wiring, and size and rated current carrying capacity (together with short-circuit current data) of bus bars and internal wiring for power circuit. In addition, a schematic or logic diagram with a written description giving the sequence of events and system operating procedures for electrical power supply management on switchboards and sequential or automatic change-over of the motors are also to be submitted for review.

## 3 Rotating Machines

### 3.1 General

#### 3.1.1 Applications *(2010)*

All rotating electrical machines of 100 kW and over intended for essential services (see 4-5-1/3.7) or for services indicated in 4-5-4/Table 11 are to be designed, constructed and tested in accordance with the requirements of 4-5-4/3.

All other rotating electrical machines are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications. Manufacturer's tests for rotating electric machines less than 100 kW for essential services or for services indicated in 4-5-4/Table 11 are to include at least the tests described in 4-5-4/3.3.1(b), regardless of the standard of construction The test certificates are to be made available when requested by the Surveyor. Acceptance of machines will be based on satisfactory performance test after installation.

#### 3.1.2 Certification on Basis of an Approved Quality Assurance Program

See 4-1-1/3.

#### 3.1.3 References

*3.1.3(a) Inclination.* For the requirements covering inclination for design condition, see 4-5-1/11.

*3.1.3(b) Insulation Material.* For the requirements covering insulation material, see 4-5-1/15.

*3.1.3(c) Capacity of Generators.* For requirements covering main generator capacity, see 4-5-2/3.1 and 4-5-2/3.3. For requirements covering emergency generator capacity, see 4-5-6/9.1.2.

*3.1.3(d) Power Supply by Generators.* For requirements covering power supply by main or emergency generator, see 4-5-2/3.1, 4-5-2/3.3, 4-5-2/5 and 4-5-6/9.1.3.

*3.1.3(e) Protection for Generator Circuits.* For requirements covering protection for generator, see 4-5-2/9.3, 4-5-2/9.5 and 4-5-2/9.7.

*3.1.3(f) Protection for Motor Circuits.* For requirements covering protection for motor branch circuit, see 4-5-2/9.13.

*3.1.3(g) Installation.* For requirements covering installation, see 4-5-3/3.3 for generators and 4-5-3/3.5 for motors.

*3.1.3(h) Protection Enclosures and its Selection.* For requirements covering degree of the protection and the selection of equipment, see 4-5-1/17 and 4-5-3/3.1, respectively.

## 3.3 Testing and Inspection

### 3.3.1 Applications *(2010)*

*3.3.1(a) Machines of 100 kW and Over*. All rotating machines of 100 kW and over intended for essential services (see 4-5-1/3.7) or for services indicated in 4-5-4/Table 11 are to be tested in accordance with 4-5-4/Table 1 in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer.

*3.3.1(b) Machines Below 100 kW.* All rotating machines of less than 100 kW intended for essential services or for services indicated in 4-5-4/Table 11 are to be tested in accordance with 4-5-4/Table 1 (item 2 through item 10 and item 12). The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

*3.3.1(c) Other Machines.* For machines not intended for essential services or for services indicated in 4-5-4/Table 11, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

### 3.3.2 Special Testing Arrangements

In cases where all of the required tests are not carried out at the plant of the manufacturer, the Surveyor is to be notified and arrangements are to be made so that the remaining tests will be witnessed.

## 3.5 Insulation Resistance Measurement

The resistance is to be measured before the commencement of the testing and after completion of the testing for all circuits. Circuits or groups of circuits of different voltages above earth are to be tested separately. This test is to be made with at least 500 volts DC and the insulation resistance in megohms of the circuits while at their operating temperatures is to be normally at least equal to:

$$\frac{\text{Rated Voltage of the Machine}}{(\text{Rating in kVA}/100) + 1000}$$

The minimum insulation resistance of the fields of machines separately excited with voltage less than the rated voltage of the machine is to be on the order of one-half to one megohm.

## 3.7 Overload and Overcurrent Capability *(1997)*

### 3.7.1 AC Generators *(2003)*

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds. The test may be performed in conjunction with the short circuit testing, provided the electrical input energy to the machine is not less than that required for the above overload capability.

3.7.2 AC Motors

*3.7.2(a) Overcurrent Capacity (2003).* Three phase induction motors having rated output not exceeding 315 kW and rated voltage not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than two minutes. For three-phase induction motors having rated outputs above 315 kW, the overcurrent capacity is to be in accordance with the manufacturer's specification. The test may be performed at a reduced speed.

*3.7.2(b) Overload Capacity.* Three-phase induction motors are to be capable of withstanding for 15 seconds, without stalling or abrupt change in speed, an excess torque of 60% of their rated torque, the voltage and frequency being maintained at their rated values.

*3.7.2(c) Overload Capacity for Synchronous Motors.* Three phase synchronous motors are to be capable of withstanding an excess torque, as specified below, for 15 seconds without falling out of synchronism, the excitation being maintained at the value corresponding to the rated load.

| | |
|---|---|
| Synchronous (wound rotor) induction motors: | 35% excess torque |
| Synchronous (cylindrical rotor) motors: | 35% excess torque |
| Synchronous (salient pole) motors: | 50% excess torque |

When automatic excitation is used, the limit of torque values is to be the same as with the excitation equipment operating under normal conditions.

## 3.9 Dielectric Strength of Insulation

3.9.1 Application

The dielectric test voltage is to be successively applied between each electric circuit and all other electric circuits and metal parts earthed, and for direct-current (DC) rotating machines between brush rings of opposite polarity. Interconnected polyphase windings are to be considered as one circuit. All windings except that under test are to be connected to earth.

3.9.2 Standard Voltage Test *(2003)*

The insulation of all rotating machines is to be tested with the parts completely assembled and not with the individual parts. The dielectric strength of the insulation is to be tested by the continuous application for 60 seconds of an alternating voltage having a frequency of 25 to 60 Hz and voltage in 4-5-4/Table 2. The requirements in 4-5-4/Table 2 apply to those machines other than high voltage systems covered by 4-5-5/1.11.1(e).

3.9.3 Direct Current Test

A standard voltage test using a direct current source equal to 1.7 times the required alternating-current voltage will be acceptable.

## 3.11 Temperature Ratings

3.11.1 Temperature Rises

*3.11.1(a) Continuous Rating Machines.* After the machine has been run continuously under a rated load until steady temperature condition has been reached, the temperature rises are not to exceed those given in 4-5-4/Table 3.

*3.11.1(b) Short-time Rating Machines.* After the machine has been run at a rated load during the rated time followed by a rest and a de-energized period of sufficient duration to reestablish the machine temperatures within 2°C (3.6°F) of the coolant, the temperature rises are not to exceed those given in 4-5-4/Table 3. At the beginning of the temperature measurement, the temperature of the machine is to be within 5°C (8°F) of the temperature of the coolant.

*3.11.1(c) Periodic Duty Rating Machines.* The machine has been run at a rated load for the designed load cycle to be applied and continued until obtaining the practically identical temperature cycle. At the middle of the period causing the greatest heating in the last cycle of the operation, the temperature rises are not to exceed those given in 4-5-4/Table 3.

*3.11.1(d) Non-periodic Duty Rating Machines.* After the machine has been run continuously or intermittently under the designed variations of the load and speed within the permissible operating range until reaching the steady temperature condition, the temperature rises are not to exceed those given in 4-5-4/Table 3.

*3.11.1(e) Insulation Material Above 180°C (356°F).* Temperature rises for insulation materials above 180°C (356°F) will be considered in accordance with 4-5-1/15.11.

#### 3.11.2 Ambient Temperature *(2007)*

These final temperatures are based on an ambient temperature of 50°C (122°F), for machines located within boiler and engine rooms in accordance with 4-5-1/19. Where provision is made for ensuring the ambient temperature of the space being maintained at 40°C (104°F) or less, as by air cooling or by locating the machine outside of the boiler and engine rooms, the temperature rises of the windings may be 5°C (9°F) higher. The ambient temperature is to be taken in at least two places within 1.83 m (6 ft) of the machine under test and by thermometers having their bulbs immersed in oil contained in an open cup.

### 3.13 Construction and Assemblies

#### 3.13.1 Enclosure, Frame and Pedestals

Magnet frames and pedestals may be separate but are to be secured to a common foundation.

#### 3.13.2 Shafts and Couplings

Rotating shaft, hollow shaft and coupling flange with bolts are to comply with 4-2-1/15, 4-2-1/17 of these Rules and 4-2-4/5.3 of the *Steel Vessel Rules*. Plans to be submitted are given in 4-2-1/1.9, 4-2-3/1.5 and 4-2-4/1.5 of the *Steel Vessel Rules*.

#### 3.13.3 Circulating Currents

Means are to be provided to prevent circulating currents from passing between the journals and the bearings, where the design and arrangement of the machine is such that damaging current may be expected. Where such protection is required, a warning plate is to be provided in a visible place cautioning against the removal of such protection.

#### 3.13.4 Rotating Exciters

Rotating exciters are to conform to all applicable requirements for generators.

#### 3.13.5 Insulation of Windings

Armature and field coils are to be treated to resist oil and water.

#### 3.13.6 Protection Against Cooling Water

Where water cooling is used, the cooler is to be so arranged as to avoid entry of water into the machine, whether through leakage or from condensation in the heat exchanger.

#### 3.13.7 Moisture Condensation Prevention *(2014)*

All generators, and each motor rated 50 kW and over, are to be provided with a means to prevent moisture condensation in the machine when idle.

Where steam-heating coils are installed for this purpose, there are to be no pipe joints inside of the casings. See item 7 in 4-5-4/Table 7 for space heater pilot lamp for alternating-current generators.

#### 3.13.8 Terminal Arrangements

Terminals are to be provided at an accessible position and protected against mechanical damage and accidental contact for earthing, short-circuit or touching. Terminal leads are to be secured to the frame and the designation of each terminal lead is to be clearly marked. The ends of terminal leads are to be fitted with connectors. Cable glands or similar are to be provided where cable penetrations may compromise the protection property of terminal enclosures.

#### 3.13.9 Nameplates

Nameplates of corrosion-resistant material are to be provided in an accessible position of the machine and are to indicate at least the information as listed in 4-5-4/Table 4a.

## 3.15 Lubrication

Rotating machines are to have continuous lubrication at all running speeds and all normal working bearing temperatures. Unless otherwise approved, where forced lubrication is employed, the machines are to be provided with means to shut down their prime movers automatically upon failure of the lubricating system. Each self-lubricating sleeve bearing is to be fitted with an inspection lid and means for visual indication of oil level or an oil gauge.

## 3.17 Turbines for Generators

Gas-turbine prime movers driving generators are to meet the applicable requirements in Section 4-2-3 of the *Steel Vessel Rules* and, in addition, are to comply with the following requirements.

### 3.17.1 Operating Governor *(2004)*

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

*3.17.1(a) Transient Frequency Variations.* The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within ±10% of the rated frequency when:

*i)* Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off,

In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 4-5-4/3.17.2, is not activated.

*ii)* Running at no load and 50% of the full load of the generator is suddenly thrown on followed by the remaining 50% load after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five seconds.

*3.17.1(b) Frequency Variations in Steady State.* The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and full load.

### 3.17.2 Overspeed Governor

In addition to the normal operating governor, an overspeed governor is to be fitted which will trip the turbine throttle when the rated speed is exceeded by more than 15%. Provision is to be made for hand tripping. See 4-5-4/3.15 for pressure-lubricated machines.

### 3.17.3 Exhaust Steam to the Turbines

If exhaust steam is admitted to the turbine, means are to be provided to prevent water entering the turbine. An automatic shut-off is to be provided for auxiliary exhaust when exhaust steam is admitted to the turbine lower stages; this shut-off is to be controlled by the governor and is to function when the emergency trip operates.

### 3.17.4 Extraction of Steam

Where provision is made for extraction of steam, approved means are to be provided for preventing a reversal of flow to the turbine.

### 3.17.5 Power Output of Gas Turbines

To satisfy the requirements of 4-5-2/3.1, the required power output of gas turbine prime movers for ship's service generator sets is to be based on the maximum expected inlet air temperature.

### 3.19 Diesel Engines for Generators

Diesel-engine prime movers are to meet the applicable requirements in Part 4, Chapter 2 of the *Steel Vessel Rules* and, in addition, are to comply with the following requirements.

#### 3.19.1 Operating Governor *(2004)*

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

*3.19.1(a) Transient Frequency Variations.* The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within ±10% of the rated frequency when:

*i)* Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off,

In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 4-5-4/3.19.2, is not activated.

*ii)* Running at no load and 50% of the full load of the generator is suddenly thrown on followed by the remaining 50% load after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five seconds.

*iii)* Where the electrical power system is fitted with a power management system and sequential starting arrangements, the application of loads in multiple steps of less than 50% of rated load in 4-5-4/3.19.1(a)ii) will be given special consideration. The details of the power management system and sequential starting arrangements are to be submitted and its satisfactory operation is to be demonstrated to the Surveyor.

*3.19.1(b) Frequency Variations in Steady State.* The permanent frequency variation is to be within ±5% of the rated frequency at all loads between no load and full load.

*3.19.1(c) Emergency Generator Prime Movers (1998).* Prime movers driving emergency generators are to be able to maintain the speed within the limits in 4-5-4/3.19.1(a) and 4-5-4/3.19.1(b) when the full load of the emergency generator is suddenly thrown on. Where loads are applied in multiple steps, the first applied load is not to be less than the sum of all emergency loads that are automatically connected.

#### 3.19.2 Overspeed Governor

In addition to the normal operating governor, each auxiliary diesel engine having a maximum continuous output of 220 kW and over is to be fitted with a separate overspeed device so adjusted that the speed cannot exceed the maximum rated speed by more than 15%. Provision is to be made for hand tripping. See 4-5-4/3.15 for pressure-lubricated machines.

### 3.21 Alternating-current (AC) Generators

#### 3.21.1 Control and Excitation of Generators

Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machine being excited.

#### 3.21.2 Voltage Regulation *(2007)*

*3.21.2(a) Voltage Regulators.* A separate regulator is to be supplied for each AC generator. When it is intended that two or more generators will be operated in parallel, reactive-droop compensating means are to be provided to divide the reactive power properly between the generators.

*3.21.2(b) Variation from Rated Voltage – Steady Conditions.* Each AC generator for ship's service driven by its prime mover having governor characteristics complying with 4-5-4/3.17.1 or 4-5-4/3.19.1 is to be provided with an excitation system capable of maintaining the voltage under steady conditions within plus or minus 2.5% of the rated voltage for all loads between zero and rated load at rated power factor. These limits may be increased to plus or minus 3.5% for emergency sets.

*3.21.2(c) Variation from Rated Voltage – Transient Conditions (2017).* Momentary voltage variations are to be within the range of minus 15% to plus 20% of the rated voltage, and the voltage is to be restored to within plus or minus 3% of the rated voltage in not more than 1.5 seconds when:

- A load equal to the starting current of the largest motor or a group of motors, but in any case, at least 60% of the rated current of the generator, and power factor of 0.4 lagging or less, is suddenly thrown on with the generator running at no load; and
- A load equal to the above is suddenly thrown off.

Subject to ABS approval, such voltage regulation during transient conditions may be calculated values based on the previous type test records, and need not to be tested during factory testing of a generator.

Consideration can be given to performing the test required by 4-5-4/Table 1, Item 4 according to precise information concerning the maximum values of the sudden loads instead of the values indicated above, provided precise information is available. The precise information concerning the maximum values of the sudden loads is to be based on the power management system arrangements and starting arrangements provided for the electrical system.

*3.21.2(d) Short Circuit Conditions (2017).* Under steady-state short-circuit conditions, the generator together with its excitation system is to be capable of maintaining a steady-state short-circuit current of not less than three times its rated full load current for a period of two seconds or of such magnitude and duration as required to properly actuate the associated electrical protective devices. In order to provide sufficient information for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer is to provide documentation showing the transient behavior of the short circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed. The influence of the automatic voltage regulator is to be taken into account, and the setting parameters for the voltage regulator are to be noted together with the decrement curve. Such a decrement curve is to be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based on physical testing. The manufacturer's simulation model for the generator and the voltage regulator may be used where this has been validated through the previous type test on the same model.

#### 3.21.3 Parallel Operation

For AC generating sets operating in parallel, the following requirements are to be complied with. See also 4-5-2/9.5.2 for protection of AC generators in parallel operation.

*3.21.3(a) Reactive Load Sharing.* The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10% of the rated reactive output of the largest generator, or 25% of the rated reactive output of the smallest generator, whichever is the less.

*3.21.3(b) Load Sharing.* For any load between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 15% of the rated output in kilowatts of the largest generator or 25% of the rated output in kilowatts of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate output with each generator carrying its proportionate share.

*3.21.3(c) Facilities for Load Adjustment.* Facilities are to be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5% of the aggregate output at normal frequency.

### 3.23 Direct-current (DC) Generators

#### 3.23.1 Control and Excitation of Generators

*3.23.1(a) Field Regulations.* Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately. This equipment is to be capable of adjusting the voltage of the DC generator to within 0.5% of the rated voltage at all loads between no-load and full-load.

*3.23.1(b) Polarity of Series Windings.* The series windings of each generator for a two wire DC system are to be connected to the negative terminal of each machine.

*3.23.1(c) Equalizer Connections.* See 4-5-4/7.15.3.

#### 3.23.2 Voltage Regulation

*3.23.2(a) Shunt or Stabilized Shunt-wound Generator.* When the voltage has been set at full-load to its rated value, the removal of the load is not to cause a permanent increase of the voltage greater than 15% of the rated voltage. When the voltage has been set either at full-load or at no-load, the voltage obtained at any value of the load is not to exceed the no-load voltage.

*3.23.2(b) Compound-wound Generator.* Compound-wound generators are to be so designed in relation to the governing characteristics of the prime mover that with the generator at full-load operating temperature and starting at 20% load with voltage within 1% of rated voltage, it gives at full-load a voltage within 1.5% of rated voltage. The average of ascending and descending voltage regulation curves between 20% load and full-load is not to vary more than 3% from rated voltage.

*3.23.2(c) Automatic Voltage Regulators.* Ship's service generators which are of a shunt type are to be provided with automatic voltage regulators. However, if the load fluctuation does not interfere with the operation of essential auxiliaries, shunt-wound generators without voltage regulators or stabilized shunt-wound machines may be used. An automatic voltage regulator will not be required for the ship's service generators of an approximately flat-compounded type. Automatic voltage regulators are to be provided for all service generators driven by variable speed engines used also for propulsion purposes, whether these generators are of the shunt, stabilized shunt or compound-wound type.

#### 3.23.3 Parallel Operation

For DC generating sets operating in parallel, the following requirements are to be complied with. See also 4-5-2/9.7.2 for protection of DC generators in parallel operation.

*3.23.3(a) Stability.* The generating sets are to be stable in operation at all loads from no-load to full-load.

*3.23.3(b) Load Sharing.* For any load between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 12% from the rated output in kilowatts of the largest generator or 25% from the rated output in kilowatts of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate output with each generator carrying its proportionate share.

*3.23.3(c) Tripping of Circuit Breaker.* DC generators which operate in parallel are to be provided with a switch which will trip the generator circuit breaker upon functioning of the overspeed device.

## 5 Accumulator Batteries

### 5.1 General

#### 5.1.1 Application

All accumulator batteries for engine starting, essential or emergency services are to be constructed and installed in accordance with the following requirements. Accumulator batteries for services other than the above are to be constructed and equipped in accordance with good commercial practice. All accumulator batteries will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

#### 5.1.2 Sealed Type Batteries

Where arrangements are made for releasing gas through a relief valve following an overcharge condition, calculations demonstrating compliance with the criteria in 4-5-3/3.7.3 under the expected rate of hydrogen generation are to be submitted together with the details of installation and mechanical ventilation arrangements.

#### 5.1.3 References

*5.1.3(a) Emergency Services.* For requirements covering emergency services and transitional source of power, see 4-5-2/5 and 4-5-6/9.1.4, respectively.

*5.1.3(b) Protection of Batteries.* For requirements covering protection of batteries, see 4-5-2/9.9.

*5.1.3(c) Battery Installation.* For requirements covering battery installation, ventilation of the battery location and protection from corrosion, see 4-5-3/3.7.

*5.1.3(d) Cable Installation.* For requirements covering cable installation in the battery room, see 4-5-3/5.23.

### 5.3 Construction and Assembly

#### 5.3.1 Cells and Filling Plugs

The cells are to be so constructed as to prevent spilling of electrolyte due to an inclination of 40 deg. from normal. The filling plugs are to be so constructed as to prevent spilling of electrolyte due to the vessel's movements such as rolling and pitching.

#### 5.3.2 Crates and Trays

The cells are to be grouped in crates or trays of rigid construction equipped with handles to facilitate handling. For protection from corrosion, see 4-5-3/3.7.4. The mass of crates or trays are not to exceed 100 kg (220.5 lb).

#### 5.3.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of each crate or tray and are to indicate at least the information as listed in 4-5-4/Table 4b.

### 5.5 Engine-starting Battery

Battery systems for engine-starting purposes may be of the one-wire type and the earth lead is to be carried to the engine frame. See also 4-1-1/17.3 and 4-5-6/9.1.7 for main engine starting and the starting arrangement of the emergency generator (intended for passenger vessels), respectively.

## 7 Switchboards, Distribution Boards, Controllers, etc.

### 7.1 General

#### 7.1.1 Applications *(2010)*

Switchboards are to provide adequate control of the generation and distribution of electric power. The following equipment are to be constructed and tested in accordance with the following requirements to the satisfaction of the Surveyor.

*7.1.1(a) Switchboards.* Switchboards for essential services or for services indicated in 4-5-4/Table 11.

*7.1.1(b) Motor Controllers.* Motor Controllers of 100 kW and over intended for essential services or for services indicated in 4-5-4/Table 11.

*7.1.1(c) Motor Control Centers.* Motor control centers with aggregate loads of 100 kW or more intended for essential services or for services indicated in 4-5-4/Table 11.

*7.1.1(d) Battery Charger Units and Uninterruptible Power System (UPS) Units.* Battery charger units of 25 kW and over and uninterruptible power system (UPS) units of 50 kVA intended for essential services, services indicated in 4-5-4/Table 11, emergency source of power or transitional source of power.

*7.1.1(e) Distribution Boards.* Distribution boards associated with the charging or discharging of the battery system or uninterruptible power system (UPS) in 4-5-4/7.1.1(d).

Switchboard, distribution board, battery charger units, uninterruptible power system (UPS) units, motor control centers and motor controllers not covered by the above paragraph are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

7.1.2 References

*7.1.2(a) Inclination.* For requirements covering inclination for design condition, see 4-5-1/11.

*7.1.2(b) Emergency Switchboard.* For requirements covering emergency switchboard for passenger vessels, see 4-5-6/9.1.5.

*7.1.2(c) Circuit Breakers.* For requirements covering generator circuit breakers, see 4-5-4/11.1.

*7.1.2(d) Feeder Protection.* For requirements covering feeder protection, see 4-5-2/9.3 to 4-5-2/9.17, 4-5-2/11.3, 4-5-2/13.1.4 and 4-5-2/13.3.3

*7.1.2(e) Hull Return and Earthed Distribution System.* For requirements covering hull return system and earthed distribution system, see 4-5-2/7.3 and 4-5-2/7.5, respectively

*7.1.2(f) Earthing.* For requirements covering earthing connections, see 4-5-3/7.

*7.1.2(g) Installation.* For requirements covering installation, see 4-5-3/3.9 for switchboard, 4-5-3/3.11 for distribution boards and 4-5-3/3.13 for motor controllers and control centers.

*7.1.2(h) Protection Enclosure and its Selection.* For requirements covering degree of the protection and the selection of equipment, see 4-5-1/17 and 4-5-3/3.1, respectively.

## 7.3 Testing and Inspection

7.3.1 Applications

*7.3.1(a) Switchboards (2010).* All switchboards intended for essential services or for services indicated in 4-5-4/Table 11, are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For other switchboards, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

*7.3.1(b) Motor Controllers (2010).* All motor controllers of 100 kW and over intended for essential services or for services indicated in 4-5-4/Table 11 are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For other motor controllers, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

*7.3.1(c) Motor Control Centers (2010).* All motor control centers with aggregate loads of 100 kW and over intended for essential services or for services indicated in 4-5-4/Table 11 are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For other motor control centers, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

*7.3.1(d) Battery Charger Units, Uninterruptible Power System (UPS) Units, and Distribution Boards (2010).* Battery charger units of 25 kW and over, uninterruptible power system (UPS) units of 50 kW and over, and distribution boards [associated with the charging or discharging of the battery system or uninterruptible power system (UPS)] are used for essential services (see 4-5-1/3.7), services indicated in 4-5-4/Table 11, emergency source of power (see 4-5-2/5), and transitional source of power (see 4-5-6/9.1.4) are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For all other battery charger units, uninterruptible power system (UPS) units, and distribution boards, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

*7.3.1(e) Test Items.* Tests are to be carried out in accordance with the requirements in 4-5-4/Table 5.

7.3.2 Special Testing Arrangements

In cases where all of the required tests are not carried out at the plant of the manufacturer, the Surveyor is to be notified and arrangements are to be made so that the remaining tests may be witnessed.

## 7.5 Insulation Resistance Measurement

The insulation resistance between current-carrying parts (connected together for the purpose of this test) and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 volts before and after the dielectric strength tests. The insulation resistance measurement after the dielectric strength tests is to be carried out before components which have been disconnected for the dielectric tests are reconnected, and the insulation resistance is not to be less than 1 megohm.

## 7.7 Dielectric Strength of Insulation *(1997)*

The dielectric strength of the insulation is to be tested for 60 seconds by an alternating voltage applied in accordance with 4-5-4/Table 5 between:

*i)* All live parts and the interconnected, exposed conductive parts, and

*ii)* Each phase and all other phases connected for this test to the interconnected exposed conductive parts of the unit.

The test voltage at the moment of application is not to exceed 50% of the values given in 4-5-4/Table 5. It is to be increased steadily within a few seconds to the required test voltage and maintained for 60 seconds. Test voltage is to have a sinusoidal waveform and a frequency between 45 Hz and 60 Hz.

7.7.1 Production-line Apparatus

Standard apparatus produced in large quantities for which the standard test voltage is 2500 volts or less may be tested for one second with a test voltage 20% higher than the one-minute test voltage.

7.7.2 Devices with Low Insulation Strength

Certain devices such as potential transformers having inherently lower insulation strength are to be disconnected during the test.

## 7.9 Construction and Assembly

7.9.1 Enclosures and Assemblies

Enclosures and assemblies are to be constructed of steel or other suitable, incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electrical (magnetic) and thermal stresses likely to be encountered in service, and are to be protected against corrosion. No wood is to be used, except for hardwood for nonconducting hand rails. Insulating materials are to be flame retardant and moisture resistant. The supporting framework is to be of rigid construction.

7.9.2 Dead Front

The dead-front type is to be used. Live-front type is not acceptable, regardless of the voltage ratings.

7.9.3 Mechanical Strength

All levers, handles, hand wheels, interlocks and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they will not be broken or distorted by manual operation.

7.9.4 Mechanical Protection *(2004)*

The sides and the rear and, where necessary, the front of switchboards are to be suitably guarded. Exposed live parts having voltages to earth exceeding a voltage of 55 volts DC or 55 volts AC rms between conductors are not to be installed on the front of such switchboards. Unless the switchboard is installed on an electrically insulated floor, non-conducting mats or gratings are to be provided at the front and rear of the switchboard. Where the floor on which the switchboard is installed is of electrically insulated construction, the insulation level of the floor to the earth is to be at least 50 MΩ. A notice plate is to be posted at the entrance to the switchboard room or on the switchboard front panel to state that the floor in the room is of electrically insulated construction. Drip covers are to be provided over switchboards when subject to damage by leaks or falling objects.

## 7.11 Bus Bars, Wiring and Contacts

7.11.1 Design

Copper bar is to be used for main and generator bus in the switchboard. Other materials and combination of materials will be specially considered. Generator bus bars are to be designed on the basis of maximum generator rating. All other bus bars and bus-bar connections are to be designed for at least 75% of the combined full-load rated currents of all apparatus that they supply, except that when they supply one unit or any group of units in continuous operation, they are to be designed for full load.

7.11.2 Operating Temperature of Bus Bars

Bus bars are to be proportioned to avoid temperatures which will affect the normal operation of electrical devices mounted on the board.

7.11.3 Short Circuit Rating

Circuit breakers and bus bars are to be mounted, braced and located so as to withstand the thermal effects and mechanical forces resulting from the maximum prospective short circuit current. Switchboard instruments, controls, etc., are to be located with respect to circuit breakers so as to minimize the thermal effects due to short circuit currents.

7.11.4 Internal Wiring

Instrument and control wiring is to be of the stranded type and is to have heat-resisting and flame-retarding insulation. Wiring from hinged panels is to be of the extra-flexible type.

7.11.5 Arrangement

*7.11.5(a) Accessibility.* The arrangement of bus bars and wiring on the back is to be such that all lugs are readily accessible.

*7.11.5(b) Locking of Connections (2004).* All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Bolted bus bar connections are to be suitably treated (e.g., silver plating) to avoid deterioration of electrical conductivity over time.

*7.11.5(c) Soldered Connections.* Soldered connections are not to be used for connecting or terminating any wire or cable of nominal cross-sectional area of greater than 2.5 $mm^2$ (4,933 circ. mils). Soldered connections, where used, are to have a solder contact length at least 1.5 times the diameter of the conductor.

7.11.6 Clearances and Creepage Distances

*7.11.6(a) General.* Bare main bus bars, but not including the conductors between the main bus bars and the supply side of outgoing units, are to have minimum clearances (in air) and creepage distances (across surfaces) in accordance with 4-5-4/Table 6.

*7.11.6(b) Alternative (2014).* Alternatively, reduced creepage and clearance distances may be used provided:

*i)* The equipment is not installed in 'Machinery Spaces of Category A' or in areas affected by a Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System.

*ii)* The minimum clearance distance shall not be less than 8 mm

*iii)* The minimum creepage distance shall not be less than 16 mm.

*iv)* The equipment complies with IEC 61439-1.

*v)* In applying IEC 61439-1, the equipment is considered to be:

- Of overvoltage Category III,
- Installed in an environment of pollution degree 3,
- Having insulating material of type IIIa, and
- Installed in inhomogeneous field conditions

*vi)* The temperature dependent criteria in IEC 61439-1 are derated to meet the ambient temperatures found on marine installations. Refer to 4-1-1/Table 1.

*vii)* The equipment is subject to an impulse voltage test with test voltage values shown in the Table below. Where intermediate values of rated operational voltage are used, the next higher rated impulse withstand test voltage is to be used. The impulse voltage test reports are to be submitted to ABS for review.

| *Rated Operational Voltage* <br> *V* | *Rated Impulse Withstand Test Voltage* <br> *kV* |
|---|---|
| 50 | 0.8 |
| 100 | 1.5 |
| 150 | 2.5 |
| 300 | 4 |
| 600 | 6 |
| 1000 | 8 |

#### 7.11.7 Terminals *(2009)*

Terminals or terminal rows for systems of different voltages are to be clearly separated from each other. The rated voltage is to be clearly indicated at least once for each group of terminals which have been separated from the terminals with other voltage ratings. Terminals with different voltage ratings, each not exceeding 50 V DC or 50 V AC may be grouped together. Each terminal is to have a nameplate indicating the circuit designation.

### 7.13 Control and Protective Devices

#### 7.13.1 Circuit-disconnecting Devices

*7.13.1(a) Systems Exceeding 50 Volts (2016).* Distribution boards, chargers or controllers for distribution to motors, appliances, and lighting or other branch circuits are to be fitted with multipole circuit breakers or a multipole switch-fuse combination in each unearthed conductor.

*7.13.1(b) System of 50 Volts and Less (2016).* For distribution boards, chargers or controllers where voltage to earth or between poles does not exceed 50 volts DC or 50 volts AC rms, the fuses may be provided without switches.

*7.13.1(c) Disconnect Device.* The rating of the disconnecting device is to be coordinated with the voltage and current requirements of the load. The disconnect device is to indicate by position of the handle, or otherwise, whether it is open or closed.

#### 7.13.2 Arrangement of Equipment

*7.13.2(a) Air Circuit Breakers.* Air circuit breaker contacts are to be kept at least 305 mm (12 in.) from the vessel's structure unless insulation barriers are installed.

*7.13.2(b) Voltage Regulators.* Voltage regulator elements are to be provided with enclosing cases to protect them from damage.

*7.13.2(c) Equipment Operated in High Temperature.* Where rheostats or other devices that may operate at high temperatures are mounted on the switchboard, they are to be naturally ventilated and so located or isolated by barriers as to prevent excessive temperature of adjacent devices. When this cannot be accomplished, the rheostat or other device is to be mounted separately from the switchboard.

*7.13.2(d) Accessibility to Fuses.* All fuses, except for instrument and control circuits, are to be mounted on or be accessible from the front of the switchboard.

*7.13.2(e) Protective Device for Instrumentation.* All wiring on the boards for instrumentation is to be protected by fuses or current limiting devices. See 4-5-2/9.17.

*7.13.2(f) Wearing Parts.* All wearing parts are to be accessible for inspection and readily renewable.

#### 7.13.3 Markings

Identification plates are to be provided for each piece of apparatus to indicate clearly its service. Identification plates for feeders and branch circuits are to include the circuit designation and the rating of the fuse or circuit-breaker trip setting required by the circuit.

### 7.15 Switchboards

In addition to 4-5-4/7.1 to 4-5-4/7.13, as applicable, the switchboards for essential or emergency services are to comply with the following requirements.

#### 7.15.1 Handrails

Insulated handrail or insulated handles are to be provided on the front of the switchboard. Similarly, where access to the rear is required, insulated handrail or insulated handles are also to be fitted on the rear of the switchboard.

#### 7.15.2 Main Bus Bar Subdivision *(1998)*

Where the main source of electrical power is necessary for propulsion of the vessel, the main bus bar is to be subdivided into at least two parts which are to be normally connected by circuit breaker or other approved means. As far as practicable, the connection of generating sets and any other duplicated equipment is to be equally divided between the parts.

#### 7.15.2 Main Bus Bar Subdivision *(2014)*

Where the main source of electrical power is necessary for propulsion of the vessel, the main bus bar is to be subdivided into at least two sections which are to be normally connected by circuit breaker or other approved means. As far as practicable, the connection of generating sets and any other duplicated equipment is to be equally divided between the sections.

If the arrangement is such that the main switchboard is divided into separate sections which are interconnected by cable, the cable is to be protected at each end against faults.

#### 7.15.3 Equalizer Circuit for Direct-current (DC) Generators

*7.15.3(a) Equalizer Main Circuit.* The current rating of the equalizer main circuit for direct-current (DC) generators is not to be less than half of the rated full-load current of the generator.

*7.15.3(b) Equalizer Bus Bars*. The current rating of the equalizer bus bars is not to be less than half of the rated full-load current of the largest generator in the group.

#### 7.15.4 Equipment and Instrumentation *(2005)*

Equipment and instrumentation are to be provided in accordance with 4-5-4/Table 7. They are to be suitable for starting, stopping, synchronizing and paralleling each generator set from the main switchboard. They may be mounted on the centralized control console, if the main switchboard is located in the centralized control station.

## 7.17 Motor Controllers and Control Centers

In addition to 4-5-4/7.1 to 4-5-4/7.13, as applicable, the motor controllers and control centers for essential or emergency services are to comply with the following requirements.

### 7.17.1 Enclosures and Assemblies

The following materials are acceptable for the enclosures:

- Cast metal, other than die-cast metal, at least 3 mm ($^1/_8$ in.) thick at every point.
- Nonmetallic materials which have ample strength, are noncombustible and non-absorptive (e.g., laminated phenolic material).
- Sheet metal of adequate strength.

Motor control centers are to be constructed so that they are secured to a solid foundation, self-supported, or braced to the bulkhead.

### 7.17.2 Disconnect Switches and Circuit Breakers *(1999)*

Means are to be provided for the disconnection of the full load from all live poles of supply of every motor rated at 0.5 kW or above and its controlgear. Where the controlgear is mounted on or adjacent to a main or auxiliary distribution switchboard, a disconnecting switch in the switchboard may be used for this purpose. Otherwise, a disconnecting switch within the controlgear enclosure or a separate enclosed disconnecting switch is to be provided. Disconnect switches and circuit breakers are to be operated without opening the enclosures in which they are installed.

### 7.17.3 Auto-starters

Alternating-current (AC) motor manual auto-starters with self-contained auto-transformers are to be provided with switches of the quick-make-and-break type, and the starter is to be arranged so that it will be impossible to throw to the running position without having first thrown to the starting position. Switches are to be preferably of the contactor or air-break-type.

## 7.19 Battery Systems and Uninterruptible Power Systems (UPS) *(2008)*

In addition to 4-5-4/7.1 to 4-5-4/7.13, as applicable, equipment for essential, emergency, and transitional sources of power services are to comply with the following requirements. Such equipment would include the battery charger unit, uninterruptible power system (UPS) unit, and the distribution boards associated with the charging or discharging of the battery system or uninterruptible power system (UPS).

### 7.19.1 Definitions *(2008)*

*Uninterruptible Power System (UPS)* – A combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure.

*Off-line UPS unit* – A UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

*Line interactive UPS unit* – An off-line UPS unit where the bypass line switch to stored energy power when the input power goes outside the preset voltage and frequency limits.

*On-line UPS unit* – A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

*DC UPS unit* – A UPS unit where the output is in DC (direct current).

### 7.19.2 Battery Charging Rate

Except when a different charging rate is necessary and is specified for a particular application, the charging facilities are to be such that the completely discharged battery can be recharged to 80% capacity in not more than 10 hours. See also 4-5-4/7.19.6(c)

#### 7.19.3 Discharge Protection

An acceptable means, such as reverse current protection, is to be provided for preventing a failed component in the battery charger unit or uninterruptible power system (UPS) unit from discharging the battery.

#### 7.19.4 Design and Construction *(2008)*

*7.19.4(a) Construction.* Battery charger units and uninterruptible power system (UPS) units are to be constructed in accordance with the IEC 62040 Series, or an acceptable and relevant national or international standard.

*7.19.4(b) Operation.* The operation of the UPS is not to depend upon external services.

*7.19.4(c) Type.* The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

*7.19.4(d) Continuity of Supply.* An external bypass is to be provided to account for a failure within the uninterruptible power system (UPS).

*7.19.4(e) Monitoring and Alarming.* The battery charger unit or uninterruptible power system (UPS) unit is to be monitored and audible and visual alarm is to be given in a normally attended location for the following.

- Power supply failure (voltage and frequency) to the connected load
- Earth fault,
- Operation of battery protective device,
- When the battery is being discharged, and
- When the bypass is in operation for on-line UPS units.

#### 7.19.5 Location *(2008)*

*7.19.5(a) Location.* The UPS unit is to be suitably located for use in an emergency. The UPS unit is to be located as near as practical to the equipment being supplied, provided the arrangements comply with all other Rules, such as 4-5-3/3.7, 4-5-3/3.9, 4-5-3/3.11, and 4-5-3/3.13 for location of electrical equipment.

*7.19.5(b) Ventilation.* UPS units utilizing valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of 4-5-3/3.7. Since valve regulated sealed batteries are considered low-hydrogen-emission batteries, calculations are to be submitted in accordance with 4-5-3/3.7.2(d) to establish the gas emission performance of the valve regulated batteries compared to the standard lead acid batteries. Arrangements are to be provided to allow any possible gas emission to be led to the weather, unless the gas emission performance of the valve regulated batteries does not exceed that of standard lead acid batteries connected to a charging device of 0.2 kW.

*7.19.5(c) Battery Installation.* For battery installation arrangements, see 4-5-3/3.7.

#### 7.19.6 Performance *(2008)*

*7.19.6(a) Duration.* The output power is to be maintained for the duration required for the connected equipment as stated in 4-5-2/5 or 4-5-6/9.1 for emergency services and 4-5-6/9.1.4 of transitional source of power, as applicable.

*7.19.6(b) Battery Capacity.* No additional circuits are to be connected to the battery charger unit or UPS unit without verification that the batteries have adequate capacity. The battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in 4-5-4/7.19.6(a).

*7.19.6(c) Recharging.* On restoration of the input power, the rating of the charging facilities are to be sufficient to recharge the batteries while maintaining the output supply to the load equipment. See also 4-5-4/7.19.2.

#### 7.19.7 Testing and Survey *(2008)*

*7.19.7(a) Surveys.* Equipment units are to be surveyed during manufacturing and testing in accordance with 4-5-4/7.3.1.

*7.19.7(b) Testing.* Appropriate testing is to be carried out to demonstrate that the battery charger units and uninterruptible power system (UPS) units are suitable for the intended environment. This is expected to include as a minimum the following tests:

- Functionality, including operation of alarms;
- Temperature rise;
- Ventilation rate;
- Battery capacity

*7.19.7(c) Test upon power input failure.* Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

# 9 Transformers

## 9.1 General

#### 9.1.1 Applications *(2004)*

All transformers which serve for essential or emergency electrical supply are to be constructed, tested and installed in accordance with the following requirements. Transformers other than the above services, auto-transformers for starting motors or isolation transformers are to be constructed and equipped in accordance with good commercial practice. All transformers are to be of the dry and air cooled type. The use of liquid immersed type transformers will be subject to special consideration. Transformers other than for essential or emergency services will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

#### 9.1.2 References

*9.1.2(a) Power Supply Arrangement.* For requirements covering arrangement of power supply through transformers to ship’s service systems onboard passenger vessels, see 4-5-6/9.5.

*9.1.2(b) Protection.* For requirements covering protection of transformers, see 4-5-2/9.15.

*9.1.2(c) Protection Enclosures and its Selection.* For requirements covering selection of the protection enclosures for location conditions, see 4-5-3/3.1.1.

#### 9.1.3 Forced Cooling Arrangement (Air or Liquid)

Where forced cooling medium is used to preclude the transformer from exceeding temperatures outside of its rated range, monitoring and alarm means are to be provided and arranged so that an alarm activates when pre-set temperature conditions are exceeded. Manual or automatic arrangements are to be made to reduce the transformer load to a level corresponding to the cooling available.

## 9.3 Temperature Rise *(2014)*

The maximum temperature rise of the transformer insulated windings, based on an ambient temperature of 45°C (113°F), is not to exceed the values listed in 4-5-4/Table 8.

## 9.5 Construction and Assembly

#### 9.5.1 Windings

All transformer windings are to be treated to resist moisture, sea atmosphere and oil vapors.

#### 9.5.2 Terminals

Terminals are to be provided in an accessible position. The circuit designation is to be clearly marked on each terminal connection. The terminals are to be so spaced or shielded that they cannot be accidentally earthed, short-circuited or touched.

#### 9.5.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the information as listed in 4-5-4/Table 4c.

#### 9.5.4 Prevention of the Accumulation of Moisture *(2002)*

Transformers of 10 kVA/phase and over are to be provided with effective means to prevent accumulation of moisture and condensation within the transformer enclosure where the transformer is disconnected from the switchboard during standby (cold standby). Where it is arranged that the transformer is retained in an energized condition throughout a period of standby (hot standby), the exciting current to the primary winding may be considered as a means to meet the above purpose. In case of hot standby, a warning plate is to be posted at or near the disconnecting device for the primary side feeder to the transformer.

### 9.7 Testing *(1999)*

For single-phase transformers rated 1 kVA and above or three-phase transformers rated 5 kVA and above intended for essential or emergency services, the following tests are to be carried out by the transformer's manufacturer in accordance with a recognized standard whose certificate of test is to be submitted for review upon request.

*i)* Measurement of winding resistance, voltage ratio, impedance voltage, short circuit impedance, insulation resistance, load loss, no load loss and excitation current, phase relation and polarity.

*ii)* Dielectric strength.

*iii)* Temperature rise (required for one transformer of each size and type). See 4-5-4/9.3.

## 10 Semiconductor Converters for Adjustable Speed Motor Drives *(2014)*

### 10.1 Application

All semiconductor converters that are used to control motor drives having a rated power of 100 kW (135 hp) and over intended for essential services (see definition in 4-5-1/3.7) or for services indicated in 4-5-4/Table 11 are to be designed, constructed and tested in accordance with the requirements of 4-5-4/10.

Manufacturer's tests for semiconductor converters that are used to control motor drives having a rated power less than 100 kW (135 hp) for essential services (see definition in 4-5-1/3.7) or for services indicated in 4-5-4/Table 11 are to include at least the tests described in 4-5-4/10.7. All other semiconductor converters used to control motor drives are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications.

The required tests may be carried out at the manufacturer facility whose certificates of tests will be acceptable and are to be submitted upon request to ABS. All semiconductor converters will only be accepted subject to a satisfactory performance test conducted to the satisfaction of the attending Surveyor after installation.

### 10.3 Standards of Compliance

The design of semiconductor converters for adjustable speed motor drives, unless otherwise contradicted by ABS Rules, shall be in compliance with the requirements of IEC Publication 61800-5-1:2007 (titled 'Adjustable speed electrical power drive systems : Safety Requirements – Electrical, thermal and energy') and 60146-1-1:2009 (titled 'Semiconductor converters – General requirements and line commutated converters – Specification of basic requirements). For convenience, the following requirements are listed.

### 10.5 Design, Construction and Assembly Requirements

#### 10.5.1 Rating

Semiconductor converters are to be rated for continuous load conditions and if required by the application, are to have specified overload capabilities.

The operation of the semiconductor converter equipment, including any associated transformers, reactors, capacitors and filter circuits, shall not cause harmonic distortion and voltage and frequency variations in excess of the values mentioned in 4-5-2/7.9 and 4-5-1/Table 1, respectively.

The semiconductor converter circuits shall be able to withstand voltage and current transients that the system may be subject to for certain applications.

The semiconductor converters are to be suitable for environmental conditions found in marine installations such as those mentioned in 4-1-1/Table 1.

#### 10.5.2 Enclosures

Enclosures and assemblies are to be constructed of steel or other suitable incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electro-magnetic and thermal stresses which may be encountered under both normal and fault conditions.

Enclosures are to be of the closed type. The degree of protection of the enclosure is to be in accordance with 4-5-3/Table 1. For HV converters, the enclosure is to satisfy the requirements in 4-5-5/Table 1.

All wearing parts are to be accessible for inspection and be readily replaceable.

#### 10.5.3 Nameplate Data

A nameplate made of corrosion resistant material is to be provided on the semiconductor assembly and is to indicate at least the following:

*i)* Manufacturer's name and identification reference/equipment serial number

*ii)* Number of input and output phases

*iii)* Rated input voltage and current

*iv)* Rated output voltage and current

*v)* Rated input and output frequency, if any

*vi)* Range of output frequency

*vii)* Maximum permissible prospective symmetrical rms short-circuit current of the power source

*viii)* Cooling methods

*ix)* Degree of protection

#### 10.5.4 Warning Labels

Appropriate warning labels informing the user of the dangers with working with the different parts of the converter assembly is to be placed at all appropriate places of the assembly.

#### 10.5.5 Hand Rails

Insulated handrails or insulated handles are to be provided for each front panel of the assembly. Where access to the rear is also required, insulated handrails or insulated handles are to be fitted to the rear of the assembly as well.

#### 10.5.6 Accessibility

All components of the semiconductor converter assembly are to be mounted in such a manner that they can be removed from the assembly for repair or replacement without having to dismantle the complete unit.

#### 10.5.7 Capacitor Discharge

Capacitors within a semiconductor converter assembly shall be discharged to a voltage less than 60 V, or to a residual charge less than 50 μC, within 5 seconds after the removal of power. If this requirement cannot be met, appropriate warning labels shall be placed on the assembly.

10.5.8 Cooling Arrangements *(2017)*

Design of cooling systems is to be based on an ambient air temperature of 45°C (113°F) indicated in 4-1-1/25 and 4-1-1/Table 1.

Semiconductor converter assemblies are to be installed away from sources of radiant energy in locations where the circulation of air is not restricted to and from the assembly and where the temperature of the inlet air to air-cooled converters will not exceed that for which the converter has been designed.

Where arrangements for forced cooling have been provided, the equipment is, unless otherwise specifically required, to be designed such that power cannot be applied to, or retained on, the semiconductor circuits, unless effective cooling is maintained. Other effective means of protection against equipment over-temperature such as reduction in the driven load may also be acceptable.

Semiconductor assemblies with forced cooling are to be provided with a means of monitoring the temperature of the cooling medium. Over-temperature of the cooling medium is to be alarmed locally and at a continuously manned location and the equipment shutdown when temperature exceeds the manufacturer specified value.

Semiconductor assemblies with liquid cooling are to be provided with a means to detect leakage. In case of leakage, an audible and visible alarm is to be initiated locally and remotely at a continuously manned location. Means to contain any leakage are to be provided so that the liquid does not cause a failure of the semiconductor assembly or any other electrical equipment located near the converter. Where the cooling liquid is required to be non-conducting, the conductivity of the cooling liquid is to be monitored and an alarm given both locally and remotely in a continuously manned location if the conductivity exceeds the manufacturer specified value.

In case of failure of the cooling system, an alarm is to be given both locally and remotely at a continuously manned location and the output current is to be reduced automatically.

Cooling liquids which are in contact with live unearthed parts of the assembly are to be non-conductive and non-flammable.

10.5.9 Emergency Stop

When required, semiconductor converter assemblies shall be provided with an emergency stop function. The emergency stop circuit is to be hard-wired and independent of any control system signal.

10.5.10 Electrical Protection *(2016)*

*10.5.10(a) Overvoltage Protection.* Means are to be provided to prevent excessive overvoltage in a supply system to which semiconductor converters are connected and to prevent the application of voltages in excess of the rating of semiconductor devices.

*10.5.10(b) Overcurrent Protection.* Arrangements are to be made so that the permissible current of semiconductor converters or semiconductor devices associated with the semiconductor converter cannot be exceeded during operation.

*10.5.10(c) Short Circuit Protection.* Semiconductor converters and the associated semiconductor devices are to be protected against short circuit.

*10.5.10(d) Filter Circuits.* Filter circuits are to be protected against overvoltage, overcurrent and short circuit.

*10.5.10(e) Alarms.* Visual and audible alarms are to be provided at the control station in the event of operation of the protection system.

10.5.11 Clearance and Creepage Distances

Clearance and creepage distances used in standard production (COTS) semiconductor converter assemblies are to be in accordance with IEC 61800-5-1 and suitable for overvoltage category III, pollution degree 3 and insulating material group IIIa. The relevant values are reproduced in the Table below for convenience.

| *System Voltage (V)* | *Minimum Clearance Distance (mm)* |
|---|---|
| ≤50 | 0.8 |
| 100 | 0.8 |
| 150 | 1.5 |
| 300 | 3.0 |
| 600 | 5.5 |
| 1000 | 8.0 |
| 3600 | 25 |
| 7200 | 60 |
| 12000 | 90 |
| 15000 | 120 |

*Note:* Interpolation is permitted.

| *Working Voltage (rms) (V)* | *Minimum Creepage Distance (mm)* |
|---|---|
| 50 | 1.9 |
| 100 | 2.2 |
| 125 | 2.4 |
| 160 | 2.5 |
| 200 | 3.2 |
| 250 | 4.0 |
| 320 | 5.0 |
| 400 | 6.3 |
| 500 | 8.0 |
| 630 | 10.0 |
| 800 | 12.5 |
| 1000 | 16 |
| 1250 | 20 |
| 1600 | 25 |
| 2000 | 32 |
| 2500 | 40 |
| 3200 | 50 |
| 4000 | 63 |
| 5000 | 80 |
| 6300 | 100 |
| 8000 | 125 |
| 10000 | 160 |

*Note:* Interpolation is permitted.

### 10.5.12 Protection and Monitoring Requirements

Semiconductor assemblies, as a minimum, shall have alarm functions for the following parameters:

*i)* Overcurrent

*ii)* Overload

*iii)* Overvoltage

*iv)* Ground fault

*v)* Loss of cooling

*vi)* Increase in resistivity of cooling medium (for liquid cooled converters)

*vii)* Over-temperature

*viii)* Loss of communication to process control

*ix)* Loss of motor speed feedback

If harmonic filters are used in conjunction with semiconductor converter assemblies, refer to 4-5-2/9.19 for additional protection requirements.

For vessels with electric propulsion, refer to 4-7-2/Table 6B of the ABS *Rules for Building and Classing Steel Vessels Under 90 Meters (295 Feet) in Length*.

10.5.13 Load-sharing

When semiconductor converters have multiple parallel/series circuits, load sharing between the multiple circuits is to be distributed uniformly, as far as practicable.

10.5.14 EMC Emission Requirements

If requested by the customer, EM immunity and EM emissions testing of the semiconductor assembly shall be done as an optional test in accordance with IEC 61800-3 (titled 'Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods').

*Note:* Radiated and conducted emissions/immunity does not depend on the equipment alone but also on the interaction between the semiconductor converter assembly and the rest of the power system. There shall be communication between the manufacturer and the customer as to what installation guidelines may need to be followed to satisfy the different EM emission/immunity requirements, such as cable routing, types of interconnect cables used, cable shielding, etc.

10.5.15 Harmonic Filter Requirements

If harmonic filter circuits are used in association with semiconductor converter assemblies to reduce the harmonics and transients in the system, they are to comply with the requirements in 4-5-2/9.19.

10.5.16 Performance

The converter control system shall be able to control the motor by speed ramp, torque or power, as per customer specification.

Upon loss of the reference signal, the converter shall either decelerate the driven motor to minimum speed/torque/power or down to standstill as per customer specification for the required application.

When, during normal operation, the motor is decelerated to standstill, it shall be possible to de-energize the motor by blocking the control signals to the power semiconductors, while leaving the converter input circuit energized.

When automatic restart is specified, the converter shall be capable of catching an already spinning motor.

## 10.7 Inspection and Testing

*(2016)* Semiconductor assemblies for motor drives shall undergo Type tests, Routine tests and Optional tests, if any specifically required by the Owner, at manufacturer's production facility as per the Table below. The Type tests, Routine tests and Optional tests shall be conducted in the presence of and witnessed by an ABS Surveyor. Type tests shall be carried out one prototype of a converter or the first of a batch of identical converters. Routine tests shall be carried on each assembly. A summary of the required type tests and routine tests are given in the Table below:

| *No.* | *Tests (see 4-5-4/10.7)* | *Type Test* | *Routine Test* | *ABS Reference* | *IEC Test Reference* |
|---|---|---|---|---|---|
| 1 | Visual inspection | x | x | 4-5-4/10.7.1 | 61800-5-1/5.2.1 |
| 2 | Insulation test (AC or DC voltage test) | x | x | 4-5-4/10.7.2 | 61800-5-1/5.2.3.2 |
| 3 | Insulation resistance test | x | x | 4-5-4/10.7.4 | 60146-1-1/7.2.3.1 |
| 4 | Impulse voltage test | x | | 4-5-4/10.7.3 | 61800-5-1/5.2.3.1 |
| 5 | Cooling system test | x | x | 4-5-4/10.7.5 | 61800-5-1/5.2.4.5 |
| 6 | Breakdown of components test | x | | 4-5-4/10.7.6 | 61800-5-1/5.2.3.6.4 |
| 7 | Light load and functional test | x | x | 4-5-4/10.7.7 | 60146-1-1/7.3.1 |
| 8 | Rated current test | x | | 4-5-4/10.7.8 | 60146-1-1/7.3.2 |
| 9 | Temperature rise test | x | | 4-5-4/10.7.9 | 61800-5-1/5.2.3.8 |
| 10 | Capacitor discharge test | x | | 4-5-4/10.7.10 | 61800-5-1/5.2.3.7 |

### 10.7.1 Visual Inspection

Semiconductor assemblies are subject to visual inspection for the following aspects:

*i)* Verify enclosure integrity, alignment of different cabinets in the assembly as per system drawings.

*ii)* Verify if nameplate is present as per 4-5-4/10.5.3.

*iii)* Check if adequate and visible warning and safety labels are present.

*iv)* General hardware and electrical point-to-point wire check.

*v)* Verify correct routing and connections of fiber optic cables and ethernet cables.

*vi)* Verify correct connection of grounding wires on the assembly.

*vii)* Point-to-point inspection of cooling system, if applicable. For drive assemblies with liquid cooling, verification of proper installation of piping and hoses, correct orientation of flow restrictors and related coolant liquid monitoring instrumentation.

*viii)* Door interlocks, if any

### 10.7.2 Insulation Test (AC or DC Voltage Test) *(2017)*

Semiconductor assemblies shall be subject to insulation tests to ensure adequate dielectric strength of insulation of its components and to verify that clearance distances have not been compromised during manufacturing operations. The insulation test is to be performed with the appropriate AC or DC voltage (equal to the peak value of the specified AC rms voltage) mentioned in Table 21/ Table 22/Table 23 of IEC 61800-5-1(2007). The AC test voltage is to be voltage of sinusoidal wave form and a frequency of 50 Hz/60 Hz. The duration of the test is to be at least 5 sec for the Type Test and 1 sec for the Routine Test. All main power, control power and logic circuits have to be subject to the Insulation test.

### 10.7.3 Impulse Voltage Test

Semiconductor assemblies shall be subject to an Impulse voltage test to simulate the impact of impulse transient over voltages generated in the mains supply or those caused by switching of equipment. The impulse voltage test is to be done as per 5.2.3.1 of IEC 61800-5-1(2007). For purposes of selection of test voltages, the semiconductor assembly shall be treated as belonging to overvoltage category III.

Impulse voltage tests shall be done as a routine test on assemblies that do not satisfy the clearance and creepage distance requirements of 4-5-4/10.5.11.

### 10.7.4 Insulation Resistance Test

One minute after the insulation test, insulation resistance shall be measured by applying a direct voltage of at least 500 V.

#### 10.7.5 Cooling System Test

Semiconductor assemblies shall be subject to cooling system tests that test for failure of the cooling system and the associated response of the semiconductor assembly to these cooling system failures as per 5.2.4.5 of IEC 61800-5-1 (2007).

In addition, for liquid cooled semiconductor assemblies, the cooling piping system shall be subject to a coolant leak pressure test. The cooling system piping shall be hydrostatically tested to 1.5 times the design pressure for a period of 30 minutes. The pressure relief mechanism shall also be checked for proper calibration and operation. The cooling system shall be verified as having no leakage by monitoring the pressure and by visual inspection.

The instrumentation critical to the operation of the cooling system such as valve positions, programming of level switch sensors, flow sensors, pressure sensors, temperature sensors, pressure relief valve operation, coolant conductivity sensor, etc., shall be checked to ensure correct calibration and functionality.

#### 10.7.6 Breakdown of Components Test

Components which have been identified by circuit analysis could result in a thermal or electric shock hazard are to be subject to a breakdown test as per 5.2.3.6.4 of IEC 61800-5-1.

#### 10.7.7 Light Load and Functional Test

Semiconductor assemblies shall be subject to a light load and functional test to ensure that all parts of the electrical circuit and the cooling system work properly together and that the assembly meets the required proof of performance as per customer requirements. The main things to be checked include, but are not limited to:

*i)* Verify that the control equipment, auxiliaries, protection equipment and main circuit are operating properly together.

*ii)* Check power supplies to different power and control circuits of the assembly and associated communication control interfaces.

*iii)* Check pre-charge circuit settings.

*iv)* Verify the various software parameters.

*v)* Check for voltage/current sharing in the semiconductor devices used in the arms of the converter.

*vi)* Testing of the converter for scenarios like, but not limited to, emergency trip of the assembly, input fault protection, loss of cooling, local and remote control operation, etc.

*vii)* Testing of the converter for any specific customer defined scenario like output power ramp-down on loss of input power, ability of the converter to catch a spinning motor after recovering from a trip or from automatic restart, etc.

#### 10.7.8 Rated Current Test

The test is carried out to verify that the equipment will operate satisfactorily at rated current. The DC terminals shall be short-circuited directly or with a reactor and an alternating voltage of sufficient value, to cause at least the rated continuous direct current to flow, shall be connected to the AC terminals of the converter and operation of the assembly shall be checked.

#### 10.7.9 Temperature Rise Test

The test is carried out to verify that parts and accessible surfaces of the semiconductor assembly do not exceed temperature limits specified below and the manufacturer’s temperature limits of safety-relevant parts. The temperature rise test is to be conducted at worst-case conditions of rated power and rated output current.

| *Materials and Components* | *Thermometer Method (°C)* | *Resistance Method (°C)* |
|---|---|---|
| Rubber/Thermoplastic-insulated conductors | 55 | - |
| User terminals | Note 1 | - |
| Copper bus bars and connecting straps | 120 | - |
| Winding Insulation | | |
| Class A | 95 | 105 |
| Class E | 100 | 115 |
| Class B | 105 | 125 |
| Class F | 115 | 135 |
| Class H | 135 | 155 |
| Class N | 175 | 195 |
| Phenolic composition | 145 | - |
| Bare resistor material | 395 | - |
| Capacitor | Note 2 | - |
| Power switching semiconductors | Note 2 | - |
| Printed wiring boards (PWB's) | Note 2 | - |
| Liquid cooling medium | Note 2 | - |

*Notes:*

1 Maximum terminal temperature shall not exceed 15°C more than the insulation temperature rating of the conductor or cable specified by the manufacturer.

2 Maximum temperature shall be as specified by the manufacturer.

#### 10.7.10 Capacitor Discharge Test

Verification of the capacitor discharge time as required in 4-5-4/10.7.7 is required to be done by a test and/or by calculation.

### 10.9 Integration Requirements

#### 10.9.1 Integration

In cases where the semiconductor converters are integrated into larger assemblies that have other components (i.e., transformers, reactors, motors, etc.), the individual tests of the other components shall be done in accordance with relevant portions of the ABS Rules.

Installation requirements such as earthing of equipment, selection of cable and acceptable cable lengths, etc., should be as per manufacturer installation guidelines.

#### 10.9.2 Reactors and Transformers for Semiconductor Converters

*10.9.2(a) Voltage Regulation.* Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

*10.9.2(b) High Temperature Alarm.* Interphase reactors and transformers used with the semiconductor converters for main and auxiliary propulsion systems are to be provided with a high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in 4-5-4/9.3.

#### 10.9.3 Critical Speeds

The semiconductor converter supplier, the driven equipment supplier and the Owner should come to an agreement on the calculations of the resulting critical lateral speeds of the whole mechanical string with special attention being paid to the following:

*i)* Take into account the influence of the stiffness of the bearing arrangement and the foundation.

*ii)* Avoid any continuous running with insufficient damping close to lateral critical speeds (±20%).

# 11 Other Electric and Electronics Devices

## 11.1 Circuit Breakers

### 11.1.1 General

Circuit breakers are to be constructed and tested to comply with IEC Publication 60947-2 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. Circuit breakers of the thermal type are to be calibrated for an ambient-air temperature, as provided in 4-5-1/19.

*Note:* Where thermal-type breakers are mounted within enclosures, it is pointed out that the temperature within the enclosure may exceed the designated ambient-air temperature.

### 11.1.2 Mechanical Property

Arc-rupturing and main contacts of all open frame circuit breakers are to be self-cleaning.

### 11.1.3 Isolation

The electrical system is to be arranged so that portions may be isolated to remove circuit breakers while maintaining services necessary for propulsion and safety of the vessel, or circuit breakers are to be mounted or arranged in such a manner that the breaker may be removed from the front without disconnecting the copper or cable connections or without de-energizing the supply to the breaker.

## 11.3 Fuses

Fuses are to be constructed and tested to comply with IEC Publication 60269 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. All components of the fuse are to be resistant to heat, mechanical stresses and corrosive influences which may occur in normal use.

## 11.5 Semiconductor Converters

### 11.5.1 General

The requirements in this Subsection are applicable to static converters for essential and emergency services using semiconductor rectifying elements such as diodes, reverse blocking triodes thyristors, etc. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. All semiconductor converters will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

### 11.5.2 Cooling Arrangements

Semiconductor converters are preferably to be of a dry and air-cooled type. Where semiconductor converters are of a liquid-immersed type, a liquid over-temperature alarm and gas overpressure protection devices are to be provided. If provision is made for breathing, a dehydrator is to be provided. Where arrangement for the forced cooling is provided, the circuit is to be designed so that power cannot be applied to, or retained on, converter stacks unless effective cooling is maintained.

### 11.5.3 Accessibility

Semiconductor converter stacks or semiconductor components are to be mounted in such a manner so that they can be removed from equipment without dismantling the complete unit.

### 11.5.4 Nameplate

A nameplate or identification is to be provided on the semiconductor converter and is to indicate at least the information as listed in 4-5-4/Table 4d.

### 11.7 Cable Junction Boxes

#### 11.7.1 General

The design and construction of the junction boxes are to be in compliance with 4-5-4/11.7.2 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

#### 11.7.2 Design and Construction

Live parts are to be mounted on durable flame-retardant moisture-resistant material, of permanently high dielectric strength and high resistance. The live parts are to be so arranged by suitable spacing or shielding with flame-retardant insulating material that short-circuit cannot readily occur between conductors of different polarity or between conductors and earthed metal. Junction boxes are to be made of flame-retardant material and are to be clearly identified, defining their function and voltage.

## 13 Cables and Wires

### 13.1 Cable Construction

#### 13.1.1 General *(1 July 2017)*

Electric cables are to have conductors, insulation and moisture-resistant jackets, in accordance with IEC Publication 60092-350, 60092-352, 60092-353, 60092-354, 60092-360, 60092-370, 60092-376, or IEEE Std. 45. Other recognized marine standards of an equivalent or higher safety level, will also be considered. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. Network cables are to comply with a recognized industry standard. Cables such as flexible cable, fiber-optic cable, etc., used for special purposes may be accepted provided they are manufactured and tested in accordance with recognized standards accepted by ABS. Conductors are to be of copper and stranded in all sizes. Conductors are not to be less than the following in cross sectional size:

- 1.0 $mm^2$ (1,973.5 circ. mils) for power and lighting,
- 0.5 $mm^2$ (986.8 circ. mils) for control cables,
- 0.5 $mm^2$ (986.8 circ. mils) for essential or emergency signaling and communications cables, except for those assembled by the equipment manufacturer, and
- 0.35 $mm^2$ (690.8 circ. mils) for telephone cables for nonessential communication services, except for those assembled by the equipment manufacturer.

See 4-5-4/Table 10 for current carrying capacity for insulated copper wires and cables.

For electric cables in hazardous areas, the electric cable construction and the cable glands are to achieve the appropriate seal, such that gas cannot migrate through the cable.

*Note:* See clause 3.16 and clause 4.6 of IEC 60092-350 concerning the provision of an extruded impervious inner sheath that will prevent the migration of gas through the cable.

#### 13.1.2 Flame Retardant Property

*13.1.2(a) Standards.* All electric cables are to be at least of a flame retardant type complying with the following:

- *(2016)* Depending on the intended installation, cables constructed to IEC Publication 60092 standards are to comply with the flammability criteria of IEC Publication 60332-3-22 or 60332-3-21, Category A or A F/R, or
- Cables constructed to IEEE Std. 45 are to comply with the flammability criteria of that standard, or
- *(2016)* Cables constructed to another recognized marine standard, where specially approved, are to comply with the flammability criteria of IEC Publication 60332-3-22 or 60332-3-21, Category A or A F/R (depending on the intended installation) or other acceptable standards.

Consideration will be given to the special types of cables, such as radio frequency cable, which do not comply with the above requirements.

*13.1.2(b) Alternative Arrangement (2005).* Flame-retardant marine cables, including network cables, which have not passed the above-mentioned bunched cable flammability criteria may be considered, provided that the cable is treated with approved flame-retardant material or the installation is provided with approved fire stop arrangements. Special consideration may be given to the flame retardancy of special types of cables, such as radio frequency cables. When specifically approved, bus duct may be used in lieu of cable.

#### 13.1.3 Fire Resistant Property *(2016)*

Where electrical cables are required to be fire resistant, they are to comply with the requirements of IEC Standard 60331-1 for cables greater than 20 mm overall in diameter, otherwise they are to comply with the IEC Standard 60331-2 for cable diameters 20 mm or less. For special cables, requirements in the following standards may be used:

- IEC Standard 60331-23: Procedures and requirements – Electric data cables
- IEC Standard 60331-25: Procedures and requirements – Optical fiber cables

Cables complying with alternative national standards suitable for use in a marine environment may be considered. Fire resistant type cables are to be easily distinguishable. See also 4-5-3/5.17.1, 4-5-6/9.11, and 4-5-6/9.15.

#### 13.1.4 Insulation Material

All electrical cables for power, lighting, communication, control and electronic circuits are to have insulation suitable for a conductor temperature of not less than 60°C (140°F). See 4-5-4/Table 9 for types of cable insulation.

#### 13.1.5 Armor for Single-conductor Cables

The armor is to be nonmagnetic for single-conductor alternating-current cables.

#### 13.1.6 Fiber Optic Cables

Fiber optic cables are to be constructed and tested to a recognized fiber optic cable construction standard acceptable to ABS. The requirements of flame retardancy for the electrical cables are applicable to the fiber optic cables. The construction of the fiber optic cable which may pass through or enter a hazardous area is to be such that escape of gases to a safe area is not possible through the cable.

### 13.3 Portable and Flexing Electric Cables

Unless otherwise required in the Rules, cables for portable equipment and cables subject to flexing service need not be armored.

### 13.5 Mineral-insulated Metal-sheathed Cable

Mineral-insulated cable provided with approved fittings for terminating and connecting to boxes, outlets and other equipment may be used for any service up to 600 volts and may be used for feeders and branch circuits in both exposed and concealed work in dry or wet locations. The moisture-resisting jacket (sheath) of mineral-insulated metal-sheathed cable exposed to corrosive conditions is to be made of or protected by materials suitable for those conditions.

## TABLE 1
## Factory Test Schedule for Generators and Motors ≥ 100 kW (135 hp) [See 4-5-4/3.3.1(a)] *(2003)*

| | Tests | *AC generators* | | *AC motors* | | *DC machines* | |
|---|---|---|---|---|---|---|---|
| | | *Type test (1)* | *Routine test (2)* | *Type test (1)* | *Routine test (2)* | *Type test (1)* | *Routine test (2)* |
| 1 | Visual inspection. | x | x | x | x | x | x |
| 2 | Insulation resistance measurement. | x | x | x | x | x | x |
| 3 | Winding resistance measurement. | x | x | x | x | x | x |
| 4 | *(2003)* Verification of voltage regulation system. | x | x (3) | | | | |
| 5 | Rated load test and temperature rise measurement. | x | | x | | x | |
| 6 | *(2003)* Overload/over-current test. | x | x (4) | x | x (4) | x | x (4) |
| 7 | Verification of steady short circuit condition. (5) | x | | | | | |
| 8 | *(2003)* Over-speed test. | x | x | x (6) | x (6) | x (6) | x (6) |
| 9 | Dielectric strength test. | x | x | x | x | x | x |
| 10 | Running balance test. (7) | x | x | x | x | x | x |
| 11 | Verification of degree of protection. | x | | x | | x | |
| 12 | Bearing check after test. | x | x | x | x | x | x |
| 13 | Air gap measurement. | x | x | | | x | x |
| 14 | Commutation check. | | | | | x | |

*Notes*

1 Type tests apply to prototype machines or to at least the first of a batch of machines.

2 *(2003)* Machines to be routine tested are to have reference to the machine of the same type that has passed a type test. Reports of routine tested machines are to contain manufacturers' serial numbers of the type tested machines and the test results.

3 *(2003)* Only functional test of voltage regulator system.

4 *(2003)* Applicable only to generators and motors ≥ 100 kW (135 hp) for essential services.

5 *(2003)* Verification at steady short circuit condition applies to synchronous generators only.

6 *(2003)* Where so specified and agreed upon between purchaser and manufacturer. Not required for squirrel cage motors.

7 Static balance (machine rated 500 rpm or less) or dynamic balance (over 500 rpm) will be accepted in lieu of the specified test on machines to be close-coupled to engines and supplied without shaft and/or bearings, or with incomplete set of bearings.

## TABLE 2
## Dielectric Strength Test for Rotating Machines [See 4-5-4/3.9]

| *Item* | | *Machine or Part* | *Test Voltage (AC rms)* |
|---|---|---|---|
| 1 | | Insulated windings of rotated machines having rated output less than 1 kVA, and of rated voltage less than 100 V with the exception of those in items 4 to 8. | 500 V + twice the rated voltage. |
| 2 | | Insulated windings of rotating machines having rated output less than 10,000 kVA with the exception of those in items 1 and 4 to 8 (See Note 2). | 1,000 V + twice the rated voltage with minimum of 1,500 V (See Note 1). |
| 3 | | *(1999)* Insulated windings of rotating machines having rated output 10,000 kVA or more, and of rated voltage (see Note 1) up to 24,000 V with the exception of those in items 4 to 8 (see Note 2). | 1,000 V + twice the rated voltage. |
| 4 | | Separately-excited field windings of DC machines. | 1,000 V + twice the maximum rated circuit voltage with minimum of 1,500 V (See Note 1). |
| 5 | | Field windings of synchronous generators and synchronous motors. | |
| | a) | Field windings of synchronous generators | Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V. |
| | b) | When the machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of winding. | Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V. |
| | c) | When the machine will be started either with:<br>– the field winding connected across resistance or more than ten times the field winding resistance, or<br>– the field windings on open circuit or without a field dividing switch. | 1,000 V + twice the maximum value of the voltage with a minimum of 1,500 V<br>– between the terminals of the field winding,<br>or<br>– between the terminals of any section for a sectionalized field winding,<br>which will be occurred under the specified starting conditions (see Note 3). |
| 6 | | Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g., if intended for rheostatic starting) | |
| | a) | For non-reversing motors or motors reversible from standstill only. | 1,000 V + twice the open-circuit standstill voltage as measured between slip-rings or secondary terminals with rated voltage applied to the primary windings. |
| | b) | For motors to be reversed or braked by reversing the primary supply while the motor is running. | 1,000 V + four times the open-circuit standstill secondary voltage as defined in item 6.a. above. |
| 7 | | Exciters (except as listed below)<br>*Exception 1*—Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field winding during starting<br>*Exception 2*—Separately excited field windings of exciters (see Item 4 above). | As for windings to which they are connected. 1,000 V + twice the rated exciter voltage with a minimum of 1,500 V. |
| 8 | | Assembled group of machines and apparatus. | A repetition of the tests in items 1 to 7 above is to be avoided if possible. But, if a test on an assembled group of several pieces of new apparatus, each one is made, the test voltage to be applied to such assembled group is to be 80% of the lowest test voltage appropriate for any part of the group (see Note 4). |

*Notes:*

1 For two-phase windings having one terminal in common, the rated voltage for the purpose of calculating the test voltage is to be taken as 1.4 times the voltage of each separate phase.

2 High-voltage tests on machines having graded insulation is to be subject to special consideration.

3 The voltage, which is occurred between the terminals of field windings or sections thereof under the specified starting conditions, may be measured at any convenient reduced supply voltage. The voltage so measured is to be increased in the ratio of the specified starting supply voltage to the test supply voltage.

4 For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

# TABLE 3
## Limits of Temperature Rise for Air-cooled Rotating Machines
## [See 4-5-4/3.11.1] *(2015)*

Ambient Temperature = 45°C

| *Item No.* | | *Part of Machine* | *Temperature Measuring Method* | *Limit of Temperature Rise, °C for Class of Insulation* | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | *A* | *E* | *B* | *F* | *H* |
| 1 | a) | AC windings of machines having rated output of 5,000 kW (or kVA) or more | Resistance | 55 | - | 75 | 95 | 120 |
| | | | Embedded temp. detector | 60 | - | 80 | 100 | 125 |
| | b) | AC windings of machines having rated output above 200 kW (or kVA) but less than 5,000 kW (or kVA) | Resistance | 55 | 70 | 75 | 100 | 120 |
| | | | Embedded temp. detector. | 60 | - | 85 | 105 | 125 |
| | c) | AC windings of machines having rated outputs of 200 kW (or kVA) or less (1) | Resistance | 55 | 70 | 75 | 100 | 120 |
| 2 | | Windings of armatures having commutators | Thermometer | 40 | 45 | 60 | 65 | 80 |
| | | | Resistance | 50 | 55 | 70 | 75 | 100 |
| 3 | | Field windings of AC and DC machines having DC excitation, other than those in item 4 | Thermometer | 40 | 45 | 60 | 65 | 80 |
| | | | Resistance | 50 | 55 | 70 | 75 | 100 |
| 4 | a) | Field winding of synchronous machines with cylindrical rotors having DC excitation winding embedded in slots, except synchronous induction motors | Resistance | - | - | 85 | 105 | 130 |
| | b) | Stationary field windings of AC machines having more than one layer | Thermometer | 45 | 60 | 65 | 80 | 100 |
| | | | Resistance | 55 | 70 | 75 | 100 | 120 |
| | | | Embedded temp. detector. | - | - | 85 | 105 | 130 |
| | c) | Low resistance field winding of AC and DC machines and compensating windings of DC machines having more than one layer | Thermometer | 55 | 70 | 75 | 95 | 120 |
| | | | Resistance | 55 | 70 | 75 | 95 | 120 |
| | d) | Single-layer windings of AC and DC machines with exposed bare or varnished metal surfaces and single layer compensating windings of DC machines (2) | Thermometer | 60 | 70 | 85 | 105 | 130 |
| | | | Resistance | 60 | 70 | 85 | 105 | 130 |
| 5 | | Permanently short-circuited windings | The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it. | | | | | |
| 6 | | Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings) | | | | | | |
| 7 | | Commutators, slip-rings and their brushes and brushing | The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it.<br>Additionally, the temperature is not to exceed that at which the combination of brush grade and commutator/slip-ring materials can handle the current over the entire operating range. | | | | | |

*Notes*

1 With application of the superposition test method to windings of machines rated 200 kW (or kVA) or less with insulation classes A, E, B or F, the limits of temperature rise given for the resistance method may be increased by 5°C.

2 Also includes multiple layer windings provided that the under layers are each in contact with the circulating coolant.

# TABLE 4
# Nameplates

**a. Rotating Machines [See 4-5-4/3.13.9]**

The manufacturer's name
The manufacturer's serial number (or identification mark)
The year of manufacture
Type of Machine (Generator or motor, etc.)
Degree of protection enclosures (by IP code)
Class of rating or duty type
The rated output
The rated voltage
The rated current and type of current (AC or DC)
The rated speed (r.p.m.) or speed range
The class of insulation or permissible temperature rise
The ambient temperature

Number of phase (for AC machines)
The rated frequency (for AC machines)
Power factor (for AC machines)
Type of winding (for DC machines)

Exciter voltage (for synchronous machines or DC machines with separate excitation)
Exciter current at rating (for synchronous machines or DC machines with separate excitation)
Open-circuit voltage between slip-rings and the slip-ring current for rated conditions (for wounded-rotor induction machines)

**b. Accumulator Battery [See 4-5-4/5.3.3]**

The manufacturer's name
The type designation
The rated voltage
The ampere-hour rating at a specific rate of discharge
The specific gravity of the electrolyte
(in the case of a lead-acid battery, the specific gravity when the battery is fully charged).

**c. Transformer [See 4-5-4/9.5.3]**

The manufacturer's name
The manufacturer's serial number (or identification mark)
The year of manufacture
The number of phases
The rated power
The rated frequency
The rated voltage in primary and secondary sides
The rated current in primary and secondary sides
The class of insulation or permissible temperature rise
The ambient temperature

**d. Semiconductor Converter [See 4-5-4/11.5.4]**

The manufacturer's name
The identification number of the equipment

## TABLE 5
## Factory Testing Schedule for Switchboards, Chargers, Motor Control Centers and Controllers [See 4-5-4/7.3.1] *(2016)*

1 Insulation resistance measurements in accordance with 4-5-4/7.5.

2 Dielectric strength test in accordance with 4-5-4/7.7 and the table below.

3 *(1998)* Protective device tripping test, such as overcurrent tripping, emergency tripping, preferential tripping, etc.

4 Inspection of the assembly including inspection of wiring and, if necessary, electrical operation test.

Standard Test Voltage for Dielectric Strength Test

| *Rated Insulation Voltage* | *Dielectric Test Voltage AC rms* |
|---|---|
| Up to and including 12 V | 250 V |
| over 12 V to 60 V inclusive | 500 V |
| over 60 V to 300 V inclusive | 2000 V |
| over 300 V to 690 V inclusive | 2500 V |
| over 690 V to 800 V inclusive | 3000 V |
| over 800 V to 1000 V inclusive | 3500 V |
| over 1000 V to 1500 V inclusive* | 3500 V |
| *Note:* *For Direct-current (DC) only | |

## TABLE 6
## Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers, Motor Control Centers and Controllers (1) [See 4-5-4/7.11.6] *(2018)*

| *Rated Insulation Voltage (V)* | *Minimum Clearances, mm (in.)* | *Minimum Creepage Distances, mm (in.)* |
|---|---|---|
| Up to 250 | 15 (19/32) | 20 (25/32) |
| From 251 to 690 | 20 (25/32) | 25 (1) |
| Above 690 (2) | 25 (1) | 35 (1 3/8) |

*Notes:*

1 The values in this table apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts, including earthing.

2 For 1 kV to 15 kV systems, see 4-5-5/1.1.3.

## TABLE 7
## Equipment and Instrumentation for Switchboard [See 4-5-4/7.15.4] *(2018)*

| *Instrumentation and Equipment* | | *Alternating-current (AC) Switchboard* | *Direct-current (DC) Switchboard* |
|---|---|---|---|
| 1. | Pilot Lamp | A pilot lamp for each generator connected between generator and circuit breaker. (3) | A pilot lamp for each generator connected between generator and circuit breaker. |
| 2. | Generator Disconnect | A generator switch or disconnecting links in series with the generator circuit breaker which is to disconnect completely all leads of the generator and the circuit breaker from the buses, except the earth lead. (1) | A generator switch, or disconnecting links, in series with the circuit breaker which will open positive, negative, neutral and equalizer leads, except that for 3-wire generators, equalizer poles may be provided on the circuit breaker. For 3-wire generators, the circuit breakers are to protect against a short circuit on the equalizer buses. (1) |
| 3. | Field Rheostat | A field rheostat for each generator and each exciter. (2) | A field rheostat for each generator. (2). |
| 4. | Insulation Monitor and Alarm | A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. (3,5) | A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. For 3-wire generators, see 4-5-5/7.3. (3) |
| 5. | Ammeter | An ammeter for each generator with a selector switch to read the current of each phase. (3) | An ammeter for each 2-wire generator. For each 3-wire generator, an ammeter for each positive and negative lead and a center-zero ammeter in the earth connection at the generator switchboard. Ammeters are to be so located in the circuit as to indicate total generator current. |
| 6. | Voltmeter | A voltmeter for each generator, with a selector switch to each phase of the generator and to one phase of the bus. (3) | A voltmeter for each generator with voltmeter switch for connecting the voltmeter to indicate generator voltage and bus voltage. For each 3-wire generator, a voltmeter with voltmeter switch for connecting the voltmeter to indicate generator voltage, positive to negative, positive to neutral, and neutral to negative. Where permanent provisions for shore connections are fitted, one voltmeter switch to provide also for reading shore-connection voltage, positive to negative. |
| 7. | Space Heater Pilot Lamp | Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator. | Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator. |
| 8. | Synchroscope or Lamps | A synchroscope or synchronizing lamps with selector switch for paralleling in any combination. (3) | Not applicable. |
| 9. | Prime Mover Speed Control | Control for prime mover speed for paralleling. (3) | Not applicable. |
| 10. | Wattmeter | Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator. (3) | Not applicable. |
| 11. | Frequency Meter | A frequency meter with selector switch to connect to any generator. (3) | Not applicable. |
| 12. | Field Switch | A double-pole field switch with discharge clips and resistor for each generator. (2) | Not applicable. |
| 13. | Voltage Regulator | A voltage regulator. (3) | Not applicable. |
| 14. | Stator Winding Temperature Indicator *(1997)* | For alternating current propulsion generator above 500 kW, a stator winding temperature indicator is to be fitted for each generator control panel. (3,4) | For direct current propulsion generator above 500 kW, an interpole winding temperature indicator is to be fitted for each generator control panel. (3,4) |

*Notes:*

1 The switch or links may be omitted when draw-out or plug-in mounted generator breakers are furnished.

2 For generators with variable voltage exciters or rotary amplifier exciters, each controlled by voltage-regulator unit acting on the exciter field, the field switch, the discharge resistor and generator field rheostat may be omitted.

3 *(2005)* Where vessels have centralized control systems in accordance with Part 4, Chapter 9 of the *Steel Vessel Rules* and the generators can be paralleled from the centralized control station, and the switchboard is located in the centralized control station, this equipment may be mounted on the control console. See 4-5-4/7.15.4.

4 *(1997)* For high voltage systems, see also 4-5-5/1.11.1(c).

5 *(2018)* For high voltage systems, see 4-5-5/1.3.5.

## TABLE 8
## Temperature Rise for Transformers [1, 2] *(2014)*

| *Insulation Class* | *Average Winding-Temperature Rise Limits at Rated Current, °C (°F)* |
|---|---|
| A (105) | 55 (99) |
| E (120) | 70 (126) |
| B (130) | 75 (135) |
| F (155) | 95 (171) |
| H (180) | 120 (216) |
| 200 | 130 (234) |
| 220 | 145 (261) |

*Notes:*

1 Metallic parts in contact with or adjacent to insulation are not to attain a temperature in excess of that allowed for the hottest-spot copper temperature adjacent to that insulation.

2 *(2014)* Temperature rises are based on an ambient temperature of 45°C (113°F). See 4-5-4/9.3.

## TABLE 9
## Types of Cable Insulation [See 4-5-4/13.1.4] *(2013)*

| *Insulation Type Designation* | *Insulation Materials* | *Maximum Conductor Temperature* |
|---|---|---|
| V75, PVC/A *(1997)* | Polyvinyl Chloride – Heat resisting *(1997)* | 75°C (167°F) * |
| R85, XLPE | Cross-linked Polyethylene | 85°C (185°F) * |
| E85, EPR | Ethylene Propylene Rubber | 85°C (185°F) * |
| R90, XLPE | Cross-linked Polyethylene | 90°C (194°F) * |
| E90, EPR | Ethylene Propylene Rubber | 90°C (194°F) * |
| M95 | Mineral (MI) | 95°C (203°F) * |
| S95 | Silicone Rubber | 95°C (203°F) * |

* A maximum conductor temperature of 250°C (482°F) is permissible for special applications and standard end fittings may be used, provided the temperature does not exceed 85°C (185°F) at the end of fittings. However, when the temperature at the end of the fittings is higher than 85°C (185°F), special consideration will be given to an appropriate end fitting.

## TABLE 10
## Maximum Current Carrying Capacity for Insulated Copper Wires and Cables *(2014)*

| *Conductor Size* | | ***Maximum Current in Amperes (see 4-5-4/13.1.1)*** *45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1-core* | | | | *2-core* | | | | *3- or 4-core* | | | |
| *mm²* | *$10^3$ circ mils* | *V75* | *R85 XLPE E85 EPR* | *R90 XLPE E90 EPR* | *M95 S95* | *V75* | *R85 XLPE E85 EPR* | *R90 XLPE E90 EPR* | *M95 S95* | *V75* | *R85 XLPE E85 EPR* | *R90 XLPE E90 EPR* | *M95 S95* |
| **1.0** | | 13 | 16 | | 20 | 11 | 14 | | 17 | 9 | 11 | | 14 |
| **1.25** | | 15 | 18 | | 23 | 13 | 15 | | 20 | 11 | 13 | | 16 |
| **1.5** | | 17 | 21 | 23 | 26 | 14 | 18 | 20 | 22 | 12 | 15 | 16 | 18 |
| | 4.11 | 21 | 25 | | 32 | 18 | 21 | | 27 | 15 | 18 | | 22 |
| **2.5** | | 24 | 28 | 30 | 32 | 20 | 24 | 26 | 27 | 17 | 20 | 21 | 22 |
| | 6.53 | 28 | 34 | | 38 | 24 | 29 | | 32 | 20 | 24 | | 27 |
| **4** | | 32 | 38 | 40 | 43 | 27 | 32 | 34 | 37 | 22 | 27 | 28 | 30 |
| | 10.4 | 38 | 45 | | 51 | 32 | 38 | | 43 | 27 | 32 | | 36 |
| **6** | | 41 | 49 | 52 | 55 | 35 | 42 | 44 | 47 | 29 | 34 | 36 | 39 |
| | 16.5 | 51 | 60 | | 68 | 43 | 51 | | 58 | 36 | 42 | | 48 |
| **10** | | 57 | 67 | 72 | 76 | 48 | 57 | 61 | 65 | 40 | 47 | 50 | 53 |
| | 20.8 | 59 | 70 | | 78 | 50 | 60 | | 66 | 41 | 49 | | 55 |
| | 26.3 | 68 | 81 | | 91 | 58 | 69 | | 77 | 48 | 57 | | 64 |
| **16** | | 76 | 91 | 96 | 102 | 65 | 77 | 82 | 87 | 53 | 64 | 67 | 71 |
| | 33.1 | 79 | 93 | | 105 | 67 | 79 | | 89 | 55 | 65 | | 74 |
| | 41.7 | 91 | 108 | | 121 | 77 | 92 | | 103 | 64 | 76 | | 85 |
| **25** | | 101 | 120 | 127 | 135 | 86 | 102 | 108 | 115 | 71 | 84 | 89 | 95 |
| | 52.6 | 105 | 124 | | 140 | 89 | 105 | | 119 | 74 | 87 | | 98 |
| | 66.4 | 121 | 144 | | 162 | 103 | 122 | | 138 | 85 | 101 | | 113 |
| **35** | | 125 | 148 | 157 | 166 | 106 | 126 | 133 | 141 | 88 | 104 | 110 | 116 |
| | 83.7 | 140 | 166 | | 187 | 119 | 141 | | 159 | 98 | 116 | | 131 |
| **50** | | 156 | 184 | 196 | 208 | 133 | 156 | 167 | 177 | 109 | 129 | 137 | 146 |
| | 106 | 163 | 193 | | 217 | 139 | 164 | | 184 | 114 | 135 | | 152 |
| | 133 | 188 | 222 | | 250 | 160 | 189 | | 213 | 132 | 155 | | 175 |
| **70** | | 192 | 228 | 242 | 256 | 163 | 194 | 206 | 218 | 134 | 160 | 169 | 179 |
| | 168 | 217 | 257 | | 289 | 184 | 218 | | 246 | 152 | 180 | | 202 |
| **95** | | 232 | 276 | 293 | 310 | 197 | 235 | 249 | 264 | 162 | 193 | 205 | 217 |
| | 212 | 251 | 297 | | 335 | 213 | 252 | | 285 | 176 | 208 | | 235 |
| **120** | | 269 | 319 | 339 | 359 | 229 | 271 | 288 | 305 | 188 | 223 | 237 | 251 |
| | 250 | 278 | 330 | | 371 | 236 | 281 | | 315 | 195 | 231 | | 260 |
| **150** | | 309 | 367 | 389 | 412 | 263 | 312 | 331 | 350 | 216 | 257 | 272 | 288 |
| | 300 | 312 | 370 | | 416 | 265 | 315 | | 354 | 218 | 259 | | 291 |
| | 350 | 343 | 407 | | 458 | 292 | 346 | | 389 | 240 | 285 | | 321 |
| **185** | | 353 | 418 | 444 | 470 | 300 | 355 | 377 | 400 | 247 | 293 | 311 | 329 |
| | 400 | 373 | 442 | | 498 | 317 | 376 | | 423 | 261 | 309 | | 349 |
| | 450 | 402 | 476 | | 536 | 342 | 405 | | 456 | 281 | 333 | | 375 |
| **240** | | 415 | 492 | 522 | 553 | 353 | 418 | 444 | 470 | 291 | 344 | 365 | 387 |
| | 500 | 429 | 509 | | 572 | 365 | 433 | | 486 | 300 | 356 | | 400 |
| | 550 | 455 | 540 | | 607 | 387 | 459 | | 516 | 319 | 378 | | 425 |
| **300** | | 477 | 565 | 601 | 636 | 405 | 480 | 511 | 541 | 334 | 396 | 421 | 445 |
| | 600 | 481 | 570 | | 641 | 409 | 485 | | 545 | 337 | 399 | | 449 |
| | 650 | 506 | 599 | | 674 | 430 | 509 | | 573 | 354 | 419 | | 472 |
| | 700 | 529 | 628 | | 706 | 450 | 534 | | 600 | 370 | 440 | | 494 |
| | 750 | 553 | 655 | | 737 | 470 | 557 | | 626 | 387 | 459 | | 516 |

## TABLE 10 (continued)
## Maximum Current Carrying Capacity for Insulated Copper Wires and Cables *(2014)*

| *Conductor Size* | | ***Maximum Current in Amperes (see 4-5-4/13.1.1)*** *45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1-core* | | | | *2-core* | | | | *3- or 4-core* | | | |
| *$mm^2$* | *$10^3$ circ mils* | *V75* | *R85 XLPE E85 EPR* | *R90 XLPE E90 EPR* | *M95 S95* | *V75* | *R85 XLPE E85 EPR* | *R90 XLPE E90 EPR* | *M95 S95* | *V75* | *R85 XLPE E85 EPR* | *R90 XLPE E90 EPR* | *M95 S95* |
| **400** | | 571 | 677 | 690 | 761 | 485 | 575 | 587 | 647 | 400 | 474 | 483 | 533 |
| | 800 | 576 | 682 | | 767 | 490 | 580 | | 652 | 403 | 477 | | 540 |
| | 850 | 598 | 709 | | 797 | 508 | 603 | | 677 | 419 | 496 | | 558 |
| | 900 | 620 | 734 | | 826 | 527 | 624 | | 702 | 434 | 514 | | 578 |
| | 950 | 641 | 760 | | 854 | 545 | 646 | | 726 | 449 | 532 | | 598 |
| **500** | | 656 | 778 | 780 | 875 | 558 | 661 | 663 | 744 | 459 | 545 | 546 | 613 |
| | 1000 | 662 | 784 | | 882 | 563 | 666 | | 750 | 463 | 549 | | 617 |
| **600** | | 736 | 872 | | 981 | 626 | 741 | | 834 | 515 | 610 | | 687 |
| **625** | | 755 | 894 | | 1006 | 642 | 760 | | 855 | 529 | 626 | | 704 |

*Notes:*

1 The values given above have been calculated for an ambient of 45°C (113°F), and assume that a conductor temperature equal to the maximum rated temperature of the insulation is reached and maintained continuously in the case of a group of four cables bunched together and laid in free air.

2 The current rating values given in 4-5-4/Table 10 (and those derived therefrom) may be considered applicable, without correction factors, for cables double-banked on cable trays, in cable conduits or cable pipes, except as noted in Note 3.

3 For bunched cables, see 4-5-3/5.11.1.

4 These current ratings are applicable for both armored and unarmored cables.

5 If ambient temperature differs from 45°C (113°F), the values in 4-5-4/Table 10 are to be multiplied by the following factors.

| *Maximum Conductor Temperature* | *Ambient Correction Factor* | | | | | |
|---|---|---|---|---|---|---|
| | *40°C (104°F)* | *50°C (122°F)* | *55°C (131°F)* | *60°C (140°F)* | *65°C (149°F)* | *70°C (158°F)* |
| 75°C (167°F) | 1.08 | 0.91 | 0.82 | 0.71 | 0.58 | — |
| 85°C (185°F) | 1.06 | 0.94 | 0.87 | 0.79 | 0.71 | 0.61 |
| 90°C (194°F) | 1.05 | 0.94 | 0.88 | 0.82 | 0.74 | 0.67 |
| 95°C (203°F) | 1.05 | 0.95 | 0.89 | 0.84 | 0.77 | 0.71 |

6 Where the number of conductors in a cable exceeds four, as in control cables, the maximum current carrying capacity of each conductor is to be reduced as in the following table:

| *No. of Conductors* | *% of 3–4/C TYPE Values in 4-5-4/Table 10* |
|---|---|
| 5–6 | 80 |
| 7–24 | 70 |
| 25–42 | 60 |
| 43 and above | 50 |

7 When a mineral-insulated cable is installed in such a location that its copper sheath is liable to be touched when in service, the current rating is to be multiplied by the correction factor 0.80 in order that the sheath temperature does not exceed 70°C (158°F).

8 Cables being accepted based on approved alternate standard may have current carrying capacity of that standard, provided the cables are in full compliance with that standard.

## TABLE 11
## Additional Services Requiring Electrical Equipment to be Designed, Constructed and Tested to the Requirements in Section 4-5-4
## [See 4-5-4/1, 4-5-4/3.1.1, 4-5-4/3.3.1, 4-5-4/7.1.1 and 4-5-4/7.3.1] *(2010)*

| | |
|---|---|
| (a) | Equipment necessary for specific class notations (Such as refrigerated cargo notations, dynamic positioning systems, etc.). See Note. |
| (b) | Cargo Pump Motors (oil carriers, gas carriers, chemical carriers, liquefied gas carriers, etc.) |
| (c) | Motors for hydraulic power unit for hydraulically driven cargo pump motors |
| (d) | High duty gas compressors on liquefied gas carriers |

*Note*: See 6-2-1/7 of the *Steel Vessel Rules* for refrigerated cargo notations and the ABS *Guide for Dynamic Positioning Systems* for dynamic positioning notations.

PART

# 4

# CHAPTER 5 Electrical Installations

# SECTION 5 Specialized Installations

## 1 High Voltage Systems

### 1.1 General

#### 1.1.1 Application *(2003)*

The following requirements in this Subsection are applicable to AC systems with nominal voltage (phase to phase) exceeding 1 kV. Unless stated otherwise, high voltage equipment and systems are to comply with the other parts in Part 4, Chapter 5 for low voltage equipment and systems, as well.

#### 1.1.2 Standard Voltages *(2003)*

The nominal standard voltage is not to exceed 15 kV. A higher voltage may be considered for special application.

#### 1.1.3 Air Clearance and Creepage Distance *(1 July 2016)*

*1.1.3(a) Air Clearance.* Phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be not less than the minimum as specified below.

| *Nominal Voltage in kV* | *Minimum Air Clearance, in mm (in.)* |
|---|---|
| 3–3.3 | 55 (2.2) |
| 6–6.6 | 90 (3.6) |
| 10–11 | 120 (4.8) |
| 15 | 160 (6.3) |

Where intermediate values of nominal voltages are accepted, the next higher air clearance is to be observed.

*1.1.3(b) Reduction.* Alternatively, reduced clearance distances may be used provided:

*i)* The equipment is not installed in 'Machinery Spaces of Category A' or in areas affected by a Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System.

*ii)* The equipment is subject to an impulse voltage test with test voltage values shown in Table below. Where intermediate values of rated operational voltage are used, the next higher rated impulse withstand test voltage is to be used. The impulse voltage test reports are to be submitted to ABS for review.

| *Rated Voltage kV* | *Rated Impulse Withstand Voltage kV (peak value)* |
|---|---|
| 3.6 | 40 |
| 7.2 | 60 |
| 12 | 75 |
| 15 | 95 |

*1.1.3(c) Insulating Material.* Any insulating material that is used to cover live parts of equipment used to comply with clearance distance requirements is to be suitable for the application. The equipment manufacturer is to submit documentation which demonstrates the suitability of such insulation material.

*1.1.3(d) Creepage Distances (1 July 2016).* Creepage distances between live parts and between live parts and earthed metal parts are to be in accordance with IEC 60092-503 for the nominal voltage of the system, the nature of the insulation material, and the transient overvoltage developed by switch and fault conditions.

*i)* The minimum creepage distances for main switchboards and generators are given in the Table below:

| *Nominal Voltage V* | *Minimum Creepage Distance for Proof Tracking Index mm (in.)* | | | |
|---|---|---|---|---|
| | *300 V* | *375 V* | *500 V* | *>600 V* |
| 1000-1100 | 26 (1.02)[(1)] | 24 (0.94)[(1)] | 22 (0.87)[(1)] | 20 (0.79)[(1)] |
| < 3300 | 63 (2.48) | 59 (2.32) | 53 (2.09) | 48 (1.89) |
| < 6600 | 113 (4.45) | 108 (4.25) | 99 (3.9) | 90 (3.54) |
| ≤ 11000[(2)] | 183 (7.20) | 175 (6.89) | 162 (6.38) | 150 (5.91) |

*Notes:*

1 A distance of 35 mm is required for busbars and other bare conductors in main switchboards.

2 Creepage distances for equipment with nominal voltage above 11 kV shall be subject to consideration.

*ii)* The minimum creepage distances for equipment other than main switchboards and generators are given in the Table below:

| *Nominal Voltage V* | *Minimum Creepage Distance for Proof Tracking Index mm (in.)* | | | |
|---|---|---|---|---|
| | *300 V* | *375 V* | *500 V* | *>600 V* |
| 1000-1100 | 18 (0.71) | 17 (0.67) | 15 (0.59) | 14 (0.55) |
| < 3300 | 42 (1.65) | 41 (1.61) | 38 (1.50) | 26 (1.02) |
| < 6600 | 83 (3.27) | 80 (3.15) | 75 (2.95) | 70 (2.76) |
| ≤ 11000* | 146 (5.75) | 140 (5.51) | 130 (5.11) | 120 (4.72) |

** Note:* Creepage distances for equipment with nominal voltage above 11 kV shall be subject to consideration.

## 1.3 System Design

### 1.3.1 Selective Coordination

Selective coordination is to be in accordance with 4-5-2/9.1.5, regardless of the system neutral earthing arrangement.

### 1.3.2 Earthed Neutral Systems

*1.3.2(a) Neutral earthing (2003).* The current in the earth fault condition is to be not in excess of full load current of the largest generator on the switchboard or relevant switchboard section and in no case less than three times the minimum current required for operation of any device in the earth fault condition.

At least one source neutral to ground connection is to be available whenever the system is in the energized mode.

*1.3.2(b) Equipment (2003).* Electrical equipment in directly earthed neutral or other neutral earthed systems is to be able to withstand the current due to a single phase fault against earth for a period necessary to trip the protection device.

### 1.3.3 Neutral Disconnection

Each generator neutral is to be provided with means for disconnection.

### 1.3.4 Hull Connection of Earthing Impedance *(2003)*

All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections will not interfere with radio, radar, communication and control equipment circuits. In systems with neutral earthed, connection of the neutral to the hull is to be provided for each generator switchboard section.

### 1.3.5 Earth Fault Detection and Indication *(2018)*

*i)* In unearthed or high impedance earthed systems, an earth fault is to be indicated by visual and audible means at the centralized control system.

*ii)* In low impedance or direct earthed systems, provision is to be made to automatically disconnect the faulty circuits. Audible and visual indication is to be provided at the centralized control station to indicate that a ground fault had occurred and has been cleared by ground fault protection. An audible alarm is to be provided if the ground fault was not successfully cleared.

*iii)* In high impedance earthed systems where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment is to be designed for the phase to phase voltage.

### 1.3.6 Number and Capacity of Transformers *(2014)*

For transformers with a high voltage winding over 1000 V, the following would not be accepted as complying with the above requirement:

*i)* The provision of a spare single phase transformer to substitute a failed transformer.

*ii)* The operation of two single phase transformers in an open delta (V-V) connection.

## 1.5 Circuit Breakers and Switches – Auxiliary Circuit Power Supply Systems *(2004)*

### 1.5.1 Source and Capacity of Power Supply

Where electrical energy or mechanical energy is required for the operation of circuit breakers and switches, a means of storing such energy is to be provided with a capacity at least sufficient for two on/off operation cycles of all of the components. However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude the use of stored energy for shunt tripping, provided alarms are activated upon loss of continuity in the release circuits and power supply failures. The stored energy may be supplied from within the circuit in which the circuit breakers or switches are located.

### 1.5.2 Number of External Sources of Stored Energy

Where the stored energy is supplied from a source external to the circuit, such supply is to be from at least two sources so arranged that a failure or loss of one source will not cause the loss of more than one set of generators and/or essential services. Where it will be necessary to have the source of supply available for dead ship startup, the source of supply is to be provided from the emergency source of electrical power

## 1.7 Circuit Protection

### 1.7.1 Protection of Generator *(2003)*

Protection against phase-to-phase fault in the cables connecting the generators to the switchboard and against inter-winding faults within the generator is to be provided. This is to trip the generator circuit breaker and automatically de-excite the generator. In distribution systems with a low impedance earthed neutral, phase-to-earth faults are to be likewise treated.

1.7.2 Protection of Power Transformers *(2014)*

Power transformers are to be provided with overload and short circuit protection. Each high-voltage transformer intended to supply power to the low-voltage ship service switchboard is to be protected in accordance with 4-5-2/9.15. In addition, the following means for protecting the transformers or the electric distribution system are to be provided:

*1.7.2(a) Coordinated Trips of Protective Devices (2002).* Discriminative tripping is to be provided for the following. See 4-5-2/9.1.5.

*i)* Between the primary side protective device of the transformer and the feeder protective devices on the low-voltage ship service switchboard, or

*ii)* Between the secondary side protective device of the transformer, if fitted, and the feeder protective devices on the low-voltage ship service switchboard.

*1.7.2(b) Load Shedding Arrangement (2002).* Where the power is supplied through a single set of three-phase transformers to a low-voltage ship service switchboard, automatic load shedding arrangements are to be provided when the total load connected to the low voltage ship service switchboard exceeds the rated capacity of the transformer. See 4-5-2/1.7 and 4-5-2/9.3.3.

*1.7.2(c) Protection from Electrical Disturbance (2002).* Means or arrangements are to be provided for protecting the transformers from voltage transients generated within the system due to circuit conditions, such as high-frequency current interruption and current suppression (chopping) as the result of switching, vacuum cartridge circuit breaker operation or thyristor-switching.

An analysis or data for the estimated voltage transients is to be submitted to show that the insulation of the transformer is capable of withstanding the estimated voltage transients. See 4-5-5/1.11.3(b).

*1.7.2(d) Protection from Earth Faults (2002).* Where a Y-neutral of three-phase transformer windings is earthed, means for detecting an earth fault are to be provided. The detection of the earth fault is to activate an alarm at the manned control station or to automatically disconnect the transformer from the high-voltage power distribution network.

*1.7.2(e) Transformers Arranged in Parallel (2014).* Refer to 4-5-2/9.15.2 for requirements.

1.7.3 Voltage Transformers for Control and Instrumentation *(2003)*

Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

1.7.4 Fuses *(2003)*

Fuses are not to be used for overload protection.

1.7.5 Over Voltage Protection *(2003)*

Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This may be achieved by:

*i)* Direct earthing of the lower voltage system,

*ii)* Appropriate neutral voltage limiters, or

*iii)* Earthed screen between primary and secondary winding of transformers

## 1.9 Equipment Installation and Arrangement

1.9.1 Degree of Protection

The degree of equipment protection is to be in accordance with 4-5-5/Table 1.

1.9.2 Protective Arrangements

*1.9.2(a) Interlocking Arrangements.* Where high-voltage equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

*1.9.2(b) Warning Plate (1 July 2016).* At the entrance of such spaces, a suitable marking is to be placed which indicates danger of high-voltage and the maximum voltage inside the space. For high-voltage electrical equipment installed outside these spaces, a similar marking is to be provided. An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling/deckhead above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200.

*1.9.2(c) Exposure of HV Equipment to Damaging Environments (2014).* Consideration should be given to designing the arrangement of the installation to avoid exposure of high voltage equipment to contaminants, such as oil or dust, as might be found in machinery spaces or close to ventilation air inlets to the space, or to water spray from water-mist systems and local fire hose connections.

### 1.9.3 Cables

*1.9.3(a) Runs of Cables (2003).* In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

*1.9.3(b) Segregation (2003).* High voltage cables of different voltage ratings are not to be installed in the same cable bunch, duct, pipe or box. Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in 4-5-5/1.1.3(a). However, high voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV or less.

Higher voltage equipment is not to be combined with lower voltage equipment in the same enclosure, unless segregation or other suitable measures are taken to ensure safe access to lower voltage equipment.

*1.9.3(c) Installation Arrangements (2003).* High voltage cables are to be installed on cable trays or equivalent when they are provided with a continuous metallic sheath or armor which is effectively bonded to earth. Otherwise, they are to be installed for their entire length in metallic casings effectively bonded to earth.

*1.9.3(d) Termination and Splices (2014).* Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials. High voltage cables of the radial field type (i.e., having a conductive layer to control the electric field within the insulation) are to have terminations which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e., tapes, wires etc.).

Splices and joints are not permitted in propulsion cables. For purposes of this Rule, propulsion cables are those cables whose service is related only to propulsion.

*1.9.3(e) Cable Rating (2014).* The rated phase to earth voltage ($U_o$) of high voltage cables shall not be less than shown in the Table below:

| *Nominal System Voltage ($U_n$) (kV)* | *Highest System Voltage ($U_m$) (kV)* | *Rated Phase to Earth Voltage ($U_o$) (kV)* | |
|---|---|---|---|
| | | *Systems with Automatic Disconnection Upon Detection of an Earth Fault* | *Systems without Automatic Disconnection Upon Detection of an Earth Fault* |
| 3.0 | 3.6 | 1.8 | 3.6 |
| 3.3 | 3.6 | 1.8 | 3.6 |
| 6.0 | 7.2 | 3.6 | 6.0 |
| 6.6 | 7.2 | 3.6 | 6.6 |
| 10.0 | 12.0 | 6.0 | 10.0 |
| 11.0 | 12.0 | 6.0 | 11.0 |
| 15.0 | 17.5 | 8.7 | 15.0 |

*1.9.3(f) Cable Current Carrying Capacities (2014).* The maximum current carrying capacity of high voltage cables is to be in accordance with the Table below:

| *Conductor Size ($mm^2$)* | *Maximum Current in Amperes 45°C Ambient; 1000 V and More* | | | |
|---|---|---|---|---|
| | *1-Core* | | *3-Core* | |
| | *85°C* | *90°C* | *85°C* | *90°C* |
| 16 | 80 | 85 | 55 | 60 |
| 25 | 105 | 115 | 75 | 80 |
| 35 | 130 | 140 | 90 | 95 |
| 50 | 165 | 175 | 115 | 120 |
| 70 | 205 | 215 | 140 | 150 |
| 95 | 245 | 260 | 170 | 185 |
| 120 | 285 | 305 | 200 | 210 |
| 150 | 330 | 350 | 230 | 245 |
| 185 | 375 | 400 | 260 | 280 |
| 240 | 440 | 470 | 310 | 325 |
| 300 | 505 | 540 | 355 | 375 |
| 400 | 605 | 645 | 425 | 450 |
| 500 | 700 | 740 | 490 | 520 |

*1.9.3(g) Marking.* High voltage cables are to be readily identifiable by suitable marking.

*1.9.3(h) Cable Test after Installation (1 July 2016).* A voltage withstand test is to be carried out on each completed cable and its accessories before a new high voltage installation, including additions to an existing installation, is put into service.

An insulation resistance test is to be carried out prior to the voltage withstand test being conducted.

For cables with rated voltage ($U_o/U$) above 1.8/3 kV ($U_m$ = 3.6 kV) an AC voltage withstand test may be carried out upon advice from high voltage cable manufacturer. One of the following test methods to be used:

*i)* An AC test voltage for 5 min with the phase-to-phase voltage of the system applied between the conductor and the metallic screen/sheath.

*ii)* An AC voltage test for 24 h with the normal operating voltage of the system.

*iii)* A DC test voltage equal to $4U_o$ may be applied for 15 minutes.

For cables with rated voltage ($U_o/U$) up to 1.8/3 kV ($U_m$ = 3.6 kV), a DC voltage equal to $4U_o$ shall be applied for 15 minutes.

After completion of the test, the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

The insulation resistance test is then repeated.

The above tests are for newly installed cables. If due to repairs or modifications, cables which have been in use are to be tested, lower voltages and shorter durations should be considered.

### 1.9.4 High Voltage Shore Connection *(2014)*

Where arrangements are made for the supply of electricity at high voltage from onshore, and designed to allow the shipboard generators to be shut down while in port, the requirements given in the ABS *Guide for High Voltage Shore Connection*.

## 1.11 Machinery and Equipment

### 1.11.1 Rotating Machines

*1.11.1(a) Protection (2014).* Refer to 4-5-5/Table 1 for ingress protection (IP) requirements.

*1.11.1(b) Windings (2003).* Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

*1.11.1(c) Temperature detectors.* Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against over-voltage.

*1.11.1(d) Space heater.* Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

*1.11.1(e) Tests (2014).* Each design of HV generator and motor is to be assessed by testing in accordance with the "type tests" schedule indicated in 4-5-4/Table 1. Each subsequent production unit of and accepted design is to be tested in accordance with the "routine tests" schedule also indicated in 4-5-4/Table 1.

*i)* *Inter-turn Insulation Test.* In addition to the tests normally required for rotating machinery, a high frequency, high voltage test, in accordance with IEC Publication 60034-15, is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

*ii)* Immediately after the high voltage test the insulation resistance is to be measured using a direct current insulation test meter between:

*a)* All current carrying parts connected together and earth

*b)* All current carrying parts of different polarity or phase where both the ends of each polarity or phase are individually accessible.

The minimum values of test voltage and corresponding insulation resistance are given in the table below. The insulation resistance is to be measured close to the operating temperature. If this is not possible then an approved method of calculation is to be used.

| *Rated Voltage $U_n$ (V)* | *Minimum Test Voltage (V)* | *Minimum Insulation Resistance (MΩ)* |
|---|---|---|
| $1000 < U_n \le 7200$ | 1000 | $U_n/1000 + 1$ |
| $7200 < U_n \le 15000$ | 5000 | $U_n/1000 + 1$ |

### 1.11.2 Switchgear and Control-gear Assemblies *(2014)*

Switchgear and control gear assemblies are to be constructed according to the IEC Publication 62271-200 and the following additional requirements:

*1.11.2(a) Mechanical Construction and Configuration (2016).*

*i)* Switchgear is to be of metal-enclosed type in accordance with IEC Publication 62271-200 or of the insulation-enclosed type in accordance with IEC Publication 62271-201.

*ii)* Refer to 4-5-4/7.15.2 for requirements for the division of main bus bars.

*1.11.2(b) Clearance and Creepage Distances.* For clearance and creepage distances, see 4-5-5/1.1.3.

*1.11.2(c) Locking Facilities.* Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers, switches and fixed disconnectors is to be possible. Withdrawable circuit breakers, when in the service position, are to have no relative motion between fixed and moving parts.

*1.11.2(d) Shutters (1 July 2016).* The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawn position, the live contacts of the bus bars are automatically covered. Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the use of colors or labels.

*1.11.2(e) Earthing and Short-circuiting Facilities (2003).* For maintenance purposes, an adequate number of earthing and short circuiting facilities are to be provided to enable equipment and cables to be earthed or short-circuited to earth before being worked upon.

*1.11.2(f) Arc Flash and Associated Installation Requirements (1 July 2016)*

*i)* Internal Arc Classification (IAC). Switchgear and control gear assemblies are to be Internal Arc Classified (IAC). Where switchgear and control gear are accessible by authorized personnel only accessibility Type A is sufficient (IEC 62271-200; Annex AA; AA 2.2). Accessibility Type B is required if accessible by non-authorized personnel. Installation and location of the switchgear and control gear is to correspond with its internal arc classification and classified sides (F, L and R).

*ii)* Calculations, in accordance with the applicable parts of Standard IEEE 1584 or other recognized standard, are to be made to establish:

- The maximum current that can flow in the case of an arc fault
- The maximum time and current that could flow if arc protection techniques are adopted
- The distance, from the location of the arc flash, at which the arc flash energy would be 1.2 calories per $cm^2$ if the enclosure is open

*iii)* In addition to the marking required by the equipment design standard, arc flash data consistent with the Design Operating Philosophy and the required PPE is also to be indicated at each location where work on the HV equipment could be conducted.

*1.11.2(g) Tests (2014).* A power frequency voltage test is to be carried out on high voltage switchgear and control-gear assemblies with test voltages shown in the Table below. The test procedure is to be in accordance with IEC Publication 62271-200 Section 7/ *Routine Test*.

| *Rated Voltage (kV)* | *Rated Power Frequency Withstand Voltage (kV)* |
|---|---|
| 3.6 | 10 |
| 7.2 | 20 |
| 12 | 28 |
| 15 | 38 |

Where intermediate values of switchgear rated voltages are used, the next higher power frequency withstand test voltage is to be used.

### 1.11.3 Transformers *(2002)*

*1.11.3(a) Application (1 July 2016).* Provisions of 4-5-5/1.11.3 are applicable to power transformers for essential services. See also 4-5-4/9. Items 4-5-5/1.11.3(c) and 4-5-5/1.11.3(d) are applicable to transformers of the dry type only. These requirements are not applicable to transformers intended for the following services:

- Instrument transformers.
- Transformers for static converters.
- Starting transformers.

Dry type transformers are to comply with the applicable Parts of the IEC Publication 60076-11. Liquid filled transformers are to comply with the applicable Parts of the IEC 60076 Series. Oil immersed transformers are to be provided with the following alarms and protections:

- Liquid level (Low) – alarm
- Liquid temperature (High) – alarm
- Liquid level (Low) – trip or load reduction
- Liquid temperature (High) – trip or load reduction
- Gas pressure relay (High) – trip

*1.11.3(b) Plans (2002).* In addition to the details required in 4-5-4/9.1, the applicable standard of construction and the rated withstanding voltage of the insulation are also to be submitted for review.

*1.11.3(c) Enclosure (2003).* Transformers are to have a degree of protection in accordance with 4-5-1/Table 2, but not less than IP23. However, when installed in spaces accessible to unqualified personnel, the degree of protection is to be increased to IP44. For transformers not contained in enclosures, see 4-5-5/1.9.1.

*1.11.3(d) Space heater.* Effective means to prevent accumulation of moisture and condensation within the transformers (when de-energized) is to be provided.

*1.11.3(e) Testing (2002).* Three-phase transformers or three-phase bank transformers of 100 kVA and above are to be tested in the presence of the Surveyor. The test items are to be in accordance with the standard applicable to the transformer. The tests are also to be carried out in the presence of the Surveyor for each individual transformer. Transformers of less than 100 kVA will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

Specific requirements are applicable for the following tests:

*i)* In the dielectric strength test, the short duration power frequency withstand voltage to be applied is to follow the standard applicable to the transformer but not less than the estimated voltage transient generated within the system. If the short duration power frequency withstand voltage is not specified in the applicable standard, IEC 60076-3 is to be referred to. For the voltage transient, see 4-5-5/1.7.2(c).

*ii)* The induced over-voltage withstand test (layer test) is also to be carried out in accordance with the standard applicable to the transformers in the presence of the Surveyor. This test is intended to verify the power-frequency withstand strength along the winding under test and between its phase (strength between turns and between layers in the windings). If the induced over-voltage withstand test is not specified in the applicable standard, IEC 60076-3 is to be referred to.

*1.11.3(f) Nameplate (2002).* In addition to the requirements in 4-5-4/Table 4c, the following information is also to be indicated on the nameplate:

- Applicable standard
- Short duration power frequency withstand voltage for verification of insulation level of each winding

### 1.11.4 Cables *(2003)*

*1.11.4(a) Standards.* Cables are to be constructed to IEC Publication 60092-353, 60092-354 or other equivalent recognized standard. See also 4-5-4/13.1.

## 1.13 Design Operating Philosophy *(2014)*

### 1.13.1 Objective

While this section covers the specific ABS requirements for High Voltage (HV) systems, it is recognized that system design and equipment construction are only parts of an overall approach that are required to allow HV systems to be operated safely. Other aspects that contribute towards HV safety include maintenance procedures, vessel and equipment operating procedures, permit to work procedures, company safety policy, personal protective equipment (PPE) and training, most of which are beyond the role of Classification. However, in order to assist ABS in its review of the design and construction of the vessel and its equipment it is necessary for ABS to be assured that the design is part of a larger overall approach or plan.

The High Voltage Design Principles document is to outline the concepts that are the basis of the design. It should identify risks and document the strategies that are used to mitigate each of the risks (e.g., remote switching, arc flash energy reduction equipment).

### 1.13.2 HV System Failures

The design should take into account each reasonably foreseeable failure type and address what actions will be expected of the crew for each failure. Due to the limited availability of specialist tools, equipment and spare parts on board and recognizing the additional dangers associated with space limitations, the remoteness of specialized medical help and facilities in the event of emergencies, it is desirable that, as far as practicable, the crew is not exposed to dangers that could be avoided. For these reasons it is preferable that the vessel's HV electrical system be designed such that the crew can safely isolate any damaged distribution equipment and switch to alternative supplies without the need to open the HV equipment.

### 1.13.3 Activities

For all HV switchboards and distribution boards, each type of operation or activity is to be identified and the means of undertaking the operation or activity safely is to be established. The operations and activities to be considered are to include the following:

*i)* Taking readings

*ii)* Normal operational switching

*iii)* Isolation and making safe

*iv)* Maintenance

*v)* Fault finding

*vi)* Inspection

*vii)* Class Surveys

Where switchgear design calls for circuit breakers to be inspected prior to being put back into service following operation on overcurrent, this should also be covered.

### 1.13.4 Accessibility *(1 July 2016)*

An adequate, unobstructed working space of at least 2 m (6 ft) is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personal performing maintenance activities. Where the clear space around a location where activity is taking place is less than 2 m (6 ft), then the activities are to be covered in sufficient detail to take into account the work involved and the possible need to have clear and safe access for emergency medical evacuation. Where recommended by the switchgear manufacturer, the working space may be reduced to a minimum of 1.5 m (5 ft) due to special considerations such as the use of arc resistant switchgear.

Activities that do not require operation at the switchboard (e.g., telephones or manual call points) should not require the operator to be within 2 m (6 ft) of the switchboard.

#### 1.13.5 Modifications

No modifications are to be made to HV switchgear without the plans being approved and the drawings being made available to the ABS Surveyor in advance of the work taking place. Testing of approved modifications is to be conducted in the presence of the ABS Surveyor. Temporary repairs are to be in full compliance with the requirements of these Rules.

#### 1.13.6 HV Systems with Enhanced Operating Redundancy

Where the HV electrical system is designed with sufficient redundancy to allow switching and isolation along the principles in 4-5-5/1.13.2 and still meet the requirements of 4-5-2/3.3 with one generator in reserve, then the activity associated with that failure is not required to be included.

### 1.15 Preliminary Operations Manual *(2014)*

#### 1.15.1 Objective

The preliminary operations manual contains the shipyard's description of operations affecting the vessel's HV equipment. The description 'preliminary' is used to capture the fact that it may not be the final document used by the vessel's Owner.

The manual is to be complete and sufficiently detailed to capture each piece of HV equipment and how the activities associated with that equipment can be achieved consistently with the Design Operating Philosophy. This manual is to be made available to the Owner by the shipyard.

The Owner will need the information contained in the preliminary operations manual to understand how the shipyard designed the HV equipment to be operated safely. It is likely that the Owner will modify some aspects of the manual to bring it in line with their own company policies, organizational responsibilities and legal duties.

The preliminary operations manual is to include for each piece of HV equipment:

*i)* Details of the tasks (operations and activities) associated with that piece of equipment

*ii)* Details of the 'Authorization' needed to perform each of the tasks

*iii)* Details of the tools required to perform each of the tasks

*iv)* Details of PPE and safety equipment (locks, barriers, tags, rescue hooks, etc.)

*v)* Identify the tasks for which a 'permit to work' system is to be used.

#### 1.15.2 Details of Authorization

For each operation or task involving HV switchgear and for access to the HV switchgear rooms, the appropriate authorizations are to be determined before delivery.

#### 1.15.3 Training Requirements for Authorization

Part of the basis of establishing any level of authorization is training. It is not expected that the shipyard will stipulate what training qualifications are required. However, a description of the subjects that would need to be covered in the training for each level of authorization should be included.

The Owner can be guided by the above information in making decisions regarding the crew training requirements.

#### 1.15.4 Test, Maintenance Tools and PPE

Where tasks require the use of PPE, the required protection clothing rating should be identifiable in the preliminary operations manual and on a label on the HV equipment where that task will take place. The level of protection offered by the PPE is to be readily identified on the PPE itself in the same terms or units as used on the labels.

Some PPE for general use is not suitable for High Voltage or arc flash hazards, mostly through inappropriate fire performance; such PPE is to be excluded from high voltage switchgear rooms. Information alerting the crew of the need to be able to recognize and use the right PPE is to be included in the manual.

#### 1.15.5 Inspection and Maintenance of Test Equipment Tools and PPE

Where PPE or test equipment is provided by the shipyard the means for its proper use, inspection, calibration and maintenance is to be made available. The instructions or directions regarding where they are kept are to be contained in the Preliminary Operations Manual.

Where the PPE is not provided by the shipyard a description or specification regarding the required tools and PPE should be provided in the Preliminary Operations Manual.

## 3 Bridge Control of Propulsion Machinery

### 3.1 Control Capability

Under all sailing conditions, including maneuvering, the speed, direction of thrust and, if applicable, the pitch of the propeller are to be fully controllable from the navigation bridge. This control is to be performed by a single control device for each independent propeller, with automatic performance of all associated services, including, where necessary, means of preventing overload of the propulsion machinery.

### 3.3 Emergency Stopping

The propulsion machinery is to be provided with an emergency stopping device on the navigation bridge and independent from the bridge control system.

### 3.5 Order of Control Station Command

Remote control of the propulsion machinery is to be possible only from one station at a time; at one control station interconnected control units are permitted. There is to be at each station an indicator showing which station is in control of the propulsion machinery. The transfer of control between navigation bridge and machinery spaces is to be possible only in the machinery space.

### 3.7 Local Control

It is to be possible to control essential machinery and the propelling machinery locally in the case of failure in any part of the automatic or remote control systems.

### 3.9 Bridge Control Indicators

Indicators for the following are to be fitted on the navigation bridge:

*i)* Propeller speed and direction where fixed pitch propellers are fitted.

*ii)* Propeller speed and pitch position where controllable pitch propellers are fitted.

*iii)* An alarm is to be provided to indicate low starting air pressure and is to be set at a level which still permits main engine starting operations.

*iv)* An alarm and warning light indicating high bilge water level in the main propulsion machinery space.

*v)* An alarm and warning light indicating the presence of a fire in the main propulsion machinery space.

## 5 Electric Propulsion System

### 5.1 General *(2007)*

#### 5.1.1 Application *(2014)*

The following requirements in this subsection are applicable to the electric propulsion system. Electric propulsion systems complying with other recognized standards will also be considered, provided it can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety standards of these Rules. Unless stated otherwise, electric propulsion equipment and systems are to comply with the applicable requirements in other parts of Part 4, Chapter 5, as well.

#### 5.1.2 Plans and Data to be Submitted

In addition to the plans and data to be submitted in accordance with 4-5-2/1, 4-5-3/1 and 4-5-4/1, the following plans and data are to be submitted for review.

- One-line diagrams of the propulsion control system for power supply, circuit protection, alarm, monitoring, safety and emergency shutdown systems, including list of alarm and monitoring points.
- Plans showing the location of the propulsion controls and its monitoring stations.
- Arrangements and details of the propulsion control console or panel, including schematic diagram of the system therein.
- Arrangements and details of electric coupling.
- Arrangements and details of the semiconductor converters enclosure for the propulsion system, including data for the semiconductor converter and cooling system with its interlocking arrangement.

### 5.3 System Design *(2007)*

#### 5.3.1 General *(2016)*

For the purposes of the electric propulsion system requirements, an electric propulsion system is one in which the main propulsion of the vessel is provided by at least one electric motor. A vessel may have more than one electrical propulsion system.

An integrated electric propulsion system is a system where a common set of generators supply power to the vessel service loads as well as the propulsion loads.

In the case of an integrated electrical propulsion system, the electrical drive train is considered to consist of the equipment connected to the electrical network such as a drive (frequency converter) and the propulsion motor(s).

All electrical equipment that is part of the electric propulsion drive train is to be built with redundancy such that a single failure will not completely disable the propulsion of the vessel. Where electric motors are to provide the sole means of propulsion for a vessel, a single propulsion motor with dual windings does not meet this requirement.

#### 5.3.2 Generating Capacity

For vessels with an integrated electric propulsion system, under normal sea-going conditions, when one generator is out of service, the remaining generator capacity is to be sufficient to carry all of the vessel services (essential services, normal services and for minimum comfortable conditions of habitability) and an effective level of propulsion.

#### 5.3.3 Power Management System *(2014)*

For vessels with an integrated electric propulsion system, a power management system is to be provided. The power management system is to control load sharing between generators, prevent blackouts, maintain power to the essential service loads and maintain power to the propulsion loads.

The system is to account for the following operating scenarios.

- All generators in operation, then the loss of one generator
- When at least one generator is not in operation and there is an increase in the propulsion loads or a loss of one of the generators, that would result in the need to start a generator that was not in operation.
- Upon failure of the power management system, there is to be no change in the available electrical power. Failure of the power management system is to be alarmed at a manned control station.

Further, the system is to prevent overloading the generators, by reducing the propulsion load or load shedding of non-essential loads. In general, the system is to limit power to the propulsion loads to maintain power to the vessel's essential service loads. However, the system is to shed non-essential loads to maintain power to the propulsion loads.

An audible and visible alarm is to be installed at each propulsion control location and is to be activated when the system is limiting the propulsion power in order to maintain power to the other essential service loads.

When at least one generator is not in operation, consideration should be given to keeping one generator in standby mode, so that it can be brought on line within 45 seconds, upon failure of one of the running generators.

Operation with only one generator on line should only be considered, when another generator can be brought on line within 45 seconds of failure of the running generator.

5.3.4 Regenerative Power *(2014)*

For systems where regenerative power may be developed, the regenerative power is not to cause overspeeding of the prime mover or variations in the system voltage and frequency which exceeds the limits of 4-5-1/9. See also 4-5-5/5.17.4(a) and 4-5-5/5.17.4(e).

5.3.5 Harmonics *(2014)*

A harmonic distortion calculation is to be submitted for review for all vessels with electric propulsion. The calculation is to indicate that the harmonic distortion levels at all locations throughout the power distribution system (main generation switchboard, downstream power distribution switchboards, etc.) are within the limits of 4-5-2/7.9. The harmonic distortion levels at dedicated propulsion buses are also to be within the limits of 4-5-2/7.9, otherwise documentation from the manufacturer is to be submitted indicating that the equipment is designed for operation at a higher level of distortion.

Where higher values of harmonic distortion are expected, any other possible effects, such as additional heat losses in machines, network resonances, errors in control and monitoring systems are to be considered.

Means of monitoring voltage harmonic distortion shall be provided, including alarms at the main generation switchboard and at continuously manned stations when to notify of an increase in total or individual harmonic distortion levels above the maximum allowable levels.

Harmonic filters, if used, are to comply with requirements mentioned in 4-5-2/9.19.

## 5.5 Propulsion Power Supply Systems *(2014)*

5.5.1 Propulsion Generators

*5.5.1(a) Power Supply.* The power for the propulsion equipment may be derived from a single generator. If a ship service generator is also used for propulsion purposes other than for boosting the propulsion power, such generator and power supply circuits to propulsion systems are also to comply with the applicable requirements in this Subsection.

*5.5.1(b) Single System.* If a propulsion system contains only one generator and one motor and cannot be connected to another propulsion system, more than one exciter set is to be provided for each machine. However, this is not necessary for self-excited generators or for multi-propeller propulsion vessels where any additional exciter set may be common for the vessel.

*5.5.1(c) Multiple Systems.* Systems having two or more propulsion generators, two or more semiconductor converters or two or more motors on one propeller shaft are to be so arranged that any unit may be taken out of service and disconnected electrically without preventing the operation of the remaining units.

*5.5.1(d) Excitation Systems.* Arrangements for electric propulsion generators are to be such that propulsion can be maintained in case of failure of an excitation system or failure of a power supply for an excitation system. Propulsion may be at reduced power under such conditions where two or more propulsion generators are installed, provided such reduced power is sufficient to provide for a speed of not less than 7 knots or $^1/_2$ of design speed, whichever is the lesser.

*5.5.1(e) Features for Other Services.* If the propulsion generator is used for other purposes than for propulsion, such as dredging, cargo oil pumps and other special services, overload protection in the auxiliary circuit and means for making voltage adjustments are to be provided at the control board. When propulsion alternating-current generators are used for other services for operation in port, the port excitation control is to be provided with a device that is to operate just below normal idling speed of the generator to remove excitation automatically.

#### 5.5.2 Propulsion Excitation

*5.5.2(a) Excitation Circuits.* Every exciter set is to be supplied by a separate feeder. Excitation circuits are not to be fitted with overload circuit-interrupting devices, except those intended to function in connection with the protection for the propulsion generator. In such cases, the field circuit breaker is to be provided with a discharge resistor, unless a permanent discharge resistor is provided.

*5.5.2(b) Field Circuits.* Field circuits are to be provided with means for suppressing voltage rise when a field switch is opened. Where fuses are used for excitation circuit protection, it is essential that they do not interrupt the field discharge resistor circuit upon rupturing.

*5.5.2(c) Ship's Service Generator Connection.* Where the excitation supply is obtained from the ship's service generators, the connection is to be made to the generator side of the generator circuit breaker with the excitation supply passing through the overload current device of the breaker.

### 5.7 Circuit Protection *(2016)*

#### 5.7.1 Setting

Overcurrent protective devices, if any, in the main circuits are to be set sufficiently high so as not to operate on overcurrents caused by maneuvering or normal operation in heavy seas or in floating broken ice.

#### 5.7.2 Direct-current (DC) Propulsion Circuits

*5.7.2(a) Circuit Protection.* Direct-current propulsion circuits are not to have fuses. Each circuit is to be protected by overload relays to open the field circuits or by remote-controlled main-circuit interrupting devices. Provision is to be made for closing circuit breakers promptly after opening.

*5.7.2(b) Protection for Reversal of the Rotation.* Where separately driven DC generators are connected electrically in series, means shall be provided to prevent reversal of the rotation of a generator upon failure of the driving power of its prime mover.

#### 5.7.3 Excitation Circuits

An overload protection is not to be provided for opening of the excitation circuit.

#### 5.7.4 Reduction of Magnetic Fluxes

Means are to be provided for selective tripping or rapid reduction of the magnetic fluxes of the generators and motors so that overcurrents do not reach values which may endanger the plant.

#### 5.7.5 Direct-current (DC) Propulsion Motors Supplied by Semiconductor Converters *(2008)*

The protection features of the semiconductor converters are to be arranged to avoid a damaging flashover in the DC propulsion motor. A possible cause of a damaging flashover would be removal of the field current. The protection features of the semiconductor converters are to take into account the increase in armature current created by the removal of the field current, due to accidental loss of the field, or activation of a protection feature intended to protect the field.

To verify compliance with the above, the maximum time-current characteristics that can be commutated by the motor as well as the time-current characteristics of the protective features of the semiconductor converters are to be submitted for review. To avoid a damaging flashover, the maximum time-current characteristics of the motor is to be provided by the motor manufacturer and is to be used by the semiconductor converter manufacturer to determine the appropriate set points for the protection features of the semiconductor converters.

## 5.9 Protection for Earth Leakage

### 5.9.1 Main Propulsion Circuits

Means for earth leakage detection are to be provided for the main propulsion circuit and be arranged to operate an alarm upon the occurrence of an earth fault. When the fault current flowing is liable to cause damage, arrangements for opening the main propulsion circuit are also to be provided.

### 5.9.2 Excitation Circuits

Means are to be provided for earth leakage detection in excitation circuits of propulsion machines but may be omitted in circuits of brushless excitation systems and of machines rated up to 500 kW.

### 5.9.3 Alternating current (AC) Systems

Alternating current propulsion circuits are to be provided with an earthing detector alarm or indicator. If the neutral is earthed for this purpose, it is to be through an arrangement which will limit the current at full-rated voltage so that it will not exceed approximately 20 amperes upon a fault to earth in the propulsion system. An unbalance relay is to be provided which is to open the generator and motor-field circuits upon the occurrence of an appreciable unbalanced fault.

### 5.9.4 Direct-current (DC) Systems

The earthing detector may consist of a voltmeter or lights. Provision is to be made for protection against severe overloads, excessive currents and electrical faults likely to result in damage to the plant. Protective equipment is to be capable of being so set as not to operate on the overloads or overcurrents experienced in a heavy seaway or when maneuvering.

## 5.11 Electric Propulsion Control

### 5.11.1 General

Failure of a control signal is not to cause an excessive increase in propeller speed. The reference value transmitters in the control stations and the control equipment are to be so designed that any defect in the desired value transmitters or in the cables between the control station and the propulsion system will not cause a substantial increase in the propeller speed.

### 5.11.2 Testing and Inspection

Controls for electric propulsion equipment are to be inspected when finished and dielectric strength tests and insulation resistance measurements made on the various circuits in the presence of the Surveyor, preferably at the plant of manufacture. The satisfactory tripping and operation of all relays, contactors and the various safety devices are also to be demonstrated.

### 5.11.3 Initiation of Control

The control of the propulsion system can be activated only when the delegated control lever is in zero position and the system is ready for operation.

### 5.11.4 Emergency Stop

Each control station shall have an emergency stop device which is independent of the control lever.

### 5.11.5 Prime Mover Control

Where required by the system of control, means are to be provided at the control assembly for controlling the prime mover speed and for mechanically tripping the throttle valve.

### 5.11.6 Control Power Failure

If failure of the power supply occurs in systems with power-aided control (e.g., with electric, pneumatic or hydraulic aid), it is to be possible to restore control in a short time.

### 5.11.7 Protection

Arrangements are to be made so that opening of the control system assemblies or compartments will not cause inadvertent or automatic loss of propulsion. Where steam and oil gauges are mounted on the main-control assembly, provision is to be made so that the steam or oil will not come in contact with the energized parts in case of leakage.

#### 5.11.8 Interlocks

All levers for operating contactors, line switches, field switches and similar devices are to be interlocked to prevent their improper operation. Interlocks are to be provided with the field lever to prevent the opening of any main circuit without first reducing the field excitation to zero, except that when the generators simultaneously supply power to an auxiliary load apart from the propulsion, the field excitation need only be reduced to a low value.

## 5.13 Instrumentation at the Control Station

#### 5.13.1 Indication, Display and Alarms

The necessary instruments to indicate existing conditions at all times are to be provided and mounted on the control panel convenient to the operating levers and switches. Instruments and other devices mounted on the switchboard are to be labeled and the instruments provided with a distinguishing mark to indicate full-load conditions. Metallic cases of all permanently installed instruments are to be permanently earthed. The following instruments, where applicable, are to be provided.

*5.13.1(a) For AC Systems (1997).* Ammeter, voltmeter, indicating wattmeter and field ammeter (*) for each propulsion generator and for each synchronous motor.

*5.13.1(b) For DC Systems.* An ammeter for each main circuit and one or more voltmeters with selector switches for reading voltage on each propulsion generator and motor.

*5.13.1(c) For Electric Slip Couplings.* An ammeter for the coupling excitation circuit.

* Field ammeter is not required for brushless generators

#### 5.13.2 Indication of Propulsion System Status

The control stations of the propulsion systems are to have at least the following indications for each propeller.

*5.13.2(a) "Ready for Operation".* Power circuits and necessary auxiliaries are in operation.

*5.13.2(b) "Faulty".* Propeller is not controllable.

*5.13.2(c) "Power Limitation".* In case of disturbance, for example, in the ventilators for propulsion motors, in the converters, cooling water supply or load limitation of the generators.

## 5.15 Equipment Installation and Arrangement *(2014)*

#### 5.15.1 General

The arrangement of bus bars and wiring on the back of propulsion-control assemblies is to be such that all parts, including the connections, are accessible. All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Clearance and creepage distance are to be provided between parts of opposite polarity and between live parts and earth to prevent arcing. See 4-5-1/21, 4-5-4/7.11.6 and 4-5-5/1.11.2(b).

#### 5.15.2 Accessibility and Facilities for Repairs

*5.15.2(a) Accessibility.* For purposes of inspection and repair, provision is to be made for access to the stator and rotor coils, and for the withdrawal and replacement of field coils. Adequate access is to be provided to permit resurfacing of commutators and slip-rings, as well as the renewal and bedding of brushes.

*5.15.2(b) Facility for Supporting.* Facilities shall be provided for supporting the shaft to permit inspection and withdrawal of bearings.

*5.15.2(c) Slip-couplings.* Slip-couplings are to be designed to permit removal as a unit without axial displacement of the driving and driven shaft, and without removing the poles.

#### 5.15.3 Propulsion Cables

Propulsion cables are not to have splices or joints, except terminal joints, and all cable terminals are to be sealed against the admission of moisture or air. Similar precautions are to be taken during installation by sealing all cable ends until the terminals are permanently attached. Cable supports are to be designed to withstand short-circuited conditions. They are to be spaced less than 915 mm (36 in.) apart and are to be arranged to prevent chafing of the cable. See 4-5-3/5.9.1.

### 5.17 Machinery and Equipment *(2014)*

#### 5.17.1 Material Tests

The following materials intended for main propulsion installation are to be tested in accordance with the ABS *Rules for Materials and Welding (Part 2)*: thrust shafts, line shafts, propeller shafts, shafting for propulsion generators and motors, coupling bolts, and in the case of direct-connected turbine-driven propulsion generators, fan shrouds, centering and retaining rings. Major castings or built-up parts such as frames, spiders and end shields are to be surface inspected and the welding is to be in accordance with the ABS *Rules for Materials and Welding (Part 2)*.

#### 5.17.2 Temperature Rating

When generators, motors or slip-couplings for electric propulsion are fitted with an integral fan and will be operated at speeds below the rated speed with full-load torque, full-load current or full-load excitation temperature rise limits according to 4-5-4/Table 3 are not to be exceeded.

#### 5.17.3 Protection Against Moisture Condensation

4-5-4/3.13.7 is applicable for rotating machines and converters, regardless of the weight of the machines.

#### 5.17.4 Prime Movers

*5.17.4(a) Capability*. The prime mover rated output is to have adequate overloading and build-up capacity for supplying the power which is necessary during transitional changes in operating conditions of the electrical equipment. When maneuvering from full propeller speed ahead to full propeller speed astern with the vessel making full way ahead, the prime mover is be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

*5.17.4(b) Speed Control.* Prime movers of any type are to be provided with a governor capable of maintaining the preset steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

*5.17.4(c) Manual Controls.* Where the speed control of the propeller requires speed variation of the prime mover, the governor is to be provided with means for local manual control, as well as for remote control. For turbines driving AC propulsion generators, where required by the system of control, the governor is to be provided with means for local hand control, as well as remote adjustment from the control station.

*5.17.4(d) Parallel Operation.* In case of parallel operation of generators, the governing system is to permit stable operation to be maintained over the entire operational speed range of the prime movers.

*5.17.4(e) Protection for Regenerated Power.* Braking resistors or ballast consumers are to be provided to absorb excess amounts of regenerated energy and to reduce the speed of rotation of the propulsion motor. These braking resistors or ballast consumers are to be located external to the mechanical and electric rotating machines. Alternatively, the amount of regenerated power may be limited by the action of the control system.

5.17.5 Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors.

*5.17.5(a) Ventilation and Protection.* Electric rotating machines for propulsion are to be enclosed ventilated or be provided with substantial wire or mesh screen to prevent personnel injury or entrance of foreign matter. Dampers are to be provided in ventilating air ducts, except when re-circulating systems are used.

*5.17.5(b) Fire-extinguishing Systems.* Electric rotating machines for propulsion which are enclosed or in which the air gap is not directly exposed are to be fitted with fire-extinguishing systems suitable for fires in electrical equipment. This will not be required where it can be established that the machinery and insulation is self-extinguishing.

*5.17.5(c) Air Coolers (2004).* Air cooling systems for propulsion generators are to be in accordance with 4-6-5/7.5 and 4-6-5/7.7.1 of the *Steel Vessel Rules*. Water-air heat exchangers of rotating propulsion machines for single systems (single generator and single motor), as specified in 4-5-5/5.5.1(b) of these Rules, are to have double wall tubes and be fitted with a leak detector feature to monitor for any water leakage. A visual and audible alarm is to be provided at a normally manned location to indicate such water leakage.

*5.17.5(d) Temperature Sensors (1997).* Stator windings of AC machines and interpole windings of DC machines rated above 500 kW are to be provided with temperature sensors. See 4-9-6/Table 4A of the *Steel Vessel Rules*.

*5.17.5(e) Generator Excitation (2014).* Excitation current for propulsion generators may be derived from attached rotating exciters, static exciters, excitation motor-generator sets or special purpose generating units. Power for these exciters may be derived from the machine being excited or from any ship service, emergency or special purpose generating units.

*5.17.5(f) Propulsion Motors (2014).* Propulsion motors are to be designed to be capable of withstanding the mechanical and thermal effects of a short-circuit at its terminals.

5.17.6 Direct-current (DC) Propulsion Motors

*5.17.6(a) Rotors.* The rotors of DC propulsion motors are to be capable of withstanding overspeeding up to the limit reached in accordance with the characteristics of the overspeed protection device at its normal operational setting.

*5.17.6(b) Overspeed Protection.* An overspeed protection device is to be provided to prevent excessive overspeeding of the propulsion motors due to light loads, loss of propeller, etc.

5.17.7 Electric Couplings

*5.17.7(a) General.* Couplings are to be enclosed ventilated or be provided with wire or mesh screen to prevent personnel injury or the entrance of foreign material. All windings are to be specially treated to resist moisture, oil and salt air.

*5.17.7(b) Accessibility for Repairs.* The coupling is to be designed to permit removal as a unit without moving the engine. See also 4-5-5/5.15.2.

*5.17.7(c) Temperature Rating.* The limits of temperature rise are to be the same as for alternating-current generators given in 4-5-4/Table 3, except that when a squirrel-cage element is used, the temperature of this element may reach such values as are not injurious. Depending upon the cooling arrangements, the maximum temperature rise may occur at other than full-load rating so that heat runs will require special consideration. For this purpose, when an integral fan is fitted, the coupling temperatures are not to exceed the limits in 4-5-4/Table 3 when operated continuously at 70% of full-load rpm, full excitation and rated torque. Temperature rises for insulation materials above 180°C (356°F) will be considered in accordance with 4-5-1/15.11.

*5.17.7(d) Excitation.* Excitation is to be provided as required for propulsion generators. See 4-5-4/3.21.1, 4-5-4/3.23.1 and 4-5-5/5.17.5(e).

*5.17.7(e) Control Equipment.* Electric-coupling control equipment is to be combined with the prime mover speed and reversing control and is to include a two-pole disconnect switch, short-circuit protection only, ammeter for reading coupling current, discharge resistor and interlocking to prevent energizing the coupling when the prime mover control levers are in an inappropriate position.

*5.17.7(f) Nameplates.* Nameplates of corrosion-resistant material are to be provided in an accessible position of the electric coupling and are to contain the following typical details:

- Manufacturer's name, serial number and frame designation
- Rated output and type of rating
- Ambient temperature range
- Rated voltage, speed and temperature rise
- Rated exciter voltage and current

### 5.17.8 Semiconductor Converters for Propulsion *(2014)*

Semiconductor converters are to comply with the requirements in 4-5-4/10.

### 5.17.9 Reactors and Transformers for Semiconductor Converters

*5.17.9(a) General.* Interphase reactors and transformers used with semiconductor converters are to conform with the requirements of 4-5-4/9.1.1, 4-5-4/9.1.2(c), 4-5-4/9.3, 4-5-4/9.5.1 and 4-5-4/9.5.2, and the following.

*5.17.9(b) Voltage Regulation.* Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

*5.17.9(c) High Temperature Alarm.* Interphase reactors and transformers used with the semiconductor converters for main and auxiliary propulsion systems are to be provided with high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in 4-5-4/Table 8.

### 5.17.10 Switches

*5.17.10(a) General Design.* All switches are to be arranged for manual operation and so designed that they will not open under ordinary shock or vibration. Contactors, however, may be operated pneumatically, by solenoids or other means in addition to the manual method which is to be provided, unless otherwise approved.

*5.17.10(b) Generator and Motor Switches.* Switches for generators and motors are preferably to be of the air-break type, but for alternating-current systems, where they are to be designed to open full-load current at full voltage, oil-break switches using nonflammable liquid may be used if provided with leak-proof, non-spilling tanks.

*5.17.10(c) Field Switches.* Where necessary, field switches are to be arranged for discharge resistors unless discharge resistors are permanently connected across the field. For alternating-current systems, means are to be provided for de-energizing the excitation circuits by the unbalance relay and ground relay.

### 5.17.11 Propulsion Cables

*5.17.11(a) Conductors.* The conductors of cables external to the components of the propulsion plant, other than cables and interconnecting wiring for computers, data loggers or other automation equipment requiring currents of very small value, are to consist of not less than seven strands and have a cross-sectional area of not less than 1.5 $mm^2$ (2,960 circ. mils).

*5.17.11(b) Insulation Materials.* Ethylene-propylene rubber, cross-linked polyethylene or silicone rubber insulated cables are to be used for propulsion power cables, except that polyvinyl chloride insulated cables may be used where the normal ambient temperature will not exceed 50°C (122°F).

*5.17.11(c) Braided Metallic Armor and Impervious Metallic Sheaths (1998).* Propulsion cables need not have braided metallic armor nor impervious metallic sheaths. Where metallic sheaths are provided, they are not to be used with single alternating current cables.

*5.17.11(d) Inner Wiring.* The insulation of internal wiring in main control gear, including switchboard wiring, shall be of flame-retardant quality.

*5.17.11(e) Testing.* All propulsion cables, other than internal wiring in control gears and switchboards, are to be subjected to dielectric and insulation tests in the presence of the Surveyor.

### 5.19 Dock and Sea Trials *(2014)*

Complete tests of the entire electric propulsion system are to be carried out during sea-trials including the following:

*i)* Duration runs with the ship at full propulsion load.

*ii)* Maneuvering tests which should include a reversal of the vessel from full speed ahead to full speed astern during which important measurements such as system currents, voltages, speed, etc. shall be recorded.

*iii)* Tests to check for operation of all protective devices, safety functions, alarms, indicators, control modes and stability tests for control.

All tests necessary to demonstrate that major components of the electric propulsion plant and the system as a whole are satisfactory for duty are to be performed. Immediately prior to trials, the insulation resistance is to be measured and recorded.

## 7 Three-wire Dual-voltage DC System

### 7.1 Three-wire DC Ship's Generators

Separate circuit-breaker poles are to be provided for the positive, negative, neutral and also for the equalizer leads, unless protection is provided by the main poles. When equalizer poles are provided for the three-wire generators, the overload trips are to be of the algebraic type. No overload trip is to be provided for the neutral pole, but it is to operate simultaneously with the main poles. A neutral overcurrent relay and alarm system is to be provided and set to function at a current value equal to the neutral rating.

### 7.3 Neutral Earthing

#### 7.3.1 Main Switchboard

The neutral of three-wire dual-voltage direct-current systems is to be solidly earthed at the generator switchboard with a zero-center ammeter in the earthing connection. The zero-center ammeter is to have a full-scale reading of 150% of the neutral-current rating of the largest generator and be marked to indicate the polarity of earth. The earth connection is to be made in such a manner that it will not prevent checking the insulation resistance of the generator to earth before the generator is connected to the bus. The neutrals of three-wire DC emergency power systems are to be earthed at all times when they are supplied from the emergency generator or storage battery. The earthed neutral conductor of a three-wire feeder is to be provided with a means for disconnecting and is to be arranged so that the earthed conductor cannot be opened without simultaneously opening the unearthed conductors.

#### 7.3.2 Emergency Switchboard

No direct earth connection is to be provided at the emergency switchboard. The neutral bus or buses are to be solidly and permanently connected to the neutral bus of the main switchboard. No interrupting device is to be provided in the neutral conductor of the bus-tie feeder connecting the two switchboards.

### 7.5 Size of Neutral Conductor

The capacity of the neutral conductor of a dual-voltage feeder is to be 100% of the capacity of the unearthed conductors.

## TABLE 1
## High Voltage Equipment Locations and Minimum Degree of Protection *(2014)*

| *Example of Location* | *Condition of Location* | *Switchboards, Distribution Boards, Motor Control Centers and Controllers* | *Generators* | *Motors* | *Transformers, Converters* | *Junction/Connection Boxes* |
|---|---|---|---|---|---|---|
| Dry control rooms Authorized Personnel Only | Danger of touching live parts only | IP32 | N/A | N/A | IP23 | IP44 |
| Dry control rooms | | IP42 | N/A | N/A | IP44 | IP44 |
| Control rooms Authorized Personnel Only | Danger of dripping liquid and/or moderate mechanical damage | IP32 | N/A | N/A | IP23 | IP44 |
| Control Rooms | | IP42 | N/A | N/A | IP44 | IP44 |
| Above floor plates in machinery spaces Authorized Personnel Only (1) | | IP32 | IP23 | IP23 | IP23 | IP44 |
| Above floor plates in machinery spaces | | IP42 | IP23 | IP43 | IP44 | IP44 |
| Emergency machinery rooms Authorized Personnel Only | | IP32 | IP23 | IP23 | IP23 | IP44 |
| Emergency machinery rooms | | IP42 | IP23 | IP43 | IP44 | IP44 |
| Below floor plates in machinery spaces Authorized Personnel Only | Increased danger of liquid and/or mechanical damage | N/A | N/A | * | * | IP44 |
| Below floor plates in machinery spaces | | N/A | N/A | * | N/A | IP44 |
| Ballast pump rooms Authorized Personnel Only | Increased danger of liquid and mechanical damage | IP44 | N/A | IP44 | IP44 | IP44 |
| Ballast pump rooms | | IP44 | N/A | IP44 | IP44 | IP44 |
| Holds for general cargo | Danger of liquid spray presence of cargo dust, serious mechanical damage, and/or aggressive fumes | * | * | * | * | IP55 |
| Open decks (2) | Not exposed to seas | N/A | IP56 | IP56 | IP56 | IP56 |
| Open decks (2) | Exposed to seas | N/A | N/A | * | * | * |

"*" indicates that equipment in excess of 1000 V is not normally permitted in these locations

*Notes:*

1 See 4-5-3/3.1.1 where the equipment is located within areas affected by local fixed pressure water-spraying or water-mist fire extinguishing systems

2 For High Voltage Shore Connections (HVSC) see the requirements in the ABS *Guide for High Voltage Shore Connection*

3 Where the IP rating of the high voltage electrical equipment has been selected on the basis that it is only accessible to authorized personnel, the entrance doors to the spaces in which such equipment is located, are to be marked accordingly.

PART
# 4

## CHAPTER 5 Electrical Installations

## SECTION 6 Specialized Vessels and Services

### 1 Oil Carriers

#### 1.1 Application

In addition to the foregoing requirements of this Section, the following requirements are applicable to vessels carrying oil having a flash point not exceeding 60°C (140°F).

*Note:* The electric installation on bulk oil vessels carrying oil having a flash point above 60°C (140°F), closed-cup test, will be subject to special consideration in each case.

#### 1.3 Earthed Distribution Systems

An earthed distribution system is not to be used, except for the following applications.

*i)* Earthed intrinsically-safe circuits.

*ii)* Power supplied, control circuits and instrumentation circuits where technical or safety reasons preclude the use of a system without an earthing connection, provided the current in the hull is limited to 5 amperes or less in both normal and fault conditions.

*iii)* Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any hazardous areas.

*iv)* Alternating-current power networks of 1 kV root mean square (rms) (line to line) and over, provided that any possible resulting current does not flow directly through any hazardous areas.

#### 1.5 Hazardous Areas

1.5.1 Self-Propelled Vessels

For self-propelled vessels, the hazardous areas include:

*i)* Cargo tanks and cargo piping

*ii)* Cofferdams, and permanent (for example, segregated) ballast tanks adjacent to cargo tanks

*iii)* Cargo pump rooms

*iv)* Compartments for cargo hoses

*v)* Enclosed or semi-enclosed spaces immediately above cargo pump rooms or having bulkheads above and in line with cargo bulkheads

*vi)* Enclosed or semi-enclosed spaces, immediately above cargo pump rooms, or above vertical cofferdams adjacent to cargo tanks, unless separated by a gas-tight deck and suitably mechanically ventilated

*vii)* Spaces, other than cofferdams, adjacent to and below the top of a cargo tank (for example, trunks, passageways and holds)

*viii)* Areas on open decks, or semi-enclosed spaces on open decks, within 3 m of any cargo tank outlets, gas or vapor outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump room entrances or cargo pump room ventilation openings

*Note:* Such areas are, for example, all areas within 3 m of cargo tank hatches, sight ports, tank cleaning opening, valve openings, sounding pipes, cargo vapor outlets, cofferdam of cargo tanks.

*ix)* Areas on open deck within spillage coaming surrounding cargo manifold valves and 3 m beyond these and other coamings intended to keep spillages clear of accommodation and service spaces, up to a height of 2.4 m above the deck

*x)* Areas on open deck over all cargo tanks (including all ballast tanks within cargo tank area) and to the full breadth of the vessel plus 3 m fore and aft on open deck, up to a height of 2.4 m above the deck which do not belong to the hazardous areas defined in 4-5-6/1.5.1viii) and 4-5-6/1.5.1ix)

*xi)* Enclosed or semi-enclosed spaces, having an opening into any hazardous area

1.5.2 Barges

For barges, the hazardous areas include:

*i)* Areas described in 4-5-6/1.5.1i) through 4-5-6/1.5.1viii)

*ii)* Areas on open deck within spillage coaming surrounding cargo manifold valves and 3 m beyond these and other coamings intended to keep spillages clear of accommodation and service spaces

## 1.7 Installation of Equipment and Cables

1.7.1 General

Electrical equipment and wiring are not to be installed in any hazardous areas unless essential for operation purposes. In such cases, the installation of equipment and wiring are to comply with 4-5-6/Table 1.

1.7.2 Cables

All cables installed within the hazardous areas described in 4-5-6/1.5 are to be sheathed with a nonmetallic external impervious sheath over a metallic braiding or a metallic armoring or to be of mineral-insulated copper- or stainless steel-sheathed type. A nonmetallic impervious sheath is to be applied over the metallic braiding, armoring or sheathing of all cables which may be subject to corrosion. Cables installed on open deck or on fore-and-aft gangways are to be protected against mechanical damage. Cable and protective supports are to be so installed as to avoid strain or chafing and due allowance made for expansion or working of the structure.

1.7.3 Sea Depth Sounder, Speed Log, and Impressed Current Cathodic Protection Systems *(2005)*

Hull fittings containing transducers for electrical depth sounding or speed log devices or containing terminals or shell penetrations for anodes or electrodes of an impressed current cathodic protection system for underwater hull protection are not to be installed in any cargo tanks of an oil carrier. However, it may be installed in hazardous areas, as permitted by 4-5-6/Table 1, provided the following are complied with:

*1.7.3(a)* Hull fittings containing terminals or shell-plating penetrations are to be housed within a gas-tight enclosure and are not to be located adjacent to cargo tank bulkhead;

*1.7.3(b)* The box containing actual electrical connection of the cable, such as terminal box or junction box, is to be filled with insulating material, such as silicon grease, silicon sealing or equivalent and also to be of gastight construction;

*1.7.3(c)* All associated cables passing through these spaces are to be installed in extra-heavy steel pipe with gas-tight joints (no flanged joints), and with corrosion resistant coating up to, and including the underside of the main deck;

*1.7.3(d)* Cable gland with gastight packing is to be provided for the cable at both ends of the cable conduit pipe; and

*1.7.3(e)* Cable inside the vertical cable conduit pipe is to be suitably supported, e.g., by sand-filling, or by strapping to a support-wire. Alternatively, the cable inside the vertical conduit pipe may be accepted without provided support if the mechanical strength of the cable is sufficient to prevent cable damage due to the cable weight within the conduit pipe under continuous mechanical load. Supporting documentation is to be submitted to verify the mechanical strength of the cable with respect to the cable weight inside the conduit.

## 1.9 Cargo Oil Pump Room

### 1.9.1 Ventilation

*1.9.1(a) System and Arrangement.* Cargo oil pump rooms are to have a mechanical extraction ventilating system and ducting, in accordance with 4-5-6/1.9.1i), 4-5-6/1.9.1ii), 4-5-6/1.9.1iii), and 4-5-6/1.9.1iv) below.

*i)* *Lower Intake.* Lower (main) intakes are to be located at the lowest floor level. The number of air changes through the main intake with the damper in item *ii)* closed is to be at least twenty changes per hour based on the gross volume of the pump room.

*ii)* *Emergency Intake.* An emergency intake is to be provided at approximately 2 m (6.5 ft) above the lowest floor with damper capable of being opened or closed from the exposed main deck and lowest floor level so that it can be used when the lower intakes are not available. The air changes in that condition is to be at least fifteen changes per hour.

*iii)* *Dampers.* Where the ratio of areas of the upper emergency intake and lower main intakes is such that the required number of respective air changes in items *i)* and *ii)* above can be obtained, the dampers may not be required.

*iv)* *Floor Plate.* Floors are to be open grating type to allow the free flow of air.

*1.9.1(b) Fan Motors and Fans.* Fan motors are to be located outside of the pump room and outside of the ventilation ducts. Fans are to be of non-sparking construction in accordance with 4-5-3/11.7. Provision is to be made for immediate shutdown of the fan motors upon release of the fire extinguishing medium.

### 1.9.2 Gas Detection *(1999)*

A system for continuously monitoring the concentration of hydrocarbon gases in the pump room is to be fitted. A system utilizing sequential sampling is acceptable, provided the system is dedicated solely to the pump room, thereby minimizing the sampling cycle. Sampling points or detector heads are to be located in the exhaust ventilation duct and lower parts of the pump room at the floor level. The system is to give a visual indication of the level of concentration of hydrocarbon gases and an audible alarm if the concentration exceeds 10% of the lower explosive limit. Such alarm is to be provided in the cargo control room and on the navigation bridge.

### 1.9.3 Lighting *(2002)*

*1.9.3(a) Lighting fitted outside the pump room.* As far as practicable, the lighting fixtures for pump room spaces are to be permanently wired and fitted outside of the pump room, except as noted below. Pump rooms adjacent to engine rooms or similar safe spaces may be lighted through substantial glass lenses or ports permanently fitted in the bulkhead or deck.

The construction of the glass lens port is to be as follows:

- Capable of maintaining watertight and gastight integrity of the bulkhead and deck.
- Suitably protected from mechanical damage.
- Provided with a steel cover capable of being closed and secured on the side of the safe space.
- Both the glass lens and its sealing arrangement will not be impaired by working of the hull.
- Structural strength of the pierced bulkhead or deck is suitably reinforced.

See also 5C-1-1/5.11 and 5C-2-1/5.9 of the *Steel Vessel Rules*.

*1.9.3(b) Lighting fitted inside the pump room.* As an alternative to 4-5-6/1.9.3(a), certified safe lighting fixtures (see 4-5-6/Table 1) may be installed in the pump room, provided they are wired with moisture-resisting jacketed (impervious-sheathed) and armored or mineral-insulated metal-sheathed cable. Lighting circuits are to be so arranged that the failure of any one branch circuit will not leave these spaces in darkness. All switches and protective devices are to be located outside of the pump room. See also 4-5-3/11.1.2 for lighting circuits in hazardous areas.

#### 1.9.4 Cable Installation

Where it is necessary for cables, other than those of intrinsically-safe circuits and those cables supplying lighting fixtures in the pump room, to pass through cargo pump rooms, they are to be installed in extra-heavy steel pipes or other arrangements providing the same degree of gas tightness and protection.

## 3 Vessels Carrying Coal in Bulk

### 3.1 Application

In addition to the foregoing requirements in this Section, the following requirements are applicable to vessels intended to carry coal in bulk by which an explosive and flammable atmosphere may occur.

### 3.3 Hazardous Areas

Space in which combustible and explosive dust/gas and air mixture is likely to occur in normal operation are to be identified as hazardous areas, such as cargo hold spaces, spaces with a direct opening to cargo hold spaces, or areas within 3 m (10 ft) of cargo hold ventilation outlets.

### 3.5 Installation of Equipment

#### 3.5.1 Classified Electrical Equipment in Hazardous Area

Machinery, all electrical power, control and safety devices and wiring installed in locations where an explosive and flammable atmosphere (as may occur in spaces for coal) is expected to exist are to have a temperature classification T4 or higher (maximum surface temperature 132°C (275°F) or lower) and are to be suitable for operation in at least a Group IIA environmental classification, as defined in IEC Publication 60079-12.

#### 3.5.2 Internal Combustion Engines in Hazardous Area

Where essential for operational purposes, the installation of internal combustion engines in hazardous areas will be subject to special consideration. In all instances, exhaust outlets are to be outside of all hazardous areas, excluding that produced by the exhaust outlet itself, and air intakes are to be not less than 3 m (10 ft) from hazardous areas.

#### 3.5.3 Cargo Hold *(1999)*

*3.5.3(a) Instruments for Measuring (1999).* Readings are to be obtainable without entry into the cargo hold and without endangering the cargo and cargo hold's atmosphere. Instruments for measuring the following are to be provided: *

*i)* Concentration of methane in the atmosphere,

*ii)* Concentration of oxygen in the atmosphere,

*iii)* Concentration of carbon monoxide in the atmosphere,

*iv)* pH value of cargo hold bilge samples.

** Note:* In addition to the instruments specified in 4-5-6/3.5.3(a), it is recommended that consideration should be given by the Owner/designers to provide the means for measuring the temperature of the cargo in the range of 0°C (32°F) to 100°C (212°F), where it is intended to carry self-heating coal. Such arrangements should permit the temperature of the coal to be measured during the loading operations and during the voyage without requiring entry into the cargo space.

*3.5.3(b) Cargo Atmosphere Measuring Equipment (1999).* An instrument for measuring methane, oxygen and carbon monoxide concentrations is to be provided, together with an aspirator, flexible connection, a length of tubing and means for sealing the sampling hole in order to enable a representative sample to be obtained from within the hatch cover surroundings. Alternative means for obtaining a representative sample will be considered.

*3.5.3(c) Sampling Points (1999).* Sampling points are to be provided for each hold, one on the port side and another on the starboard side of the hatch cover, as near to the top of the hatch cover as possible. Each sampling point is to be fitted with a screw cap and a threaded stub of approximately 12 mm (0.5 in.) bore, welded to the side of the hatch cover to prevent ingress of water and air. Alternative sampling point arrangements/details will be considered.

*3.5.3(d) Warning Plate (1999).* Permanent warning plates are to be installed in conspicuous places in cargo areas to state that smoking, naked flames, burning, cutting, chipping, welding or other sources of ignition are prohibited.

# 5 Cargo Vessels Carrying Motor Vehicles with Fuel in Their Tanks

## 5.1 Application

In addition to the foregoing requirements in this Section, the following requirements are applicable to the cargo spaces carrying motor vehicles with fuel in their tanks.

## 5.3 Ventilation System

### 5.3.1 Arrangement

The ventilating system for enclosed spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion is to be independent from other ventilation systems and is to be capable of being controlled from a position outside of the space.

### 5.3.2 Capacity

An effective power ventilation system, sufficient to give at least six air changes per hour based on the volume of empty enclosed spaces in which vehicles are to be transported or stored, is to be provided. See also 4-5-6/5.5.2.

### 5.3.3 Fans

Exhaust fans are to be of non-sparking construction in accordance with 4-5-3/11.7.

### 5.3.4 Material and Arrangement of Ducts

Ventilation ducts, including dampers, are to be of steel. Ducts serving spaces capable of being sealed are to be separated for such space.

### 5.3.5 Exhaust Inlet and Outlet

Inlet for exhaust ducts are to be located within 450 mm (17.75 in.) above the vehicle deck. The outlet is to be sited in a safe position, having regard to the source of ignition near the outlet.

### 5.3.6 Emergency Shutdown

Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation system in case of fire, taking into account the weather and sea conditions. See also 4-5-6/5.3.1.

### 5.3.7 Navigation Bridge Indication

Means are to be provided on the navigation bridges or other appropriate locations to indicate any loss of the ventilating capacity.

## 5.5 Location and Type of Equipment *(2010)*

### 5.5.1 Certified Safe Type Equipment

Closed ro-ro cargo spaces carrying motor vehicles with fuel in their tank for their own propulsion are to be regarded as hazardous. Electrical equipment and wiring, except where permitted otherwise in 4-5-6/5.5.2 below, are to be of the types certified safe and suitable for use in flammable petrol and air mixture. Specifically, certified safe equipment for use in Zone 1 areas in accordance with IEC Publication 60079 Part 14 (Gas Group IIA and Temperature Class T3) is required.

5.5.2 Alternative Arrangements

Except for a distance within 450 mm (17.75 in.) above a platform that does not have openings of sufficient size permitting penetration of petroleum gases downward, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks may be permitted as an alternative. Specifically, an enclosure of at least IP55 or apparatus suitable for use in Zone 2 areas in accordance with IEC Publication 60079 Part 14 is required.

In such cases, the ventilating system is to be so designed and operated as to provide continuous ventilation of the cargo spaces at the rate of at least ten air changes per hour whenever vehicles are onboard.

5.5.3 Equipment in Ducts from Vehicle Space

Electrical equipment and wiring installed within an exhaust ventilation duct is to be of a type certified safe for use in explosive petrol and air mixtures (see 4-5-6/5.5.1 above).

## 7 Vessels Carrying Hazardous Chemicals in Bulk

Vessels intended for the carriage of hazardous chemicals in bulk are to comply with the requirements in Part 151 of Subchapter 0 of Chapter I Title 46 Code of Federal Regulations or other recognized standard. See also 3-2-3/3.

## 9 Passenger Vessels

In addition to the foregoing requirements in this Section, passenger vessels having a gross tonnage over 100 tons are to comply with the requirements in this Subsection.

### 9.1 Emergency Source of Power

9.1.1 General

A self-contained emergency source of electrical power is to be provided.

*9.1.1(a) Location (2018).* The emergency source of electrical power, associated power transformer, if any, transitional source of emergency power, emergency switchboard, emergency lighting switchboard, and the fuel oil tank for emergency generator prime mover are to be located above the uppermost continuous deck, outside the machinery casing, and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

The emergency electrical power space is to contain only machinery and equipment supporting the normal operation of the emergency power source.

*9.1.1(b) Separation*

*i)* *Machinery Space of Category A.* The location of the emergency source of electrical power, associated power transformer, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard is to be such that a fire or other casualty in the space containing the main source of electrical power, power transformer, if any, and the main switchboard, or in any machinery space of Category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard, including trunks to such spaces, are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard.

*ii)* *Machinery Space Other Than Category A.* Spaces containing emergency sources of power are to be separated from machinery spaces other than Category A machinery spaces, by a boundary insulated to a level of not less than A-15 for bulkheads and decks and A-0 for the overhead from any such space (including trunks to such spaces). Where the emergency source of power is a generator, the above is not intended to preclude the location of the emergency generator in the same space as its prime mover, regardless of size.

*iii)* *Alternative Arrangement.* Where it can be shown that the arrangements of the spaces containing the emergency source of power in relation to machinery space of Category A are in compliance with the requirements of the governmental authority of the country whose flag the vessel flies, either of the following may be considered in lieu of 4-5-6/9.1.1(b)i):

- Contiguous boundaries insulated to A-60 with the insulation extending at least 450 mm (18 in.) beyond the boundary of the space containing the emergency source of power.
- Separation by a cofferdam having dimensions as required for ready access and extending at least 150 mm (6 in.) beyond the boundaries of the space containing the emergency source of power. Except for cables feeding services located in the machinery space of Category A or those spaces containing main source of electrical power, associated transformer or converter, if any, and main switchboard, emergency electric cables are not to be installed in such cofferdams unless the cofferdam is insulated to A-60.

9.1.2 Emergency Services

*9.1.2(a) General.* The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously and for equipment which can be shown as not being required in actual service to draw their rated loads, In the latter case, supporting details are to be submitted. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the period specified in 4-5-6/9.1.2(b) through 4-5-6/9.1.2(g), if they depend upon an electrical source for their operation.

*9.1.2(b) Lighting Systems and Navigation Light for a period of 3 hours:*

*i)* At muster and embarkation stations for the survival craft

*ii)* At the survival craft, their launching appliances and the area of water into which they are to be launched

*iii)* In all service and accommodation alleyways, stairways and exits, personnel elevators and shafts

*iv)* In the machinery spaces and main generating stations, including their control positions

*v)* In all control stations, machinery control rooms, and at each main and emergency switchboard

*vi)* At all stowage positions for firemen's outfits

*vii)* At the steering gear

*viii)* At the fire pump referred to in 4-5-6/9.1.2(d), at the sprinkler pump, if any, at the emergency bilge pump, if any, and at the starting positions of their motors; and

*ix)* Navigation lights and other lights required by the governmental authority

*9.1.2(c) Communication System, Navigation Aid, and Alarm Systems for a period of 3 hours:*

*i)* All internal communication equipment as required in an emergency.

*ii)* Navigational aids.

*iii)* Required fire detection and fire alarm systems.

*iv)* Intermittent operation of the daylight signaling lamp, the ship's whistle, manually operated call points, and other internal signals that are required in an emergency; unless such services have an independent supply for the period of 3 hours from an accumulator battery suitably located for use in an emergency,

*9.1.2(d) Emergency Fire Pump.* For a period of 3 hours, one of the fire pumps which may be required by 4-4-1/9.1.2 if dependent upon the emergency generator for its source of power.

*9.1.2(e) Steering Gear.* Steering gear to comply with 4-5-6/9.3 if powered from emergency source, for a period of 10 minutes of continuous operation.

*9.1.2(f) Watertight Doors.* For a period of half an hour, any watertight doors required by Section 3-3-1 to be power-operated together with their indicators and warning signals.

*9.1.2(g) Elevators.* For a period of half an hour, the emergency arrangements to bring the elevators to deck level for the escape of persons. The passenger elevators may be brought to deck level sequentially in an emergency.

### 9.1.3 Power Supply

*9.1.3(a) General.* The emergency source of electrical power may be either a generator or an accumulator battery in accordance with 4-5-6/9.1.3(b) or 4-5-6/9.1.3(c) below:

*9.1.3(b) Generator (2014).* Where the emergency source of electrical power is a generator, it is to be:

*i)* Driven by a prime mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C (110°F), and

*ii)* Started automatically upon failure of the main source of electrical power supply and connected automatically to the emergency switchboard, then those services referred to in 4-5-6/9.1.4 are to be connected automatically to the emergency generator as quickly as is safe and practicable subject to a maximum of 45 seconds, or provided with a transitional source of emergency electrical power as specified in 4-5-6/9.1.4 unless an emergency generator is provided capable both of supplying the services referred to in 4-5-6/9.1.4 of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 seconds, and

*iii)* An adequate fuel capacity for the emergency generator prime mover is to be provided.

Where it is intended to use fuel with a flash point of less than 60°C (140°F) then details of the precautions used to address the associated hazardous area issues are to be submitted to ABS for review (see also 4-6-5/3.1.2 of the *Steel Vessel Rules*).

*9.1.3(c) Accumulator Battery.* Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

*i)* Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;

*ii)* Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

*iii)* Immediately supplying at least those services specified in 4-5-6/9.1.4.

*9.1.3(d) Emergency Generator for Non-emergency Services (2008).* Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used, exceptionally, and for short periods, to supply non-emergency circuits during blackout situation, dead ship condition and routine use for testing. The generator is to be safeguarded against overload by automatically shedding such non-emergency services so that supply to the required emergency loads is always available. See also 4-5-6/9.1.5(e).

### 9.1.4 Transitional Source of Power

The transitional source of emergency electrical power where required by 4-5-6/9.1.3(b)ii) is to consist of an accumulator battery which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and be so arranged as to automatically supply in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

*i)* The lighting required by 4-5-6/9.1.2(b). For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

*ii)* All services required by 4-5-6/9.1.2(c)i), 4-5-6/9.1.2(c)iii) and 4-5-6/9.1.2(c)iv) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

### 9.1.5 Emergency Switchboard

*9.1.5(a) General.* The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

*9.1.5(b) Emergency Switchboard for Generator.* Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

*9.1.5(c) Accumulator Battery.* No accumulator battery fitted in accordance with 4-5-6/9.1.3(c) or 4-5-6/9.1.4 is to be installed in the same space as the emergency switchboard. An indicator is to be mounted on the main switchboard or in the machinery control room to indicate when these batteries are being discharged.

*9.1.5(d) Interconnector Feeder Between Emergency and Main Switchboards (2014).* The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be protected at the main switchboard against overload and short circuit. The interconnector feeder is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard against short circuit. In addition, the circuit protection device at the emergency switchboard on the interconnector feeder is to trip to prevent overloading of the emergency generator.

In designs where the main switchboard voltage is different from that of the emergency switchboard the power to the emergency switchboard is to be supplied from the main ship service switchboard.

As far as practicable, the circuit coordination is to be arranged such that the outgoing circuits from the main ship service switchboard will coordinate with the transformer circuit breakers to prevent the supply to the emergency switchboard from being unavailable due to a fault on one of the other outgoing circuits from the main ship service switchboard.

*Note:* For the purpose of this Rule, the main ship service switchboard is a switchboard which is connected to the secondary of the step-down transformer producing the required voltage.

*9.1.5(e) Disconnection of Non-emergency Circuits.* For ready availability of the emergency source of electrical power, arrangements are to be made where necessary to automatically disconnect non-emergency circuits from the emergency switchboard so that electrical power is to be available automatically to the emergency circuits.

### 9.1.6 Arrangements for Periodic Testing

Provision is to be made to enable the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

#### 9.1.7 Starting Arrangements for Emergency Generator Sets

*9.1.7(a) Cold Conditions.* Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C (32°F). If this is impracticable, or if lower temperatures are likely to be encountered, heating arrangements are to be provided for ready starting of the generating sets.

*9.1.7(b) Number of Starts.* Each emergency generator that is arranged to be automatically started is to be equipped with approved starting devices with a stored energy capability of at least three consecutive starts. Unless a second independent means of starting is provided, the source of stored energy is to be protected to preclude critical depletion by automatic starting system (i.e., the automatic starting system is only allowable for consumption of the stored energy source to a level that would still provide the capability for starting the emergency generator upon intervention by a personnel). In addition, a second source of energy is to be provided for an additional three starts within 30 minutes unless manual starting can be demonstrated to be effective to the Surveyor.

*9.1.7(c) Charging of Stored Energy.* The stored energy is to be maintained at all times, as follows:

*i)* Electrical and hydraulic starting systems are to be maintained from the emergency switchboard;

*ii)* Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

*iii)* All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

*9.1.7(d) Manual Starting.* Where automatic starting is not required, manual (hand) starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or power charge cartridges, where they can be demonstrated as being effective to the Surveyor.

When manual (hand) starting is not practicable, the requirements of 4-5-6/9.1.7(b) and 4-5-6/9.1.7(c) are to be complied with except that starting may be manually initiated.

### 9.3 Emergency Power Supply for Steering Gear

Where the rudder stock is required by 3-2-4/23.5.1 to be over 230 mm (9 in.) diameter using $K_s$ = 1.0 in way of the tiller, excluding strengthening for navigation in ice, an alternative power supply, sufficient at least to supply the steering gear power unit and also its associated control system and rudder angle indicator, is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. The steering gear power unit under alternative power supply is to be capable of moving the rudder from 15 degrees on one side to 15 degrees on the other side in not more than 60 seconds with the vessel at the summer draft while running at one half the maximum speed ahead or 7 knots, whichever is the greater. The capacity is to be sufficient for at least 10 minutes of continuous operation.

### 9.5 Power Supply Through Transformers and Converters

Each required transformer is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides. Each of the secondary circuits is to be provided with a multipole isolating switch. A circuit breaker provided in the secondary circuit in accordance with 4-5-2/9.15.1 will be acceptable in lieu of multipole isolating switch.

## 9.7 Interior Communication Systems

### 9.7.1 Main Propulsion Control Stations

A common talking means of voice communication and calling is to be provided between the local propulsion control station and local control positions for main propulsion engines and controllable pitch propellers. Voice communication systems are to provide the capability of carrying on a conversation while the vessel is being navigated. Final subcircuits for power supply to these are to be independent of the other electrical system and the control, monitoring and alarm systems. Communication network and power supply circuit for the voice communication system may be combined with the system required in 4-5-6/9.7.2.

### 9.7.2 Voice Communications

*9.7.2(a) Propulsion and Steering Control Stations.* A common talking means of voice communication and calling is to be provided between the navigation bridge, local propulsion control station, and the steering gear compartment so that the simultaneous talking among these spaces is possible at all times and the calling to these spaces is always possible even if the line is busy.

*9.7.2(b) Elevator.* Where an elevator is installed, a telephone is to be permanently installed in all cars and connected to a continuously manned area. The telephone may be sound powered, battery operated or electrically powered from the emergency source of power,

*9.7.2(c) Independence of Power Supply Circuit.* Final subcircuit for power supply to these voice communication systems is to be independent of other electrical systems and control, monitoring, and alarm systems. See 4-5-6/9.1.2(c) for power supply.

## 9.9 Manually Operated Alarms

### 9.9.1 General Emergency Alarm System *(2009)*

*9.9.1(a)* The general emergency alarm system is to be capable of sounding the general emergency alarm signal consisting of seven or more short blasts followed by one long blast on the vessel’s whistle or siren and additionally on an electrically operated bell or klaxon or other equivalent warning system, which is to be powered from the vessel’s main supply and the emergency source of electrical power required by 4-5-6/9.1, as appropriate. The system is to be capable of operation from the navigation bridge and, except for the vessel’s whistle, also from other strategic points.

*9.9.1(b)* There are to be not less than two sources of power supply for the electrical equipment used in the operation of the General Emergency Alarm System, one of which is to be from the emergency switchboard and the other from the main switchboard. The supply is to be provided by separate feeders reserved solely for that purpose. Such feeders are to run to an automatic change-over switch situated in, or adjacent to, the main general emergency alarm control panel.

*9.9.1(c)* An alarm is to be provided to indicate when there is a loss of power in any one of the feeders required by 4-5-6/9.9.1(b).

*9.9.1(d)* As an alternative to two feeders as described in 4-5-6/9.9.1(b), a battery may be considered as one of the required sources, provided the battery has the capacity of at least 30 minutes of continuous operation for alarming and 18 hours in standby. A low voltage alarm for the battery and the battery charger output is to be provided. The battery charger is to be supplied from the emergency switchboard.

*9.9.1(e)* The system is to be audible throughout all the accommodation and normal crew working spaces and open decks. The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message on the public address system.

### 9.9.2 Engineers’ Alarm

An engineers’ alarm operable from the main propulsion control station is to be provided. It is to be audible in the engineers’ accommodation. See 4-5-6/9.1.2(c) for power supply.

9.9.3 Elevator

A device which will activate an audible and visual alarm in a manned control center is to be provided in all cars. Such alarm system is to be independent of power and control systems of the elevator. See 4-5-6/9.1.2(c) for power supply.

## 9.11 Services Required to be Operable Under a Fire Condition *(2008)*

For the purpose of 4-5.6/9.15, services required to be operable under a fire condition include, but not limited thereto, are the following:

*i)* Fire and general alarm system

*ii)* Fire extinguishing system including fire extinguishing medium release alarms

*iii)* Emergency Fire Pump

*iv)* Fire detection system

*v)* Control and power systems for all power operated fire doors and their status indicating systems

*vi)* Control and power systems for all power operated watertight doors and their status indicating systems

*vii)* Emergency lighting

*viii)* Public address system

*ix)* Remote emergency stop/shutdown arrangement for systems which may support the propagation of fire and/or explosion

*x)* Low Location Lighting

## 9.13 High Fire Risk Areas *(1 July 2016)*

For the purpose of 4-5-6/9.15, the examples of the high fire risk areas are the following:

*i)* Machinery spaces as defined by 3-4-1/3.13 and 3-4-1/3.15, except spaces having little or no fire risk such as machinery spaces which do not contain machinery having a pressure lubrication system and where storage of combustibles is prohibited (e.g., ventilation and air-conditioning rooms, windlass room, steering gear room, stabilizer equipment room, electrical propulsion motor room, rooms containing section switchboards and purely electrical equipment other than oil-filled electrical transformers (above 10 kVA), shaft alleys and pipe tunnels, and spaces for pumps and refrigeration machinery not handling or using flammable liquids).

*ii)* Spaces containing fuel treatment equipment and other highly flammable substances

*iii)* Galley and pantries containing cooking appliances

*iv)* Laundry containing drying equipment

*v)* For vessels carrying more than 36 passengers, the spaces defined by paragraph (8), (12), and (14) of 5C-7-4/5.5.2(b) of the *Steel Vessel Rules*.

## 9.15 Emergency and Essential Feeders *(2013)*

9.15.1 Location

As far as practicable, cables and wiring for emergency and essential services, including those listed in 4-5-6/9.11, are not to pass through high fire risk areas (see 4-5-6/9.13). For Emergency Fire Pumps, see requirements in 4-5-6/9.15.3.

These cables and wiring are also to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

9.15.2 Services Necessary Under a Fire Condition

Where cables for services required to be operable under a fire condition (see 4-5-6/9.11) including their power supplies pass through high fire risk areas (see 4-5-6/9.13) or main vertical fire zones (see 3-4-1/5), other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. For Emergency Fire Pumps, see requirements in 4-5-6/9.15.3. This may be achieved by any of the following measures:

*9.15.2(a)* Fire resistant cables in accordance with 4-5-4/13.1.3 are installed and run continuous to keep the fire integrity within the high fire risk area. See 4-5-6/Figure 1.

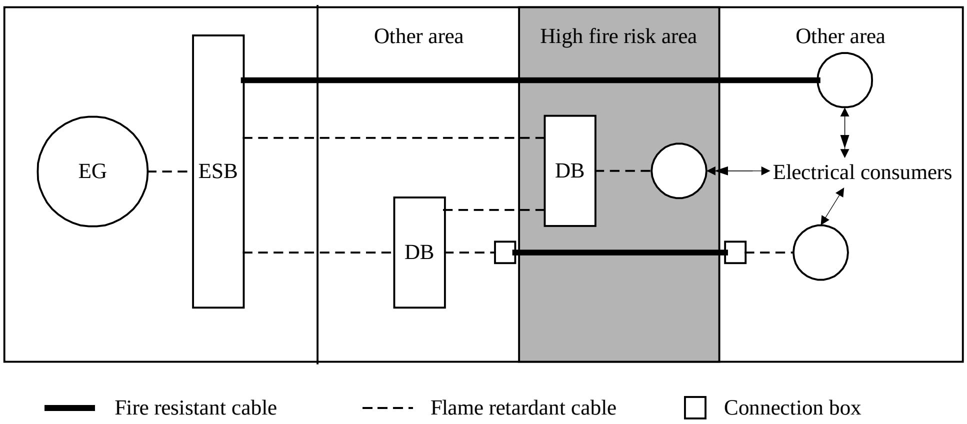
*9.15.2(b)* At least two loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Systems that are self-monitoring, fail safe or duplicated with cable runs separated as widely as practicable, may be exempted from the requirements in 4-5-6/9.15.2(a) and 4-5-6/9.15.2(b).

9.15.3 Electrical Cables for the Emergency Fire Pump

The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their sources of power and prime movers. They are to be of a fire resistant type, in accordance with 4-5-4/13.1.3, where they pass through other high fire risk areas.

**FIGURE 1**
**Cables within High Fire Risk Areas** ***(2008)***



## TABLE 1
## Electrical Equipment in Hazardous Areas for Oil Carriers [See 4-5-6/1.7.1]

| *Hazardous Area* | *Acceptable Electrical Equipment* | |
|---|---|---|
| Cargo tanks and cargo piping as defined by 4-5-6/1.5.1 i) and 4-5-6/1.5.2i). | a1 | Category "ia" intrinsically-safe apparatus and its associated wiring only. |
| Cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks, as defined by 4-5-6/1.5.1ii) and 4-5-6/1.5.2i). | b1 | Category "ia" intrinsically-safe apparatus and its associated wiring. |
| | b2 | Hull fittings containing transducers for electrical depth sounding or log devices or containing the terminals. See 4-5-6/1.7.3. |
| | b3 | Shell penetrations for anodes or electrodes of an impressed current cathodic protection system for underwater hull protection. See 4-5-6/1.7.3. |
| Cargo pump rooms, as defined by 4-5-6/1.5.1iii) and 4-5-6/1.5.2i). | c1 | Intrinsically-safe apparatus. |
| | c2 | Electrical devices as described in items b2 and b3 above this Table. |
| | c3 | Explosion-proof lighting fixtures. See 4-5-3/11.1.2 and 4-5-6/1.9.3. |
| | c4 | Explosion-proof type audible and/or visual devices for communication, general alarm and fire extinguishing medium release alarm. |
| | c5 | Through-run of cables in extra-heavy pipe. See 4-5-6/1.9.4. |
| Compartments for cargo hoses, as defined by 4-5-6/1.5.1iv) and 4-5-6/1.5.2i).<br>Enclosed or semi-enclosed spaces, as defined by 4-5-6/1.5.1v), 4-5-6/1.5.1vi) and 4-5-6/1.5.2i). | d1 | Intrinsically-safe apparatus. |
| | d2 | Explosion-proof type lighting fixtures. See 4-5-3/11.1.2. |
| | d3 | Through-runs of cable. |
| Spaces adjacent to and below the top of cargo tank, except for cofferdams, as defined by 4-5-6/1.5.1vii) and 4-5-6/1.5.2i). | e1 | Intrinsically-safe apparatus. |
| | e2 | Electrical devices as described in items b2 and b3 of this Table. |
| | e3 | Explosion-proof type lighting fixtures. See 4-5-3/11.1.2 |
| | e4 | Explosion-proof type audible and/or visual devices for communication, general alarm and fire extinguishing medium release alarm. |
| | e5 | Through-run of cable; excepting those for intrinsically-safe circuits, such cables require special consideration. |
| Areas on open deck or semi-enclosed spaces on open deck, as defined by 4-5-6/1.5.1viii) and 4-5-6/1.5.2i).<br>Areas on open deck as defined by 4-5-6/1.5.1ix) and 4-5-6/1.5.2ii) | f1 | Explosion-proof, intrinsically-safe, increased safety or pressurized type equipment suitable for use on open deck. |
| | f2 | Through-runs of cables without expansion bends in these areas. |
| Areas on open deck over all cargo tanks, including all ballast tanks within cargo tank area, as defined by 4-5-6/1.5.1x). | g1 | Explosion-proof, intrinsically safe, increased safety or pressurized type equipment suitable for use on open deck. |
| | g2 | Through-runs of cables. |
| Enclosed or semi-enclosed spaces having an opening into any hazardous area, as defined by 4-5-6/1.5.1xi). | h1 | Explosion-proof or intrinsically-safe type equipment. |

PART

# 7

# Survey After Construction

The independent booklet, ABS *Rules for Survey After Construction (Part 7)* is to be referred to. This booklet consists of the following Chapters: