



GUIDE FOR BUILDING AND CLASSING

LIFTBOATS

JANUARY 2014 (Updated February 2014 – see next page)

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

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Updates

February 2014 consolidation includes:

- January 2014 version plus Corrigenda/Editorials

Foreword

This Guide was developed for the Classification of Liftboats and specifies the requirements for design, construction and survey after construction of the Liftboat (including hull structure, equipment and machinery systems) for use by designers, builders, owners and operators in the offshore industry.

This Guide will become effective immediately after its publication.

Changes to Conditions of Classification (1 January 2008)

For the 2008 edition, Part 1, Chapter 1, “Scope and Conditions of Classification” was consolidated into a generic booklet, entitled *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* for all units, installations, vessels or systems in offshore service. The purpose of this consolidation was to emphasize the common applicability of the classification requirements in “Part 1, Chapter 1” to ABS-classed offshore units, pipelines, risers, and other offshore structures, and thereby make “Conditions of Classification” more readily a common Rule of the various ABS Rules and Guides, as appropriate.

Thus, Part 1, Chapter 1 of this Guide specifies only the unique requirements applicable to liftboats. These supplemental requirements are always to be used with the aforementioned *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

GUIDE FOR BUILDING AND CLASSING LIFTBOATS

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Notices and General Information

Introduction

1. The year 2014 edition of the *Guide for Building and Classing Liftboats* consists of the seven (7) booklets as shown in Table 1. With regard to two booklets, Part 1, and Part 2:
 - a) The purpose of the generic title *ABS Rules for Conditions of Classification – Offshore Units and Structures (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 units, installations, vessels or systems in offshore service, etc., as specified in the Foreword to Part 1. Additional specific requirements are contained in Part 1 of this *Guide for Building and Classing Liftboats*.
 - 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.
2. The numbering system applied in the Rules is shown in Table 2.
3. Notice No. 9, as per Table 3, with an effective date of 1 January 2014, has been incorporated into the 2014 *Guide for Building and Classing Liftboats*. In addition, the changes contained in the previously published Notices 1 through 8 to the 2009 *Guide for Building and Classing Liftboats* (together with Corrigenda items) have also been incorporated into the text of the 2014 *Guide for Building and Classing Liftboats*.
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 *Guide for Building and Classing Liftboats* 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 *Guide for Building and Classing Liftboats*, 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 2014 Liftboat Guide

Guide for Building and Classing Liftboats		
Notices and General Information		2014
Part 1:	Conditions of Classification (Supplement to the ABS <i>Rules for Conditions of Classification – Offshore Units and Structures</i>) ⁽¹⁾	2014
Part 3:	Hull Construction and Equipment	2014
Part 4:	Machinery and Systems	2014
Part 5:	Surveys After Construction	2014
Rules for Conditions of Classification – Offshore Units and Structures – not included ^(1,2)		
Part 1:	Rules for Conditions of Classification – Offshore Units and Structures	2014
Rules for Materials and Welding – not included ⁽²⁾		
Part 2:	Rules for Materials and Welding	2014

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 this Guide

<i>Division</i>	<i>Number</i>
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 Guide. 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 Guide and associated process instructions, check sheets, etc.

Change Notice No. 9 (2014)

TABLE 3
Summary of Changes for the 2014 Guide

EFFECTIVE DATE 1 January 2014 – shown as (2014)
(based on the contract date for new construction between builder and Owner)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 3	Hull Construction and Equipment	
3-2-9/7	Testing	To align the testing requirements for watertight doors prescribed in SOLAS Reg.II-1/16.2 and IACS UI SC156.
3-2-12/Figure 3	Propeller Nozzle Section View	To define Zone 2 for tilted nozzles.
3-2-13/1.3	Materials for Rudder, Rudder Stock and Steering Equipment	To address the galvanic compatibility of materials.
3-2-13/3.1	Rudder Blades without Cutouts	To clarify that that any appendages (e.g., rudder bulb) will be included in the rudder area.
3-2-13/3.5 (New)	Rudders Blades with Twisted Leading-Edge	To provide requirements for twisted rudders.
3-2-13/Table 1A	Coefficient k_c for Ordinary Rudders	To provide requirements for twisted rudders.
3-2-13/Table 1B	Coefficient k_c for High-Lift/Performance Rudders	To provide requirements for twisted rudders.
3-2-13/5.3	Rudders without Cutouts	To clarify that that any appendages (e.g., rudder bulb) will be included in the rudder area.
3-2-13/Table 3	Coefficient α	To provide requirements for twisted rudders.
3-2-13/5.7 (New)	Rudders with Twisted Leading-Edge	To provide requirements for twisted rudders.
3-2-A1/3	Spade Rudders	To provide requirements for rudders with embedded rudder trunk.
3-2-A1/Figure 1	Spade Rudder	To provide requirements for rudders with embedded rudder trunk.
3-5-1/9.5.2	Sea Loads	To align the requirements with IACS UR S27 and to make 3-5-1/13.1 applicable to all vessel lengths.
PART 4	Machinery and Systems	
4-1-1/Table 2	Ambient Temperatures for Unrestricted Service	To align the table with the modified ambient temperature requirements in 4-6-1/17.3.
4-2-1/3.3	Booster Pumps	To waive the requirement for a spare pump for multiple-engine installations, provided that at least forty percent of the total rated propulsion power remains
4-2-1/9.7	Lubricating Oil Pumps	To waive the requirement for a spare pump for multiple-engine installations, provided that at least forty percent of the total rated propulsion power remains
4-2-1/11.7	Circulating Water Pumps	To waive the requirement for a spare pump for multiple-engine installations, provided that at least forty percent of the total rated propulsion power remains
4-2-1/17.1	Flexible Shaft Couplings	To align the requirement with 4-3-2/5.19.5 of the <i>Steel Vessel Rules</i> .
4-3-1/1.1 (New)	Definitions	To provide definitions of terms used in this Section, in line with the <i>Steel Vessel Rules</i> .
4-3-1/19.7 (New)	Locking Arrangement	To provide requirements for locking arrangements, in line with the <i>Steel Vessel Rules</i> .
4-3-1/23 (New)	Circulating Currents	To provide requirements regarding circulating currents between the propeller, shaft and the hull, in line with 4-3-2/11.5 of the <i>Steel Vessel Rules</i> .
4-3-2/1.1 (New)	Definitions	To provide definitions of terms used in this Section, in line with the <i>Steel Vessel Rules</i> .

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-3-2/7.1.3	Nozzle Propellers (Wide Tip Blades)	To provide the criteria for a wide tip propeller blades.
4-5-1/9.11	Collision Bulkhead Penetrations	To allow for local control of the valve and to delete redundant requirements.
4-5-2/5.8	Other Materials	To clarify the requirements for materials equivalency for fuel oil, lubrication oil and other flammable oil services based on IMO MSC Circ. 1321.
4-5-2/19.3	Valve Connections to Shell	To align the requirements with IACS UR P1.2.4 and Load Line Interpretation LL36.
4-5-3/5.15 (New)	Oil Pollution Prevention Measures	To align the requirement with 4-6-4/5.7 of the <i>Steel Vessel Rules</i> .
4-5-3/Table 1 (New)	Dimensions and Details of Standard Discharge Connection Flange	To align the requirement with 4-6-4/5.7 of the <i>Steel Vessel Rules</i> .
4-5-3/9.9.3(d)i)	Testing of Vent Outlet Automatic Closing Devices	To provide additional tightness test criteria to the type tests of air pipe closing devices, in line with IACS UR P3.
4-5-3/9.9.3(d)ii) (New)	Discharge/Reverse Flow Test	To provide additional requirements, in line with IACS UR P3, for the case when the float of an air pipe closing device is sucked into the opening by negative pressure in the tank resulting in the float blocking the flow of air into the tank and leading to structural damage during tank emptying.
4-5-3/Figure 1 (New)	Example of Normal Position	To provide new specific type test conditions based upon the direction of the opening of the device, in line with IACS UR P3.
4-5-3/Figure 2 (New)	Example of Inclination 40 degrees Opening Facing Upward	To provide new specific type test conditions based upon the direction of the opening of the device, in line with IACS UR P3.
4-5-3/Figure 3 (New)	Example of Inclination 40 degrees Opening Facing Downward	To provide new specific type test conditions based upon the direction of the opening of the device, in line with IACS UR P3.
4-5-3/Figure 4 (New)	Example of Inclination 40 degrees Opening Facing Sideways	To provide new specific type test conditions based upon the direction of the opening of the device, in line with IACS UR P3.
4-7-1/3.1 (New)	Cascade Protection	To define terminology used in later sections of the Rules.
4-7-1/3.3 (New)	Earth	To define terminology used in later sections of the Rules.
4-7-1/3.13 (New)	High Voltage	To define terminology used in later sections of the Rules.
4-7-1/3.19 (New)	Inhomogeneous Field	To define terminology used in later sections of the Rules.
4-7-1/3.23 (New)	Low Voltage	To define terminology used in later sections of the Rules.
4-7-1/3.25 (New)	Minimum Comfortable Condition of Habitability	To define terminology used in later sections of the Rules.
4-7-1/3.27 (New)	Nominal Voltage	To define terminology used in later sections of the Rules.
4-7-1/3.33 (New)	Overvoltage Category	To define terminology used in later sections of the Rules.
4-7-1/3.35 (New)	Overvoltage Withstand Test	To define terminology used in later sections of the Rules.
4-7-1/3.39 (New)	Pollution Degree	To define terminology used in later sections of the Rules.
4-7-1/7	Standard Distribution System	To clarify that four wire systems with insulated/isolated neutral points (i.e., neutrals that are not grounded) and hull return systems are not accepted.
4-7-1/15	Degree of Protection for Enclosure	To provide a reference to 4-7-5/Table 1 for IP requirements for High Voltage equipment.
4-7-1/17.1	General	To align the requirements with IACS UR M40.

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-7-2/5.5.2	Generator	To highlight the fact that if fuel with a lower flash point is used then extra precautions are needed to counter the increased risk.
4-7-2/5.9.4	Interconnector Feeder Between Emergency and Main Switchboards	To clarify the requirement relating to the interconnection of the feeder between the main and emergency switchboards.
4-7-2/7.1.6(a)	Continuity of Supply	To remind the user that there are additional requirements for High Voltage transformers that need to be met elsewhere in the Rules.
4-7-2/7.9	Harmonics	To clarify what other effects are to be considered when higher values of harmonic distortion are expected.
4-7-2/9.19 (New)	Protection of Harmonic Filter Circuits	To require detection of a current imbalance in cases where multiple filter circuits are used and detection of deterioration of capacitors that may be used in these harmonic filters.
4-7-2/17.1.2(f)	<No Title>	To align the requirements with IMO Resolution MSC.218(82).
4-7-3/1.1	Booklet of Standard Details	To provide a cross reference to requirements for assistance in identifying required content and to emphasize that only one booklet of standard wiring practice is required.
4-7-3/3.3.1(b)	Equipment in Areas Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces	To align the requirements with IACS UR E20 Rev. 1.
4-7-3/Figure 1	Example of Area Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces	To align the requirements with IACS UR E20 Rev. 1.
4-7-3/5.1.9 (New)	Ultra Violet (UV) Light Protection for Wiring Insulation within Fluorescent Light Fixtures	To address concerns regarding deterioration of the insulation on the supply conductors within fluorescent light fixtures.
4-7-3/Table 1	Minimum Degree of Protection	To refer to high voltage protection requirements and to require unused outlets in galleys and laundries to have covers such that these outlets maintain their IP rating when not in use.
4-7-4/3.13.7	Moisture Condensation Prevention	To redefine the requirement for moisture condensation prevention in motors and generators to be based on kW instead of weight.
4-7-4/7.11.6(b) (New)	Alternative	To provide an alternative to the existing conservative clearance and creepage distances for switchboards that are built in accordance with IEC 61439-1, provided they are not installed in Cat A Machinery spaces or in areas subject to FWBLAFFS and to require equipment to be subject to an impulse voltage test.
4-7-4/7.15.2	Main Bus Bar Subdivision	To require cable protection at each end for main switchboards divided into separate sections which are interconnected by cable.
4-7-4/9.3	Temperature Rise	To align the requirements for permissible temperature rise of transformer windings with IEC 60076-11.
4-7-4/10 (New)	Semiconductor Converters for Adjustable Speed Motor Drives	To consolidate requirements for semiconductor convertors and to align the requirements with IEC 61800-5-1 and 60146-1-1.
4-7-4/Table 5	Factory Testing Schedule for Switchboards, Chargers, Motor Control Centers, and Controllers	To limit the rated voltage range to 1200 V for DC.
4-7-4/Table 8	Temperature Rise for Transformers	To align the requirements for permissible temperature rise of transformer windings with IEC 60076-11.
4-7-4/Table 10	Maximum Current Carrying Capacity for Cables	To have the conductor sizes to go in the ascending order from 1.0 mm ² to 625 mm ² .
4-7-5/1.1.3(b) (New)	Reduction	To specify the impulse test voltages that the equipment needs to be tested to if reduced clearance distances are used.
4-7-5/1.1.3(c) (New)	Insulating Material	To require documentation to be submitted to ABS to prove that this insulation is appropriate for the application.
4-7-5/1.1.3(d)	Creepage Distance	To align the requirements with IEC 60092-503.

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-7-5/1.1.3(e) (New)	Creepage Distances	To align the requirements with IEC 60092-503.
4-7-5/1.1.3(f) (New)	Non-standardized Parts	To align the requirements with IACS UR E11.
4-7-5/1.3.6	Number and Capacity of Transformers	To clarify the requirement.
4-7-5/1.7.2(d) (Deleted)	Detection of Phase-to-phase Internal Faults	To delete outdated requirement.
4-7-5/1.7.2(e)	Transformers Arranged in Parallel	To delete redundant requirement.
4-7-5/1.9.2(c) (New)	Exposure of HV Equipment to Damaging Environments	To reinforce the markings and access requirements to spaces containing High Voltage equipment.
4-7-5/1.9.3(d)	Termination and Splices	To clarify that these requirements are in addition to those in the Low Voltage part of the Rules, to emphasize that allowing splices in High Voltage cable does not overrule the requirements regarding splices not being permitted in propulsion cables, and to clarify that cables with mixed service use are not considered to be propulsion cables for purposes of this Rule.
4-7-5/1.9.3(e) (New)	Cable Rating	To specify the minimum cable ratings that are permissible on vessels for different system nominal voltages.
4-7-5/1.9.3(f) (New)	Cable Current Carrying Capacities	To specify minimum current carrying capacities of high voltage cables.
4-7-5/1.9.3(h)	Cable Test after Installation	To prevent the need for cables which have a higher rating to be tested to the rating of the cable rather than to the rated voltage that they are connected to.
4-7-5/1.9.4 (New)	High Voltage Shore Connection	To specify that the application of the <i>ABS Guide for High Voltage Shore Connection</i> is mandatory.
4-7-5/1.11.1(a)	Protection	To provide a reference to 4-7-5/Table 1 for IP requirements for High Voltage equipment.
4-7-5/1.11.1(d) (Deleted)	Cooler	To remove unnecessary placeholder.
4-7-5/1.11.1(e)	Tests	To reinforce that all the tests mentioned in the Low Voltage portion of the Rules apply to High Voltage equipment as well, irrespective of size and rating.
4-7-5/1.11.2(a) (Deleted)	Protection	To provide a reference to 4-7-5/Table 1 for IP requirements for High Voltage equipment.
4-7-5/1.11.2(a)	Mechanical Construction and Configuration	To clarify that the requirement for the division of bus bars is a general requirements and not a High Voltage specific one.
4-7-5/1.11.2(c) (Deleted)	Configuration	To clarify that the requirement for the division of bus bars is a general requirements and not a High Voltage specific one.
4-7-5/1.11.2(f) (New)	Arc Flash and Associated Installation Requirements	To provide the basic arc flash requirements for High Voltage switchgear, in line with IEC 62271-200.
4-7-5/1.11.2(g)	Tests	To specify the values of the power frequency withstand voltage that should be applied to High Voltage Switchgear, in line with IEC 62271-1.
4-7-5/1.13 (New)	Design Operating Philosophy	To specify the safety approach in HV design and provide the background for the introduction of Arc Flash requirements.
4-7-5/1.15 (New)	Preliminary Operations Manual	To tie in with the Design Principles Document and to allow the Owner to understand the designer's intended operating procedures for incorporation into their own.
4-7-5/3.1.1	Application	To clarify the requirement.
4-7-5/3.3.1	General	To define the difference between a general electric propulsion system and an integrated electric propulsion system and to emphasize that all equipment related to the electric propulsion drive train is to be built with redundancy such that a single failure will not result in loss of propulsion and steering.

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-7-5/3.3.3	Power Management System	To emphasize that upon failure; there shall be no loss in available power for propulsion and steering and to specify that failure of the PMS is to be alarmed at a manned control station.
4-7-5/3.3.4	Regenerative Power	To clarify the requirement.
4-7-5/3.3.5	Harmonics	To require monitoring of the harmonics on board a vessel with electric propulsion, to specify some of the harmful effects of having excessive harmonics in the electrical system network, and to reference requirements related to harmonic filters.
4-7-5/3.5.3 (Deleted)	Semiconductor Converters	To consolidate requirements for semiconductor convertors.
4-7-5/3.15.3 (Deleted)	Semiconductor Converters	To consolidate requirements for semiconductor convertors.
4-7-5/3.17.5(e) (New)	Generator Excitation	To relocate text of 4-7-5/3.17.6 into 4-7-5/3.17.5(e) since this section covers Rules related to all rotating machinery for propulsion
4-7-5/3.17.5(f) (New)	Propulsion Motors	To require the propulsion motor of being capable of withstanding a short circuit at its terminals
4-7-5/3.17.6 (Deleted)	Propulsion Generators	To relocate text of 4-7-5/3.17.6 into 4-7-5/3.17.5(e) since this section covers Rules related to all rotating machinery for propulsion
4-7-5/3.17.8	Semiconductor Converters for Propulsion	To consolidate requirements for semiconductor convertors.
4-7-5/3.19	Dock and Sea Trials	To clarify the requirement.
4-7-5/Table 1 (New)	High Voltage Equipment Locations and Minimum Degree of Protection	To consolidate protection requirements for high voltage systems and to introduce requirements for locations for where High Voltage (HV) equipment can and cannot be installed

Conditions of Classification

(Supplement to the ABS Rules for Conditions of Classification – Offshore Units and Structures)

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PART

1

CHAPTER 1 Scope and Conditions of Classification

SECTION 1 Classification (1 January 2008)

1 Scope (1 February 2014)

In accordance with Section 1-1-2 of this Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, the classification ~~✕~~ **A1 Liftboat** ~~✕~~ **AMS** is to be assigned to liftboats meeting the requirements of this Guide.

A liftboat is a self-propelled, self-elevating vessel with a relatively large open deck capable of carrying equipment and supplies in support of various offshore mineral exploration and production or offshore construction activities. A liftboat also has the capability of rapidly raising its hull clear of the water on its own legs so as to provide a stable platform from which maintenance and construction work may be conducted.

Liftboats with an overall hull length of 61 meters (200 feet) and above **or with leg length greater than 91.44 meters (300 feet)** are to comply with the *ABS Guide for Building and Classing Mobile Offshore Units*.

3 Classification (1 January 2008)

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

Additional requirements specific to liftboats are contained in the following Sections.

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 classification boundaries, symbols and notations are specific to liftboats.

1 Liftboats Built Under Survey

Liftboats which have been built to the satisfaction of the ABS Surveyor, to the full requirements of this Guide or the equivalent, where approved by the Committee, will be classed and distinguished in the *Record* by the classification notation **⌘ A1 Liftboat ⌘ AMS** where **⌘ A1** indicates compliance with the hull requirements of this Guide and **⌘ AMS** indicates compliance with the machinery requirements for self-propelled liftboats.

3 Liftboats Not Built Under Survey

Liftboats which have not been built under ABS survey, but which are submitted for classification will be subject to special classification survey. Where found satisfactory and thereafter approved by the Committee, they will be classed and distinguished in the *Record* by the symbols and notation as described in 1-1-2/1 of this Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* but the mark **⌘** signifying survey during construction will be omitted.

5 Service Limitations

This Guide is intended for liftboats designed for unrestricted service. Liftboats which are not designed to meet the full criteria for unrestricted service and are subject to geographical limitations, will be classed with a notation **Restricted Service**. See also Section 1-1-5 of this Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

7 Temporary Mooring Equipment Symbol

The symbol **Ⓜ** will be placed after the symbols of classification to signify that the equipment for temporary mooring of the liftboat is in compliance with 3-5-1/1.

9 Propulsion Machinery (29 November 2007)

Machinery which is required for propulsion and which has been constructed and installed to the satisfaction of the Surveyor, to the full requirements of this Guide or their equivalent when found satisfactory after trial and approved by the Committee, will be classed and distinguished in the *Record* by the notation **⌘ AMS**. This notation is mandatory for classification of self-propelled commercial vessels built under ABS survey, classed and distinguished in the *Record* by the symbol **⌘ A1**.

11 Thrusters

Thruster machinery for propulsion assist or athwartship thrust complying with the applicable requirements of Section 4-3-5 of the *ABS Rules for Building and Classing Steel Vessels*, manufactured and installed under ABS survey and found satisfactory after trials, will be distinguished in the *Record* by the notation **✕ PAS** or **✕ APS** as appropriate.

13 Geographical Limitations

Liftboats which have been built to the satisfaction of the ABS Surveyors to special modified requirements for a restricted service, where approved by the Committee for that particular service will be classed and distinguished in the *Record* by the symbols and notations as described in 1-1-2/1, 1-1-2/3, 1-1-2/7, 1-1-2/9 and 1-1-2/11 above but the symbols and notations will either be followed by or have included in them the appropriate restricted service, e.g., **Gulf of Mexico**, etc. See Appendix 1-1-A1 of this Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

15 Centralized or Automatic Control Systems

Where, in addition to the individual liftboat controls, it is proposed to provide remote, centralized, or automatic control systems for propulsion units, essential auxiliaries, or for cargo handling, relevant data is to be submitted to permit the assessment of the effect of such systems on the safety of the liftboat. All controls necessary for the safe operation of the liftboats are to be provided to the Surveyor's satisfaction. The automatic and remote control system are to be in accordance with the applicable requirements of Part 4, Chapter 7 of the *ABS Rules for Building and Classing Steel Vessels Under 90 meters in Length*.

PART

1

CHAPTER 1 Scope and Conditions of Classification

SECTION 3 Rules for Classification (1 January 2008)

1 Application of Rules

1.1 General

This Guide is applicable to self-propelled steel liftboats intended for unrestricted service, except where specifically mentioned otherwise.

Where reference is made herein to the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*, the *ABS Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length (Under 90m Rules)* or the *ABS Rules for Building and Classing Mobile Offshore Drilling Unit (MODU Rules)*, the latest edition of those Rules is intended.

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 or Guides regarding other features is to be considered as guidance to the designer, builder, owner, et al.

1.3 Application (2005)

The application of this Guide 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 2004 are not applicable to a liftboat for which the contract for construction was signed on 30 June 2004.) See also 1-1-3/3 of this Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

PART

1

CHAPTER 1 Scope and Conditions of Classification

SECTION 4 Plans and Design Data to be Submitted

1 Hull and Design Data (2011)

Plans showing the scantlings, arrangements, and details of the principal parts of the structure of each liftboat to be built under survey are to be submitted for review and approved before the work of construction is commenced. These plans are to clearly indicate the scantlings, joint details and welding, or other methods of connection.

Plans should generally be submitted electronically to ABS. However, hard copies will also be accepted. In general, these plans are to include the following where applicable:

- General arrangement
- Inboard and outboard profile
- An arrangement plan of watertight compartmentation
- Diagrams showing the extents to which the watertight and weathertight integrity is intended to be maintained, including the location, type and disposition of watertight and weathertight closures.
- Summary of distributions of fixed and variable weights for each reviewed condition
- Type, location and quantities of permanent ballast.
- Loading for all decks
- Transverse sections showing scantlings
- Longitudinal sections showing scantlings
- Decks
- Helicopter deck with helicopter particulars (See 3-2-11/5)
- Framing
- Shell plating
- Watertight bulkheads and flats
- Structural bulkheads and flats
- Tank bulkheads and flats with level of top of overflows and air pipes
- Pillars and girders
- Diagonals and struts
- Legs
- Structure in way of jacking or other elevating arrangements
- Footings, spudcans, pads, or mats
- Superstructures and deck houses
- Arrangement and details of watertight doors and hatches

- Foundations for anchoring equipment, industrial equipment, etc., where attached to hull structure, superstructures or deckhouses
- Welding details and procedures
- Lines and offsets
- Curves of form or equivalent data
- Wind heeling moment curves or equivalent data
- Capacity plan
- Tank sounding tables
- Corrosion control arrangements
- Methods and locations for nondestructive testing
- Description of environmental conditions including minimum anticipated atmospheric and sea temperatures, for each mode of operation

3 Machinery Plans

Plans are to be submitted showing the arrangements and details of all propulsion and auxiliary machinery, steering gear, boilers and pressure vessels, electrical systems, jacking or other self-elevating systems, bilge and ballast systems, fire extinguishing systems, and other pumps and piping systems as described in 4-1-1/7.

5 Calculations

The following calculations are to be submitted.

- Structural analysis including fatigue analysis
- Resultant forces and moments from wind, waves, current, mooring and other environmental loading
- Effects of icing on structural loading and stability, and upon wind resistance area of exposed structural elements, where appropriate, based on the intended geographic area of operation.
- Stability calculations, both intact and damaged
- Calculations substantiating adequacy of structure to transmit forces between legs and hull through the jacking or other self-elevating system
- Evaluation of the liftboat's ability to resist overturning while bearing on the sea bed
- Submitted calculations are to be suitably referenced.
- Results from model tests or dynamic response calculations may be submitted as alternatives or a substantiation for required calculations.

7 Additional Plans

Where certification under the other regulation described in Section 1-1-5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part I)*, is requested, submission of additional plans and calculations may be required.

9 Submissions (2011)

Plans from designers and builders are generally to be submitted electronically to ABS. However, hard copies will also be accepted.

All plan submissions originating from manufacturers are understood to have been made with the cognizance of the builder.

PART

1

CHAPTER 1 Scope and Conditions of Classification

SECTION 5 Operating Manual

1

An operating manual which is consistent with the information and criteria upon on which classification is based is to be placed aboard the liftboat for the guidance of the operating personnel. Liftboats not meeting the criteria for unrestricted service are to have the notation **Restricted Service** placed in the Operating Manual. In cases where liftboats are designed to the criteria for unrestricted service, but where certain additional conditions specified by the owner are presented which do not meet the criteria for unrestricted service, the Operating Manual is to contain a notation **Limited Service Condition** for each such additional condition. Insofar as classification is concerned, the operating manual is to include, as appropriate, the following information:

1.1

A general description of the liftboat including major dimensions, lightship characteristics – including a lightship weight changes log, etc.

1.3

Summaries of approved modes of operation (See 3-1-1/1.7) including, for each mode of operation:

- i) Limiting environmental conditions including wave height and period, wind velocity, current velocity, minimum air and sea temperatures, soil penetration, air gap, and water depth
- ii) Design deck loadings, icing loads, variable load, total elevated load, rated capacities of cranes and elevating systems, and types of helicopter for which the helideck is designed
- iii) Draft or draft range, leg length, leg/footing position and whether buoyant or non-buoyant, disposition of movable equipment such as crane booms, limitations on the usage of cranes, etc.
- iv) Maximum allowable KG versus draft curves or equivalent and associated limitations or assumptions, including damage and subdivision standards upon which the allowable KG is based
- v) Disposition (open or closed) of watertight and weathertight closures
- vi) Identification of “Restricted Service” or “Limited Service” conditions

1.5

Information showing:

- i) General arrangements
- ii) Preload capacity
- iii) Watertight and weathertight boundaries, location of unprotected openings, and watertight and weathertight closures
- iv) Type, location and quantities of permanent ballast
- v) Allowable deck loadings
- vi) Capacity, center of gravity, and free surface correction for each tank
- vii) Capacity and center of gravity of each void

- viii) Location and means of draining voids
- xi) Description of the propulsion equipment; type and model of the engines and reduction gear, shaft line arrangement, bearings and seals, gear and propeller
- x) Hydrostatic table or curves
- xi) Simplified electrical one line diagrams of main power and emergency power systems
- xii) Schematic diagrams of the bilge and preload system

1.7

Procedure for elevating, preloading, and lowering including preload requirements and maximum draft before elevating, and maximum deadweight onboard, before lowering, to not immerse the load line. Loading and KG work sheets, sample calculations for, transit at maximum draft, elevating, preload, elevated, storm survival afloat and elevated. Blank loading forms and instructions for their use are also to be included.

1.9

Procedures regarding cargo loading and securing, and limitations on height and weight.

3

The Operating Manual is to be submitted for review by the American Bureau of Shipping solely to ensure the presence of the above information which is to be consistent with the design information and limitations considered in the liftboat's classification. The American Bureau of Shipping is not responsible for the operation of the liftboat.

The Operating Manual required by this section does not need to be in addition to that required by flag and coastal Administrations. These administrations may require that additional information be included in the Operating Manual.

PART

1

CHAPTER **1** **Scope and Conditions of Classification**

SECTION **6** **Construction Booklet**

A set of plans showing the location and extent of different grades and strengths of structural materials, together with a description of the material and welding procedures employed, should be placed aboard the liftboat.

PART

1

CHAPTER 1 Scope and Conditions of Classification

APPENDIX 1 Requirements for Building and Classing Liftboats Intended for Service in Domestic Waters

Note: This Appendix is prepared to make provision for users of this Guide to design, build and operate liftboats intended solely for restricted service in domestic waters. It is recommended that any liftboat which may possibly change its service area from domestic to international at a future date should at least comply with the requirements listed in 1-1-A1/3.1 of this Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, as applicable, so that the upgrading work for compliance with SOLAS, etc. will avoid essential conversion of the liftboat's structural arrangements.

1 General

For a liftboat intended for service in domestic waters ABS will consider the Flag Administration's Ships Safety Regulations as an alternative in satisfying specific areas of this Guide.

Where approved by the Committee for a particular service, the liftboat will be classed and distinguished in the *Record* by the symbols **✕ A1** followed by class notation, if applicable, and the restricted service area (e.g., **✕ A1 Liftboat, U.S. Domestic Restricted Service**, etc.).

3 Requirements Replaced with National Regulations

The following requirements in this Guide may be replaced with the Regulations of the Flag Administration for those liftboats intended solely for service in domestic waters:

3.1 Basic Construction

<i>Section/Paragraph</i>	<i>Requirement</i>
3-2-6/1	Double Bottom
3-2-9/5	Watertight Bulkhead
3-1-3/1	Structural Fire Protection
4-6-2/9	Fixed Fire Fighting System in Engine Room
4-7-2/5	Emergency Generator Room

3.3 Machinery and Equipment

<i>Section/Paragraph</i>	<i>Requirement</i>
4-2-1/3.3, 4-2-1/9.7, 4-2-1/11.7	Spare Pumps
4-7-2/5	Emergency Power
4-7-2/5.9	Emergency Switchboard
4-6-2/5.3	Emergency (Second) Fire Pump

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

CHAPTER 1 Materials for Hull Construction

CHAPTER 2 Equipment

CHAPTER 3 Materials for Machinery, Boilers, Pressure Vessels, and Piping

APPENDIX 1 List of Destructive and Nondestructive Tests Required for Materials and Responsibility for Verifying

APPENDIX 4 Procedure for the Approval of Manufacturers of Hull Structural Steel

APPENDIX 5 Procedure for the Approval of Manufacturers of Hull Structural Steels Intended for Welding with High Heat Input

APPENDIX 6 Nondestructive Examination of Marine Steel Castings

APPENDIX 7 Nondestructive Examination of Hull and Machinery Steel Forgings

APPENDIX 8 Additional Approval Procedure for Steel with Enhanced Corrosion Resistance Properties

Rules for Welding and Fabrication

CHAPTER 4 Welding and Fabrication

APPENDIX 2 Requirements for the Approval of Filler Metals

APPENDIX 3 Application of Filler Metals to ABS Steels

APPENDIX 9 Welding Procedure Qualification Tests of Steels for Hull Construction and Marine Structures

Hull Construction and Equipment

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CHAPTER 1 General

SECTION 1 Definitions

1 General

Dimensions such as length, breadth, depth, etc., used to define the overall size of the liftboat will be published in the *Record* together with other pertinent particulars.

1.1 Dimensions

1.1.1 Length (L)

L is the distance in meters or feet on the summer load line, from the fore side of the stem to the centerline of the rudder stock. For use with the Rules, L is not to be less than 96% and need not be greater than 97% of the length on the summer load line. The forward end of L is to coincide with the fore side of the stem on the waterline on which L is measured.

1.1.2 Breadth (B)

B is the greatest molded breadth in meters or feet.

1.1.3 Depth (D)

D is the molded depth at side in meters or feet, measured at the middle of L , from the molded base line to the top of the freeboard-deck beams. In liftboats having rounded gunwales, D is to be measured to the point of intersection of the molded lines of the deck and side shell plating. In cases where watertight bulkheads extend to a deck above the freeboard deck and are to be recorded in the *Record* as effective to that deck, D is to be measured to the bulkhead deck.

1.1.4 Draft (d)

The molded draft, d , is the vertical distance from the molded base line to the assigned load waterline.

1.3 Molded Displacement and Block Coefficient

1.3.1 Molded Displacement (Δ)

Δ is the molded displacement of the liftboat in metric tons (long tons), excluding appendages, taken at the summer load line.

1.3.2 Block Coefficient (C_b)

C_b is the block coefficient obtained from the following equation.

$$C_b = \Delta / 1.025 L B_{wl} d \quad (\text{SI \& MKS units})$$

$$C_b = 35 \Delta / L B_{wl} d \quad (\text{US units})$$

where

Δ = molded displacement as defined in 3-1-1/1.3.1

L = Rule length as defined in 3-1-1/1.1.1

d = molded draft as defined in 3-1-1/1.1.4

B_{wl} = the greatest molded breadth at summer load line

1.5 Decks

1.5.1 Freeboard Deck

The freeboard deck normally is the uppermost continuous deck having permanent means for closing all openings in its weather portions, and below which all openings in the liftboat's side are equipped with permanent means for watertight closure.

1.5.2 Bulkhead Deck

The bulkhead deck is the highest deck to which watertight bulkheads extend and are made effective.

1.5.3 Strength Deck

The strength deck is the deck which forms the top of the effective hull girder at any part of its length.

1.5.4 Superstructure Deck

A superstructure deck is a deck above the freeboard deck to which the side shell plating extends. Except where otherwise specified the term superstructure deck where used in the Rules refers to the first such deck above the freeboard deck.

1.7 Mode of Operation

A mode of operation is a condition or manner in which a liftboat may operate or function while on location or in transit and includes the following.

1.7.1 Normal Operating Condition

A normal operating condition is a condition wherein a liftboat is on location to perform service and other related functions, and the combined environmental and operational loadings are within the appropriate design limits established for such operations.

1.7.2 Severe Storm Condition

A severe storm is a condition wherein a liftboat may be subjected to the most severe environmental loadings for which it was designed. During the severe storm condition it may be necessary to discontinue operations due to the severity of the environmental loadings. The liftboat may be either afloat or supported by the sea bed.

1.7.3 Transit Conditions

All liftboat movements from one geographical location to another.

1.9 Weathertight

Weathertight means that in any sea condition associated with the mode of operation, water will not penetrate into the liftboat.

1.11 Watertight

Watertight means the capability of preventing the passage of water through the structure in any direction under a head of water for which the surrounding structure is designed.

1.13 Gross Tonnage

The measurement of the internal volume of spaces within the liftboat as defined by the International Convention on Tonnage Measurement of Ships, 1969. When the liftboat engages exclusively in domestic voyages, the national tonnage measurement by the flag Administration may be used.

1.15 Systems of Measurement

These Rules are written in three systems of units, i.e., SI units, 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 three systems of units is as follows:

SI units (MKS units, US customary units)

1.17 Deck Line

For the purpose of the subdivision standard, the deck line will be the intersection of the molded surface of the deck and side of the hull. The edges of deck extensions, appendages and sponsons of a lesser depth than the hull installed to fit the elevating system and leg wells, do not need to be considered as a part of the deck line.

1.19 Deckhouses

A deckhouse is an enclosed structure above the freeboard deck having side plating set inboard of the side-shell plating more than 4% of the breadth B of the liftboat.

CHAPTER 1 General

SECTION 2 Environmental Loadings

1 Loading Criteria

1.1 General (2008)

A liftboat's modes of operation are to be investigated using anticipated loads, including gravity and functional loads together with relevant environmental loads due to the effects of wind, waves and currents, and where deemed necessary by the Owner or designer, the effects of earthquake, sea bed supporting capabilities, temperature, fouling, etc. The Owner is to specify the environmental conditions for which the plans of the liftboat are to be approved.

1.3 Wind Loading

1.3.1 General

The minimum wind velocity for unrestricted offshore service for all normal operating and transit conditions is not to be less than 36 m/s (70 kn). All liftboats in unrestricted offshore service are to have the capability to withstand a severe storm condition wherein a wind velocity of not less than 51.5 m/s (100 kn) is assumed. In order to comply with the severe storm condition, all liftboats are to show compliance with this requirement at all times or have the capability to change mode of operation. The steps to be taken to comply with the 51.5 m/s (100 kn) criteria from the 36 m/s (70 kn) criteria are the responsibility of the owners. Liftboats which, due to the intended limited service, are not designed to meet the above criteria may be considered for restricted service classification. For any restricted classification, the minimum wind velocity is to be taken at not less than 25.7 m/s (50 kn).

1.3.2 Wind Pressure

In the calculation of wind pressure P , the following equation is to be used and the vertical height is to be subdivided approximately in accordance with the values listed in 3-1-2/Table 2.

$$P = f V_k^2 C_h C_s \quad \text{N/m}^2 (\text{kgf/m}^2, \text{lbf/ft}^2)$$

where

$$\begin{aligned} f &= 0.611 (0.0623, 0.00338) \\ V_k &= \text{wind velocity in m/s (m/s, kn)} \\ C_h &= \text{height coefficient from 3-1-2/Table 2} \\ C_s &= \text{shape coefficient from 3-1-2/Table 1} \end{aligned}$$

1.3.3 Wind Force

The wind force F is to be calculated in accordance with the following equation for each vertical area and the resultant force and vertical point of application is to be determined.

$$F = PA$$

where

$$\begin{aligned} F &= \text{force in N (kgf, lbf)} \\ P &= \text{pressure in N/m}^2, (\text{kgf/m}^2, \text{lbf/ft}^2) \\ A &= \text{projected area in m}^2 (\text{ft}^2) \text{ of all exposed surfaces} \end{aligned}$$

In calculating the wind forces, the following procedures are recommended.

- i) In the case of liftboats with tubular legs, the projected areas of all legs are to be included (i.e., no shielding allowance is to be taken).
- ii) The block projected area of a clustering of deck houses may be used in lieu of calculating each individual area. The shape coefficient may be assumed to be 1.1.
- iii) Isolated houses, structural shapes, cranes, etc., are to be calculated individually using the appropriate shape coefficient from 3-1-2/Table 1.

1.5 Wave Loadings

1.5.1 General

Wave criteria specified by the Owner may be described by means of wave energy spectra or by deterministic waves having shape, size, and period appropriate to the depth of water in which the liftboat is to operate. Waves are to be considered as coming from any direction relative to the liftboat. Consideration is to be given to waves of less than maximum height due to their period. The effects on various structural elements may be greater.

1.5.2 Determination of Wave Loads

The determination of wave loads for use in structural design is to be based on acceptable calculations, model tests or full scale measurements. For structures comprised of slender members that do not significantly alter the incident wave field, semi-empirical formulations such as Morison's equation may be used. For calculations of wave loads on structural configuration that significantly alter the incident wave field, diffraction methods are to be used which account for both the incident wave force (i.e., Froude-Krylov force) and the forces resulting from wave diffraction and radiation.

In general, Morison's equation may be used for structures composed of slender members the diameters (or equivalent diameters giving the same cross-sectional areas parallel to the flow) of which are less than 20% of the wave lengths being considered and are small in relation to the distances between structural members subject to wave loading (e.g., liftboats in the elevated condition).

For each combination of wave height, wave period and water depth being considered, a range of wave crest positions relative to the structure is to be investigated to ensure an accurate determination of the maximum wave force on the structure.

1.5.3 Morison's Equation

The hydrodynamic force acting normal to the axis of a cylindrical member, as given by Morison's equation, is expressed as the sum of the force vectors indicated in the following equation.

$$F_W = F_D + F_I$$

where

$$\begin{aligned} F_W &= \text{hydrodynamic force vector per unit length along the member, acting normal to the axis of the member} \\ F_D &= \text{drag force vector per unit length} \\ F_I &= \text{inertia force vector per unit length} \end{aligned}$$

The drag force vector per unit length for a stationary rigid member is given by:

$$F_D = (C/2) D C_D |u_n| u_n \quad \text{kN/m (tf/m, lbf/ft)}$$

where

$$\begin{aligned} C &= 1.025 (0.1045, 1.99) \\ D &= \text{projected width in m (ft) of the member in the direction of the cross-flow component of velocity (in the case of a circular cylinder, } D \text{ denotes the diameter)} \\ C_D &= \text{drag coefficient (dimensionless)} \end{aligned}$$

- u_n = component of the velocity vector, normal to the axis of the member in m/s (ft/s)
 $|u_n|$ = absolute value of u_n in m/s (ft/s)

The inertia force vector per unit length for a stationary, rigid member is given by

$$F_I = C(\pi D^2/4) C_M a_n \text{ kN/m (tf/m, lbf/ft)}$$

where

- C_M = inertia coefficient based on the displaced mass of fluid per unit length (dimensionless)
 a_n = component of the fluid acceleration vector normal to the axis of the member, in m/s² (ft/s²)

For structures that exhibit substantial rigid body oscillations due to wave action, the modified form of Morison's equation given below may be used to determine the hydrodynamic force.

$$\begin{aligned} F_w &= F_D + F_I \\ &= (C/2) D C_D (u_n - u'_n) |u_n - u'_n| + C(\pi D^2/4) a_n + C(\pi D^2/4) C_m (a_n - a'_n) \end{aligned}$$

where

- u'_n = component of the velocity vector of the structural member normal to its axis in m/s (ft/s)
 C_m = added mass coefficient (i.e., $C_m = C_M - 1$)
 a'_n = of the acceleration vector of the structural member normal to its axis, in m/s² (ft/s²)

For structural shapes other than circular cylinders, the term $\pi D^2/4$ in the above equations is to be replaced by the actual cross-sectional area of the shape.

Values of u_n and a_n for use in Morison's equation are to be determined using wave theories appropriate to the wave heights, wave periods, and water depths being considered. Reynold's number, Keulegan-Carpenter number and surface roughness are to be based on reliable data obtained from literature, model or full scale tests. For circular cylindrical members at Reynold's number greater than 1×10^6 , C_D and C_M may be taken at 0.62 and 1.8 respectively provided that marine fouling is prevented or periodically removed.

1.5.4 Wave Induced Dynamic Responses (2010)

Consideration is to be given to the possibility of structural vibrations induced by action of waves in the case of liftboats in elevated condition. The dynamic response induced by the actions of waves or waves acting with current is to be considered if either of the following conditions is met.

- The natural vibratory period, T_n (in seconds), of the liftboat in a global translational mode (i.e., either lateral deck sway or surge displacement) is in the range 0.9 to 1.1 of the wave period, T (in seconds).
- The dynamic amplification factor (DAF), obtained in the manner described below is greater than 1.10.

T_n can be determined from the following equation applied to one leg:

$$T_n = 2\pi \sqrt{(M_e / K_e)}$$

where

- M_e = effective mass associated with one leg. This is to consider: the mass representing the *Total Elevated Load* divided by the number of legs; the mass of a leg above its effective clamping location; and one half the mass of a leg below the effective clamping location, excluding the spudcan, but including the added mass of water displaced by the leg.

K_e = effective bending stiffness of one leg to resist horizontal displacement at the level of the elevated hull. The determination of the leg bending stiffness is to consider: the leg as being pin-ended at least 3 m (10 ft) below the sea bed, the hull to leg stiffness, and the effects of lateral frame displacement on the leg with the highest compressive load due to the supported weight and the other environmental load effects acting with considered wave and current.

The dynamic amplification factor, DAF is determined from the following equation:

$$DAF = \left\langle \left\{ 1 - \left(\frac{T_n}{T} \right)^2 \right\}^2 + \left\{ 2c \left(\frac{T_n}{T} \right) \right\}^2 \right\rangle^{-0.5}$$

where:

c = fraction of critical damping (to be taken ≤ 7 percent)

T_n and T are as previously defined.

1.7 Current Loading

1.7.1 Current Associated with Waves

When determining loads due to the simultaneous occurrence of waves and current using Morison's equation, the current velocity is to be added vectorially to the wave particle velocity before the total force is computed. When diffraction methods are used for calculating wave force the drag force due to current should be calculated in accordance with 3-1-2/1.7.2 and added vectorially to the calculated wave force.

The current velocity is to include components due to tidal current, storm surge current and wind driven current. In lieu of defensible alternative methods, the vertical distribution of current velocity in still water and its modification in the presence of waves as shown in 3-1-2/Figure 1 are recommended, where:

$$V_c = V_t + V_s + V_w [(h - z)/h], \quad \text{for } z \leq h$$

$$V_c = V_t + V_s \quad \text{for } z > h$$

and

V_c = current velocity, m/s (ft/s)

V_t = component of tidal current velocity in the direction of the wind, m/s (ft/s)

V_s = component of storm surge current, m (ft)

V_w = wind driven current velocity, m/s (ft/s)

h = reference depth for wind driven current, m (ft). In the absence of other data h may be taken as 5 m (16.4 ft).

z = distance below still water level under consideration, m (ft)

d = still water depth, m (ft)

In the presence of waves, the current velocity profile is to be modified, as shown in 3-1-2/Figure 1, such that the current velocity at the instantaneous free surface is a constant.

1.7.2 Drag Force

When calculating the drag force on submerged parts of the structure due to current alone, the following equation may be used.

$$f_D = C/2 D C_D u_c |u_c|$$

where

f_D = current drag force vector per unit length along the member, acting normal to the axis of the member in kN/m (tf/m, lbf/ft)

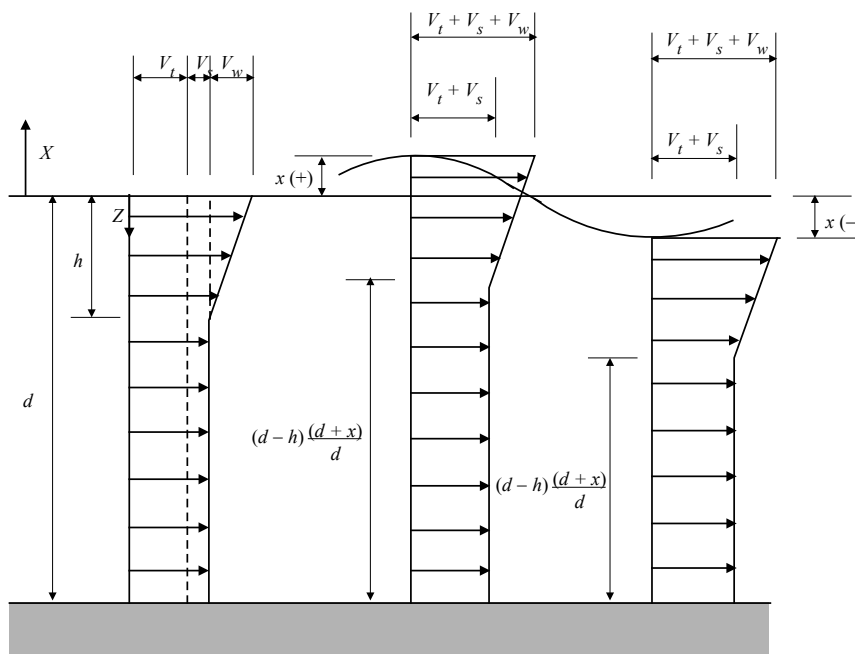
u_c = component of the current velocity vector, V_c , normal to the axis of the member in m/s (ft/s)

$|u_c|$ = absolute value of u_c

C , D and C_D are as defined in 3-1-2/1.5.3.

All of the above values are to be taken in a consistent system of units, C_D being dimensionless. Drag coefficients in steady flow vary considerably with section shape. Reynold's number and surface roughness are to be based on reliable data obtained from literature, model or full scale tests.

FIGURE 1
Current Velocity Profile



1.9 Loadings due to Vortex Shedding

Consideration is to be given to the possibility of flutter of structural members due to vortex shedding.

1.11 Gravity and Functional Loads (2008)

1.11.1 General

The gravity loads are steel, equipment and outfitting weights, liquid and solid variables, and live loads and should be taken into account in the design of the structural strength and stability. The load effects due to operations should also be taken into account.

1.11.2 Combinations of Gravity and Functional Loads for Design

For all modes of operation, the combinations of gravity and function loads are to be specified by the Owners or Designers as per the operations designed. However, maximums (or minimums) of the combinations that produce the most unfavorable load effects in the strength or stability of the unit should be taken for design.

1.11.3 Deck Loadings

As indicated in 1-1-4/1 of the Supplement to the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, a loading plan is to be prepared for each design. This plan is to show the maximum uniform and concentrated loadings to be considered for all areas for each mode of operation. In the preparation of this plan the following loadings are to be considered as minimums.

Crew spaces (walkways, general traffic areas, etc.)

4510 N/m² (460 kgf/m², 94 lbf/ft²) or 0.64 m (2.1 ft) head

Work areas

9020 N/m² (920 kgf/m², 188 lbf/ft²) or 1.28 m (4.2 ft) head

Storage areas

13000 N/m² (1325 kgf/m², 272 lbf/ft²) or 1.84 m (6.0 ft) head

TABLE 1
Values of C_s

Shapes or combinations of shapes which do not readily fall into the specified categories will be subject to special consideration.

Spherical	0.4
Cylindrical shapes (all sizes)	0.5
Hull (surface type)	1.0
Deck house	1.0
Isolated Structural shapes (cranes, angles, channels, beams, etc.	1.5
Under deck areas (smooth surfaces)	1.0
Under deck areas (exposed beams and girders)	1.3

TABLE 2
Values of C_h

The height h in m (ft) is the vertical distance from the design water surface to the center of area A defined in 3-1-2/1.3.3.

<i>Height (meters)</i>	<i>Height (feet)</i>	C_h
10.0–15.3	110–501	1.00
15.3–30.5	150–100	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
91.5–106.5	300–350	1.48
106.5–122.0	350–400	1.52
122.0–137.0	400–450	1.56
137.0–152.5	450–500	1.60
152.5–167.5	500–550	1.63
167.5–183.0	550–600	1.67
183.0–198.0	600–650	1.70
198.0–213.5	650–700	1.72
213.5–228.5	700–750	1.75
228.5–244.0	750–800	1.77
244.0–256.0	800–850	1.79
256.0–256.0	850–850	1.80

PART 3

CHAPTER 1 General

APPENDIX 1 Shallow Water Wave Theory

The method presented is a simplification based on an interpolation between the solitary and Airy theories, and several others. The analysis is based on vertical cylindrical structures and thus may be used for liftboats having structural and stability columns or, without serious error, truss type legs with non-cylindrical components. The method also assumes that the structure extends to the bottom of the sea. In the event that the legs or columns stop short of the bottom, it may either be assumed that the forces have diminished greatly at such point, and the non-existent portion below ignored, or an adjustment may be made, finding the effective wave height at that distance below the water, and making another calculation of the imaginary portion below the actual structure, and subtracting from the original value.

1 Equations

$$F_{Dm} = 0.5C_D\rho D h_w^2 K_{Dm}$$

$$F_{im} = 0.5C_m\rho D^2 h_w K_{im}$$

$$L_w = (L_w/L_a)(L_a/L_o)KT^2$$

$$M_{Dm} = S_D F_{Dm}$$

$$M_{im} = S_i F_{im}$$

$$M_{Tm} = (F_m/F_{Dm})M_{Dm}$$

3 Nomenclature

C_D	=	drag coefficient (use 0.71 for following example)
C_m	=	inertial or mass coefficient (use 2.00 for following example)
D	=	pile diameter, m (ft)
F_{Dm}	=	maximum value of total horizontal drag force (occurs at wave crest), N (kgf, lbf)
F_{im}	=	maximum value of total horizontal inertial force (occurs at between crest and $1/4$ of wave length), N (kgf, lbf)
F_m	=	maximum value of combined drag and inertia forces, N (kgf, lbf)
g	=	acceleration of gravity
h	=	still-water depth, m (ft)
h_w	=	wave height, crest to trough, m (ft)
K	=	1.56 m/s^2 (5.12 ft/s^2)
K_{Dm}	=	drag force factor at crest, m/s^2 (ft/s^2)
K_{im}	=	inertial force factor, m/s^2 (ft/s^2)
L_a	=	linear theory wave length for period T and depth h , m (ft)

L_o	=	deepwater linear theory wave length = $1.56T^2$ m (5.12 T^2 ft)
L_w	=	wave length, including the effect of finite wave height, m (ft)
M_{Dm}	=	moment on pile about bottom associated with maximum drag force, N-m (kgf-m, ft-lbf)
M_{im}	=	moment on pile about bottom associated with maximum inertial force, N-m (kgf-m, ft-lbf)
M_{Tm}	=	maximum total moment on pile about bottom, N-m (kgf-m, ft-lbf)
S	=	lever arm for F_m , m (ft)
S_D	=	lever arm for F_{Dm} , m (ft)
S_i	=	lever arm for F_{im} , m (ft)
T	=	wave period, sec
W	=	unit weight of sea water, kg/m ³ (lb/ft ³)
β	=	angular position of maximum moment ahead of wave crest, degrees
ρ	=	mass density = W/g kg/m ³ (lb/ft ³)
ζ_o	=	crest elevation above still water, m (ft)

5 Example

Given:

Wave height	h_w	=	35 ft
Still-water depth	h	=	85 ft
Wave period	T	=	12 s
Pile diameter	D	=	8 ft
Drag coefficient	C_D	=	0.71
Inertia coefficient	C_m	=	2.00

7 Compute

1	h_w/T^2	=	35/144
		=	0.243 ft/s ²
2	h/T^2	=	85/144
		=	0.590 ft/s ²
3	h_w/h	=	35/85
		=	0.412

From 3-1-A1/Figure 1, using equations 1 and 2, determine $\zeta_o/h_w = 0.68$

then	ζ_o	=	0.68 (h_w)
		=	0.68 (35)
		=	23.8 ft

From 3-1-A1/Figure 2, using equation 2, determine $L_d/L_o = 0.75$

From 3-1-A1/Figure 3, using equations 1 and 2 determine $L_w/L_a = 1.04$

$$\begin{aligned} \text{as} \quad L_w &= (L_w/L_a)(L_a/L_o)KT^2 \\ \text{then} \quad L_w &= (1.04)(0.75)(5.12)(12)^2 \\ &= 575 \text{ ft} \end{aligned}$$

From 3-1-A1/Figure 4, equations 1 and 2, determine $K_{Dm} = 13.0 \text{ ft/s}^2$

$$\begin{aligned} \text{as} \quad F_{Dm} &= 0.5C_D\rho Dh_w^2 K_{Dm} \\ \text{then} \quad F_{Dm} &= 0.5(0.71)(1.993)(8)(35)^2(13.0) \\ &= 90,200 \text{ lbf} \end{aligned}$$

From 3-1-A1/Figure 5, using equations 2 and 3, determine $S_D/h = 0.91$

$$\begin{aligned} \text{then} \quad S_D &= 0.91(h) \\ &= 0.91(85) \\ &= 77.4 \text{ feet} \\ \text{and as} \quad M_{Dm} &= F_{Dm}S_D \\ \text{then} \quad M_{Dm} &= 90,200 (77.4) \\ &= 6,980,000 \text{ ft-lbf} \end{aligned}$$

From 3-1-A1/Figure 6, using equation 2, determine $K_{im} = 19.5 \text{ feet/sec}^2$

$$\begin{aligned} \text{as} \quad F_{im} &= 0.5C_m\rho D^2 h_w K_{im} \\ \text{then} \quad F_{im} &= 0.5(2.00)(1.993)(8)^2(35)(19.5) \\ &= 87,200 \text{ lbf} \end{aligned}$$

From 3-1-A1/Figure 7, using equations 2 and 3, determine $S_i/h = 0.78$

$$\begin{aligned} \text{then} \quad S_i &= 0.78(h) \\ &= 0.78(85) \\ &= 66.3 \text{ ft} \\ \text{as} \quad M_{im} &= F_{im}S_i \\ \text{then} \quad M_{im} &= 87,200(66.3) \\ &= 5,780,000 \text{ ft-lbf} \\ \text{and} \quad F_{im}/F_{Dm} &= 87,200/90,200 \\ &= 0.967 \end{aligned}$$

From 3-1-A1/Figure 8, using $F_{im}/F_{Dm} = 0.967$, determine $F_m/F_{Dm} = 1.37$

$$\begin{aligned} \text{then} \quad F_m &= 1.37F_{Dm} \\ &= 1.37(90,200) \\ &= 123,500 \text{ lbf} \\ \text{and as} \quad M_{Tm} &= (F_m/F_{Dm})M_{Dm} \\ \text{then} \quad M_{Tm} &= 1.37M_{Dm} \\ &= 1.37(6,980,000) \\ &= 9,560,000 \text{ ft-lbf} \end{aligned}$$

Maximum total force:

$$F_m = 123,500 \text{ lbf}$$

Maximum total moment:

$$M_{Tm} = 9,560,000 \text{ ft-lbf}$$

$$\text{as } S = M_{Tm}/F_m$$

$$\begin{aligned} \text{then } S &= 9,560,000/123,500 \\ &= 77.4 \text{ ft} \end{aligned}$$

From 3-1-A1/Figure 9 position of maximum moment ahead of wave crest:

$$\begin{aligned} \text{as } D^2h/h_w^2L_w &= (8)^2(85)/(35)^2(575) \\ &= 0.00772 \end{aligned}$$

$$\text{then } \beta = 13 \text{ degrees}$$

FIGURE 1
Ratio of Crest Elevation to Wave Height

SI and Metric Units

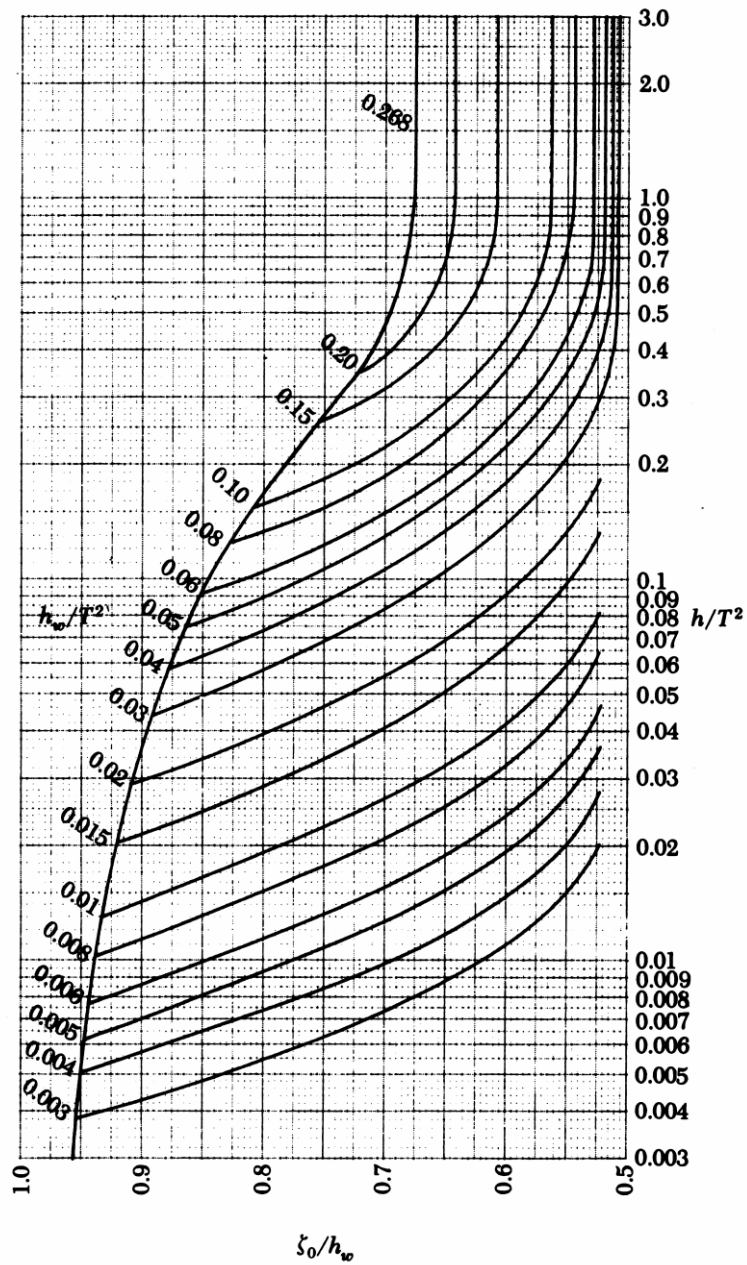


FIGURE 1
Ratio of Crest Elevation to Wave Height

U.S. Units

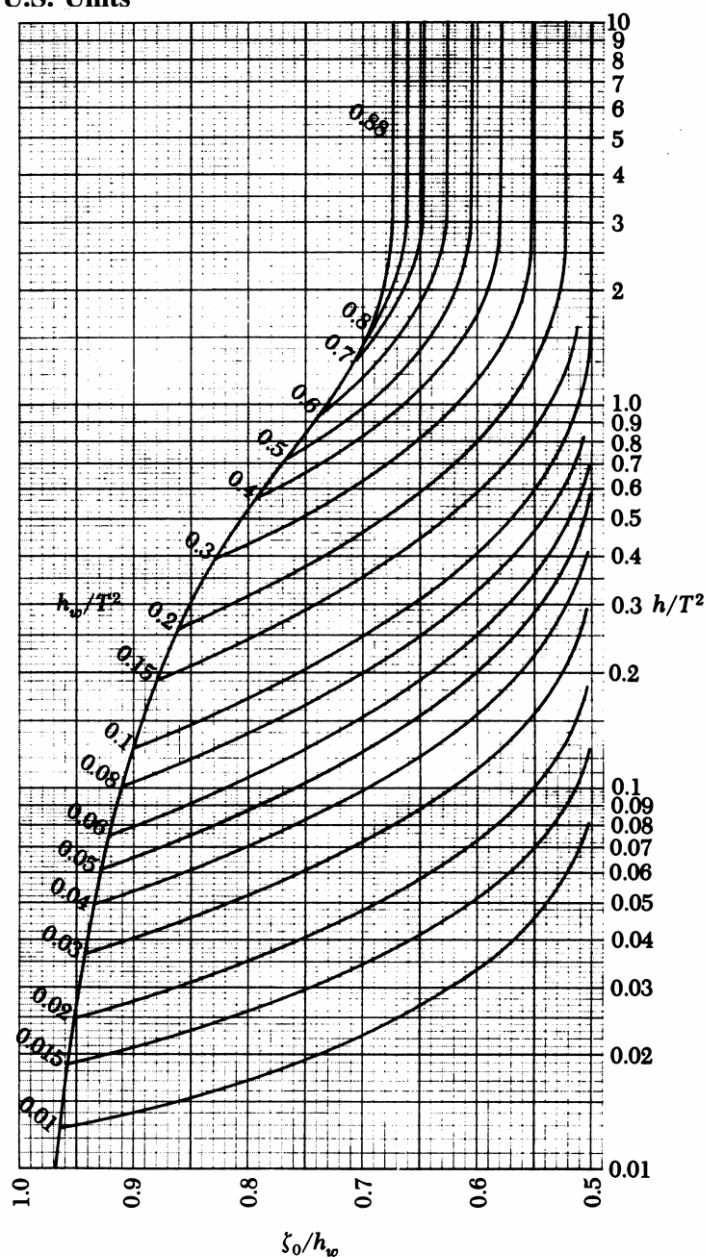


FIGURE 2
Relative Wave Height

SI and Metric Units

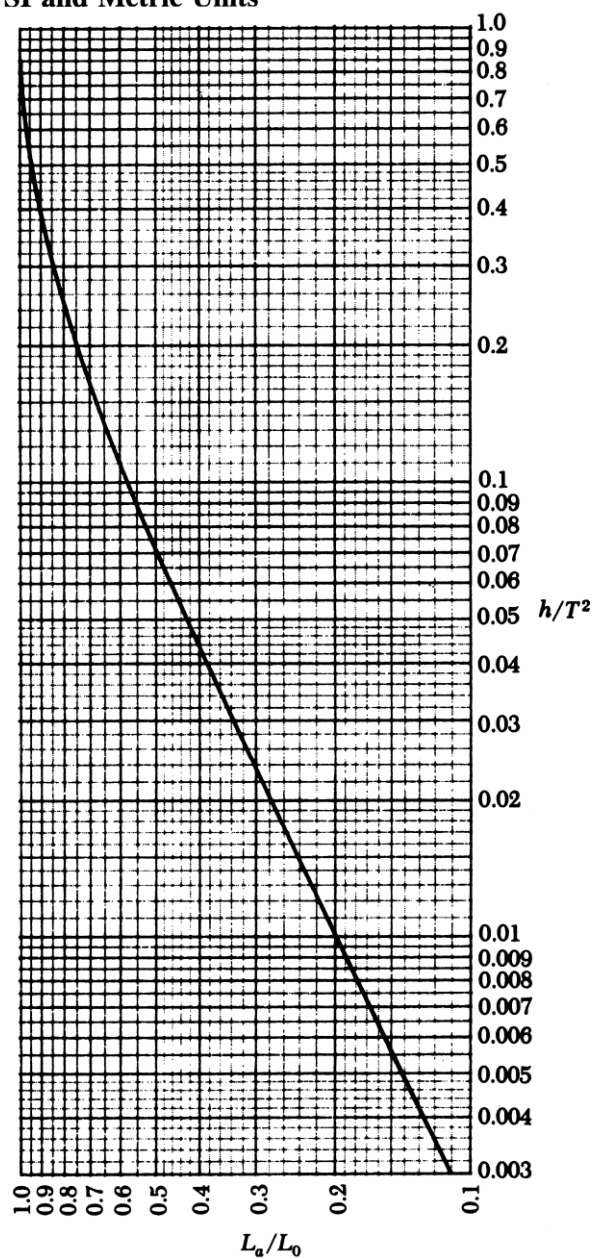


FIGURE 2
Relative Wave Height

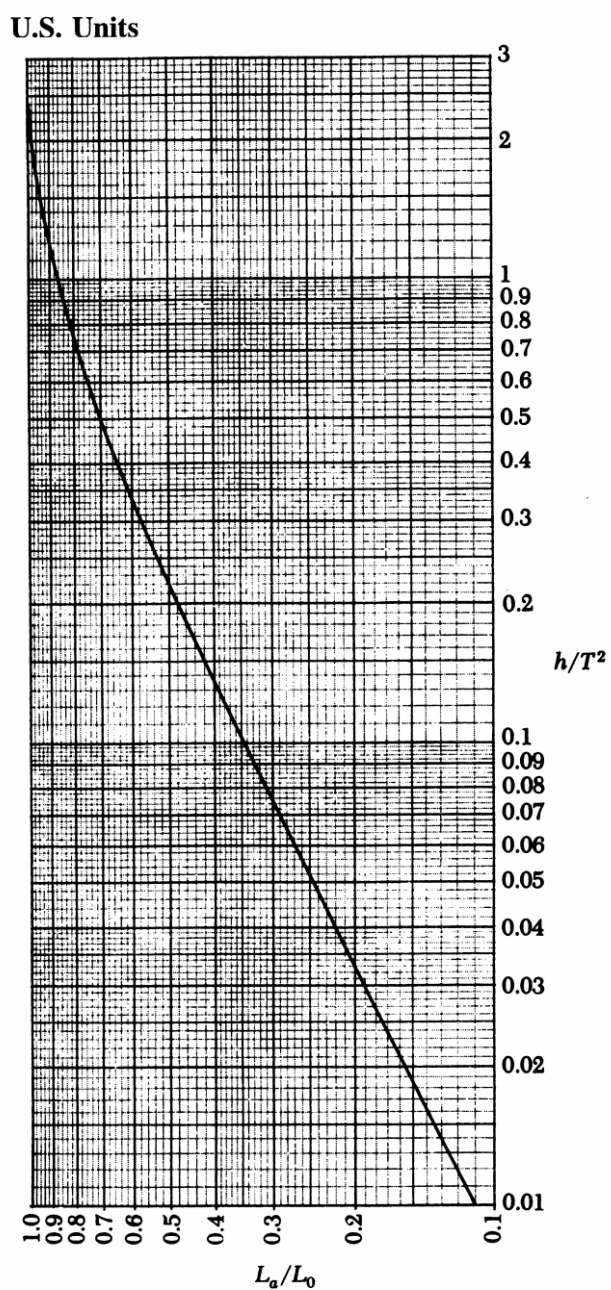


FIGURE 3
Wave Length Correction Factor

SI and Metric Units

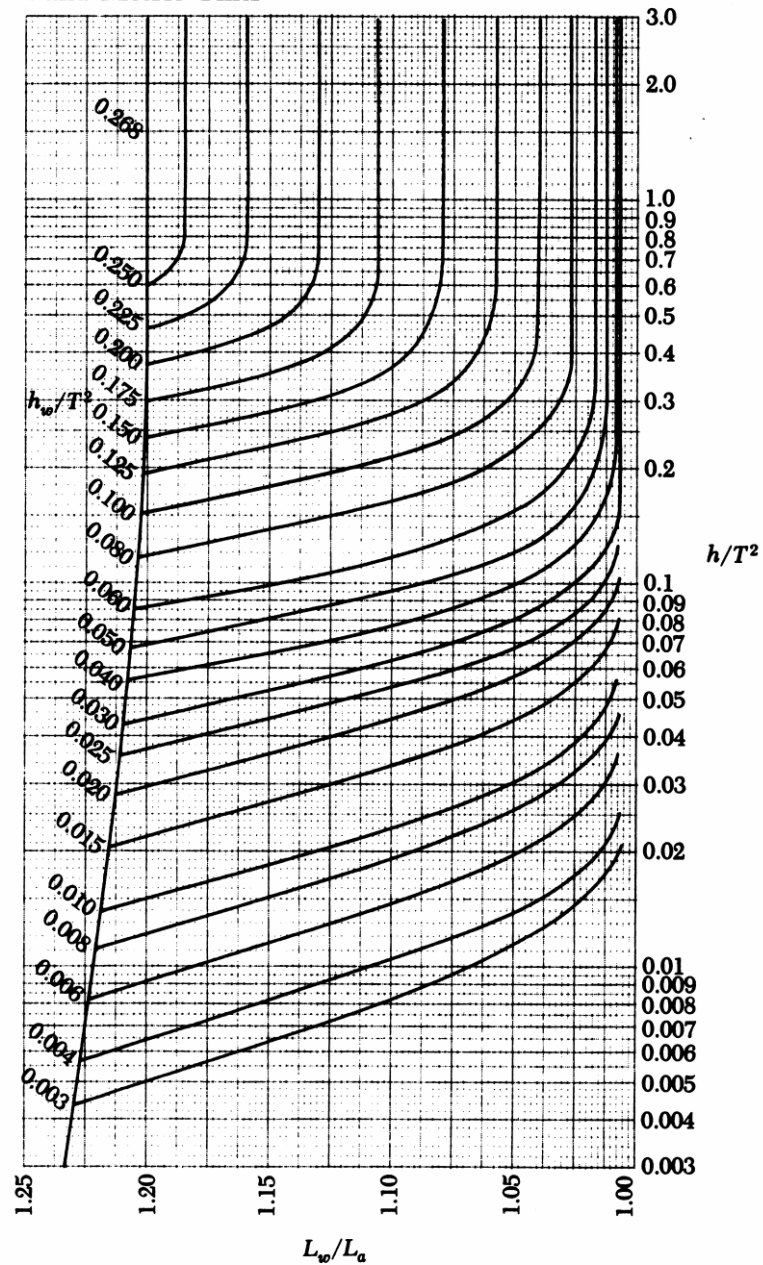


FIGURE 3
Wave Length Correction Factor

U.S. Units

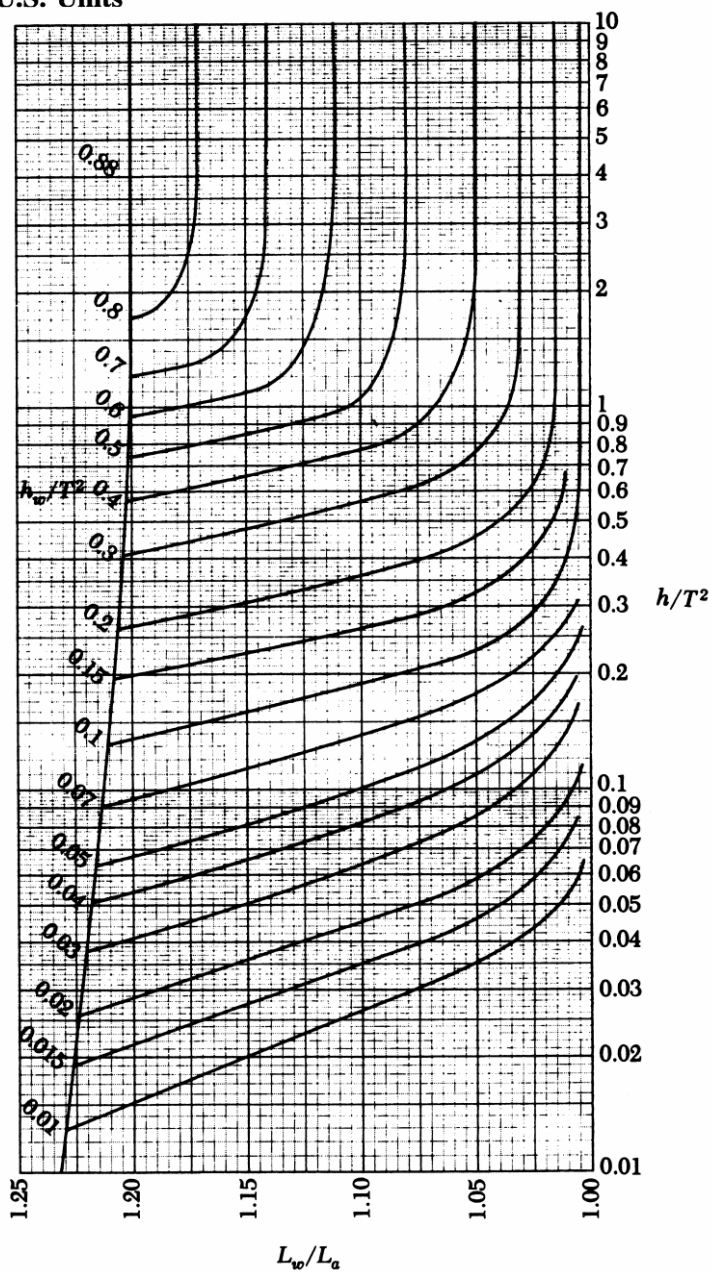


FIGURE 4
Drag Force Factor

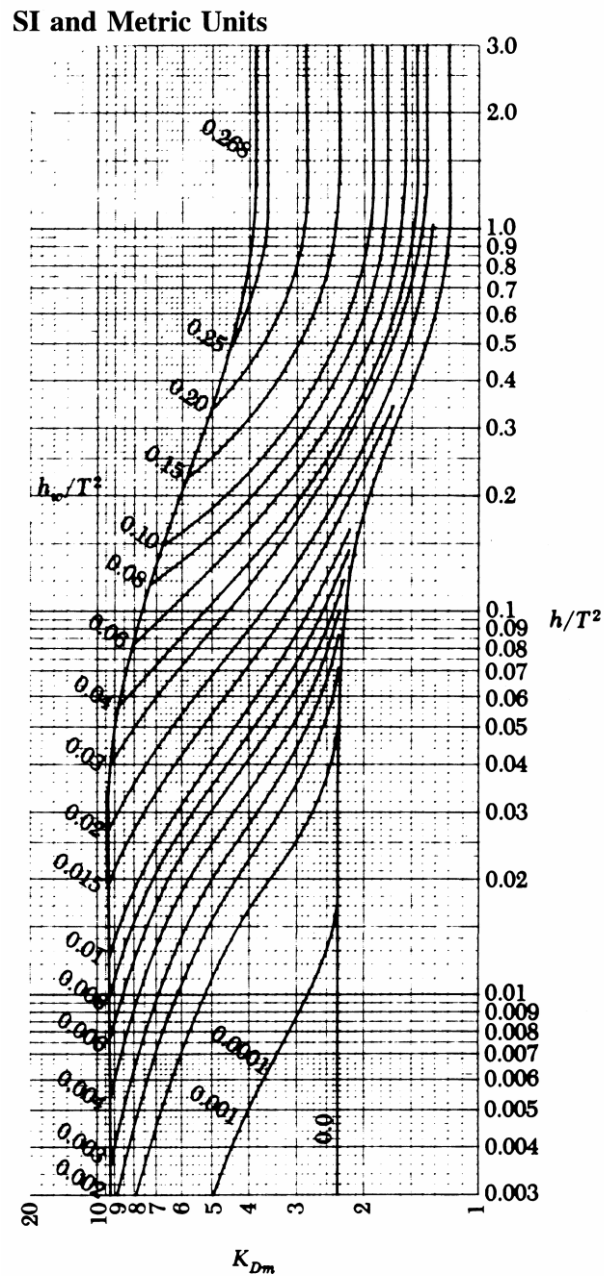


FIGURE 4
Drag Force Factor

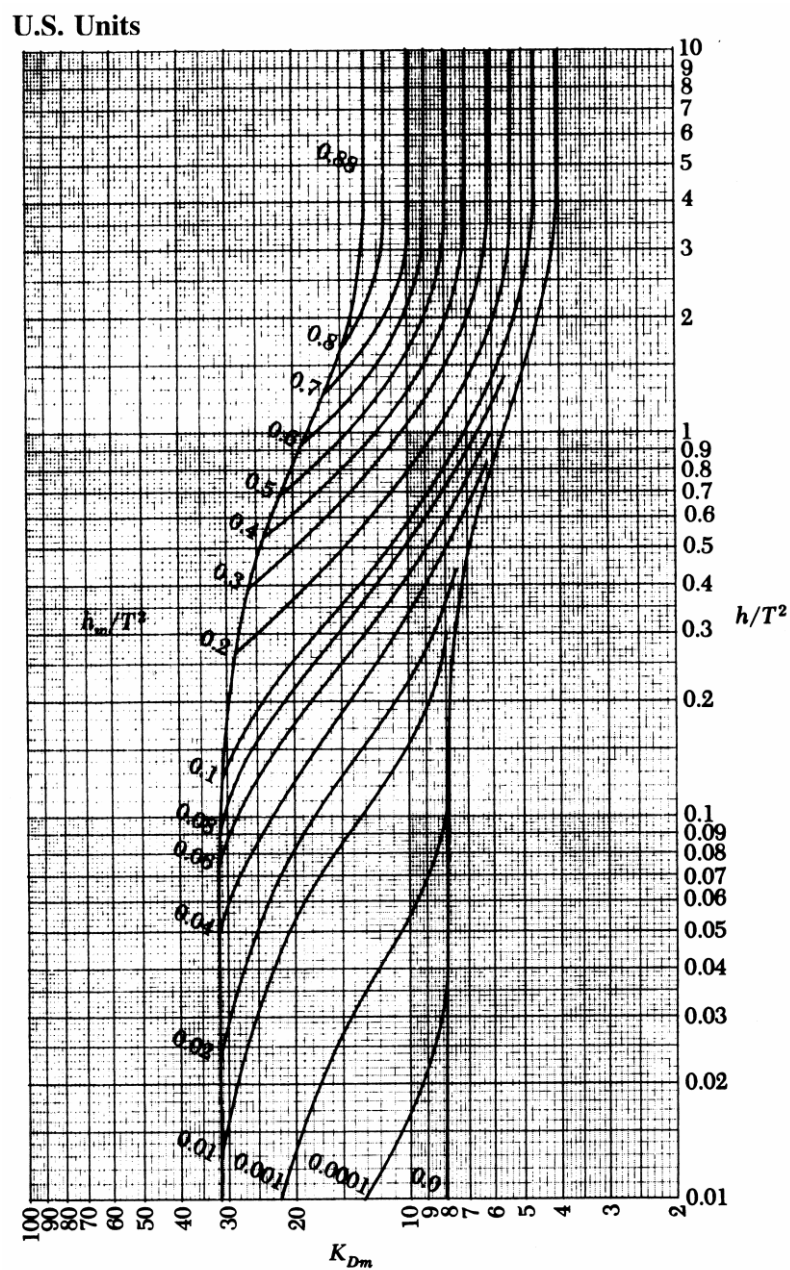


FIGURE 5
Ratio of Drag Force Lever to Still Water Depth

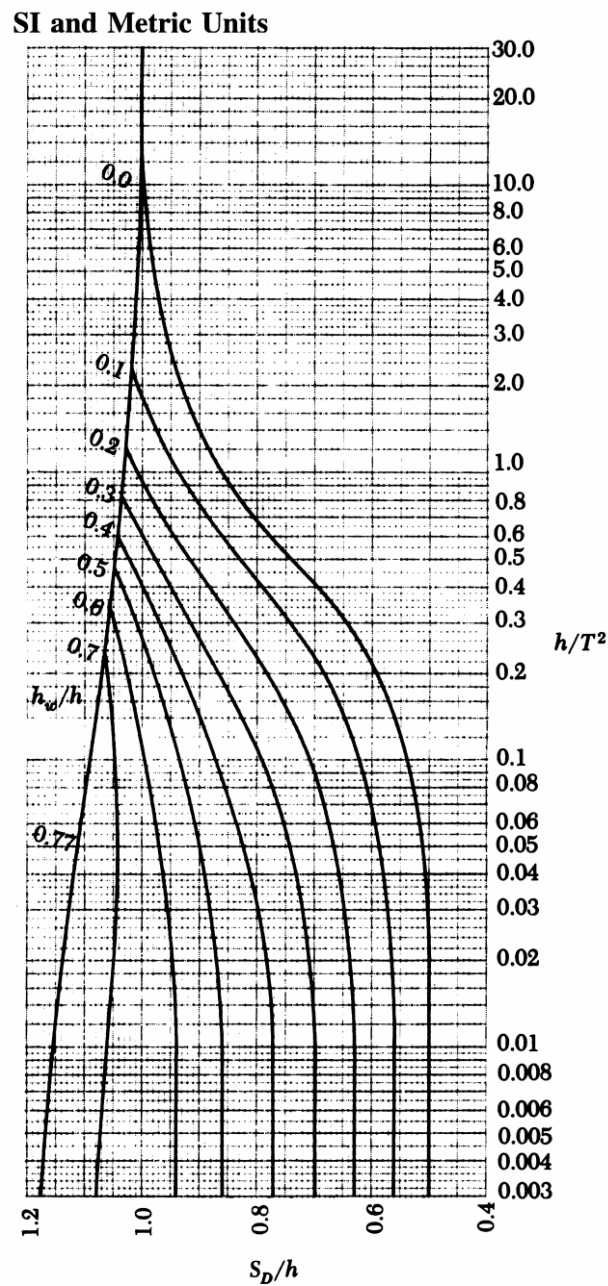


FIGURE 5
Ratio of Drag Force Lever to Still Water Depth

U.S. Units

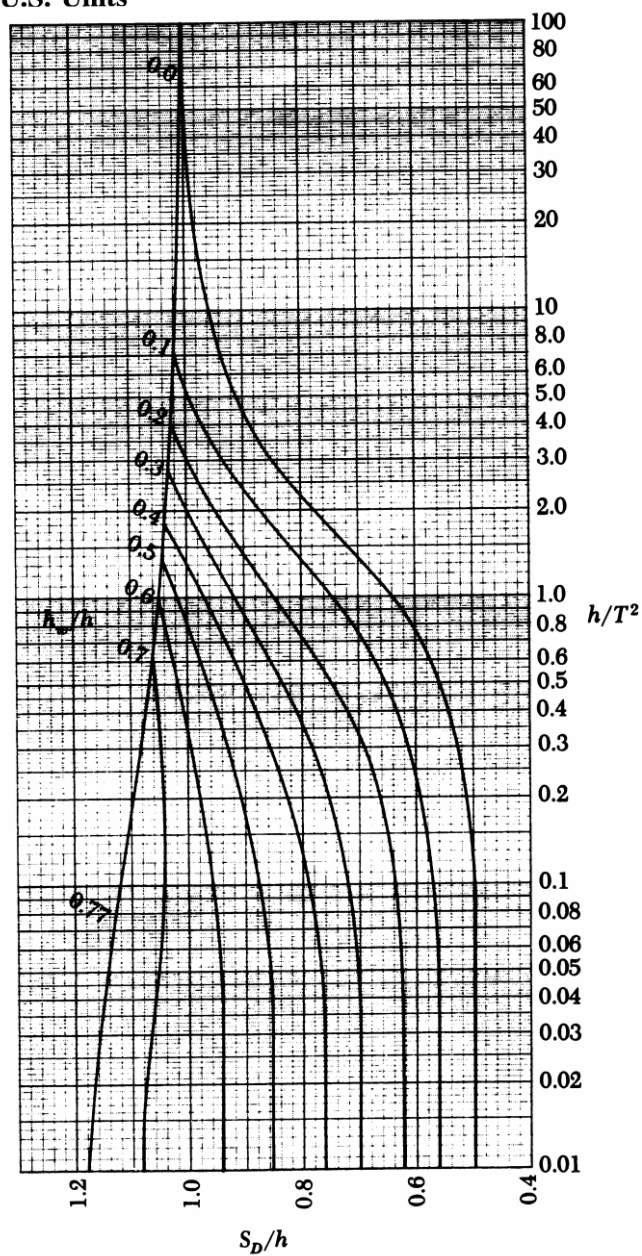


FIGURE 6
Inertial Force Factor

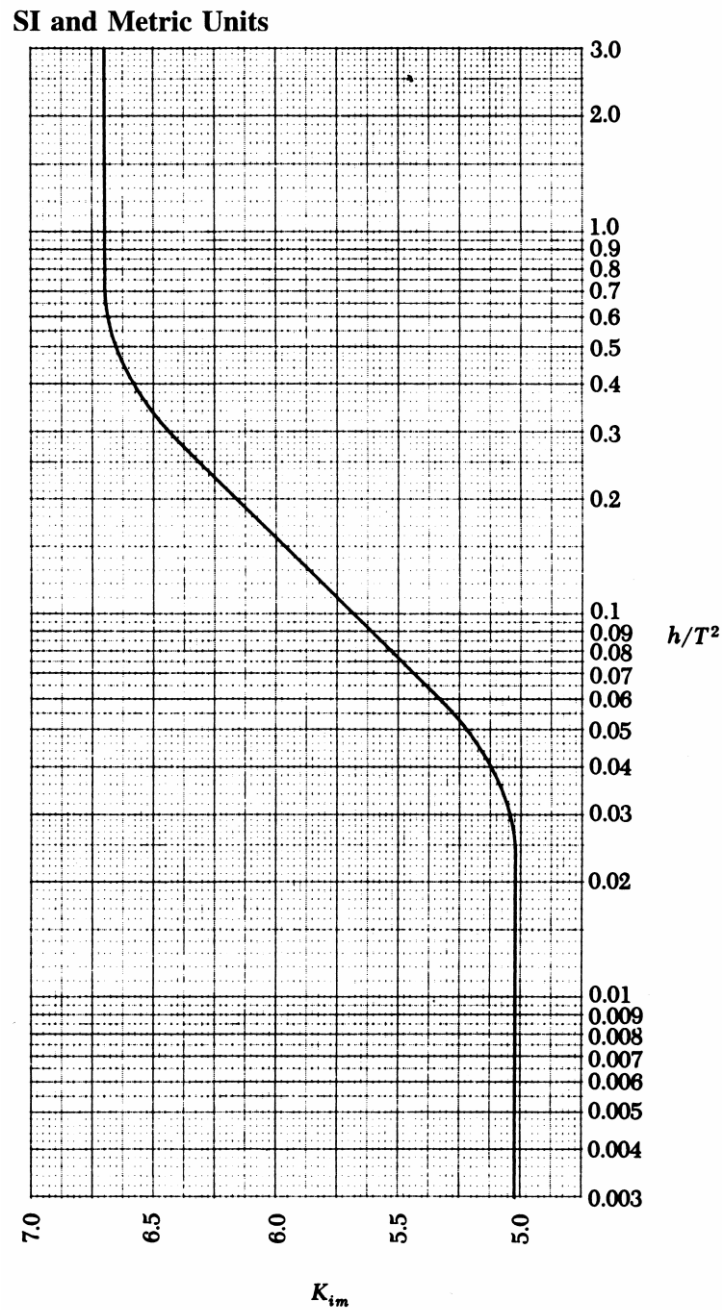


FIGURE 6
Inertial Force Factor

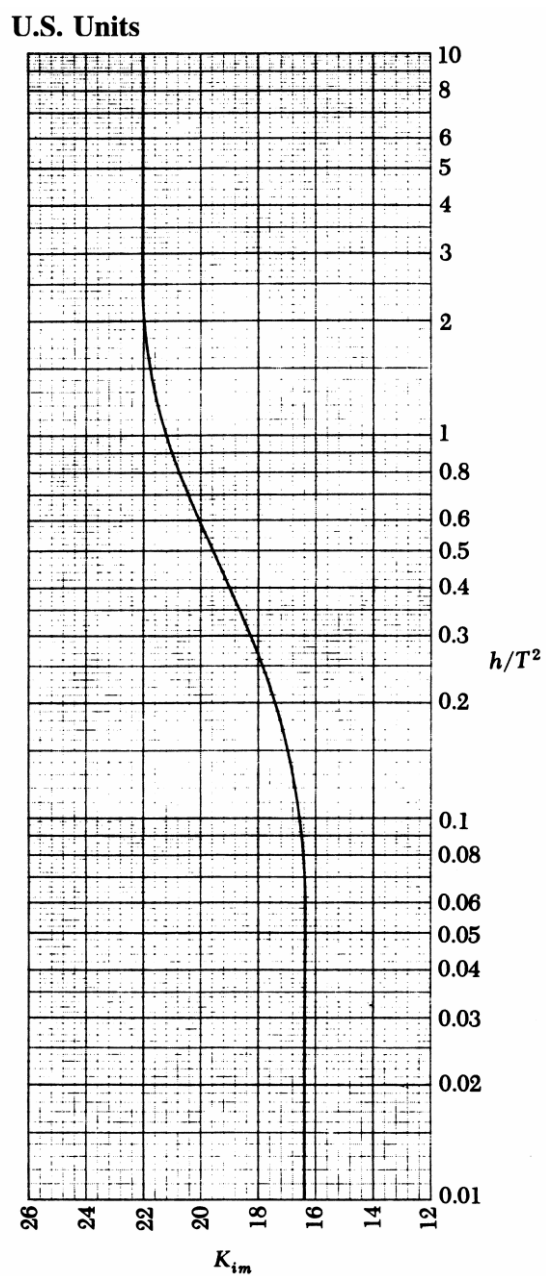


FIGURE 7
Ratio of Inertial Force Lever to Still Water Depth

SI and Metric Units

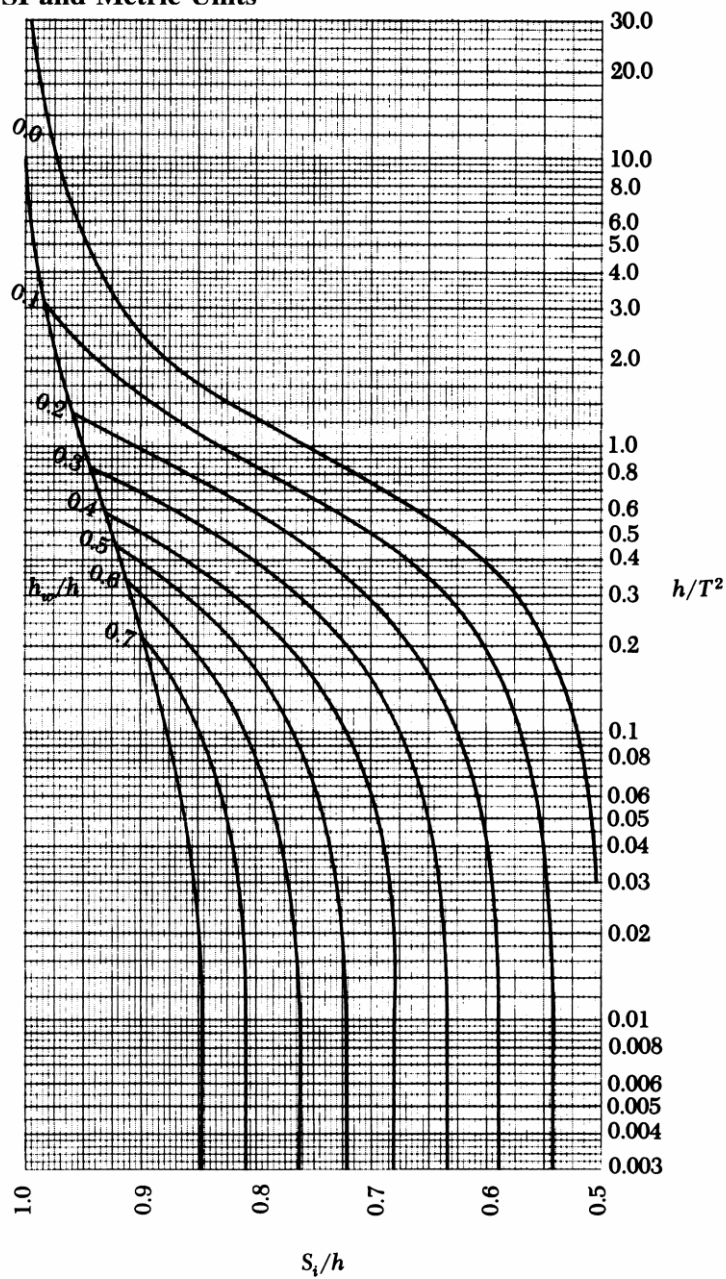


FIGURE 7
Ratio of Inertial Force Lever to Still Water Depth

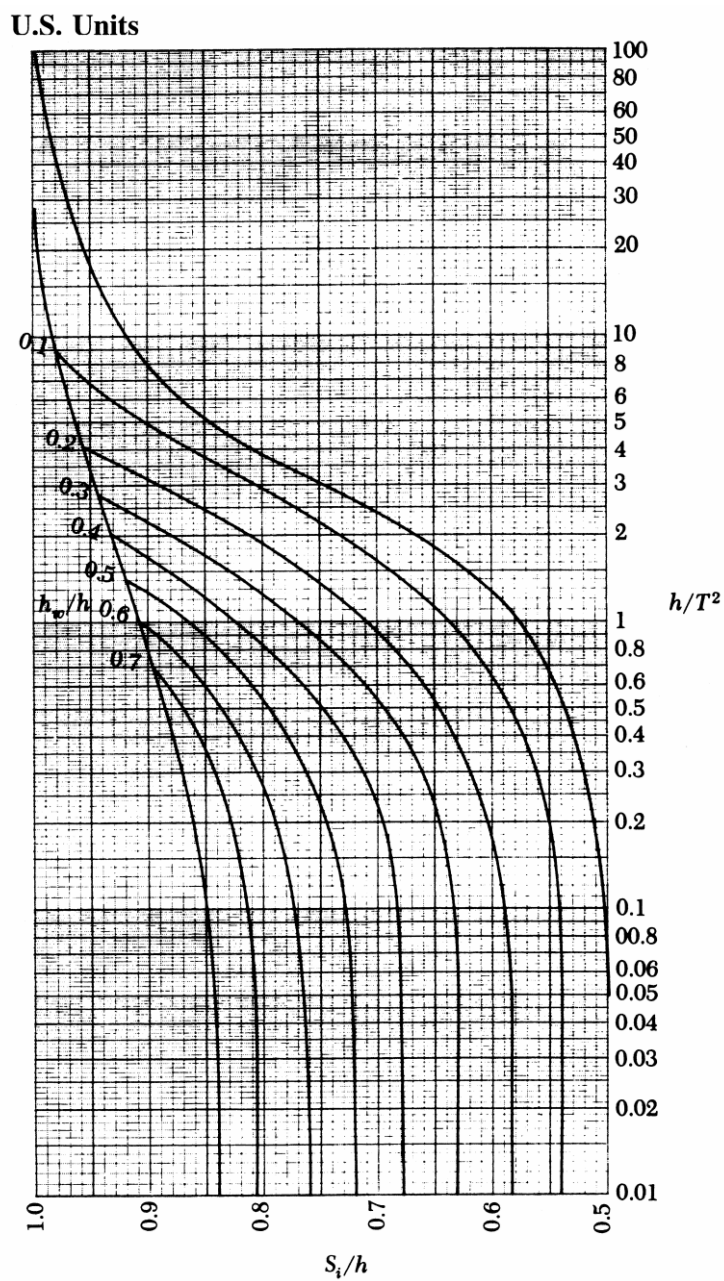


FIGURE 8
Ratio Total Force to Drag Force

SI and Metric Units

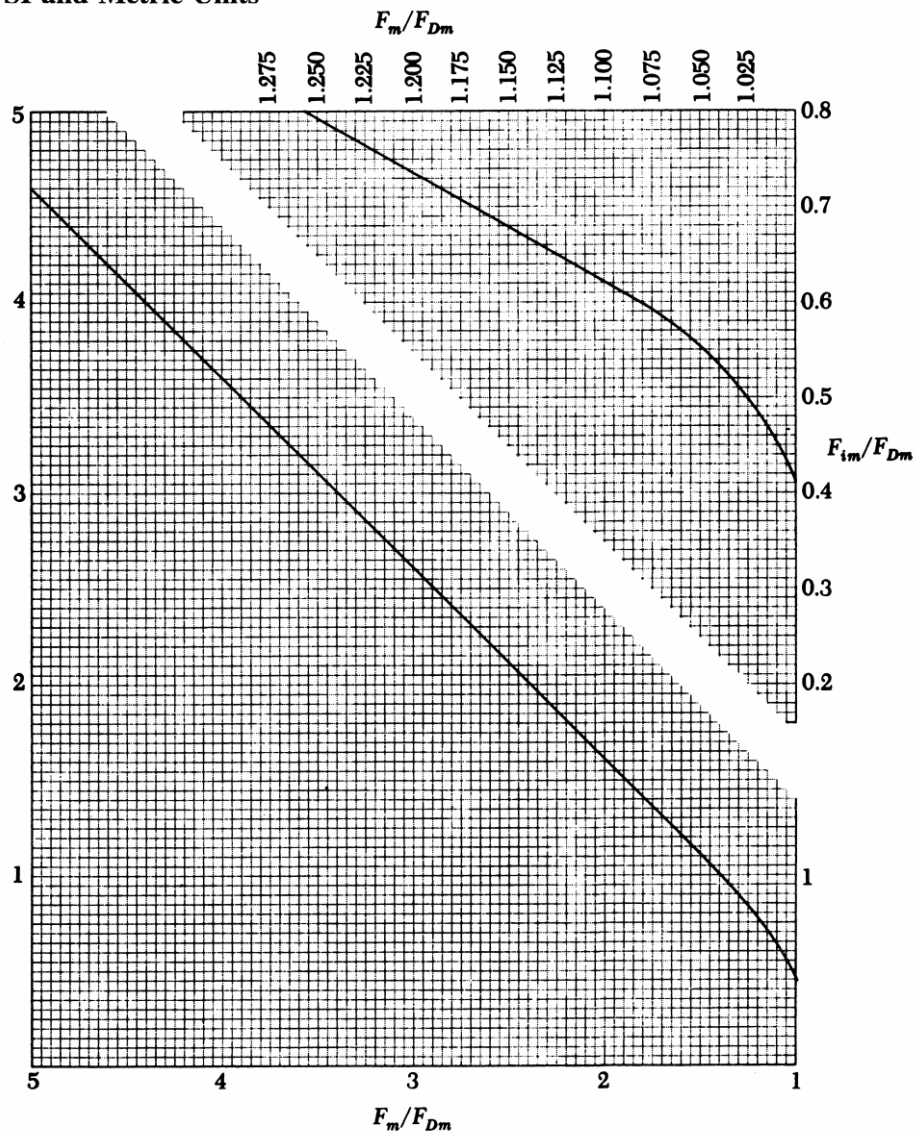
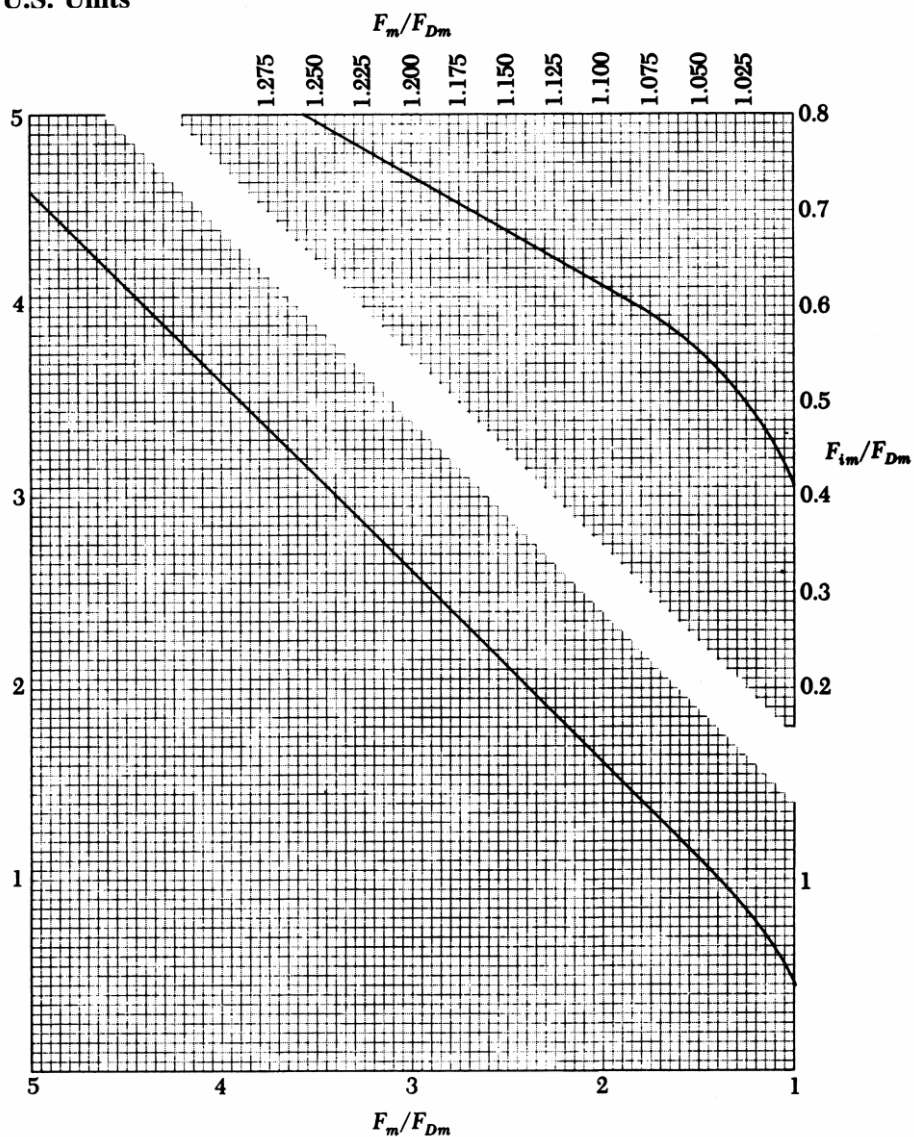


FIGURE 8
Ratio Total Force to Drag Force

U.S. Units



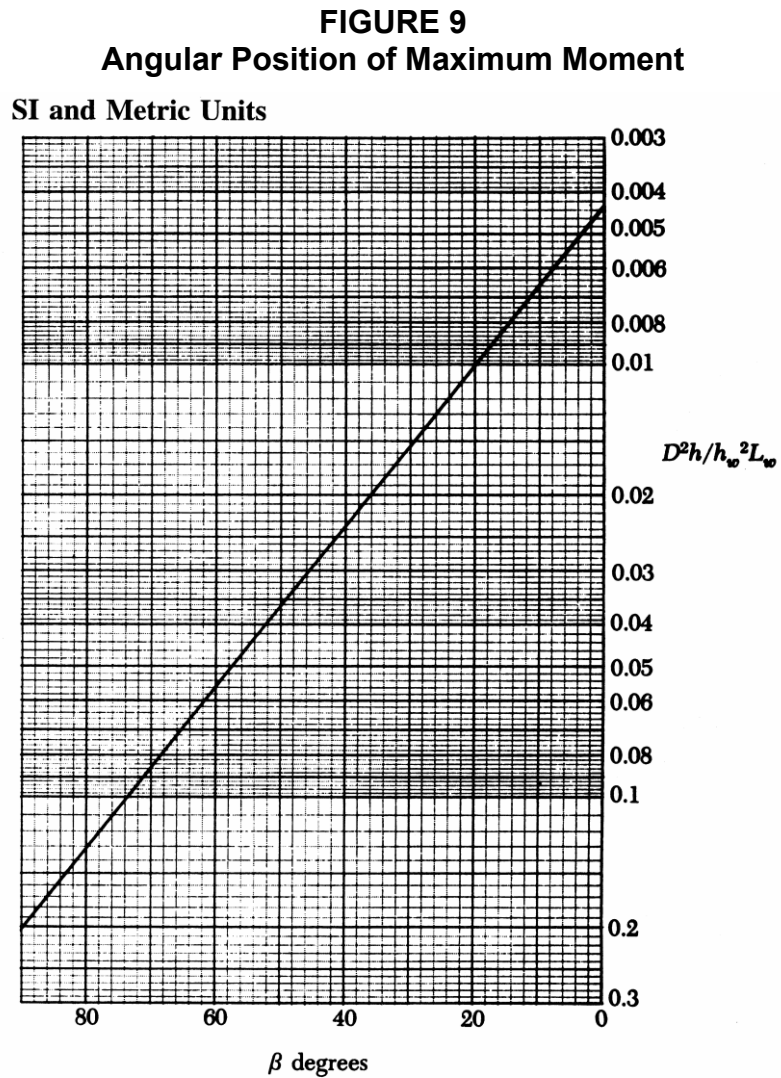
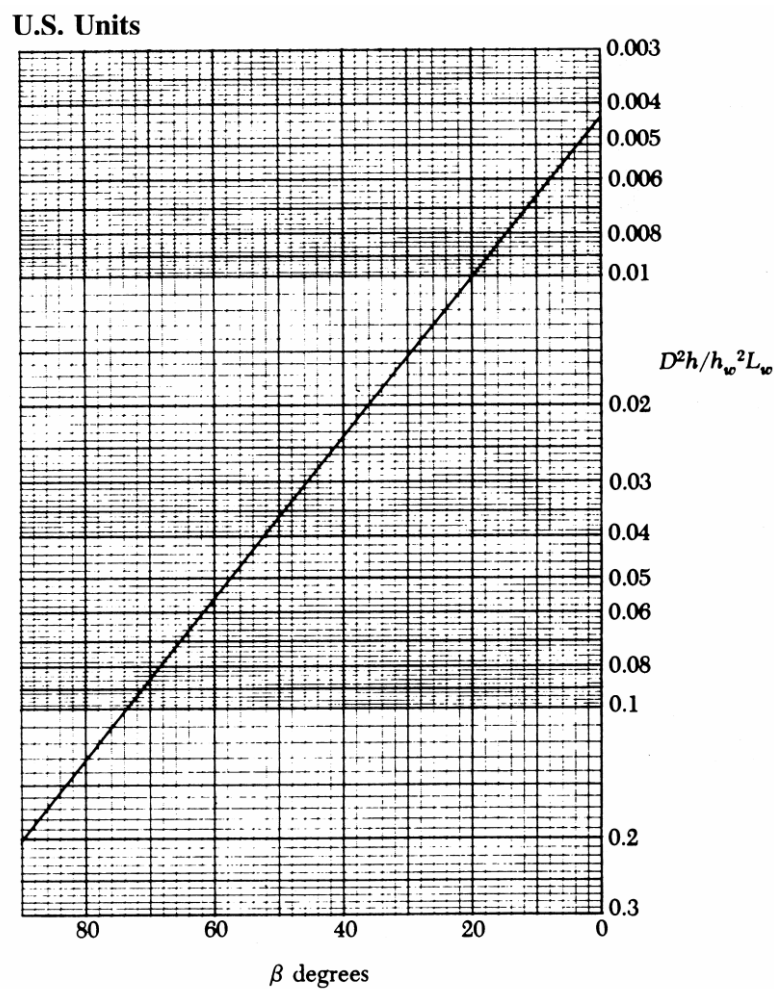


FIGURE 9
Angular Position of Maximum Moment



PART

3

CHAPTER 1 General

SECTION 3 Material Selection

1 Materials

1.1 General

This Section covers materials used for the construction of liftboats. Structural materials are to be suitable for intended service conditions. They are to be of good commercial quality, defined by a recognized specification and free of injurious defects. Materials used in the construction of the hull and machinery of drilling units are to be in accordance with the *ABS Rules for Materials and Welding (Part 2)*.

1.3 Characteristics

Materials used are required to exhibit satisfactory formability and weldability characteristics. For materials other than those indicated in the tables for Ordinary and Higher Strength Hull Structural Steel in Chapter 1 “Materials for Hull Construction” of the *ABS Rules for Materials and Welding (Part 2)* evidence of satisfactory formability and weldability are to be submitted for review.

1.5 Toughness

Materials are to exhibit fracture toughness which is satisfactory for the intended application as evidenced by previous satisfactory service experience or appropriate toughness tests.

1.7 Materials Other than Steel

When material other than steel is used as a structural material, documentation is to indicate the mechanical properties, toughness, fatigue and corrosion characteristics of the proposed material. Where such materials are used in combination with steel, galvanic effects should be taken into account as applicable.

3 Hull Steel Grades

3.1 Ordinary and Higher Strength Steel

The tables for Ordinary and Higher Strength Hull Structural Steel in Chapter 1 “Materials for Hull Construction” of the *ABS Rules for Materials and Welding (Part 2)* show the chemical, mechanical properties, and heat treatment specifications for the various grades of ABS ordinary and higher strength hull structural steel.

3.3 Quenched and Tempered Steel

Refer to Appendix 3-1-A3, “Material Selection for ABS Grades of High Strength Quenched and Tempered Steels” in the *ABS Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules)*.

3.5 Additional Requirements

In cases where principal loads, from either service or weld residual stresses, are imposed perpendicular to the plate thickness, the use of special plate with improved through thickness (Z direction) properties may be required.

3.7 Other Grades

Materials, test specimens, and mechanical testing procedures having characteristics differing from those prescribed herein may be approved upon application, due regard being given to the established practices in the country in which the material is produced and the purpose for which the materials is intended.

5 Selection of Grades

5.1 General

For the classification of liftboats, it is necessary to take into account minimum expected service temperature and structural element category when selecting structural materials. The various parts of the liftboat are grouped according to their material application categories. The structural elements falling into these categories are described, in general, in 3-1-3/5.3.

5.3 Liftboats

5.3.1 Secondary Application Structure (Least Critical)

Internal framing, including bulkheads and girders, in cylindrical legs

Internal bulkheads and framing members of upper hull structure

Internal bulkheads of bottom footing supporting structure, except where the structure is considered primary application

Deck, side and bottom plating of upper hull, except where the structure is considered primary application

Floating frames or yokes in jacking or other self-elevating systems

Quarters

5.3.2 Primary Application Structure (Intermediate)

External plating of cylindrical legs

Main structural members of lattice type legs

Combinations of bulkhead, deck, side bottom plating within the upper hull, which form “box” or “I” type main supporting structure

Bottom footing structure which receives initial transfer of load from legs

Internal bulkheads, shell and deck of bottom footing supporting structure which distribute major loads, either uniform or concentrated. (Reference may be made to the 0°C (32°F) temperature of 3-1-3/Table 1 for such applications.)

Fixed frames in jacking or other self-elevating systems

Leg tower, leg tower supporting structure including supporting braces

Leg Wing hull appendages

5.3.3 Special Application Structure (Most Critical)

Legs in way of intersection with the footing structure

Connection of hull and leg tower supporting braces

Intersections of lattice type leg structures which incorporate novel construction, including the use of steel castings

5.5 Selection Criteria for ABS Grades of Steel (2009)

3-1-3/Table 1 shows selection criteria for each structural element category for ABS grades of ordinary and higher strength hull structural steels to be used in liftboats expected to experience service temperatures as low as -30°C (-22°F). Service temperature refers to the temperature of the steel and is generally assumed to be the same as the lowest of the average daily atmospheric temperatures, based on available meteorological data for anticipated areas of operation. Where the steel temperature is shown to be warmer than the minimum expected atmospheric temperature, the warmer temperature may be applied; where the minimum steel temperature is 0°C (32°F) or warmer, the material requirements indicated for 0°C (32°F) are generally applicable. In addition, where material being considered is located in close proximity to, or below, the minimum waterline, the material selection may be based on that indicated for the 0°C (32°F) temperature.

These requirements are applicable for liftboats that are limited to areas of operation where ice strengthening is not required.

Where it is desired to use steels other than those in 3-1-3/Table 1 and as referenced in 3-1-3/3.3, or thicknesses above the maximum indicated in 3-1-3/Table 1, they are to be specially considered.

5.7 Criteria for Other Steels

5.7.1 General

Appropriate supporting information or test data is to indicate that the toughness of the steels will be adequate for their intended application in the platform at the minimum design service temperature. In the absence of supporting data, tests are required to demonstrate that steels would meet the following Charpy V-Notch (CVN) impact requirements.

5.7.2 CVN Requirements (2009)

Steels in the 235–400 N/mm^2 (24–41 kgf/mm^2 , 34–58 ksi) yield strength range are to meet the following CVN requirements

Yield Strength			Longitudinal CVN								
			Thickness								
			$T \leq 50 \text{ mm (2.0 in.)}$			$50 \text{ mm (2.0 in.)} < T \leq 70 \text{ mm (2.8 in.)}$			$70 \text{ mm (2.8 in.)} < T \leq 100 \text{ mm (4.0 in.)}$		
N/mm^2	(kgf/mm^2)	(ksi)	J	(kgf-m)	(ft-lbf)	J	(kgf-m)	(ft-lbf)	J	(kgf-m)	(ft-lbf)
235–305	(24–31)	(34–44)	27	(2.8)	(20)	34	(3.5)	(25)	41	(4.2)	(30)
315–400	(32–41)	(45.5–58)	34	(3.5)	(25)	41	(4.2)	(30)	50	(5.1)	(37)

5.7.3 CVN Temperatures

The CVN requirements are to be obtained when tested at the following temperatures:

Secondary application structure:	service temperature
Primary application structure:	10°C (18°F) below service temperature
Special application structure:	30°C (54°F) below service temperature

5.7.4 Extra High Strength Steels

Steels in the 415–690 N/mm² (42–70 kgf/mm², 60–100 ksi) yield strength range are to meet a longitudinal CVN impact requirement of 34 J (3.5 kgf-m, 25 ft-lbf) at the following test temperatures.

<i>Application (per 3-1-3/5.3)</i>		
<i>Service Temperature</i>	<i>Secondary⁽¹⁾ and Primary</i>	<i>Special Test Temperature</i>
–10°C (32°F)	–30°C (–22°F)	–40°C (–40°F)
–10°C (14°F)	–40°C (–40°F)	–50°C (–58°F)
–20°C (–4°F)	–40°C (–40°F)	–50°C (–58°F)
–30°C (–22°F)	–50°C (–58°F)	–60°C (–75°F)
–40°C (–40°F)	–60°C (–75°F)	–70°C (–94°F) ⁽²⁾
–50°C (–58°F)	–70°C (–94°F)	–80°C (–112°F) ⁽²⁾

Notes:

- 1 For secondary members toughness criteria may be relaxed.
- 2 –40°C and –50°C service temperatures are listed for guidance only.

5.7.5 Alternative Requirements

As an alternative to the requirements in 3-1-3/5.7.2 and 3-1-3/5.7.4 steels may comply with the following.

- i) For transverse specimens, $\frac{2}{3}$ of energy values shown for longitudinal specimens
- ii) For longitudinal specimens, lateral expansion is not to be less than 0.5 mm (0.02 in.). For transverse specimens – lateral expansion is not to be less than 0.38 mm (0.015 in.).
- iii) Nil-ductility temperature (NDT) as determined by drop weight tests is to be 5°C (9°F) below the temperature specified in 3-1-3/5.7.3.
- iv) Compliance with 3-1-A3/Table 3 for ABS Grades of quenched and tempered steels in Appendix 3-1-A3 of the *MODU Rules*.

TABLE 1
Material Selection Requirements for ABS
Ordinary and Higher Strength Steels (2009)

Numbers in table are maximum thicknesses in mm (in.)

Blank areas indicate no application

Grade	Service Temperature °C (°F)																	
	Secondary Applications						Primary Applications						Special Applications					
	0 (32)	-10 (14)	-20 (-4)	-30 (-22)	-40* (-40)*	-50* (-58)*	0 (32)	-10 (14)	-20 (-4)	-30 (-22)	-40* (-40)*	-50* (-58)*	0 (32)	-10 (14)	-20 (-4)	-30 (-22)	-40* (-22)	-50* (-58)*
A	100 (4.00)	19 (0.75)	12.5 (0.50)	—	—	—	19 (0.75)	12.5 (0.50)	—	—	—	—	—	—	—	—	—	—
B	100 (4.00)	25 (1.00)	19 (0.75)	12.5 (0.50)	—	—	25 (1.00)	19 (0.75)	12.5 (0.50)	—	—	—	16 (0.63)	—	—	—	—	—
D	100 (4.00)	35 (1.375)	35 (1.375)	22.5 (0.89)	12.5 (0.50)	—	35 (1.375)	35 (1.375)	22.5 (0.89)	12.5 (0.50)	—	—	22.5 (0.89)	16 (0.63)	—	—	—	—
DN	100 (4.00)	100 (4.00)	100 (4.00)	27.5 (1.08)	22.5 (0.89)	16 (0.63)	100 (4.00)	100 (4.00)	27.5 (1.08)	22.5 (0.89)	16 (0.63)	—	27.5 (1.08)	22.5 (0.89)	16 (0.63)	—	—	—
E	100 (4.00)	100 (4.00)	100 (4.00)	100 (4.00)	100 (4.00)	27.5 (1.08)	100 (4.00)	100 (4.00)	100 (4.00)	50 (2.00)	27.5 (1.08)	16 (0.63)	100 (4.00)	100 (4.00)	27.5 (1.08)	16 (0.63)	12.5 (0.50)	—
AH	100 (4.00)	25 (1.00)	19 (0.75)	12.5 (0.50)	—	—	19 (0.75)	19 (0.75)	12.5 (0.50)	—	—	—	19 (0.75)	—	—	—	—	—
DH	100 (4.00)	100 (4.00)	100 (4.00)	19 (0.75)	12.5 (0.50)	—	100 (4.00)	100 (4.00)	19 (0.75)	12.5 (0.50)	—	—	19 (0.75)	16 (0.63)	—	—	—	—
DHN	100 (4.00)	100 (4.00)	100 (4.00)	27.5 (1.08)	22.5 (0.89)	16 (0.63)	100 (4.00)	100 (4.00)	27.5 (1.08)	22.5 (0.89)	16 (0.63)	—	27.5 (1.08)	22.5 (0.89)	16 (0.63)	—	—	—
EH	100 (4.00)	100 (4.00)	100 (4.00)	100 (4.00)	100 (4.00)	27.5 (1.08)	100 (4.00)	100 (4.00)	100 (4.00)	100 (4.00)	27.5 (1.08)	16 (0.63)	100 (4.00)	100 (4.00)	27.5 (1.08)	16 (0.63)	12.5 (0.50)	—

*-40°C and -50°C (-40°F and -58°F) service temperatures are listed for guidance only.

CHAPTER 2 Hull Structures and Arrangements

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CHAPTER 2 Hull Structures and Arrangements

SECTION 1 Longitudinal Strength

1 General

Liftboats are to have longitudinal hull girder section modulus in accordance with the requirements of this Section. A breadth to depth ratio up to approximately 4 is acceptable in association with longitudinal bulkheads and trusses arranged at suitable intervals. Liftboat hulls whose proportions exceed these limits will be subject to special consideration. For liftboat hull strength in the elevated condition, see 3-2-3/9.7.

3 Longitudinal Hull-Girder Strength

3.1 Minimum SM

The required hull-girder section modulus SM_R amidships, to the deck and bottom is to be obtained from the following equation:

$$SM_R = K SM_b \text{ cm}^2\text{-m (in}^2\text{-ft)}$$

where

$$K = 0.629 + M_s / (f_p SM_b) \text{ but is not to be taken less than 1.0}$$

$$M_s = \text{maximum still-water bending moment in the governing loaded or ballasted condition in kN-m (tf-m, Ltf-ft). When still-water bending moment calculations are not submitted } K \text{ will be taken as 1.0, refer to 3-2-1/7}$$

$$f_p = 17.5 \text{ kN/cm}^2 (1.784 \text{ tf/cm}^2, 11.33 \text{ Ltf/in}^2)$$

$$SM_b = C_1 C_2 L^2 B (C_b + 0.7) \text{ cm}^2\text{-m (in}^2\text{-ft)}$$

$$C_1 = 4.1 \quad 30 < L < 45 \text{ m}$$

$$= 16.33 (L/100)^2 - 15.47 (L/100) + 7.77 \quad 45 < L < 90 \text{ m}$$

$$C_1 = 4.11 \quad 100 < L < 150 \text{ ft}$$

$$= 16.33 (L/328)^2 - 15.47 (L/328) + 7.77 \quad 150 < L < 295 \text{ ft}$$

$$C_2 = 0.01 \text{ (SI or MKS units)} \quad 1.44 \times 10^{-4} \text{ (U.S. Units)}$$

$$L = \text{length, in meters (feet), as defined in 3-1-1/1.1.1}$$

$$B = \text{breadth, in meters (feet), as defined in 3-1-1/1.1.2}$$

$$C_b = \text{block coefficient, as defined in 3-1-1/1.3.2}$$

3.3 Hull Girder Moment of Inertia

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

$$I = 0.03 SM_R L \text{ cm}^2\text{-m}^2 (\text{in}^2\text{-ft}^2)$$

where

$$L = \text{length of liftboat, as defined in 3-1-1/1.1.1}$$

$$SM_R = \text{hull girder section modulus required for the liftboat per 3-2-1/3.1, in cm}^2\text{-m (in}^2\text{-ft)}$$

5 Section Modulus Calculation

5.1 Items to be Included in Calculation

In general the following items may be included in the calculation of the section modulus, provided they are continuous or effectively developed throughout the midship $0.4L$ and gradually tapered beyond. The sectional areas of the decks may be gradually reduced to one half of the amidships deck area at $0.15L$ from the ends.

- Deck plating (strength deck and other effective decks)
- Shell and inner-bottom plating
- Deck and bottom girders
- Plating and longitudinal stiffeners of longitudinal bulkheads, longitudinals of deck, sides, bottom and inner bottom.

In general, the net sectional areas of longitudinal strength members are to be used in the hull-girder section modulus calculations. 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.

7 Still Water Bending Moment and Shear Force Calculations

Still water bending moment and shear force calculations are to be submitted for liftboats of 76 meters (250 feet) in length and above. They are to include at least the full load and ballast conditions and any contemplated loading conditions that might be expected to have an unfavorable influence on the hull-girder strength.

These calculations are to show bending moment and shear force values along the length of the liftboat.

9 Longitudinal Strength with Higher-Strength Material

9.1 General

Liftboats in which the effective longitudinal material of either the upper or lower flanges of the main hull-girder, or both, are constructed of materials having mechanical properties greater than those of ordinary strength hull structural steel [see Section 2-1-2 of the *ABS Rules for Materials and Welding (Part 2)*], are to have longitudinal strength generally in accordance with the preceding Paragraphs of this Section, but the value of the hull girder section modulus may be modified as permitted by the following Paragraphs. Applications of the higher-strength material are to be continuous over the length of the liftboat to locations where the stress levels will be suitable for the adjacent mild steel structure. Higher strength steel is to be extended to suitable locations below the strength deck and above the bottom, so that the stress levels will be satisfactory for the remaining ordinary strength steel structure. Longitudinal framing members are to be continuous throughout the required extent of the higher-strength steel. Calculations showing that adequate strength has been provided against buckling are to be submitted for review and care is to be exercised against the adoption of reduced thickness of materials that may be subject to damage during normal operations.

9.3 Hull Girder Moment of Inertia (2012)

The hull girder moment of inertia is to be not less than required by 3-2-1/3.3 using the mild steel section modulus obtained from 3-2-1/3.1.

9.5 Hull Girder Section Modulus

When either the top or bottom flange of the hull girder, or both, is constructed of higher-strength material, the section modulus as obtained from 3-2-1/3.1 may be reduced by the factor Q .

$$SM_{hts} = Q(SM)$$

where

$$Q = 0.78 \text{ for Grade H32}$$

$$Q = 0.72 \text{ for Grade H36}$$

H32, H36 are as specified in 2-1-3/Tables 1-4 of the *ABS Rules for Materials and Welding (Part 2)*.

Q factors for steels having other yield point or yield strength will be specially considered.

CHAPTER 2 Hull Structures and Arrangements

SECTION 2 Structural Analysis

1 Structural Analysis

1.1 Analysis of Primary Structure

The primary structure of the hull is to be analyzed using the loading conditions stipulated below and the resultant stresses are to be determined. Conditions representative of all modes of operation are to be considered to determine critical cases. Calculations for critical conditions are to be submitted for review. The analysis is to be performed using recognized calculation methods and is to be fully documented and referenced. The analytical model shall be established such that the flexibility of the hull/leg interface is properly accounted for. Where the leg has a rack fitted on one side only, the effect of the eccentricity in the vertical load shall be included.

For rack and pinion elevating systems, the pinions shall be included in the analysis to insure that the maximum allowable pinion load is not exceeded. The basis for the assumed pinion stiffness is to be submitted for review.

For each loading condition considered, the following stresses are to be determined, and are not to exceed the allowable stresses given in 3-2-2/3.

1.1.1

Stresses due to static loadings only, where the static loads include operational gravity loadings and weight of the liftboat, with the liftboat afloat or resting on the sea bed in calm water.

1.1.2

Stresses due to combined loadings, where the applicable static loads in 3-2-2/1.1.1 are combined with relevant environmental loadings, including acceleration and heeling forces.

1.3 Consideration of Local Stresses

Local stresses are to be combined with primary stresses, where applicable, to determine total stress levels.

In the analysis of the primary structure as well as local stresses, due consideration of the elevating rack connection to tubular legs shall be given. Where a single rack is used, the overall eccentricity of the applied vertical load shall be considered in the computation of the bending stress in the leg.

The horizontal load resulting from the tooth angle is to be considered in computing stresses in both the leg and the elevating system support structure.

1.5 Combination of Stress Components

The scantlings are to be determined on the basis of a method included in a recognized standard, which combines the individual stress components acting on the various structural elements of the liftboat.

1.7 Consideration of Buckling

The possibility of buckling of structural elements is to be considered.

1.9 Consideration of Fixity

Where the footing or pad is considerably larger than the diameter of the leg, there may be some bottom fixity in soft soil conditions. This may be considered as follows:

1.9.1

Where no bottom fixity is considered in the analysis, the legs of the liftboat are assumed to be pinned 5 feet below the sea bed. For purposes of calculating global leg buckling, the effective length factor, K , shall be 2.0.

1.9.2

Where the analysis considers fixity at the pad to reduce the effective length factor, K , the designer shall submit calculations in accordance with a recognized standard to justify the fixity used in the analysis. In addition, the calculations will include the anticipated maximum penetration; the leg will be modeled to $1/2$ the depth of the pad at this penetration.

The assumed soil strength, or range of strengths, for which the analysis is valid, will be defined in the Booklet of Operating Conditions in sufficient detail for the operator to determine the suitability of the liftboat for different soil conditions.

1.11 Determination of Bending Stresses

1.11.1 Effective Flange Area

The required section modulus of members such as girders, webs, etc., supporting frames and stiffeners is to be obtained on an effective width of plating basis in accordance with the following criteria. The section is to include the structural member in association with an effective width of plating not exceeding one-half the sum of spacing on each side of the member or 33% of the unsupported span ℓ , whichever is less; for girders and webs along hatch openings, an effective breadth of plating not exceeding one-half the spacing or 16.5% of the unsupported span ℓ , whichever is less, is to be used. The required section modulus of frames and stiffeners is assumed to be provided by the stiffener and a maximum of one frame space of the plating to which it is attached.

1.11.2 Eccentric Axial Loading (P -delta)

Where appropriate, elastic deflections are to be taken into account when determining the effects of eccentricity of axial loading, and the resulting bending moments are to be superimposed on the bending moments computed for other types of loadings. This can be a first order approximation.

1.13 Determination of Shear Stresses

When computing shear stresses in structural members, only the effective shear area of the web of the member is to be considered as being effective. In this regard, the total depth of the member may be used as the web depth.

1.15 Stress Concentration

The effect of notches, stress raisers, and local stress concentrations are to be taken into account when considering load carrying elements. When stress concentrations are considered to be of high intensity in certain elements, the acceptable stress levels will be subject to special consideration.

1.17 Analysis and Details of Structural Connections

Unless connections of structural members are specifically detailed as hinged joints, proper consideration is to be given in the structural analysis to the degree of restraint at such connections. Structural connections are to be detailed in such a manner as to ensure full transmission of stresses between members joined, and to minimize stress concentrations. The following details are to be considered, as may be appropriate.

1.17.1

Shear web plates, continuous through the joint, to transmit tension and compression loads between members by means of shear in the web plate.

1.17.2

Flaring or transitioning of the joint, to lower stress levels or to minimize concentrations of stress or both.

1.17.3

Thicker joint material, high strength steel, or both, consistent with good weldability, to reduce the effect of high stress levels.

1.17.4

Brackets or other supplemental transition members, with scallops and proper end attachment details to minimize high stress concentrations

Critical connections that depend upon the transmission of tensile stresses through the thickness of the plating of one of the members may result in lamellar tearing and are to be avoided wherever possible. Where unavoidable, plate material with suitable through-thickness (Z direction) properties may be required with appropriate inspection procedures.

1.19 Fatigue Analysis

The possibility of fatigue damage due to cyclic loading is to be considered in the design of the major structure.

As a minimum, the leg-to-pad connection and the leg tower brace-to-main deck connection are to be evaluated.

An appropriate loading spectrum in accordance with accepted theories is to be used in the fatigue analysis. For the leg tower brace to main deck connection, the loading spectrum should be developed based on the transit conditions.

The calculated fatigue life of the structure should be clearly denoted in the operating manual for the liftboat.

The calculated fatigue life of the structure should be at least the design life of the liftboat, but not less than 20 years.

1.21 Dynamic Analysis

Structural dynamic effects should be incorporated in the structural analysis when footing or (pad) fixity is considered in the structural analysis. The dynamic effects can be incorporated in structural analysis by means of Dynamic Amplification Factor (DAF) calculated using the equation for a single degree of freedom system.

Where no bottom fixity is considered in the analyses, then the dynamic analysis need not be carried out.

3 Allowable Stresses

3.1 General

The scantlings of effective structural elements of the primary frame of the liftboat, analyzed in accordance with 3-2-2/1, are to be determined on the basis of the allowable stresses specified herein.

3.3 Individual Stresses

Individual stress components and, as applicable, direct combinations of such stresses, are not to exceed the allowable stress F , as obtained from the following equation:

$$F = F_y / F.S.$$

where

F_y = specified minimum yield point or yield strength as defined in Chapter 1 of the ABS *Rules for Materials and Welding (Part 2)*

$F.S.$ = factor of safety

For static loading as defined in 3-2-2/1.1.1:

$$= 1.67 \quad \text{for axial or bending stress}$$

$$= 2.50 \quad \text{for shear stress}$$

For combined loading as defined in 3-2-2/1.1.2:

$$= 1.25 \quad \text{for axial or bending stress}$$

$$= 1.88 \quad \text{for shear stress}$$

3.5 Buckling Considerations

Where buckling of a structural element due to compressive or shear stresses, or both, is a consideration, the compressive or shear stress is not to exceed the corresponding allowable stress F as obtained from the following equation:

$$F = F_{cr}/F.S.$$

where

$$F_{cr} = \text{critical compressive or shear buckling stress of the structural element, appropriate to its dimensional configuration, boundary conditions, loading pattern, material, etc.}$$

$$F.S. = \text{factor of safety}$$

$$= 1.67 \quad \text{for static loading as defined in 3-2-2/1.1.1}$$

$$= 1.25 \quad \text{for combined loading as defined in 3-2-2/1.1.2}$$

3.7 Members Subjected to Combined Axial Load and Bending

3.7.1

When structural members are subjected to axial compression in combination with compression due to bending, the computed stresses are to comply with the following requirements:

When $f_a/F_a \leq 0.15$

$$(f_a/F_a) + (f_b/F_b) \leq 1.0$$

When $f_a/F_a > 0.15$

$$(f_a/F_a) + [C_m f_b / (1 - f_a / F'_e) F_b] \leq 1.0$$

and in addition, at ends of members:

$$1.67 (f_a/F_y) + (f_b/F_b) \leq 1.0 \quad \text{for static loading as defined in 3-2-2/1.1.1}$$

$$1.25 (F_a/F_y) + (F_b/F_b) \leq 1.0 \quad \text{for combined loading as defined in 3-2-2/1.1.2}$$

3.7.2

When structural members are subjected to axial tension in combination with tension due to bending, the computed stresses are to comply with the following requirements:

$$f_a + f_b \leq F_y/1.67 \quad \text{for static loading as defined in 3-2-2/1.1.1}$$

$$f_a + f_b \leq F_y/1.25 \quad \text{for combined loading as defined in 3-2-2/1.1.2}$$

However, the computed bending compressive stress, f_b taken alone shall not exceed F_b

where

$$f_a = \text{computed axial compressive or tensile stress}$$

$$f_b = \text{computed compressive or tensile stress due to bending}$$

- F_a = allowable axial compressive stress, which is to be the least of the following:
- i) Yield stress divided by factor of safety for axial stress specified in 3-2-2/3.3
 - ii) Overall buckling stress divided by factor of safety specified in 3-2-2/3.9.1
 - iii) Local buckling stress divided by factor of safety specified in 3-2-2/3.9.2
- F_b = allowable axial compressive stress due to bending determined by dividing the yield stress or local buckling stress, whichever is less, by the factor of safety specified in 3-2-2/3.3
- F'_e = Euler buckling stress, may be increased $1/3$ for combined loading as defined in 3-2-2/1.1.2
- $$= \frac{5.15.E}{(K\ell/r)^2}$$
- E = Modulus of Elasticity
- ℓ = unsupported length of column
- K = effective length factor which accounts for support conditions at ends of length ℓ . For cases where lateral deflection of end supports may exist, K is not to be considered less than 1.0.
- r = radius of gyration
- C_m = is a coefficient as follows:
- i) For compression members in frames subject to joint translation (sideways), $C_m = 0.85$;
 - ii) For restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports, in the plane of bending, $C_m = 0.6 - 0.4(M_1/M_2)$
But not less than 0.4, where M_1/M_2 is the ratio of the smaller to larger moments at the ends of that portion of the member un-braced in the plane of bending under consideration. M_1/M_2 is positive when the member is bent in reverse curvature and negative when it is bent in single curvature;
 - iii) For compressive members in frames braced against joint translation in the plane of loading and subject to transverse loading between their supports, the value of C_m may be determined by rational analysis. However, in lieu of such analysis the following values may be used;
 - (a) For members whose ends are restrained, $C_m = 0.85$;
 - (b) For members whose ends are unrestrained, $C_m = 1$.

3.9 Column Buckling Stresses

3.9.1 Overall Buckling

For compression members which are subject to overall column buckling, the critical buckling stress is to be obtained from the following equations:

$$F_{cr} = F_y - (F_y^2 / 4 \pi^2 E)(K\ell/r)^2 \quad \text{When } K\ell/r < (2\pi^2 E/F_y)^{1/2}$$

$$F_{cr} = \pi^2 E / (K\ell/r)^2 \quad \text{When } K\ell/r \geq (2\pi^2 E/F_y)^{1/2}$$

where

F_{cr} = critical overall buckling stress

F_y = as defined in 3-2-2/3.3

E , K , ℓ and r are as defined in 3-2-2/3.7.2.

The factor of safety for overall column buckling is to be as follows.

For static loading as defined in 3-2-2/1.1.1:

$$F.S. = 1.67 [1 + 0.15 (K\ell/r)/(2\pi^2 E/F_y)^{1/2}] \quad \text{When } K\ell/r < (2\pi^2 E/F_y)^{1/2}$$

$$F.S. = 1.92 \quad \text{When } K\ell/r \geq (2\pi^2 E/F_y)^{1/2}$$

For combined loading as defined in 3-2-2/1.1.2:

$$F.S. = 1.25 [1 + 0.15 (K\ell/r)/(2\pi^2 E/F_y)^{1/2}] \quad \text{When } K\ell/r < (2\pi^2 E/F_y)^{1/2}$$

$$F.S. = 1.44 \quad \text{When } K\ell/r \geq (2\pi^2 E/F_y)^{1/2}$$

3.9.2 Local Buckling

Members which are subject to axial compression or compression due to bending are to be investigated for local buckling, as appropriate, in addition to overall buckling as specified in 3-2-2/3.9.1.

In the case of unstiffened or ring-stiffened cylindrical shells, local buckling is to be investigated if the proportions of the shell conform to the following relationship.

$$D/t > E/9F_y$$

where

D = mean diameter of cylindrical shell

t = thickness of cylindrical shell (expressed in the same units as D)

E and F_y are as defined in 3-2-2/3.9.1.

3.11 Equivalent Stress Criteria for Plated Structures

For plated structures, members may be designed according to the von Mises equivalent stress criterion, where the equivalent stress σ_{eqv} , defined as follows, is not to exceed $F_y/F.S.$

$$\sigma_{eqv} = (\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3 \tau_{xy}^2)^{1/2}$$

where

σ_x = calculated in-plane stress in the x direction

σ_y = calculated in-plane stress in the y direction

τ_{xy} = calculated in-plane shear stress

F_y = as defined in 3-2-2/3.3

$F.S.$ = 1.43 for static loading as defined in 3-2-2/1.1.1

1.11 for combined loading as defined in 3-2-2/1.1.2

Note: The Factor of Safety will be specially considered when the stress components account for surface stresses due to lateral pressures.

The buckling strength of plated structures is to be designed according to the latest version of the ABS *Guide for Buckling and Ultimate Strength Assessment for Offshore Structures*, or other recognized standard acceptable to ABS.

PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 3 Hull and Other Primary Structures

1 General

1.1 Materials

This Guide, except where specified otherwise, is intended for liftboats constructed of steel manufactured and having the properties as specified in Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*. Where it is intended to use steel or other material having properties differing from those specified in Chapter 3 of the above referenced *Part 2*, the use of such material and the corresponding scantlings will be specially considered.

1.3 Hull Primary Structure

Scantlings of the major structural elements of the hull are to be determined in accordance with this Guide. If the hull design is barge shaped, the section modulus requirements for framing members in general may be determined from the following equations:

i) *For shell longitudinal frames, beams or bulkhead stiffeners:*

$$SM = 7.8 \, chs\ell^2 \quad \text{cm}^3$$

$$SM = 0.0041 \, chs\ell^2 \quad \text{in}^3$$

ii) *For deck, bottom, side transverses or bulkhead webs and girders:*

$$SM = 4.74 \, chs\ell^2 \quad \text{cm}^3$$

$$SM = 0.0025 \, chs\ell^2 \quad \text{in}^3$$

Where the values of c , h , s and ℓ are as indicated in 3-2-3/Figure 1.

Scantlings of the structural elements of ship-shaped designs are to be in accordance with Sections 3-2-4 through 3-2-10 and Sections 3-2-12 and 3-2-13 of this Guide.

3 Design

3.1 Continuity

Care is to be taken to provide structural continuity. Changes in scantlings are to be gradual. Strength members are not to change direction abruptly. Where major longitudinal members end at transverse structural members, tapering may be required forward or aft of the transverses. Stanchions and bulkheads are to be aligned to provide support and to minimize eccentric loading. Major appendages outside the hull and strength bulkheads in superstructures are to be aligned with major structural members within the hull.

3.3 Brackets

Where brackets are fitted having thicknesses as required by 3-2-3/Table 1 and faces at approximately 45 degrees with the bulkhead deck or shell and the bracket is supported by a bulkhead, deck or shell structural member, the length of each member, ℓ , may be measured at a point 25% of the extent of the bracket beyond the toe of the bracket as shown in 3-2-3/Figure 2. The minimum overlap of the bracket arm along the stiffener is not to be less than obtained from the following equation.

$$x = 1.4y + 30 \text{ mm}$$

$$x = 1.4y + 1.2 \text{ in.}$$

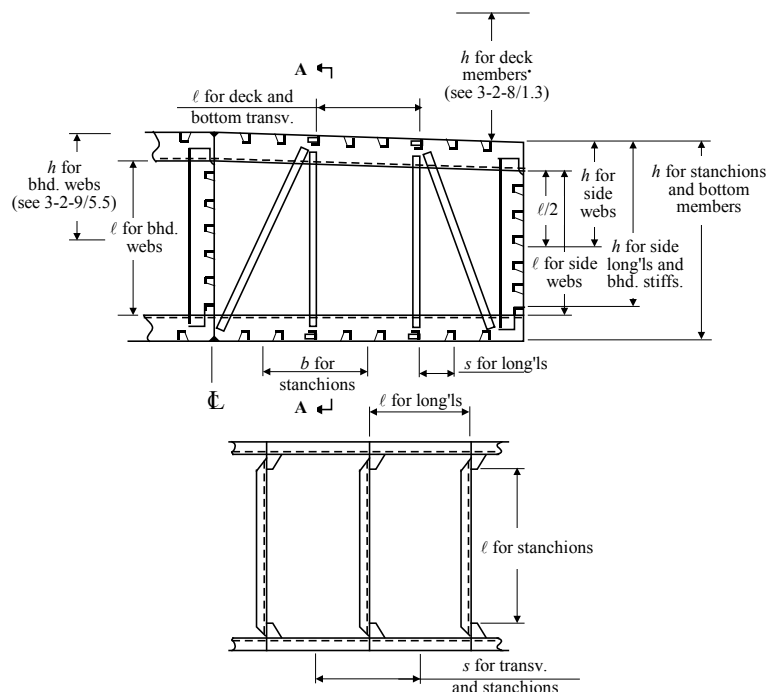
where

x = length of overlap along stiffener in mm (in.)

y = depth of stiffener in mm (in.)

Where a bracket laps a member, the amount of overlap generally is to be 25.5 mm (1 in.).

FIGURE 1
Typical Hull Construction



Section A-A

*Not to be less than $L/50 + 0.762$ meters ($L/50 + 2.5$ feet), where L is the length of the liftboat in m (ft)

Note: Typical transverse section (longitudinal framing) shown

Bottom transverses (or girders)	$c = 1.50$	Bottom long's (or frames)	$c = 1.34$
Side webs (or girders)	$c = 1.50$	Side long's (or frames)	$c = 1.00$
Deck transverses (or girders)	$c = 1.00$	Deck long's (or beams)	$c = 0.60$
Bulkhead webs (or girders)	$c = 1.00$	Bulkhead stiffeners	$c = 0.70$

Stanchions $W = nbhs$ kN (tf, Ltf)

where

$$n = 10.5 (1.07, 0.03)$$

ℓ , b , h and s are in meters (feet).

In way of tanks, scantlings are also to meet the requirements of Section 3-2-10.

FIGURE 2
Bracket

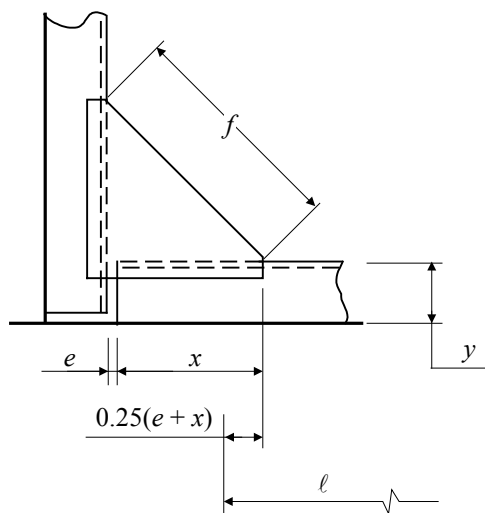


TABLE 1
Brackets

SI and MKS Units

<i>Length of Face f, mm</i>	<i>Thickness, mm</i>		<i>Width of Flange, mm</i>
	<i>Plain</i>	<i>Flanged</i>	
Not exceeding 305	5.0	---	---
Over 305 to 455	6.5	5.0	38
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

<i>Length of Face f, in.</i>	<i>Thickness, in</i>		<i>Width of Flange, in.</i>
	<i>Plain</i>	<i>Flanged</i>	
Not exceeding 12	$\frac{3}{16}$	---	---
Over 12 to 18	$\frac{1}{4}$	$\frac{3}{16}$	$1\frac{1}{2}$
Over 18 to 26	$\frac{5}{16}$	$\frac{1}{4}$	2
Over 26 to 36	$\frac{3}{8}$	$\frac{5}{16}$	$2\frac{1}{2}$
Over 36 to 54	$\frac{7}{16}$	$\frac{3}{8}$	3

5 Structural Sections

The scantling requirements of this Guide are applicable to structural angles, bars, and rolled or built-up sections.

5.1 Deep Supporting Members

The required section modulus of members such as girders, webs, supporting frames, beams and stiffeners is to be obtained on an effective width of plating basis in accordance with this Subsection. The section is to include the structural member in association with an effective width of plating not exceeding one-half the sum of spacing on each side of the member or 33% of the unsupported span ℓ , whichever is less; for girders and webs along hatch openings, an effective breadth of plating not exceeding one-half the spacing or 16.5% of the unsupported span ℓ , whichever is less, is to be used. The section modulus of a shape, bar, or fabricated section not attached to plating is that of the member only.

5.3 Frames, Beams and Stiffeners

5.3.1 Section Modulus

The required section modulus is assumed to be provided by the stiffener and a maximum of one frame space of the plating to which it is attached.

5.3.2 Web Thickness

The ratio of depth to thickness of the web portion of members is not to exceed the following:

Members with flange $50C_1 C_2$

Members without flange $15C_1 C_2$

where

$C_1 = 0.95$ (horizontal web within tank)

$= 1.0$ (all other cases)

$C_2 = 1.0$ (ordinary strength steel)

$= 0.92$ (HT32)

$= 0.90$ (HT36)

7 Structural Design Details

7.1 General

The designer is to give consideration to the following:

7.1.1

The thickness of internals in locations susceptible to rapid corrosion.

7.1.2

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

7.1.3

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.

7.3 Termination of Structural Members

Unless permitted elsewhere in this Guide, structural members are to be effectively connected to the adjacent structures in such a manner 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°. 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, see 3-2-7/1.3, beyond the last floor or web that supports the longitudinal.

9 Structural Considerations in Elevated Condition

9.1 Legs

9.1.1 Legs Types

Legs may be either caisson type or truss type. Caisson type legs may be considered as either stiffened or unstiffened caissons.

9.1.2 Legs Penetrating the Sea Bed

Legs which may penetrate the sea bed, are to be considered pinned at least 1.5 m (5 ft) below the sea bed. For legs with large footings, see 3-2-2/1.9 for the consideration of using soil fixity in the design of leg scantlings. Overburden pressure on the footings due to deep penetration can be considered when calculating the bottom fixity for determination of the effective length factor “K”.

9.1.3 Leg Scantlings

Leg scantlings are to be determined in accordance with an acceptable method of rational analysis. Calculations are to be submitted for review. When computing stress in the legs, the maximum overturning load on the liftboat, using the most adverse combination of applicable variable loadings together with the loadings as outlined in Section 3-2-1 is to be considered. Forces and moments due to lateral frame deflections of the legs are to be taken into account. See 3-2-2/1.21 with respect to the requirements for inclusion of the liftboat’s dynamic effects.

9.1.4 Safety Against Overturning

Liftboats which are to rest on the sea bed are to have sufficient positive downward gravity loadings on the support footings to withstand the overturning moment due to the combined environmental loads from any direction with the lateral deflection of the legs taken into consideration.

The safety against overturning is to be assessed using the most unfavorable direction and combination of environmental, gravity, variable and other loads during normal and severe storm operating conditions.

Liftboats with individual footings are to have righting moments calculated about the most unfavorable axis through the center of one or more footings and are to have a minimum factor of safety of 1.1 for the conditions defined below.

Normal Loading Conditions for Calculation of Safety Against Overturning

- i) *Normal Operating Condition.* Liftboats are assumed to have minimum design variable loads and cranes or other deck equipment in the most unfavorable position.
- ii) *Severe Storm Condition.* Liftboats are assumed to have minimum design variable load and all deck equipment in the stowed position.

9.3 Leg Tower and Supporting Braces (2011)

The leg tower and supporting braces are to have adequate strength to properly transmit the loads between the legs and the hull. In the analysis of the leg tower and supporting braces, consideration should be given to the design loads. The design loads should be the maximum anticipated loads from the operations in elevated and transit modes. The connection of the brace to main deck and the structure underneath the main deck should be designed to the same loads.

During lifting operations, the loads imposed on the jacking system are to consider the effects of friction at the leg guides. Allowance for the friction at the leg guides is to be not less than 5% of the total lifting gravity loads.

9.5 Footing/Pad

The leg pads or footings shall be analyzed for the maximum vertical reaction plus the effects of the associated hydrostatic pressure. In addition, where bottom fixity is considered, the pad and the leg-to-pad connection are to be analyzed for the maximum restraining moment in addition to the above loads. Where bottom fixity is not considered in the global analysis, the “restraining” moment for the pad analysis shall be 20% of the moment in the leg at the hull structure.

9.7 Hull Structure

The hull is to be considered as a complete structure having sufficient strength to resist all induced stresses while in the elevated position and supported by all legs. All fixed and variable loads are to be distributed, using an acceptable method of rational analysis, from the various points of application to the supporting legs. The scantlings of the hull are then to be determined consistent with this load distribution, but the scantlings are not to be less than those required by 3-2-3/1.3. Scantlings of liftboats having other than rectangular hull configurations are to be in accordance with Sections 3-2-4 through 3-2-10 and Sections 3-2-12 and 3-2-13 of this Guide. All liftboats are to comply with the requirements for Longitudinal Strength in Section 3-2-1 of this Guide.

9.9 Wave Clearance

A crest clearance of either 1.2 m (4 ft) or 10% of the combined storm tide, astronomical tide, and height of the maximum wave crest above the mean low water level, whichever is less, between the underside of the liftboat in the elevated position and the crest of the wave is to be maintained. This crest elevation is to be measured above the level of the combined astronomical and storm tides.

9.11 Preload

9.11.1 Capability

Liftboats are to have the capability of being preloaded such that the vertical leg reaction achieved on each leg is at least equal to the computed maximum vertical leg reaction due to the maximum gravity plus overturning load of the severe storm condition or operating condition, whichever is greater.

9.11.2 Leg Strength

All legs are to have adequate strength to withstand the preload condition described in 3-2-3/9.11.1. The factor of safety for combined loadings given in 3-2-2/3.3 is to be used when considering structural aspects of the preload condition.

9.13 Sea Bed Conditions

The review of the liftboat is to be based upon the Owner’s assumptions regarding the sea bed conditions.

9.15 Appurtenant Structures (2008)

9.15.1 General

Structures which do not contribute directly to the overall strength of the liftboat (i.e., their loss or damage would not impair the structural integrity of the liftboat) are considered appurtenant structures.

Appurtenant structures, which are necessary components of safety systems covered by this Guide, or designed to support heavy loads, are to be adequate for the nature and magnitude of applied loads in all modes of operation. Raw Water (seawater intake) structure, lifeboat deck for life saving, crane pedestal and pipe racks are considered in this category. Unless noted otherwise, allowable stresses specified in 3-2-2/3 are to be used as the stress limits, except for those structural parts whose primary function is to absorb energy during deformation, in which case sufficient ductility is to be demonstrated.

9.15.2 Lifeboat Deck

The strength of a lifeboat deck is to be designed to meet the following requirements:

- i) The most adverse combination of list and trim for which life boat launching is possible with Safe Working Load (total weight of lifeboat, passengers and supplies) with allowable stresses equal to Ultimate Tensile stress divided by a factor of 4.5.
- ii) The most critical motion at the transit draft with allowable stresses equal to the minimum yield stress divided by a factor of 1.25. For liftboats, the worst motion can be taken as 15° single amplitude rolling or pitching with 10 second period without a motion calculation.

9.15.3 Crane Pedestal and Foundation

The crane pedestal is to be designed in accordance with the recognized standard that the crane is certified to, such as Chapter 2, "Guide for Certification of Cranes" of the *ABS Guide for Certification of Lifting Appliances*, or API Spec. 2C.

In addition, it should also be designed to resist motion-induced loads in severe storm, normal operating and transit conditions using the allowable stresses defined in 3-2-2/3, considering the operating limits of the crane.

The hull structure supporting the pedestal should also be designed to resist the same applied loads as the pedestal using the allowable stresses defined in 3-2-2/3.

9.15.4 Pipe Racks

Pipe racks, including the reinforcements for the hull, are to be designed to adequately resist the load effects of drill pipes or risers imposed on the pipe rack supports in the severe storm, normal operating and transit conditions with the allowable stresses defined in 3-2-2/3. Considerations should also be given to the unit in damaged conditions, where the pipe racks are to withstand the load effects caused by the trim and heel of the liftboat with the allowable stresses defined in 3-2-2/3 in association with a factor of safety of 1.0.

PART

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CHAPTER 2 Hull Structures and Arrangements

SECTION 4 Shell Plating

1 General

Shell plating is to be of not less thickness than is required by the equations for thickness of side and bottom plating as required by this Section, nor less than required by Section 3-2-1 for longitudinal strength and Section 3-2-10 for deep tank plating.

3 Bottom Shell Plating

3.1 Extent of Bottom Plating

The term “bottom plating” refers to the plating from the keel to the upper turn of the bilge or upper chine.

3.3 Bottom Shell Plating

The thickness of the bottom shell plating is not to be less than that obtained from the following equations:

3.3.1

$$t = \frac{s\sqrt{h}}{254} + 2.54 \quad \text{mm} \qquad t = \frac{s\sqrt{h}}{460} + 0.10 \quad \text{in.}$$

where

t	=	thickness of bottom shell plating, in mm (in.)
s	=	frame spacing, in mm (in.)
h	=	depth, in m (ft), as defined in 3-1-1/1.1.3, but not less than $0.1L$ or $1.18d$, whichever is greater
d	=	draft for scantlings, as defined in 3-1-1/1.1.4; or $0.066L$, whichever is greater
L	=	length of liftboat, in m (ft), as defined in 3-1-1/1.1.1

3.3.2

$$t = \frac{s}{R} \sqrt{\frac{SM_R}{SM_A}} \frac{1}{\sqrt{Q}} \quad \text{mm (in.)}$$

where

R	=	45 with transverse framing
	=	55 with longitudinal framing
SM_R	=	hull-girder section modulus required by 3-2-1/3, in $\text{cm}^2\text{-m}$ ($\text{in}^2\text{-ft}$)
SM_A	=	bottom hull-girder section modulus, in $\text{cm}^2\text{-m}$ ($\text{in}^2\text{-ft}$)
Q	=	as defined in 3-2-1/9.5

t and s are as defined above.

3.5 Bottom Forward

For liftboats of 61 m (200 ft) in length and above, where the heavy weather ballast draft or operating draft forward is less than $0.04L$, the plating on the flat of bottom forward, forward of the location given in 3-2-6/Table 1 is to be not less than required by the following equation:

$$t = 0.0046s \sqrt{(0.005L_1^2 - 1.3d_f^2) / d_f} \quad \text{mm}$$

$$t = 0.0026s \sqrt{(0.005L_1^2 - 1.3d_f^2) / d_f} \quad \text{in.}$$

where

s = frame spacing, in mm (in.)

L = length of liftboat, as defined in 3-1-1/1.1.1

d_f = heavy weather ballast draft at the forward perpendicular, in m (ft)

5 Side Shell Plating

5.1 General

The side shell plating, t , is not to be less in thickness than that obtained from the following equation:

$$t = \frac{s\sqrt{h}}{268} + 2.54 \quad \text{mm}$$

$$t = \frac{s\sqrt{h}}{485} + 0.10 \quad \text{in.}$$

where

t = thickness, in mm (in.)

s = spacing of transverse frames or longitudinals, in mm (in.)

d = draft for scantlings, as defined in 3-1-1/1.1.4, or $0.066L$, whichever is greater

h = depth, in m (ft), as defined in 3-1-1/1.1.3, but not less than $0.1L$ or $1.18d$, whichever is greater

5.3 Shell Plating at Ends

The minimum shell plating thickness, t , at ends is to be obtained from the following equations and is not to extend for more than $0.1L$ from the ends. Between the midship $0.4L$ and the end $0.1L$ the thickness of the plating may be gradually tapered.

$$t = 0.0455L + 0.009s \quad \text{mm}$$

$$t = 0.000545L + 0.009s \quad \text{in.}$$

where

s = frame spacing, in mm (in.)

L = length of liftboat, as defined in 3-1-1/1.1.1, in m (ft)

Where the strength deck at the ends is above the freeboard deck, the thickness of the side plating above the freeboard deck may be reduced to the thickness given for forecastle and poop sides at the forward and after ends respectively.

5.5 Forecastle and Poop Side Plating

5.5.1 Forecastle Side Plating

The thickness, t , of the plating is to be not less than obtained from the following equation:

$$t = 0.038(L + 30.8) + 0.006s \quad \text{mm}$$

$$t = 0.00045(L + 103.3) + 0.006s \quad \text{in.}$$

5.5.2 Poop Side Plating

The thickness, t , of the plating is to be not less than obtained from the following equation:

$$t = 0.0296(L + 39.5) + 0.006s \text{ mm} \quad t = 0.00035(L + 132.9) + 0.006s \text{ in.}$$

where

s = spacing of frames, in mm (in.)

L = length of liftboat, as defined in 3-1-1/1.1.1, in m (ft)

5.7 Bow and Stern Thruster Tunnels

The thickness of the tunnel plating is to be not less than required by 3-2-4/5.3, nor is the thickness to be less than obtained from the following equation:

$$t = 0.008 d + 3.3 \text{ mm} \quad t = 0.008 d + 0.13 \text{ in.}$$

where

d = inside diameter of the tunnel, in mm (in.), but is to be taken as not less than 968 mm (38 in.)

Where the outboard ends of the tunnel are provided with bars or grids, the bars or grids are to be effectively secured.

7 Compensation

Compensation is to be provided for openings in the shell plating where required to maintain the longitudinal and transverse strength of the hull. All openings are to have well-rounded corners. Those in the upper side shell are to be located a suitable distance below the deck edge. Cargo and gangway openings are to be kept well clear of other discontinuities in the hull girder. Local provision is to be made to maintain the longitudinal and transverse strength of the hull.

Thick plating or doublers, of sufficient breadth to prevent damage from the flukes of stockless anchors, are to be fitted around the hawse pipes.

9 Breaks

Breaks in liftboat hulls having partial superstructures are to be specially strengthened to limit the local increases in stresses at these points. The stringer plates and sheer strakes at the lower level are to be increased in thickness well beyond the break in both directions. The thickness is to be increased 25% in way of breaks of superstructures. The side plating of the superstructure is to be increased in thickness and the side plating is to extend well beyond the end of the superstructure in such fashion as to provide a long gradual taper. Where the breaks of the forecastle or poop are appreciably beyond the midship $0.5L$, these requirements may be modified. Gangways, large freeing ports, side shell doors, and other openings in the shell or bulwarks are to be kept well clear of the breaks, and any holes which must unavoidably be cut in the plating are to be kept as small as possible and are to be circular or oval in form.

11 Bilge Keels

Bilge keels, where fitted, are to be attached to the shell by a doubler. In general, both the bilge keel and the doubler are to be continuous. The connection of the bilge keel to the doubler, and the doubler to the shell, are to be by double continuous fillet welds.

Butt welds in the bilge keel and doubler are to be full penetration and are to be kept clear of master erection butts. In general, shell butts are to be flush in way of the doubler; doubler butts are to be flush in way of the bilge keel. In general, scallops and cutouts are not to be used. Where desired, a crack-arresting hole at least 25 mm (1 in.) in diameter may be drilled in the bilge keel butt weld as close as practicable to the doubler.

The ends of the bilge keel are to be suitably tapered and are to terminate on an internal stiffening member. The material tensile properties of bilge keels and doublers are to be as required for bottom shell plating.

13 Higher-strength Materials

13.1 General

In general, applications of higher-strength materials are to take into consideration the suitable extension of the higher-strength material above and below the bottom and deck respectively, as required by 3-2-1/9.1. Care is to be taken against the adoption of reduced thickness of material that might be subject to damage during normal operation. The thickness of bottom and side-shell plating, where constructed of higher-strength materials are to be not less than required for purposes of longitudinal hull-girder strength; nor are they to be less than required by the foregoing Paragraphs of this Section when modified as indicated by the following Paragraphs.

13.3 Bottom Plating of Higher-strength Material

Bottom shell plating where constructed of higher-strength material and where longitudinally framed is to be not less in thickness than obtained from the following equation.

$$t_{hts} = (t_{ms} - C)\sqrt{Q} + C$$

where

$$\begin{aligned} t_{hts} &= \text{thickness of higher-strength material, in mm (in.)} \\ t_{ms} &= \text{thickness, in mm (in.), of ordinary-strength steel as required by preceding Paragraphs} \\ &\quad \text{of this Section, or from the requirements of other Sections of this Guide, as applicable} \\ C &= 4.3 \text{ mm (0.17 in.)} \end{aligned}$$

Q is as defined in 3-2-1/9.5.

13.5 Side Plating of Higher-strength Material

Side-shell plating where constructed of higher-strength material is to be not less in thickness than obtained from the following equation.

$$t_{hts} = [t_{ms} - C][(Q + 2\sqrt{Q})/3] + C$$

where t_{hts} , t_{ms} , C and Q are as defined in 3-2-4/13.3 for bottom plating.

13.7 End Plating

End-plating thickness, including plating on the flat of bottom forward, where constructed of higher-strength materials, will be subject to special consideration.

PART

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CHAPTER 2 Hull Structures and Arrangements

SECTION 5 Deck Plating

1 General

The thickness of the deck plating is not to be less than required to obtain the hull-girder section modulus given in Section 3-2-1, nor less than required by this Section.

3 Deck Plating

The thickness of plating on each deck is to be less than obtained from the following equations.

3.1 All Decks

$$t = s \sqrt{h} / 254 + 254 \text{ mm} \qquad t = s \sqrt{h} / 460 + 0.10 \text{ in.}$$

$$t = s/K \text{ mm} \qquad t = s/K \text{ in.}$$

where

- t = thickness, in mm (in.)
- s = beam or longitudinal spacing, in mm (in.)
- K = 100 for all decks except transversely framed decks
 = $70 + 0.984(61 - L)$ SI and MKS units, $70 + 0.30(200 - L)$ U.S. units, for transversely framed decks
- L = length as defined in 3-1-1/1.1.1, but not less than 30.5 m (100 ft)
- h = height, in m (ft), as follows:
 - = *for a deck or portion of deck forming a tank top*, the greater of the following distances:
 - two-thirds of the distance from the tank top to the top of the overflow, or
 - two-thirds of the distance from the tank top to the bulkhead deck or freeboard deck
 - = *for a lower deck on which cargo or stores are carried*, the tween-deck height at side; where the cargo weights are greater than normal [7010 N/m^3 (715 kgf/m^3 , 45 lbf/ft^3)], h is to be suitably adjusted
 - = *for an exposed deck on which cargo is carried*, 3.66 m (12 ft). where it is intended to carry deck cargoes in excess of 25850 N/m^2 (2636 kgf/m^2 , 540 lbf/ft^2) this head is to be increased in proportion to the added loads which will be imposed on the structure

Elsewhere the value of h is to be not less than obtained from the appropriate equation below, where L = length of liftboat, in m (ft), as defined in 3-1-1/1.1.1.

3.3.1 Exposed freeboard deck having no deck below

$$h = 0.028L + 1.08 \text{ m}$$

$$h = 0.028L + 3.57 \text{ ft}$$

- 3.3.2 Exposed freeboard deck having a deck below, forecastle deck, superstructure deck forward of amidships 0.5L

$$h = 0.028L + 0.66 \text{ m}$$

$$h = 0.028L + 2.14 \text{ ft}$$

- 3.3.3 Freeboard deck within superstructure, any deck below freeboard deck, superstructure deck between 0.25L forward of and 0.20L aft of amidships

$$h = 0.014L + 0.87 \text{ m}$$

$$h = 0.014L + 2.86 \text{ ft}$$

- 3.3.4 All other locations

$$h = 0.014L + 0.43 \text{ m}$$

$$h = 0.014L + 1.43 \text{ ft}$$

5 Compensation

Compensation is to be provided for openings in the strength deck and other effective decks to maintain the longitudinal and transverse strength. All openings are to have well-rounded corners, and are to be suitable distance from the deck edge, from cargo hatch covers, from superstructure breaks, and from other areas of structural discontinuity.

7 Higher-strength Material

7.1 Thickness

In general, applications of higher strength materials are to take into consideration the suitable extension of the higher strength material below the deck, forward, and aft. Care is to be taken to avoid the adoption of reduced thickness of material such as might be subject to damage during normal operation. The thickness of deck plating, for longitudinally framed decks, where constructed of higher-strength material is to be not less than required for longitudinal strength, nor is it to be less than obtained from the following equation.

$$t_{hts} = (t_{ms} - C) \sqrt{Q} + C$$

where

$$t_{hts} = \text{thickness of higher-strength material, in mm (in.)}$$

$$t_{ms} = \text{thickness of ordinary-strength steel, in mm (in.), as required in 3-2-5/3}$$

$$C = 4.3 \text{ mm (0.17 in.)}$$

$$Q = \text{as defined in 3-2-1/9.5}$$

Where the deck plating is transversely framed, or where the Guide does not provide a specific thickness for the deck plating, the thickness of the higher-strength material will be specially considered, taking into consideration the size of the liftboat, intended service and the foregoing Rule requirements.

PART

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CHAPTER **2 Hull Structures and Arrangements**

SECTION **6 Bottom Structure**

1 Double Bottoms

1.1 General

Inner bottoms are to be fitted fore and aft between the peaks or as near thereto as practicable in liftboat hulls for liftboats of 500 GT or over. Where, for special reasons, it may be desired to omit the inner bottom, the arrangements are to be clearly indicated on the plans when first submitted for approval. A double bottom need not be fitted in way of deep tanks provided the safety of the liftboat in the event of bottom damage is not thereby impaired. It is recommended that the inner bottom be arranged to protect the bilges as much as possible and that it be extended to the sides of the liftboat.

Consideration may be given for omitting the inner bottom in way of the engines room(s) on liftboats of 500 GT or over provided that any one engine room compartment can withstand flooding in accordance with the criteria specified in 3-3-1/3.3.

Shell longitudinals and frames in way of deep tanks are to have not less strength than is required for stiffeners on deep tank bulkheads.

1.3 Center Girder

A center girder is to be fitted extending as far forward and aft as practicable. The plates are to be continuous within the midship three-quarters length; elsewhere they may be intercostal between floors. Where double bottoms are to be used for fuel oil or fresh water, the girders are to be intact, but need not be tested under pressure; this requirement may be modified in narrow tanks at the ends of the liftboat or where other intact longitudinal divisions are provided at about $0.25B$ from centerline. Where the girders are not required to be intact, manholes may be cut in every frame space outside the midships three-quarters length; they may be cut in alternate frames spaces within the midships three-quarters length.

1.3.1 Thickness Amidships

The thickness of the center girder within the midship one-half length is not to be less than obtained from the following equation.

$$t = 0.056L + 5.5 \text{ mm}$$

$$t = 0.00067L + 0.22 \text{ in.}$$

where

$$t = \text{thickness, in mm (in.)}$$

$$L = \text{length of liftboat, in m (ft), as defined in 3-1-1/1.1.1}$$

1.3.2 Thickness at Ends

The thickness of the center girder forward and aft of the midship one-half length may be reduced to 85% of the girder thickness amidships.

1.3.3 Depth

The depth of the center girder is not to be less than obtained from the following equation.

$$h_g = 32B + 190\sqrt{d} \quad \text{mm} \qquad h_g = 0.384B + 4.13\sqrt{d} \quad \text{in.}$$

where

$$\begin{aligned} h_g &= \text{depth, in mm (in.)} \\ B &= \text{breadth of liftboat, in m (ft), as defined in 3-1-1/1.1.2} \\ d &= \text{draft for scantlings, in m (ft), as defined in 3-1-1/1.1.4} \end{aligned}$$

1.5 Side Girders

Where the distance between the center girder and the side shell exceeds 4.57 m (15 ft), intercostal side girders are to be fitted approximately midway between the center girder and the side shell. The minimum thickness of the intercostal side girders is not to be less than obtained from the following equation:

$$t = 0.036L + c \quad \text{mm} \qquad t = 0.00043L + c \quad \text{in.}$$

where

$$\begin{aligned} t &= \text{thickness, in mm (in.)} \\ L &= \text{length of liftboat, in m (ft), as defined in 3-1-1/1.1.1} \\ c &= 6.2 \text{ mm (0.24 in.) in engine space} \\ &= 4.7 \text{ mm (0.18 in.) elsewhere} \end{aligned}$$

1.7 Floors

Solid floors are to be fitted at every frame under the engine room, at every frame in the peaks, and under transverse bulkheads. Elsewhere the solid floors are to have a maximum spacing of 3.66 m (12 ft) in association with intermediate open floors or longitudinal framing. The thickness of solid floors is to be equal to the thickness of side girders obtained in 3-2-6/1.5.

1.9 Frames

In transversely framed liftboats, open floors consisting of frames and reverse frames are to be fitted at all frames where solid floors are not fitted. Center and side brackets are to overlap the frames and reverse frames for a distance equal to $0.05B$; they are to be of the thickness required for solid floors in the same location and are to be flanged on their outer edges. Alternatively, longitudinal framing is to be fitted in association with widely spaced floors. The section modulus, SM , of each frame, reverse frame, bottom, or inner bottom longitudinal in association with the plating to which it is attached is not to be 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

$$\begin{aligned} s &= \text{frame spacing, in m (ft)} \\ \ell &= \text{unsupported span between supporting members, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 and are supported by bulkheads, inner bottom, or side shell, the length, } \ell, \text{ may be measured as permitted therein.} \\ h &= \text{vertical distance, in m (ft), from the middle of } \ell \text{ to the deck at side; in way of a deep tank, } h \text{ is the greatest distance from the middle of } \ell \text{ to a point located at two-thirds of the distance from the top of the tank to the top of the overflow; a point located above the top of the tank not less than } 0.01L + 0.15 \text{ m or } 0.46 \text{ m (} 0.01L + 0.5 \text{ ft or } 1.5 \text{ ft), whichever is greater.} \end{aligned}$$

c for transverse frames and reverse frames:

- = 0.8 clear of tanks
- = 1.0 in way of tanks
- = 0.5 with struts

c for longitudinal frames:

- = 1.0 clear of tanks, and in way of tanks
- = 0.715 with struts clear of tanks, and with struts in way of tanks

c for inner bottom longitudinals:

- = 0.85 clear of tanks, and in way of tanks

1.11 Struts

Struts are to be angle bar sections, fitted midway between floors. In general they are not to be used where heavy cargoes are carried, or in the bottom forward slamming area. The permissible load W_a for struts is to be determined in accordance with 3-2-8/3.3. The calculated load W is to be determined by:

$$W = nphs \text{ kN (tf, Ltf)}$$

where

- n = 10.5 (1.07, 0.03)
- p = sum of the half lengths, in m (ft), on each side of the strut of the frames supported
- h = as defined in 3-2-6/1.9
- s = frame spacing, in m (ft)

Struts are to be positioned so as to divide the span into approximately equal intervals.

1.13 Inner-bottom Plating

The thickness of the inner-bottom plating throughout the length of the liftboat is to be not less than obtained from the following equation. Where applicable, the plating is to meet deep tank requirements.

$$t = 0.037L + 0.009s + c \text{ mm} \quad t = 0.000445L + 0.009s + c \text{ in.}$$

where

- t = thickness, in mm (in.)
- L = length of liftboat, in m (ft), as defined in 3-1-1/1.1.1
- s = frame spacing, in mm (in.)
- c = 1.5 mm (0.06 in.) in engine space
- = -0.5 mm (-0.02 in.) elsewhere

Where no ceiling is fitted under cargo hatchways, the thickness of the inner-bottom plating is to be increased 2.0 mm (0.08 in.). For liftboats with longitudinally-framed inner bottoms, the minimum thickness of inner-bottom plating may be reduced by 1 mm (0.04 in.).

Margin plates which are approximately horizontal are to have thicknesses not less than the adjacent inner bottom plating. Where they are nearly vertical, they are to be not less than the required inner bottom plating in the engine space and are to extend the full depth of the inner bottom.

1.15 Sea Chests

Where the double bottom structure forms part of a sea chest, the thickness of the plating is to be not less than the required thickness of the shell plating, using the appropriate value of stiffener spacing, s .

1.17 Access, Lightening, Air and Drainage Holes

Access holes in double bottom tank tops and lightening holes in nontight members are to be sufficient in size and number to assure accessibility to all parts of the double bottom; the proposed locations and sizes of the holes are to be indicated on the drawings submitted for approval. Tank top access hole covers are to be of steel or equivalent material, and where no ceiling is fitted in a cargo hold, the covers are to be protected against damage by the cargo. Air and drainage holes are to be cut in all nontight parts of the double bottom structure to assure the free escape of gases to the vents and the free drainage of liquids to the suctions.

3 Single Bottoms with Floors and Keelsons

3.1 General

Single bottoms may be fitted in accordance with 3-2-6/1.1.

3.3 Center Keelsons

Single-bottom liftboats are to have center keelsons formed of continuous or intercostal center girder plates with horizontal top plates. The thickness of the keelson and the area of the horizontal top plate are to be not less than obtained from the following equations. The keelsons are to extend as far forward and aft as practicable.

3.3.1 Center-girder Plate Thickness Amidships

$$t = 0.063L + 5 \text{ mm} \qquad t = 0.00075L + 0.2 \text{ in.}$$

3.3.2 Center-girder Plate Thickness at Ends

$$t = 85\% \text{ of center keelson thickness amidships}$$

3.3.3 Horizontal Top-plate Area Amidships

$$A = 0.168L^{3/2} - 8 \text{ cm}^2 \qquad A = 0.0044L^{3/2} - 1.25 \text{ in}^2$$

3.3.4 Horizontal Top-plate Area at Ends

$$A = 0.127L^{3/2} - 1 \text{ cm}^2 \qquad A = 0.0033L^{3/2} - 0.15 \text{ in}^2$$

where

$$\begin{aligned} t &= \text{thickness of center-girder plate, in mm (in.)} \\ L &= \text{length of liftboat, as defined in 3-1-1/1.1.1, in m (ft.)} \\ A &= \text{area of horizontal top plate, in cm}^2 \text{ (in}^2\text{)} \end{aligned}$$

3.5 Side Keelsons

Side keelsons are to be arranged so that there are not more than 2.13 m (7 ft) from the center keelson to the inner side keelson, from keelson to keelson and from the outer keelson to the lower turn of bilge; forward of the midship one-half length the spacing of keelsons on the flat of floor is not to exceed 915 mm (36 in.). Side keelsons are to be formed of continuous rider plates on top of the floors. They are to be connected to the shell plating by intercostal plates. The intercostal plates are to be attached to the floor plates. In the engine space the intercostal plates are to be of not less thickness than the center girder plates. The scantlings of the side keelsons are to be obtained from the following equations:

3.5.1 Side Keelson and Intercostal Thickness Amidships

$$t = 0.063L + 4 \text{ mm} \qquad t = 0.00075L + 0.16 \text{ in.}$$

3.5.2 Side Keelson and Intercostal Thickness at Ends

$$t = 85\% \text{ of the thickness amidships}$$

3.5.3 Side Keelson and Intercostal, Horizontal Top Plate Area Amidships

$$A = 0.038L^{3/2} + 17 \text{ cm}^2 \qquad A = 0.001L^{3/2} + 2.6 \text{ in}^2$$

3.5.4 Side Keelson and Intercostal, Horizontal Top Plate Area at Ends

$$A = 0.025L^{3/2} + 20 \text{ cm}^2$$

$$A = 0.00065L^{3/2} + 3.1 \text{ in}^2$$

t , L and A are as defined in 3-2-6/3.3.

3.7 Floors

3.7.1 Section Modulus

With transverse framing, a floor as shown in 3-2-6/Figure 1 is to be fitted on every frame and is to be of the scantlings necessary to obtain a section modulus SM not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \text{ cm}^3$$

$$SM = 0.0041chs\ell^2 \text{ in}^3$$

where

s = floor spacing, in m (ft)

ℓ = span, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 and are supported by bulkheads, inner bottom, or side shell, the length, ℓ , may be measured as permitted therein.

h = draft, d , in m (ft), as defined in 3-1-1/1.1.4, but not to be less than $0.66D$ or $0.066L$, whichever is greater.

c = 0.55

The above requirements are limited to cargo holds where cargoes of specific gravity 0.715 or less are uniformly loaded. In way of engine room and in the forward $0.2L$, the floor face bar area is to be doubled.

3.7.2 Depth

The minimum depth of floors at centerline is not to be less than obtained from the following equation:

$$h_f = 62.5\ell \text{ mm}$$

$$h_f = 0.75\ell \text{ in.}$$

where

h_f = floor depth, in mm (in.)

ℓ = unsupported span of floors, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 the length ℓ may be measured as permitted therein.

3.7.3 Thickness

The minimum thickness of floors is not to be less than obtained from the following equation:

$$t = 0.01h_f + 3 \text{ mm}$$

$$t = 0.01h_f + 0.12 \text{ in.}$$

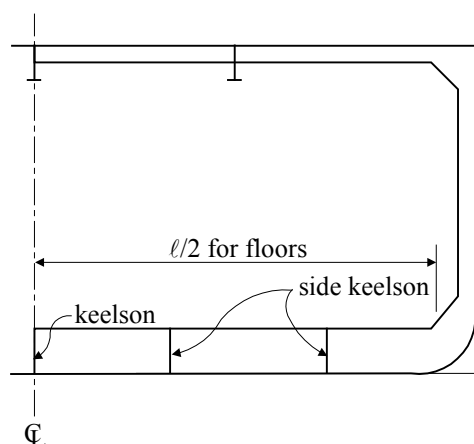
where

t = floor thickness, in mm (in.)

h_f = floor depth, in mm (in.)

Floors under engine girders are to be not less in thickness than the thickness required for keelsons.

**FIGURE 1
Plate Floors**



5 Single Bottoms with Longitudinal or Transverse Frames

5.1 General

Single bottoms may be fitted in accordance with 3-2-6/1.1. The following requirements apply where the single bottom is not subject to internal cargo loading as described in 3-2-6/3.7, or they may be applied as an alternative to 3-2-6/3. Frames are not to have less strength than is required for watertight bulkhead stiffeners or girders in the same location in association with head to the bulkhead deck. In way of deep tanks, frames are not to have less strength than is required for stiffeners or girders on deep tank bulkheads. The calculated section modulus for frames is based upon the intact sections being used. Where a hole is cut in the outstanding flange of any member or a large opening is made in the web of the frame, the net section is to be used in determining the section modulus of the member in association with the plating to which it is attached.

5.3 Bottom Girders and Transverses

5.3.1 Section Modulus

The section modulus, SM , of each bottom girder and transverse, where intended as a primary supporting member, in association with the plating to which it is attached, is not to be less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \text{ cm}^3$$

$$SM = 0.0041chs\ell^2 \text{ in}^3$$

where

$$c = 0.915$$

$$h = \text{depth, in m (ft), from the center of area supported to the deck at side}$$

$$s = \text{spacing, in m (ft)}$$

$$\ell = \text{unsupported span, in m (ft). Where brackets are fitted in accordance with 3-2-3/3 and are supported by bulkheads, inner bottom, or side shell, the length } \ell \text{ may be measured as permitted therein.}$$

Tripping brackets are to be fitted at intervals of about 3 m (10 ft) and stiffeners are to be fitted as may be required.

5.3.2 Depth

The minimum depth of the girder or transverse is to be not less than 2.5 times the depth of the cutouts for bottom frames, unless effective compensation for cutouts is provided nor less than obtained from the following equation:

$$h_w = 145\ell \text{ mm} \qquad h_w = 1.75\ell \text{ in.}$$

where

$$h_w = \text{girder or transverse depth, in mm (in.)}$$

ℓ is as defined in 3-2-6/5.3.1.

5.3.3 Thickness

The minimum thickness of the web is to be not less than obtained from the following equation:

$$t = 0.01h_w + 3 \text{ mm} \qquad t = 0.01h_w + 0.12 \text{ in.}$$

where

$$t = \text{thickness, in mm (in.)}$$

h_w is as given in 3-2-6/5.3.2.

5.5 Center Girder

In general, a center girder is to be fitted, complying with 3-2-6/5.3.3, however alternative arrangement that provide suitable support for docking, will be considered.

5.7 Frames

The section modulus, SM , of each bottom frame to the chine or upper turn of bilge, in association with the plating to which it is attached, is not to be less than obtained from the following equation:

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

where

- c = 0.80 for transverse frames clear of tanks
- = 1.00 for longitudinal frames clear of tanks, and in way of tanks
- = 1.00 for transverse frames in way of tanks
- s = frame spacing, in m (ft)
- ℓ = unsupported span, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 and are supported by bulkheads, inner bottom, or side shell, the length ℓ may be measured as permitted therein.
- h = vertical distance, in m (ft), from the middle of ℓ to the deck at side; in way of a deep tank, h is the greatest of the distances, in m (ft), from the middle of ℓ to:
 - A point located at two-thirds of the distance from the top of the tank to the top of the overflow
 - A point located above the top of the tank not less than $0.01L + 0.15 \text{ m (0.5 ft)}$ or 0.46 m (1.5 ft) , whichever is greater

L is as defined in 3-1-1/1.1.1.

7 Fore-end Strengthening

7.1 General

For liftboats 61 m (200 ft) in length and over, where the heavy weather ballast draft forward is less than $0.04L$, strengthening of the flat of bottom forward is to be in accordance with 3-2-6/7.3, 3-2-6/7.5, 3-2-6/7.7 and 3-2-6/3.5. Information on the heavy weather ballast draft forward used for the required fore-end strengthening is to be furnished to the master for guidance. The heavy weather ballast draft is also to be indicated on the shell expansion plan.

7.3 Extent of Strengthening

The flat of bottom forward is defined as being forward of the locations indicated in 3-2-6/Table 1. For intermediate values of C_b , the locations are to be obtained by interpolation. Aft of these locations, a suitable transition is to be provided between the increased scantlings and structural arrangements of the flat of bottom forward and the structure aft of the locations given in 3-2-6/Table 1.

TABLE 1
Location of Flat of Bottom Forward

C_b is the block coefficient at the summer load waterline, based on L as defined in 3-1-1/1.1.1

C_b	Location Forward of Amidships
0.6 or less	$0.25L$
0.8 or more	$0.30L$

7.5 Longitudinal Framing

When longitudinal framing is used for the bottom and inner bottom, longitudinals and side girders are to be continued as far forward as practicable at not more than their amidship spacing. The section modulus of flat of bottom longitudinals forward of the location indicated in 3-2-6/Table 1 is to be not less than required by the following equation, nor less than required by 3-2-6/5.7:

$$SM = 8.47 (0.005L^2 - 1.3d_f^2)s\ell^2/d_f \text{ cm}^3 \quad SM = 0.0044 (0.005L^2 - 1.3d_f^2)s\ell^2/d_f \text{ in}^3$$

where

- d_f = heavy weather ballast draft at the forward perpendicular, in m (ft)
- L = length of liftboat, as defined in 3-1-1/1.1.1
- s = spacing of longitudinals, in m (ft)
- ℓ = distance between floors, in m (ft)

The spacing of floors forward of $0.25L$ forward of amidships is to be not greater than that given in 3-2-6/Table 2 nor greater than the spacing amidships.

TABLE 2
Spacing of Floors

d_f	C_b	<i>From 0.25L to 0.3L from Amidships</i>	<i>Forward of 0.3L from Amidships</i>
0.02L or less	0.60 or less	3s	2s
	> 0.60	3s	3s
0.035L	all values	3s	3s
0.04L and more	all values	As required elsewhere in the Rules	

Notes:

d_f is the heavy weather ballast draft at the forward perpendicular and C_b is the block coefficient at the summer load waterline, based on L as defined in 3-1-1/1.1.1.

s is the spacing of the transverse side frames, or s in 3-2-7/3 where the side shell is longitudinally framed.

For values of d_f between those shown below, the required floor spacing may be obtained by interpolation.

7.7 Transverse Framing

Where the heavy weather ballast draft forward is less than 0.04L, solid floors are to be fitted on every frame and additional full-depth and half-depth side girders are to be introduced so that the spacing of full-depth girders forward of the locations in 3-2-6/Table 1 does not exceed 2.13 m (7 ft) and so that the spacing of alternating half- and full-depth girders forward of the location in 3-2-6/Table 1 does not exceed 1.07 m (3.5 ft). Where the heavy weather ballast draft forward is 0.04L or more, the arrangement of solid floors and side girders may be in accordance with 3-2-6/1.7 and 3-2-6/1.5.

9 Higher-strength Materials

9.1 General

In general applications of higher-strength materials for bottom structures are to meet the requirements of this Section, but may be modified as permitted by the following Paragraphs. Care is to be exercised to avoid the adoption of reduced thickness of material such as might be subject to damage during normal operation and calculations are to be submitted to show adequate provision against buckling. Longitudinal framing members are to be of essentially the same material as the plating they support.

9.3 Inner-bottom Plating

Inner-bottom plating, where constructed of higher-strength material and where longitudinally framed, is to be not less in thickness than required by 3-2-6/1.1 or for tank top plating as modified by the following equation.

$$t_{hts} = [t_{ms} - C][(Q + 2\sqrt{Q})/3] + C$$

where

- t_{hts} = thickness of higher-strength material, in mm (in.)
- t_{ms} = thickness of mild steel, as required by 3-2-6/1.13, in mm (in.), increased where required for no ceiling
- C = 3 mm (0.12 in.) or 5 mm (0.20 in.) where the plating is required by 3-2-6/1.13 to be increased for no ceiling
- Q = as defined in 3-2-1/9.5

The thickness of inner-bottom plating, where transversely framed, will be specially considered.

9.5 Bottom and Inner-bottom Longitudinals

The section modulus of bottom and inner-bottom longitudinals, where constructed of higher-strength material and in association with the higher-strength plating to which they are attached, are to be determined as indicated in 3-2-6/1.9 except that the value may be reduced by the factor Q as defined in 3-2-1/9.5.

9.7 Center Girders, Side Girders and Floors

Center girders, side girders, and floors, where constructed of higher-strength materials, generally are to comply with the requirements of 3-2-6/1.3, 3-2-6/1.5 or 3-2-6/1.7 but may be modified as permitted by the following equation:

$$t_{hts} = [t_{ms} - C][(Q + 2\sqrt{Q})/3] + C$$

where t_{hts} , t_{ms} and C are as defined in 3-2-6/9.3.

Q is as defined in 3-2-1/9.5.

11 Machinery Space

11.1 General

Special attention is directed to arranging, for the provision of plated through beams and such casing and pillar supports as are required to secure structural efficiency. All parts of the machinery, shafting, etc., are to be efficiently supported and the adjacent structure is to be adequately stiffened.

Consideration is to be given to the submittal of plans of the foundations for main propulsion units, reduction gears, and thrust bearings and of the structure supporting those foundations to the machinery manufacturer for review. (See also 4-3-1/21.)

11.3 Engine Foundations

11.3.1 Single Bottom Liftboats

In liftboats with single bottoms the engines are to be seated on thick plates laid across the top of deep floors or upon heavy foundation girders efficiently bracketed and stiffened. Intercoastal plates are to be fitted between the floors beneath the lines of bolting to distribute the weight effectively through the bottom structure to the shell. Seat plates are to be of thickness and width appropriate to the holding-down bolts and are to be effectively attached to girders and intercostals.

11.3.2 Double Bottom Liftboats

On liftboats with double bottoms the engines are to be seated directly upon thick inner-bottom plating or upon thick seat plates on top of heavy foundations arranged to distribute the weight effectively. Additional intercoastal girders are to be fitted within the double bottom to ensure the satisfactory distribution of the weight and the rigidity of the structure.

11.5 Thrust Foundations

Thrust blocks are to be bolted to efficient foundations extending well beyond the thrust blocks and arranged to distribute the loads effectively into the adjacent structure: extra intercoastal girders, effectively attached, are to be fitted in way of the foundations as may be required.

11.7 Shaft Stools and Auxiliary Foundations

Shaft stools and auxiliary foundations are to be of ample strength and stiffness in proportion to the weight supported.

PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 7 Side Frames, Webs and Stringers

1 General

1.1 Basic Considerations

Frames, or webs and stringers, are not to have less strength than is required for watertight bulkhead stiffeners, or girders, in the same location in association with heads to the bulkhead deck. In way of deep tanks, frames or webs and stringers are not to have less strength than is required for stiffeners or girders on deep tank bulkheads. The calculated section modulus is based upon the intact sections being used. Where a hole is cut in the flange of any member or a large opening is made in the web of the member, the net section is to be used in determining the section modulus of the member in association with the plating to which it is attached.

1.3 End Connections

At the ends of unbracketed frames, both the web and the flange are to be welded to the supporting member. At bracketed end connections continuity of strength is to be maintained at the connection to the bracket and at the connection of the bracket to the supporting member. Welding is to be in accordance with 3-2-15/Table 1. Where longitudinal frames are not continuous at bulkheads, end connections are to effectively develop their sectional area and resistance to bending. Where a structural member is terminated, structural continuity is to be maintained by suitable back-up structure, fitted in way of the end connection of frames, or the end connection is to be effectively extended by a bracket or flat bar to an adjacent beam, stiffener, etc.

3 Longitudinal Side Frames

The section modulus, SM , of each longitudinal side frame above the chine or upper turn of bilge is to be not less than obtained from the following equation:

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

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

where

$$c = 0.915$$

$$h = \text{vertical distance, in m (ft), from the frame to the freeboard deck at side, but not less than } 0.02L + 0.46 \text{ m (0.02L + 1.5 ft)}$$

$$s = \text{frame spacing, in m (ft)}$$

$$\ell = \text{straight-line unsupported span, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 and are supported by bulkheads, the length } \ell \text{ may be measured as permitted therein.}$$

5 Transverse Side Frames

5.1 Section Modulus

The section modulus, SM , of each transverse side frame above the chine or upper turn of bilge, in association with the plating to which the frame is attached is not to be less than obtained from the following equation.

$$SM = 7.8chs\ell^2 \text{ cm}^3$$

$$SM = 0.0041 chs\ell^2 \text{ in}^3$$

where

- c = 0.915
- s = frame spacing, in m (ft)
- ℓ = straight-line unsupported span, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 and are supported by decks or inner bottoms, the length ℓ may be measured as permitted therein.
- h = the vertical distance, in m (ft), from the mid length of the frame to the freeboard deck at side, but not less than $0.02L + 0.46 \text{ m}$ ($0.02L + 1.5 \text{ ft}$).
= on frames having tween decks above, the vertical distance in m (ft) from the middle of ℓ to the load line or 0.4ℓ , whichever is greater, plus $bh_1/33$ ($bh_1/100$).
- b = horizontal distance, in m (ft), from the outside of the frames to the first row of deck beam supports.

5.3 Peak Frames

5.3.1 General

For liftboats greater than 61 m (200 ft) in length, peak frames are to be efficiently connected to deep floors of not less thickness than obtained from 3-2-6/1.7 for floors in engine spaces. The floors are to extend as high as necessary to give lateral stiffness to the structure and are to be properly stiffened on their upper edges. Care is to be taken in arranging the framing and floors to assure no wide areas of unsupported plating adjacent to the stem. Breast hooks are to be arranged at rectangular intervals at and between the stringers above and below the waterline. In general, the frames above the lowest deck are to be as required by 3-2-7/5, but in liftboats having large flare with unusually long frames, stringers and webs above the lowest deck or suitably increased frames may be required.

5.3.3 Section Modulus

For liftboats greater than 61 m (200 ft) in length the section modulus of each peak frame is to be not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \text{ cm}^3$$

$$SM = 0.0041 chs\ell^2 \text{ in}^3$$

where

- c = 1.13 for forepeak frames
= 0.90 for aft peak frames
- h = $0.110L - 1.990 \text{ m}$ ($0.110L - 8.98 \text{ ft}$) for forepeak frames
= $0.062L - 1.122 \text{ m}$ ($0.062L - 3.68 \text{ ft}$) for aft peak frames
- s = frame spacing, in m (ft)
- ℓ = straight line unsupported span, in m (ft.), not to be taken less than 2.13 m (7.0 ft)
- L = length as defined in 3-1-1/1.1.1, but is not to be taken less than 30 m (98.5 ft)

7 Side Web Frames

7.1 Section Modulus

The section modulus, SM , of each side web frame supporting longitudinal framing or shell stringers above the chine or upper turn of bilge, in association with the plating to which the web frame is attached is not to be less than obtained from the following equation:

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

where

- c = 0.915 aft of the forepeak
= 1.13 in the forepeak, for liftboat greater than 61 m (200 ft) in length.
- s = frame spacing, in m (ft)
- ℓ = straight-line unsupported span, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 and are supported by decks or inner bottoms, the length ℓ may be measured as permitted therein.
- h = the vertical distance, in m (ft), from the mid length of the frame to the freeboard deck at side, but not less than $0.02L + 0.46 \text{ m}$ ($0.02L + 1.5 \text{ ft}$)
- b = horizontal distance, in m (ft), from the outside of the frames to the first row of deck beam supports.
- K = 1.0 where the deck is longitudinally framed and a deck transverse is fitted in way of each web frame.
= number of transverse frame spaces between web frames where the deck is transversely framed.

7.3 Proportions

The depth of each web frame is to be not less than $125\ell \text{ mm}$ ($1.5\ell \text{ in.}$) or, unless effective compensation is provided for cutouts, 2.5 times the cutout for frame or longitudinal if greater. The thickness of the web of web frame or stringer is to be not less than 0.01 times the depth plus 3 mm (0.12 in.), ℓ is as defined in 3-2-7/7.1.

7.5 Tripping Brackets and Stiffeners

7.5.1 Stiffeners

Where the shell is longitudinally framed, stiffeners attached to the longitudinal frames and extending to the full depth of the web frame are to be fitted at least at alternate longitudinal frames. Other stiffening arrangements may be considered based on the structural stability of the web plates.

7.5.2 Tripping Brackets

Tripping brackets are to be fitted at intervals of about 3 m (10 ft) and near the change of section. Where the breadth of the flanges on either side of the web exceeds 200 mm (8 in.), tripping brackets are to be arranged to support the flange.

9 Side Stringers

9.1 Section Modulus

The section modulus, SM , of each side stringer, in association with web frames and transverse frames is to have a section modulus, SM , not be less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \text{ cm}^3$$

$$SM = 0.0041chs\ell^2 \text{ in}^3$$

where

- c = 0.915
= 1.13 in the forepeak, for liftboat greater than 61 m (200 ft) in length.
- h = vertical distance, in m (ft), from the middle of s to the freeboard deck at side but not less than $0.02L + 0.46$ m ($0.02L + 1.5$ ft)
= for stringers in the peaks, not less than given in 3-2-7/5.3
- s = sum of the half lengths (on each side of the stringer), in m (ft), of the frames supported
- ℓ = span, in m (ft), between web frames, or between web frame and bulkhead; where brackets are fitted in accordance with 3-2-3/3.3 and are supported by transverse bulkheads, the length ℓ may be measured as permitted therein

9.3 Proportions

Side stringers are to have a depth of not less than 0.125ℓ (1.5 in per ft of span ℓ) plus one-quarter of the depth of the slot for the frames, but need not exceed the depth of the web frames to which they are attached. In general the depth is not to be less than 2.5 times the depth of the slots, or the slots are to be fitted with filler plates. The thickness of each stringer is to be not less than $0.014L + 7.2$ mm ($0.00017L + 0.28$ in.) where L is as defined in 3-1-1/1.1.1.

9.5 Tripping Brackets and Stiffeners

9.5.1 Stiffeners

Stiffeners attached to the frame and extending to the full depth of the stringer are to be fitted at least at alternate transverse frames. Other stiffening arrangement may be considered based on the structural stability of the web plates.

9.5.2 Tripping Brackets

The arrangements of tripping brackets is to be in accordance with 3-2-7/7.5.2.

PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 8 Beams, Deck Girders, Deck Transverses and Pillars

1 Beams

1.1 Spacing

Beams may be fitted either transversely or longitudinally. Transverse beams, where provided, are to be fitted at each transverse side frame at the tops of tanks, tunnel tops, and bulkhead recesses. Elsewhere these beams are not to be more than two frame spaces apart and those in different tiers are to be fitted on the same frames.

1.3 Section Modulus

The section modulus, SM , of each transverse or longitudinal beam in association with the plating to which it is attached is not to be less than obtained from the following equations.

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

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

where

c	=	1.00	for transverse or longitudinal beams at the tops of tanks, with deep tanks h , 3-2-8/1.3.1 or 3-2-8/1.3.2 below
	=	$1/(1.709 - 0.651k)$	for longitudinal beams of strength decks and effective lower decks
	=	0.60	for all other transverse beams
	=	0.70	for all other longitudinal beams
k	=	$SM_R Y / I_A$	
SM_R	=	required hull-girder section modulus amidships from 3-2-1/3, in $\text{cm}^2\text{-m}$ ($\text{in}^2\text{-ft}$)	
Y	=	distance, in m (ft), from the neutral axis to the deck being considered, always taken as positive	
I_A	=	hull-girder moment of inertia of the liftboat amidships, in $\text{cm}^2\text{-m}^2$ ($\text{in}^2\text{-ft}^2$)	
		The values of I_A and Y are to be those obtained using the area of the longitudinal beams given by the above equation.	
s	=	beam spacing, in m (ft)	
ℓ	=	unsupported span, in m (ft). At the tops of tanks and bulkhead recesses the maximum span permissible between supports is 4.57 m (15 ft). Where brackets are fitted in accordance with 3-2-3/3.3 the length ℓ may be measured as permitted therein.	

- h = height, in m (ft), as follows
- = *for a deep tank top* is the greater of the following:
- two-thirds of the distance from the top of the tank to the top of the overflow, or
 - two-thirds of the distance from the top of the tank to the bulk-head deck or freeboard deck, or
 - the height to the load line, or
- $0.01L + 0.15$ m ($0.01L + 0.5$ ft)
- = *for a lower deck on which cargo or stores are carried*, the tween-deck height at side; where the cargo weights differ from 7010 N/m^3 (715 kgf/m^3 , 45 lbf/ft^3), h is to be proportionately adjusted
- = *for an exposed deck on which cargo is carried*, 3.66 m (12 ft). where it is intended to carry deck cargoes in excess of 25850 N/m^2 (2636 kgf/m^2 , 540 lbf/ft^2) this head is to be increased in proportion to the added loads which will be imposed on the structure

Elsewhere the value of h is obtained from the appropriate equation below, where L = length of the liftboat, in m (ft), as defined in 3-1-1/1.1.1.

1.3.1 Exposed freeboard deck having no deck below

$$h = 0.02L + 0.76 \text{ m}$$

$$h = 0.02L + 2.5 \text{ ft}$$

1.3.2 Exposed freeboard deck having a deck below, forecastle deck, superstructure deck forward of amidships $0.5L$

$$h = 0.02L + 0.46 \text{ m}$$

$$h = 0.02L + 1.5 \text{ ft}$$

1.3.3 Freeboard deck within superstructure, any deck below freeboard deck, superstructure deck between $0.25L$ forward of and $0.30L$ aft of amidships

$$h = 0.01L + 0.61 \text{ m}$$

$$h = 0.01L + 2.0 \text{ ft}$$

1.3.4 All other first tier above freeboard deck locations

$$h = 0.01L + 0.30 \text{ m}$$

$$h = 0.01L + 1.0 \text{ ft}$$

1.3.5 Second tier above freeboard deck; deckhouse top or short super-structure*

$$h = 0.01L + 0.15 \text{ m}$$

$$h = 0.01L + 0.5 \text{ ft}$$

* Where used only as weather covering may be used as 3-2-8/1.3.6, but L need not be taken greater than 45.70 m (150 ft).

1.3.6 Third tier above freeboard deck deckhouse top or short super-structure*

$$h = 0.01L \text{ m}$$

$$h = 0.01L \text{ ft}$$

* Where used only as weather covering may be used as 3-2-8/1.3.6, but L need not be taken greater than 45.70 m (150 ft).

1.5 Special Heavy Beams

Special reinforced beams are to be fitted under concentrated loads such as the ends of deckhouses, masts, winches, auxiliary machinery, etc. Beams at the heads of web frames are to be suitably increased in strength and stiffness.

1.7 Container Loading

Where it is intended to carry containers, the exact locations of the container pads and the maximum total static load on the pads are to be indicated on the plans. Where the pads are not in line with the supporting structures, headers are to be provided to transmit the loads to these members.

Each member intended to support containers is to have a section modulus, SM , in cm^3 (in^3) not less than obtained from the following equation:

$$SM = M/f$$

where

M = maximum bending moment due to maximum static container loading, in kN-cm (kgf-cm, Ltf-in)

f = permissible maximum bending stress, as given in 3-2-8/Table 1.

In determining the maximum bending moment, members may be considered fixed-ended provided the member is continuous over the adjacent spans or is effectively attached to a bulkhead stiffener or frame or has suitable end connections. Where this is not the case, the member is to be considered simply-supported. Where weather deck containers are supported by pedestals, the section modulus required by 3-2-8/1.3, with h equal to the distance between the deck and the underside of the container, but not greater than 50% of the value given in 3-2-8/1.3.1 through 3-2-8/1.3.6, is to be added to the above required section modulus.

TABLE 1
Values of f

	kN/cm^2	kgf/cm^2	Ltf/in^2
Effective longitudinal members	12.36	1262	8
Transverse members and longitudinal members inside the line of openings	13.90	1420	9
The net sectional area of the web of the member in cm^2 (in^2) including effective brackets where applicable, is to be not less than obtained from the following equation: $A = F/q$ Where F = shearing force at the point under consideration, kN (kgf, Ltf) q = allowable average shear stress in the web, not to exceed 10.35 kN/cm^2 (1057 kgf/cm^2, 6.7 Ltf/in^2)			

1.9 Hatch-end Beams

Each hatch-end beam, similar to that shown in 3-2-8/Figure 1, which is supported by a centerline pillar without a pillar at the corner of the hatchway, is to have a section modulus, SM , not less than obtained from the following equations:

1.9.1 Where Deck Hatch-side Girders are Fitted Fore and Aft Beyond the Hatchways

$$SM = K(AB + CD)h\ell \text{ cm}^3$$

$$SM = 0.000527K(AB + CD)h\ell \text{ in}^3$$

1.9.2 Where Girders are not Fitted on the Line of the Hatch Side Beyond the Hatchway

$$SM = KABh\ell \text{ cm}^3$$

$$SM = 0.000527KABh\ell \text{ in}^3$$

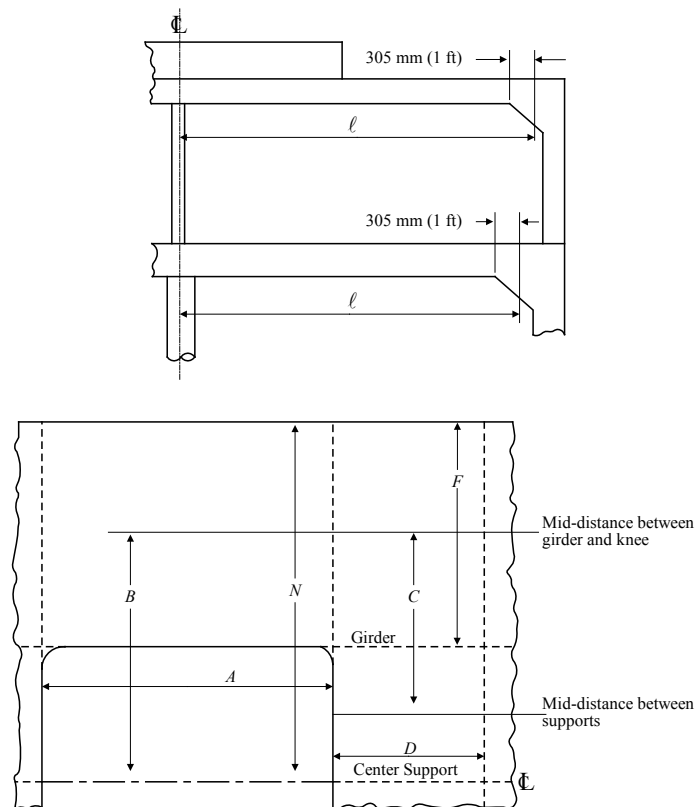
where

- A = length of the hatchway, in m (ft)
- B = distance from the centerline to the midpoint between the hatch side and the line of the toes of the beam knees, in m (ft)
- C = distance from a point midway between the centerline and the line of the hatch side to the midpoint between the hatch side and the line of the toes of the beam knees, in m (ft); where no girder is fitted on the centerline beyond the hatchway C is equal to B
- D = distance from the hatch-end beam to the adjacent hold bulkhead, in m (ft)
- h = height for the beams of the deck under consideration, as given in 3-2-8/1.3, in m (ft)
- ℓ = distance from the toe of the beam knee to the centerline plus 0.305 m (1 ft), in m (ft)
- K = $2.20 + 1.29(F/N)$ when $F/N \leq 0.6$
= $4.28 - 2.17(F/N)$ when $F/N > 0.6$
- N = one-half the breadth of the liftboat in way of the hatch-end beam
- F = distance from the side of the liftboat to the hatch-side girder

Weather deck hatch-end beams which have deep coamings above deck for the width of the hatch may have the flange area reduced from a point well within the line of the hatch side girder to approximately 50% of the required area at centerline; in such cases it is recommended that athwartships brackets be fitted above deck at the ends of the hatch-end coaming.

Brackets at the end of hatch-end beams are to be generally as described in 3-2-3/3.3. Where brackets are not fitted, the length ℓ is to be measured to the side of the liftboat and the face plates or flanges on the beams are to be attached to the shell by heavy horizontal brackets extending to the adjacent frame.

FIGURE 1
Hatch-end Beams



3 Stanchions and Pillars

3.1 General

Supports under pillars are to be sufficient strength to distribute the loads effectively. Tween-deck pillars are to be arranged directly above those below, or effective means are to be provided for transmitting their loads to supports below. Tripping brackets are to be fitted on members in way of pillars, both when the pillar is over and under the member.

3.3 Permissible Load

The permissible load a pillar can carry is to be equal to or greater than the pillar load W as determined in 3-2-8/3.5. The permissible load may be obtained from the following equation:

$$W_a = (k - n \ell/r)A$$

where

- W_a = load, in kN (tf, Ltf)
- k = 12.09 (1.232, 7.83)
- n = 0.0444 (0.00452, 0.345)
- ℓ = unsupported length of the pillar, in cm (ft)
- r = least radius of gyration of pillar, in cm (in.)
- A = area of pillar, in cm² (in²)

3.5 Calculated Load

The load on a pillar is to be obtained from the following equation:

$$W = nbhs$$

where

W	=	load, in kN (tf, Ltf)
n	=	7.04 (0.715, 0.02)
b	=	mean breadth, in m (ft), of area supported
h	=	height, in m (ft), above the deck supported as defined below
s	=	mean length, in m (ft), of area supported

For a pillar below an exposed deck on which cargo is carried, h is the distance from the deck supported to a point 3.66 m (12 ft) above the exposed deck. Where it is intended to carry deck cargoes in excess of 2636 kilograms per square meter (540 pounds per square foot) this head is to be increased in proportion to the added loads which will be imposed on the structure.

For a pillar below the freeboard deck, h is to be measured to a point not less than $0.02L + 0.76$ m ($0.02L + 2.5$ ft) above the freeboard deck.

For a pillar below the superstructure deck, h is to be measured to a point not less than $0.02L + 0.46$ m ($0.02L + 1.5$ ft) above the superstructure deck.

The height h for any pillar is not to be less than the given height in 3-2-8/1.3 for the beams at the top of the pillar plus the sum of the heights given in the same Paragraph for the beams of all complete cargo decks and one-half the heights given for all partial superstructure decks above.

L is the length of liftboat, in m (ft), as defined in 3-1-1/1.1.1.

3.7 Pillars in Double Bottoms and Under Tank Tops

Pillars in double bottoms and under the tops of deep tanks are to be solid in cross section. Pillars under the tops of deep tanks are not to be less than required by 3-2-8/3.3 and 3-2-8/3.5, nor are they to have less section area than cW cm² (in²) where W is to be obtained from the following equation:

$$W = nbhs$$

where

W	=	load in kN (tf, Ltf)
n	=	10.5 (1.07, 0.03)
b	=	breadth, in m (ft), of the area of the top of the tank supported by the pillar
h	=	height, in m (ft), as required by 3-2-8/1.3 for the tank-top beams
s	=	length, in m (ft), of the area of the top of the tank supported by the pillar
c	=	0.1035 (1.015, 0.16)

3.9 Bulkheads

Bulkheads supporting girders or bulkheads fitted in lieu of girders are to be stiffened to provide supports not less effective than required for pillars.

3.11 Attachments

Wide spaced tubular or solid pillars are to bear solidly at head and heel and are to be attached by welding, properly proportioned on the size of the pillar. The attachments of stanchions or pillars under bulkhead recesses, tunnel tops or deep-tank tops which may be subjected to tension loads are to be specially developed to provide sufficient welding to withstand the tension load.

5 Deck Girders and Deck Transverses

5.1 General

Girders and transverses are to be fitted as required to support beams and longitudinals. Additional girders are to be fitted as required under masts, king posts, deck machinery, or other heavy concentrated loads.

5.3 Deck Girders and Transverses Clear of Tanks

Section modulus, SM of each longitudinal deck girder and deck transverse clear of tanks is not to be less than obtained from the following equation:

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

where

- c = 0.60
- b = mean breadth of area of deck supported (for girders), or spacing of deck transverses (for transverses), in m (ft)
- h = height, in m (ft), as required by 3-2-8/1.3 for the beams supported
- ℓ = unsupported span, in m (ft). Where brackets are fitted at bulkhead supports, in accordance with 3-2-3/3.3, the length ℓ may be measured as permitted therein.

5.5 Proportions

The minimum depth of a deck girder or transverse supporting member is to be 58.3ℓ mm (0.7ℓ in.) where ℓ is as defined in 3-2-8/5.3; the depth is also not to be less than 2.5 times the cutout for the beam or longitudinal unless effective compensation is provided for the cutouts. The minimum thickness is to be 1 mm per 100 millimeters (0.01 in per inch) of depth plus 4 mm (0.16 in.).

5.7 Tripping Brackets and Stiffeners

Tripping brackets are to be fitted on girders and transverses at a spacing of about 3 m (10 ft). Stiffeners are to be fitted as may be required.

5.9 Deck Girders and Transverses in Tanks

The requirements for deck girders or transverse supporting members in tanks may be obtained in the same manner as given in 3-2-8/5.3, 3-2-8/5.5 and 3-2-8/5.7 except that c is equal to 0.915. The minimum depth of a girder or transverse supporting member is to be 83.3ℓ mm (1.0ℓ in.), where ℓ is as defined in 3-2-8/5.3.

5.11 Hatch Side Girders

Scantlings for hatch side girders supporting athwartship shifting beams or supporting hatch covers are to be obtained in the same manner as deck girders (3-2-8/5.3 and 3-2-8/5.9). Such girders along lower deck hatches under trunks in which covers are omitted are to be increased in proportion to the extra load which may be required to be carried due to the loading up into the trunks. The structure on which the hatch covers are seated is to be effectively supported.

Where deep coamings are fitted above decks, such as at weather decks, the girder below deck may be modified so as to obtain a section modulus, in cm^3 (in^3), when taken in conjunction with the coaming up to and including the horizontal coaming stiffener, of not less than 35% more than the required girder value as derived from 3-2-8/5.3. Where hatch side girders are not continuous under deck beyond the hatchways to the bulkheads, brackets extending for at least two frame spaces beyond the ends of the hatchways are to be fitted.

Where hatch side girders are continuous beyond the hatchways, care is to be taken in proportioning their scantlings beyond the hatchway. Gusset plates are to be fitted at hatchway corners arranged so as to tie effectively the flanges of the side coamings and extension pieces or continuous girders and the hatch-end beam flanges both beyond and in the hatchway.

5.13 Container Loading

Where it is intended to carry containers, the structure is to comply with 3-2-8/1.7.

5.15 End Attachments

End attachments of deck girders are to be effectively attached by welding.

7 Higher-strength Materials

7.1 General

In general, applications of higher-strength materials for deck beams, girders and transverses are to meet the requirements of this Section, but may be modified as permitted as permitted by the following Paragraph. Calculations are to be submitted to show adequate provision against buckling. Longitudinal members are to be of essentially the same material as the plating they support.

7.3 Beams, Girders and Transverses of Higher-strength Materials

Each beam, girder and transverse of higher-strength material, in association with the higher-strength plating to which it is attached, is generally to comply with the requirements of the appropriate preceding Paragraphs of this Section and is to have a section modulus SM_{hts} not less than obtained from the following equation.

$$SM_{hts} = SM(Q)$$

where

SM = required section modulus in ordinary-strength material as determined elsewhere in this Section

Q = as defined in 3-2-1/9.5

PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 9 Watertight Bulkheads and Flats

1 General

Watertight bulkheads and flats are to be in accordance with this Section. In all cases, the plans submitted are to clearly indicate the location and extent of the watertight bulkheads and flats.

For ship shaped and barge shaped liftboats the watertight bulkheads are to comply with the applicable requirements of Section 3-2-7 of the *ABS Rules for Building and Classing Steel Vessels Under 90 meters in Length (Under 90m Rules)* or Section 3-2-6 of the *ABS Rules for Building and Classing Steel Barges (Barge Rules)*.

3 Arrangement of Watertight Bulkheads

3.1 Collision Bulkhead

3.1.1 General

A collision bulkhead is to be fitted on all liftboats as required by the appropriate Rule reference in 3-2-9/1. In no case is the collision bulkhead to be located at a distance less than 1.5 m (5 ft) abaft the point at which the forward end of the freeboard length is measured. See 3-3-1/1.3.2.

3.3 Engine Room

The engine room is to be enclosed by watertight bulkheads extending to the freeboard deck.

3.5 Chain Lockers (2012)

For liftboats with length L (as defined in 3-1-1/1.1.1) greater than 24 meters (79 feet), chain lockers and chain pipes, where fitted, are to be made watertight up to the weather deck. The arrangements are to be such that accidental flooding of the chain locker cannot result in damage to auxiliaries or equipment necessary for the proper operation of the liftboat nor in successive flooding into other spaces. Bulkheads between separate chain lockers not forming a part of subdivision bulkhead (* see 3-2-9/Figure 1A below), or bulkheads which form a common boundary of chain lockers (see 3-2-9/Figure 1B below), need not be watertight.

Where means of access into chain lockers are provided, they are to be closed by a substantial cover secured by closely spaced bolts. Doors are not permitted.

Where a means of access to chain lockers is located below the weather deck, the access cover and its securing arrangements are to be in accordance with recognized standards (such as ISO 5894-1999), or equivalent for watertight manhole covers. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

For closure of chain pipes, see 3-2-11/7.11.

The arrangements on liftboats that are not subject to the International Convention on Load Lines or its Protocol may be specially considered.

FIGURE 1A (2007)

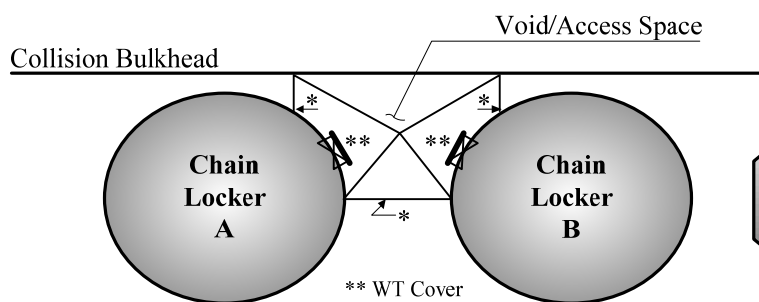
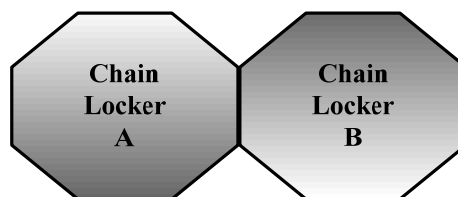


FIGURE 1B (2007)



5 Construction of Watertight Bulkheads

5.1 Plating

Watertight bulkhead plating thickness is to be obtained from the following equation:

$$t = sk\sqrt{qh}/c + 15 \text{ mm} \quad \text{but not less than 6 mm or } s/200 + 2.5 \text{ mm}$$

$$t = sk\sqrt{qh}/c + 0.06 \text{ in.} \quad \text{but not less than 0.24 in. or } s/200 + 0.10 \text{ in.}$$

where

- t = thickness, in mm (in.)
- s = spacing of stiffeners, in mm (in.)
- k = $(3.075\sqrt{\alpha} - 2.077)/(\alpha + 0.272)$ ($1 \leq \alpha \leq 2$)
= 1.0 ($\alpha > 2$)
- α = aspect ratio of the panel (longer edge/shorter edge)
- q = $235/Y$ (N/mm²), $24/Y$ (kgf/mm²) or $34,000/Y$ (psi)
- Y = specified minimum yield point or yield strength, in N/mm² (kgf/mm², psi), as defined in 2-3-1/13 of the *ABS Rules for Materials and Welding (Part 2)* for the higher strength material or 72% of the specified minimum tensile strength, whichever is less
- h = distance from the lower edge of the plate to the bulkhead deck at center, in m (ft)
- c = 290 (525)

For liftboats under 30.5 m (100 ft) in length, the following deductions may be made to the thickness obtained from the above equation for mild steel only.

L meters	Deduction mm	L feet	Deduction in.
24.40 to 30.50	0.25	80 to 100	0.01
21.35 to 24.40	0.50	70 to 80	0.02
18.30 to 21.35	0.75	60 to 70	0.03
Under 18.30	1.00	Under 60	0.04

In general, main nontight transverse strength bulkhead plating is to be similar to that required for watertight bulkheads. Other non-tight strength bulkheads plating is to be not less than $S/150$, or 4 mm (0.16 in.), whichever is greater. The section modulus of non-watertight bulkhead stiffeners is to be not less than one-half of that required by 3-2-9/5.3.

5.3 Stiffeners

The section modulus, SM , of each bulkhead stiffener in association with the plating to which it is attached is to be not less than obtained from the following equation:

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

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

where

c	=	0.30	for a stiffener with effective brackets of arm length not less than $\ell/8$ at both ends of its span
	=	0.43	for a stiffener with an effective bracket of arm length not less than $\ell/8$ at one end and a clip connection or horizontal girder at the other end
	=	0.56	for a stiffener with clip connections at both ends or a clip connection at one end and a horizontal girder at the other end
	=	0.60	for a stiffener between horizontal girders or for a stiffener with no end attachments.
h	=	distance from the middle of ℓ to the bulkhead deck at center, in m (ft). Where this distance is less than 6.10 m (20 ft), h is to be taken as 0.8 times the distance plus 1.22 m (4 ft).	
s	=	spacing of stiffeners, in m (ft)	
ℓ	=	distance, in m (ft), between the heels of the end attachments. Where horizontal girders are fitted, ℓ is the distance from the heel of the end attachment to the first girder, or the distance between the horizontal girders	

In liftboats under 46 meters (150 ft) in length, the above values for c may be 0.29, 0.38, 0.46 and 0.58 respectively, and h may be taken as the distance in meters or in feet from the middle of ℓ to the bulkhead deck at center in every case. For liftboats between 46 and 65.5 meters (150 and 215 feet) intermediate values for c may be obtained by interpolation.

An effective bracket for the application of these values of c is to have scantlings not less than shown in 3-2-3/Table 1 and is to extend onto the stiffener for a distance at least one-eighth of the length ℓ of the stiffener.

5.5 Girders and Webs

Each horizontal girder or vertical web supporting bulkhead stiffeners is to have a section modulus, SM , not less than obtained from the following equation:

$$SM = 4.74chs\ell^2 \quad \text{cm}^3$$

$$SM = 0.0025chs\ell^2 \quad \text{in}^3$$

where

c	=	1.0
h	=	vertical distance, in m (ft), to the bulkhead deck at center from the middle of s in the case of a horizontal girder or from the middle of ℓ in the case of a vertical web. Where this distance is less than 6.10 m (20 ft), h is to be taken as 0.8 times the distance plus 1.22 m (4 ft).
s	=	sum of half lengths, in m (ft) (on each side of the girder or web), of the stiffeners supported by the girder or web
ℓ	=	unsupported span of girder or web, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 the length ℓ may be measured as permitted therein

The depth of a girder or web is not to be less than twice the depth of the cutout unless effective compensation is provided for stiffener cutouts. Tripping brackets are to be fitted at intervals of about 3 m (10 ft), and stiffeners are to be fitted as may be required.

Lower brackets to inner bottoms are to extend over the floor adjacent to the bulkhead. Where stiffeners cross horizontal girders, they are to be effectively attached.

5.7 Corrugated Bulkheads

5.7.1 Plating

The plating of corrugated bulkheads is to be of the thickness required by 3-2-9/5.1 with the following modification. The spacing to be used is the greater of dimensions a or c as indicated in 3-2-9/Figure 2. The angle ϕ is to be 45 degrees or more.

5.7.2 Stiffeners

The section modulus, SM , for a corrugated bulkhead is to be not less than obtained from the following equation:

$$SM = 7.8chs\ell^2 \text{ cm}^3$$

$$SM = 0.0041chs\ell^2 \text{ in}^3$$

where

- ℓ = distance between supporting members, in m (ft)
- s = value determined from 3-2-9/5.3 using $a + b$ (3-2-9/Figure 2)
- c = 0.56
- h = as defined in 3-2-9/5.3

The developed section modulus SM may be obtained from the following equation, where a , t , and d are as indicated in 3-2-9/Figure 2:

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

5.7.3 End Connections

The structural arrangements and size of welding at the ends of corrugations are to be designed to develop the required strength of corrugation stiffeners. Joints within 10% of the depth of corrugation from the outer surface of corrugation, d_1 , are to have double continuous welds with fillet size w not less than 0.7 times the thickness of the bulkhead plating or penetration welds of equal strength (3-2-9/Figure 3). See also 3-2-15/3.

FIGURE 2
Corrugated Bulkhead

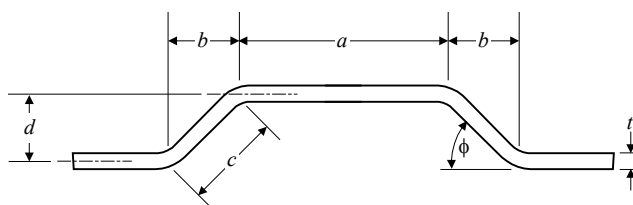
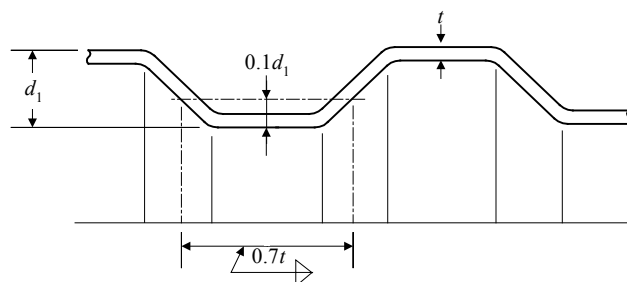


FIGURE 3
Corrugated Bulkhead End Connections



7 Testing of Watertight Doors at Manufacturer (2014)

Watertight doors are to be tested for operation at the manufacturer's plant. Hydrostatic testing of doors is also to be carried out 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 liftboat, to:

- i) The bulkhead deck or freeboard deck, as applicable, or
- ii) The most unfavorable damage waterplane, if that be greater

CHAPTER 2 Hull Structures and Arrangements

SECTION 10 Tank Bulkheads and Flats

1 General Arrangement

The arrangement of all deep tanks, their intended service, and the heights of the overflow pipes are to be indicated clearly on the drawings submitted for approval. Tanks forward of the collision bulkhead are not to be arranged for the carriage of oil or other flammable or combustible substances.

3 Construction

Boundary bulkheads and tight divisions of all deep tanks are to be constructed in accordance with the requirements of this Section where they exceed those of Section 3-2-9. Where the specific gravity of the liquid exceeds 1.05, the design head, h , in this Section is to be increased by the ratio of the specific gravity to 1.05.

5 Construction of Deep-tank Bulkheads

5.1 Plating

The minimum thickness of deep-tank boundary bulkheads and tight divisions is to be obtained from the following equation.

$$t = (sk\sqrt{qh}/254) + 2.5 \text{ mm} \quad \text{but not less than } 6.5 \text{ mm or } s/150 + 2.5 \text{ mm, whichever is greater}$$

$$t = (sk\sqrt{qh}/460) + 0.10 \text{ in.} \quad \text{but not less than } 0.25 \text{ in. or } s/150 + 0.10 \text{ in., whichever is greater}$$

where

t = thickness, in mm (in.)

s = stiffener spacing, in mm (in.)

k = $(3.075\sqrt{\alpha} - 2.077)/(\alpha + 0.272)$ $(1 \leq \alpha \leq 2)$

= 1.0 $(\alpha > 2)$

α = aspect ratio of the panel (longer edge/shorter edge)

q = $235/Y$ N/mm² ($24/Y$ kgf/mm², $34,000/Y$ psi)

Y = as defined in 3-2-9/5.1

h = the greatest of the following distances, in m (ft), from the lower edge of the plate to:

- A point located at two-thirds of the distance to the bulkhead or freeboard deck, or
- A point located at two-thirds the distance from the top of the tank to the top of the overflow, or
- The load line, or
- A point located above the top of the tank not less than the greater of the following:
 - $0.01L + 0.15$ m (0.5 ft) where L is as defined in 3-1-1/1.1.1, or 0.46 m (1.5 ft)

5.3 Stiffeners

The section modulus, SM , of each deep-tank stiffener in association with the plating to which it is attached is not to be 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	=	0.595	for stiffeners having effective bracket of arm length not less than $\ell/8$ attachments at both ends
	=	0.747	for stiffeners having effective bracket of arm length not less than $\ell/8$ attachments at one end and clip connections or horizontal girders at the other end
	=	0.90	for stiffeners having clip connections at both ends or having such attachments at one end and horizontal girders at the other end
	=	1.00	for stiffeners having horizontal girders at both ends
ℓ	=	distance, in m (ft), between the heels of the end attachments. Where horizontal girders are fitted, ℓ is the distance from the heel of the end attachment to the first girder or the distance between the horizontal girders	
s	=	stiffener spacing, in m (ft)	
h	=	the greatest of the following distances, in m (ft), from the middle of ℓ to:	
		• A point located at two-thirds of the distance from the middle of ℓ to the bulkhead or freeboard deck, or • A point located at two-thirds of the distance from the top of the tank to the top of the overflow, or • The load line, or • A point located above the top of the tank not less than the greater of the following: • $0.01L + 0.15$ m (0.5 ft) where L is the length of a liftboat as defined in 3-1-1/1.1.1, or 0.46 m (1.5 ft)	

An effective bracket for the application of these values of c is to have scantlings not less than shown in 3-2-3/Table 1 and is to extend onto the stiffener for a distance at least one-eighth of the length ℓ of the stiffener.

5.5 Corrugated Bulkheads

Where corrugated bulkheads are used as deep-tank boundaries, the scantlings may be developed from 3-2-9/5.7. The plating thickness t and value of SM are to be as required by 3-2-10/5.1 and 3-2-10/5.3, respectively, with $c = 0.90$.

5.7 Girders and Webs

Horizontal girders or vertical webs supporting bulkhead stiffeners in deep tanks are to have a section modulus as required by this Paragraph. Girders or webs supporting frames or beams in deep tanks are to have section modulus as required by Sections 3-2-7 and 3-2-8, respectively, or as required by this Paragraph, whichever is the greater. The section modulus, SM , of each girder or web is not to be less than obtained from the following equation:

$$SM = 4.74chs\ell^2 \quad \text{cm}^3 \qquad SM = 0.0025chs\ell^2 \quad \text{in}^3$$

where

c	=	1.5
h	=	vertical distance, in m (ft), from the middle of s in the case of a girder or from the middle of ℓ in the case of a web to the same heights to which h for the stiffeners is measured (see 3-2-10/5.3)

s = sum of half lengths (on each side of the girder or web), in m (ft), of the frames or stiffeners supported by the girder or web

ℓ = unsupported length of girder or web, in m (ft). Where brackets are fitted in accordance with 3-2-3/3.3 the length ℓ may be measured as permitted therein

The depth of a girder or web is not to be less than 2.5 times the depth of the cutout unless effective compensation is provided for stiffener cutouts. The thickness is to be not less than 1 mm per 100 millimeters (0.01 in. per inch) of depth plus 3 mm (0.12 in.). Tripping brackets are to be fitted at intervals of about 3 m (10 ft) and stiffeners are to be fitted as may be required.

7 Tank Top Plating

Tops of tanks are to have plating 1 mm (0.04 in.) thicker than would be required for vertical plating at the same level; the thickness is not to be less than required for deck plating. Beams, girders and pillars are to be as required by Section 3-2-8.

9 Higher-strength Materials

9.1 General

In general, applications of higher-strength materials for deep-tank plating are to meet the requirements of this Section, but may be modified as permitted by the following Paragraphs. Calculations are to be submitted to show adequate provision to resist buckling.

9.3 Plating

Deep-tank plating of higher-strength material is to be of not less thickness than obtained by 3-2-10/5.1.

9.5 Stiffeners

Each stiffener of higher-strength material, in association with the higher-strength plating to which it is attached, is to have section modulus, SM_{hts} , not less than obtained from the following equation:

$$SM_{hts} = 7.8chs\ell^2Q \text{ cm}^3$$

$$SM_{hts} = 0.0041chs\ell^2Q \text{ in}^3$$

c , h , s , and ℓ are as defined in 3-2-10/5.3 and Q is as defined in 3-2-1/9.5.

11 Drainage and Air Escape

Limber and air holes are to be cut as required in nontight parts of the tanks to ensure the free flow of liquids to the suction pipes and the escape of air to the vents. Arrangements are to be made for draining the tops of the tanks.

13 Testing

Requirements for testing are contained in Section 3-6-1.

PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 11 Superstructures and Deckhouses and Protection of Deck Openings

1 Superstructures and Deckhouses

Superstructures and deckhouses are to be constructed in accordance with the *Under 90m Rules* except as modified herein. For materials of deckhouses other than steel, see 3-2-3/1.1.

1.1 Deckhouses

1.1.1 Design Head

The design head for side and end bulkhead plating and stiffeners of deckhouses on the freeboard deck is to be obtained from the following:

$$h = c h_b$$

where

h	=	design head, in m (ft)
h_b	=	$0.133L - 3.0$ m
	=	$0.133L - 9.8$ ft
		but not to be less than 2.8 m (9.2 ft)
c	=	1.0 for front bulkheads
	=	0.6 for aft bulkheads
	=	See 3-2-11/1.1.4 for side bulkheads
L	=	length of the liftboat, in m (ft), as defined in 3-1-1/1.1.1

1.1.2 Plating

The plating thickness is not to be less than obtained from the following equation:

$$t = 3s\sqrt{h} \text{ mm} \qquad t = s\sqrt{h}/50 \text{ in.}$$

In no case is the plate thickness to be less than $5.0 + 0.01L$ mm ($0.2 + 0.00012L$ in.).

where

s	=	spacing of stiffeners, in m (ft)
h	=	design head, as defined in 3-2-11/1.1.1
L	=	length of the liftboat, in m (ft), as defined in 3-1-1/1.1.1

1.1.3 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:

$$SM = 3.5sh\ell^2 \text{ cm}^3 \qquad SM = 0.00185sh\ell^2 \text{ in}^3$$

where

$$\begin{aligned} s &= \text{spacing of stiffeners, in m (ft)} \\ h &= \text{design head, as defined in 3-2-11/1.1.1} \\ \ell &= \text{tween deck height, in m (ft)} \end{aligned}$$

1.1.4 House Sides

Side bulkheads of houses are generally to have scantlings based on the requirements for after bulkheads of houses. Where they are close to the side shell of the liftboat, they may be required to conform to the requirements of bulkheads of unprotected house fronts.

1.1.5 End Attachment

Both ends of the webs of lowest tier bulkheads stiffeners are to be efficiently attached.

1.1.6 Racking Resistance

Partial bulkheads, deep webs, etc. are to be fitted at the sides and ends of large deckhouses to provide resistance to racking.

3 Interior Accommodation Decks

The following sections give requirements for the plating and stiffeners for internal deckhouse accommodation decks that are located above the main deck.

3.1 Plating

3.1.1 General

The thickness of deck or platform plating is not to be less than that required for the purposes of overall strength of the deckhouse, and for local loading.

3.1.2 Accommodation Decks

The thickness of the deck plating in crew spaces is to be adequate for the intended service and is not to be less than that obtained from the following equation:

$$t = K s \sqrt{h} + a \text{ mm (in.)} \qquad \text{but not less than 4.6 mm (0.18 in.)}$$

where

$$\begin{aligned} s &= \text{spacing of deck plating, in mm (in.)} \\ K &= 0.0039 \text{ (0.00218)} \\ a &= 2.5 \text{ mm (0.10 in.)} \\ h &= \text{as specified in 3-1-2/1.11} \end{aligned}$$

3.3 Beams

Each 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:

$$SM = nchs\ell^2 \text{ cm}^3 \text{ (in}^3\text{)}$$

where

$$\begin{aligned} n &= 7.8 \text{ (0.0041)} \\ c &= 0.6 \text{ for beams clear of tanks} \end{aligned}$$

- h = as specified in 3-1-2/1.11
 s = spacing of beams, in m (ft)
 ℓ = length, in m (ft), from the inner edge of the beam knee to the nearest line of girder support, or between girder supports, whichever is greater.

3.5 Girders

3.5.1 Strength Requirements

Each deck or platform girder clear of tanks is to have a section modulus SM not less than obtained from the following equation:

$$SM = nchb\ell^2 \quad \text{cm}^3 \text{ (in}^3\text{)}$$

where

- n = 4.74 (0.0025)
 c = 1.0
 h = height, in m (ft), as required by 3-2-11/3.3
 b = mean breadth of the area of the deck supported
 ℓ = length, unsupported span, in m (ft). Where 45° brackets are fitted at the bulkhead in accordance with 3-2-3/Table 1, the length ℓ may be measured as shown in 3-2-3/Figure 2.

3.5.2 Proportions

Girders on accommodation decks are to have a depth not less than 0.0583ℓ m (ft) and in general the depth of girders clear of tanks is not to be less than twice the depth of the cutouts for beams and stiffeners. The thickness is not to be less than 1 percent of depth plus 3 mm (0.12 in.) but need not exceed 11 mm (0.44 in.) provided adequate sheer area is maintained as necessary.

3.5.3 Tripping Brackets

Girders are to be supported by tripping brackets at intervals of about 3 m (10 ft), and where the width of the unsupported face plate exceeds 200 mm (8 in.), the tripping brackets are to support to face plate.

5 Helicopter Decks

5.1 General

Helicopter landing facilities, where provided, are to meet the following structural and safety requirements. The attention of owners, builders and designers is directed to various international and governmental regulations and guides regarding the operational and other design requirements for helicopters landing on vessels. See also Section 1-1-5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* and 4-5-7/1. Plans showing the arrangement, scantlings, and details of the helicopter deck are to be submitted. The arrangement plan is to show the overall size of the helicopter deck and the designated landing area. If the arrangement provides for the securing of a helicopter or helicopters to the deck, the predetermined position(s) selected to accommodate the secured helicopter, in addition to the locations of deck fittings for securing the helicopter, are to be shown. The type of helicopter to be considered is to be specified and calculations for appropriate loading conditions are to be submitted.

TABLE 1
Allowable Factors of Safety Based on Y for Helicopter Decks

Y = specified minimum yield point or yield strength of the material

	<i>Plating</i>	<i>Beams</i>	<i>Girders, Stanchions Truss Supports, etc. (See Note 3)</i>
Overall Distributed Loading	1.67	1.67	1.67
Helicopter Landing Impact Loading	(See Note 1) 1.00 ⁽²⁾	1.00	1.10
Stowed Helicopter Loading	1.00	1.10	1.25

Notes:

- 1 The minimum plate thickness t is generally not to be less than obtained from the following:

<i>Beam Spacing</i>	<i>t</i>	<i>Beam Spacing</i>	<i>t</i>
460 mm	4.0 mm	18 in.	0.16 in.
610 mm	5.0 mm	24 in.	0.20 in.
760 mm	6.0 mm	30 in.	0.24 in.

- 2 Alternatively, ultimate state limit methods may be considered.
- 3 For members subjected to axial compression, the factor of safety is to be based on the yield stress or critical buckling stress, whichever is less.

5.3 Structure

Scantlings of helicopter decks and supporting structure are to be determined on the basis of the following loading conditions, whichever is greater, in association with the allowable factors of safety shown in 3-2-11/Table 1. Plastic design considerations may be applied for deck plating and stiffeners.

5.3.1 Overall Distributed Loading

A minimum distributed loading of 2010 N/m² (205 kgf/m², 42 lbf/ft²) is to be taken over the entire helicopter deck.

5.3.2 Helicopter Landing Impact Loading

A load of not less than 75% of the helicopter maximum take-off weight is to be taken on each of two square areas, 0.3 m × 0.3 m (1 ft × 1 ft). Alternatively, the manufacturer's recommended wheel impact loading will be considered. The deck is to be considered for helicopter landings at any location within the designated landing area. The structural weight of the helicopter deck is to be added to the helicopter impact loading when considering girders, stanchions, truss supports, etc. Where the upper deck of a superstructure or deckhouse is used as a helicopter deck and the spaces below are normally manned (quarters, bridge, control room, etc.) the impact loading is to be multiplied by a factor of 1.15.

5.3.3 Stowed Helicopter Loading

If provisions are made to accommodate helicopters secured to the deck in a predetermined position, the structure is to be considered for a local loading equal to the manufacturer's recommended wheel loadings at maximum take-off weight, multiplied by a dynamic amplification factor based on the predicted motions of the liftboat for this condition, as may be applicable for the liftboat under consideration.

In addition to the helicopter load, a uniformly distributed loading of 490 N/m² (50 kgf/m², 10.5 lbf/ft²), representing wet snow or ice, is to be considered, if applicable. For the girders, stanchions, truss supports, etc., the structural weight of the helicopter deck is also to be considered.

5.3.4 Loading due to Motions of Liftboat

The structure supporting helicopter decks is to withstand the loads resulting from the motions of the liftboat.

5.3.5 Special Landing Gear

Helicopters fitted with landing gear other than wheels will be specially considered.

5.3.6 Environmental Loading

Calculations are to consider anticipated wind and wave impact loadings on helicopter decks and their supporting structures.

5.5 Safety Net

The unprotected perimeter of the helicopter landing deck is to be provided with safety netting or equivalent.

5.7 Aluminum Decks

Aluminum may be used for helicopter decks above deckhouses provided the following conditions are complied with:

- i) There are to be no openings in the exterior bulkheads directly below the helicopter decks.
- ii) All windows in the lower exterior bulkheads are to be fitted with steel shutters.

7 Protection of Deck Openings

All openings in decks are to be framed to provide efficient support and attachment for the ends of the deck beams. The proposed arrangement and details for all hatchways are to be submitted for approval. Where cargo hatches are fitted, their coamings and covers are to be constructed in accordance with the *Under 90m Rules*.

7.1 Positions of Deck Openings

For the purpose of the Guide, two positions of deck openings are defined as follows.

Position 1: Upon exposed freeboard and raised quarter decks, and upon exposed superstructure decks situated forward of a point located $L/4$ from the forward end of L .

Position 2: Upon exposed superstructure decks situated abaft $L/4$ from the forward end of L .

7.3 Miscellaneous Openings in Freeboard and Superstructure Decks

7.3.1 Manholes and Scuttles

Manholes and flush scuttles in Position 1 or 2 or within superstructures other than enclosed superstructures are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

7.3.2 Other Openings

Openings in freeboard decks other than hatchways, machinery space openings, manholes and flush scuttles are to be protected by an enclosed superstructure, or by a deckhouse or companionway of equivalent strength and weathertightness. Any such opening in an exposed superstructure deck or in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or a space within an enclosed superstructure is to be protected by an efficient deckhouse or companionway. Doorways in such deckhouses or companionways are to be fitted with doors complying with the requirements of 3-2-11/7.7.

7.3.3 Escape Openings (1 July 2012)

- i) The closing appliances of escape openings are to be of a type that is operable from each side.
- ii) The maximum force needed to open the hatch cover is not to exceed 150 N (15.3 kgf, 33.7 lbf).
- iii) The use of a spring equalizing, counterbalance or other suitable device on the hinge side to reduce the force needed for opening is acceptable.

7.3.4 Chain Pipe Opening (1 July 2012)

For liftboats with length L (as defined in 3-1-1/1.1.1) greater than 24 meters (79 feet), chain pipes through which anchor cables are led are to be provided with permanently attached closing appliances to minimize the ingress of water. A canvas cover with appropriate lashing arrangement will be acceptable* for this purpose. A cement and wire mesh arrangement is not permitted.

The arrangement on liftboats that are not subject to the International Convention on Load Lines or its Protocol may be specially considered.

* *Note:* Examples of acceptable arrangements are such as:

- i) Steel plates with cutouts to accommodate chain links or
- ii) Canvas hoods with a lashing arrangement that maintains the cover in the secured position.

7.5 Companionway Sills

In Position 1 the height above the deck of sills to the doorways in companionways is to be at least 600 mm (23.5 in.). In Position 2 they are to be at least 380 mm (15 in.).

7.7 Doors for Access Openings

Doors for access openings into enclosed superstructures and deckhouses are to be of steel or other equivalent material, permanently and strongly attached to the bulkhead. The doors are to be provided with gaskets and clamping devices, or other equivalent arrangements, permanently attached to the bulkhead or to the doors themselves, and the doors are to be so arranged that they can be operated from both sides of the bulkhead.

7.9 Sills of Access Openings

Except as otherwise provided in this Guide, the height of the sills of access openings in bulkheads at the ends of enclosed superstructures and deckhouses is to be at least 380 mm (15 in.) above the deck.

7.11 Small Hatches on the Exposed Fore Deck (2004)

7.11.1 Application

This Paragraph is applicable to liftboats with length L (as defined in 3-1-1/1.1.1) greater than 80 meters (263 feet).

The requirements of this Paragraph apply to all small hatches [opening normally 2.5 m² (27 ft²) or less] located on the exposed fore deck within the forward $0.25L$, where the deck in way of the hatch is less than $0.1L$ or 22 m (72.2 ft) above the summer load line, whichever is less.

Hatches designed for emergency escape need not comply with 3-2-11/7.11.3i), 3-2-11/7.11.3ii), the third paragraph of 3-2-11/7.11.4 and 3-2-11/7.11.5.

7.11.2 Strength

For small rectangular steel hatch covers, the plate thickness, stiffener arrangement and scantlings are to be in accordance with 3-2-11/Table 2 and 3-2-11/Figure 1. Stiffeners, where fitted, are to be aligned with the metal-to-metal contact points required in 3-2-11/7.11.4 (see also 3-2-11/Figure 1). Primary stiffeners are to be continuous. All stiffeners are to be welded to the inner edge stiffener (see 3-2-11/Figure 2).

The upper edge of the hatchway coaming is to be suitably reinforced by a horizontal section, normally not more than 170 to 190 mm (6.9 to 7.5 in.) from the upper edge of the coaming.

For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement is to provide strength and stiffness equivalent to the requirements for small rectangular hatches.

For small hatch covers constructed of materials other than steel, the required scantlings are to provide strength and stiffness equivalent to 235 N/mm² (24 kgf/mm², 34,000 psi) yield strength steel.

7.11.3 Primary Securing Devices

The primary securing devices are to be such that their hatch covers can be secured in place and made weathertight by means of a mechanism employing any one of the following methods:

- i) Butterfly nuts tightening onto forks (clamps), or
- ii) Quick acting cleats, or
- iii) A central locking device.

Dogs (twist tightening handles) with wedges are not acceptable.

7.11.4 Requirements for Primary Securing

The hatch cover is to be fitted with a gasket of elastic material. This is to be designed to allow a metal-to-metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The metal-to-metal contacts are to be arranged close to each securing device in accordance with 3-2-11/Figure 1, and of sufficient capacity to withstand the bearing force.

The primary securing method is to be designed and manufactured such that the designed compression pressure is achieved by one person without the need of any tools.

For a primary securing method using butterfly nuts, the forks (clamps) are to be of robust design. They are to be designed to minimize the risk of butterfly nuts being dislodged while in use; by means of curving the forks upward and a raised surface on the free end, or a similar method. The plate thickness of unstiffened steel forks is not to be less than 16 mm ($\frac{5}{8}$ in.). An example arrangement is shown in 3-2-12/Figure 2.

For small hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges are to be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

On small hatches located between the main hatches, for example between Nos. 1 and 2, the hinges are to be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

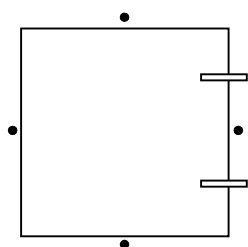
7.11.5 Secondary Devices

Small hatches on the fore deck are to be fitted with an independent secondary securing device e.g., by means of a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It is to be fitted on the side opposite to the hatch cover hinges.

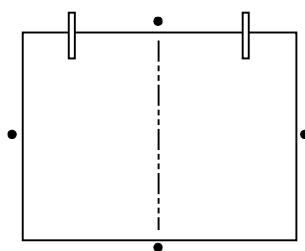
TABLE 2
Scantlings for Small Steel Hatch Covers on the Fore Deck (2004)

Nominal Size (mm × mm)	Cover Plate Thickness (mm)	Primary Stiffeners	Secondary Stiffeners
		Flat Bar (mm × mm); number	
630 × 630	8	---	---
630 × 830	8	100 × 8; 1	---
830 × 630	8	100 × 8; 1	---
830 × 830	8	100 × 10; 1	---
1030 × 1030	8	120 × 12; 1	80 × 8; 2
1330 × 1330	8	150 × 12; 2	100 × 10; 2

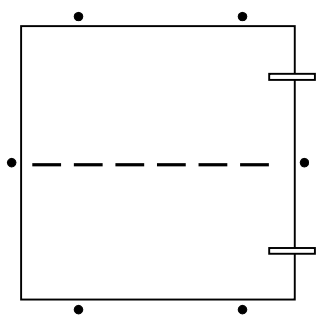
FIGURE 1
Arrangement of Stiffeners (2004)



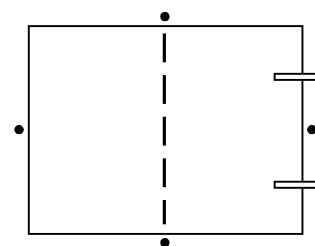
Nominal size 630 × 630



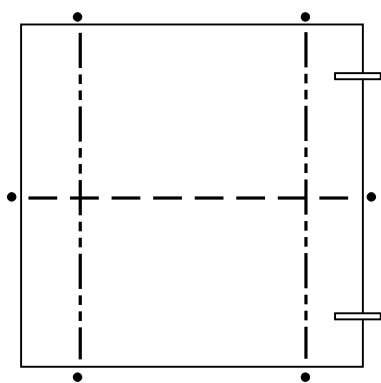
Nominal size 630 × 830



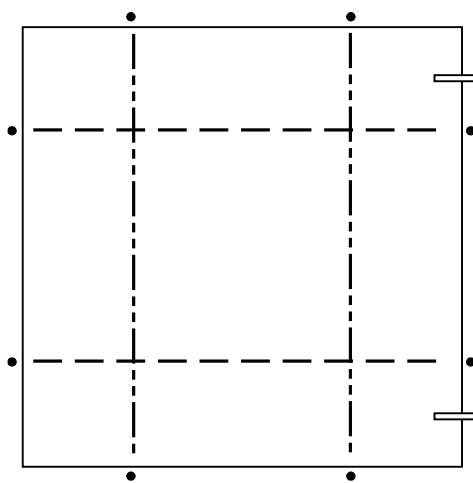
Nominal size 830 × 830



Nominal size 830 × 630



Nominal size 1030 × 1030



Nominal size 1330 × 1330

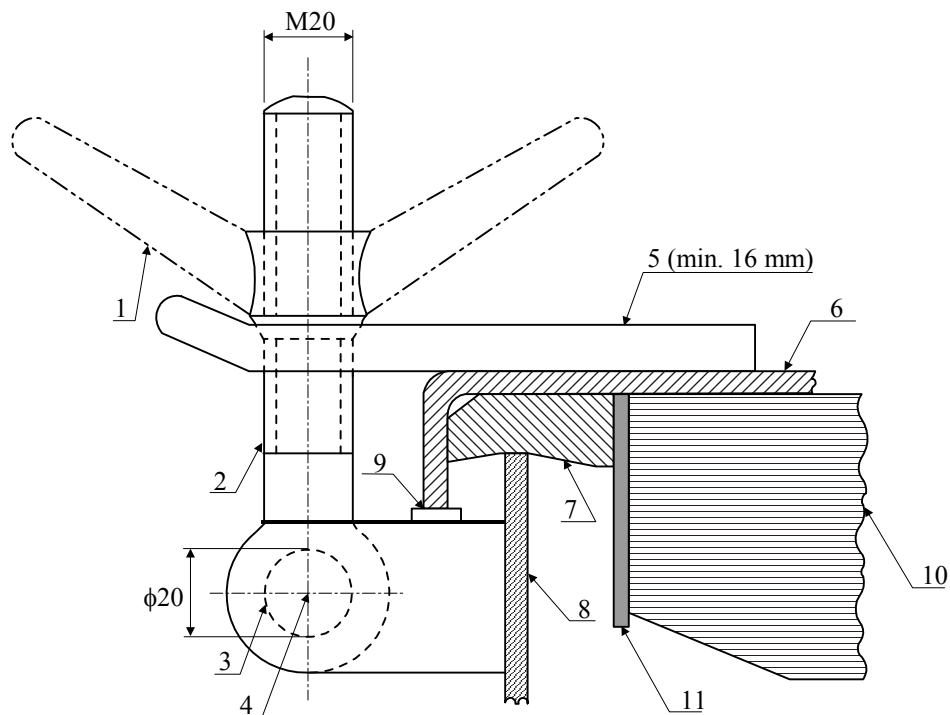
— Hinge

• Securing device/metal to metal contact

— — — Primary stiffener

----- Secondary stiffener

FIGURE 2
Example of Primary Securing Method (2004)



- (Note: Dimensions in millimeters)
- 1: butterfly nut
 - 2: bolt
 - 3: pin
 - 4: center of pin
 - 5: fork (clamp) plate
 - 6: hatch cover
 - 7: gasket
 - 8: hatch coaming
 - 9: bearing pad welded on the bracket of a toggle bolt for metal to metal contact
 - 10: stiffener
 - 11: inner edge stiffener

CHAPTER 2 Hull Structures and Arrangements

SECTION 12 Keels, Stems, Stern Frames, Shaft Struts, and Propeller Nozzles

1 Keels

1.1 Bar Keels

Bar keels are to have thicknesses and depths not less than obtained from the following equations:

$$t = 0.625L + 12.5 \text{ mm}$$

$$t = 0.0075L + 0.50 \text{ in.}$$

$$h = 1.46L + 100 \text{ mm}$$

$$h = 0.0175L + 4 \text{ in.}$$

where

$$t = \text{thickness, in mm (in.)}$$

$$h = \text{depth, in mm (in.)}$$

$$L = \text{length of liftboat, in m (ft), as defined in 3-1-1/1.1.1}$$

Thicknesses and widths other than given above are acceptable provided the section moduli and moments of inertia about the transverse horizontal axis are not less than given above, nor is h/t more than 4.5.

1.3 Plate Keels

The thickness of the plate keel throughout the length of the liftboat is to be not less than the bottom shell required in 3-2-4/3.3.

3 Stems

3.1 Bar Stems

Bar stems are to have thicknesses and widths not less than obtained from the following equations:

$$t = 0.625L + 6.35 \text{ mm}$$

$$t = 0.0075L + 0.25 \text{ in.}$$

$$w = 1.25L + 90 \text{ mm}$$

$$w = 0.015L + 3.5 \text{ in.}$$

where

$$t = \text{thickness, in mm (in.)}$$

$$w = \text{width, in mm (in.)}$$

$$L = \text{length of liftboat, in m (ft), as defined in 3-1-1/1.1.1}$$

This thickness and width is to be maintained between the keel and design load waterline. Above the designed load waterline they may be gradually reduced until the area at the head is 70% of that obtained from the equations.

Thicknesses and widths other than given above are acceptable provided the section moduli and moments of inertia about the longitudinal axis are not less than above, nor w/t more than 5.5. The thickness of the bar stem in general should also not be less than twice the shell thickness.

3.3 Cast or Forged Stems

Cast or forged stems of special shape are to be proportioned to provide strengths at least equivalent to those of bar stems as obtained in 3-2-12/3.1, and all joints and connections are to be at least as effective as would be required on equivalent bar stems.

3.5 Plate Stems

Where plate stems are used, they are not to be less in thickness than the bottom shell plating required in 3-2-4/1 and 3-2-4/3, where s is the frame spacing, or 610 mm (24 in.) if greater.

5 Sternposts

5.1 Bar Sternposts

Bar sternposts without propeller bosses are to have thicknesses and widths not less than obtained from the following equations:

$$\begin{aligned} t &= 0.73L + 10 \text{ mm} & t &= 0.0088L + 0.39 \text{ in.} \\ b &= 1.283L + 87.4 \text{ mm} & b &= 0.0154L + 3.44 \text{ in.} \end{aligned}$$

where

$$\begin{aligned} t &= \text{thickness, in mm (in.)} \\ b &= \text{width, in mm (in.)} \\ L &= \text{length of liftboat, in m (ft), as defined in 3-1-1/1.1.1} \end{aligned}$$

Above the bottom shell plating, sternposts may be gradually reduced until the areas at their heads are half the areas obtained from the above equations.

Thickness or width less than given above are acceptable provided the section modulus and moment of inertia about the longitudinal axis are not less than those of a plate having the minimum thickness and width given above, and with b/t not less than 4.0.

5.3 Cast, Forged, or Fabricated Sternposts

Cast, forged, or fabricated sternposts of special shape are to be so proportioned as to provide strengths at least equivalent to those of bar posts as obtained from 3-2-12/5.1, and all joints and connections are to be at least as effective as would be required on equivalent bar posts.

7 Stern Frames

Except as modified in 3-2-12/9, the scantlings of stern frames of single screw liftboats are to be in accordance with the following, as applicable.

7.1 Below the Boss

7.1.1 Fabricated Stern Frame

The thickness t , width w and length ℓ are not to be less than given by the following equations:

$$\begin{aligned} t &= 0.225\sqrt{L} \text{ cm} & t &= 0.049\sqrt{L} \text{ in.} \\ w &= 5\sqrt{L} \text{ cm} & w &= 1.09\sqrt{L} \text{ in.} \\ \ell &= 4\sqrt{L} \text{ cm} & \ell &= 0.87\sqrt{L} \text{ in.} \end{aligned}$$

Widths and lengths other than given above are acceptable provided the section modulus, SM , about the longitudinal axis is not less than:

$$\begin{aligned} SM &= 1.60L^{1.5} \text{ cm}^3 & SM &= 0.0164L^{1.5} \text{ in}^3 \end{aligned}$$

where

- t = thickness of side plating, in cm (in.) (See 3-2-12/Figure 1)
 w = width of stern frame, in cm (in.) (See 3-2-12/Figure 1)
 ℓ = length of stern frame, in cm (in.) (See 3-2-12/Figure 1)
 L = length of liftboat, in m (ft), as defined in 3-1-1/1.1.1

7.1.2 Cast Stern Frame

The thicknesses t_1 , t_2 , width w and length ℓ are not to be less than given by the following equations:

$$t_1 = 0.3\sqrt{L} \text{ cm} \qquad t_1 = 0.065\sqrt{L} \text{ in.}$$

but not less than 2.5 cm (1.0 in.)

$$t_2 = 1.25t_1$$

$$w = 5\sqrt{L} \text{ cm} \qquad w = 1.09\sqrt{L} \text{ in.}$$

$$\ell = 4\sqrt{L} \text{ cm} \qquad \ell = 0.87\sqrt{L} \text{ in.}$$

Widths and lengths other than given above are acceptable provided the section modulus, SM , about the longitudinal axis is not less than:

$$SM = 1.60L^{1.5}K_g \text{ cm}^3 \qquad SM = 0.0164L^{1.5}K_g \text{ in}^3$$

where

- t_1 = thickness of casting at end. (See 3-2-12/Figure 1)
 t_2 = thickness of casting at mid-length (See 3-2-12/Figure 1)
 K_g = material factor defined in 3-2-13/1.3

w , ℓ and L are as defined in 3-2-12/7.1.1.

The thickness in way of butt welding to shell plating may be tapered below t_1 . The length of taper is to be at least three times the offset.

The castings are to be cored out to avoid large masses of thick material likely to contain defects and to maintain a relatively uniform section throughout. Suitable radii are to be provided in way of changes in section.

7.3 Above the Boss

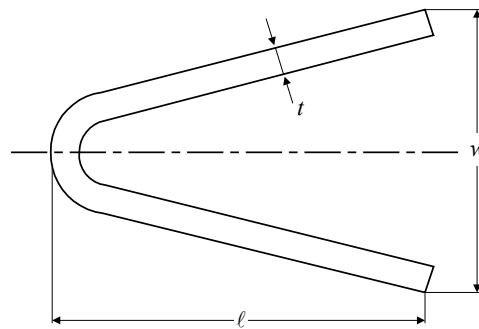
Above the propeller boss, the scantlings are to be in accordance with 3-2-12/7.1 except that in the upper part of the propeller aperture where the hull form is full and centerline supports are provided, the thickness may be reduced to 80% of the requirements in 3-2-12/7.1 subject to the same minimum for cast steel stern frames.

7.5 Secondary Members

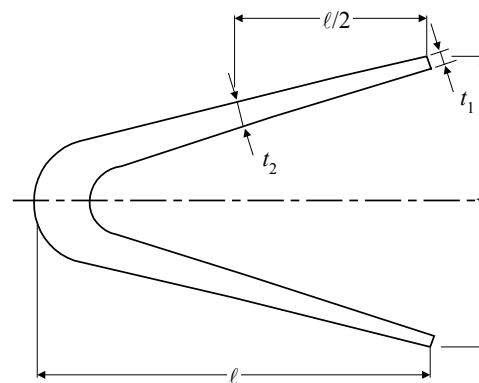
Where round bars are used at the after edge of stern frames, their scantlings and connection details are to be such as to facilitate welding.

Ribs or horizontal brackets of thickness not less than $0.8t$ or $0.8t_1$ are to be provided at suitable intervals, extended forward and attached to the adjacent floor. Where t or t_1 is reduced in accordance with 3-2-12/7.3, a proportionate reduction in the thickness of ribs or horizontal brackets may be made.

FIGURE 1
Stern Frame



a. Fabricated



b. Cast

9 Stern Frames with Shoe Pieces

The scantlings below the boss of stern frames with shoe pieces are to be gradually increased to provide strength and stiffness in proportion to those of the shoe pieces.

11 Shoe Pieces

11.1 General

The shoe piece is to be sloped to avoid pressure from the keel blocks when docking and is to extend at least two frame spaces forward of the forward edge of the propeller boss.

11.3 Design Stress

The equivalent stress σ_e in the shoe piece at any section is not to exceed $115/K_g$ N/mm² ($11.7/K_g$ kgf/mm², 16700/ K_g psi) and is to be obtained from the following equation:

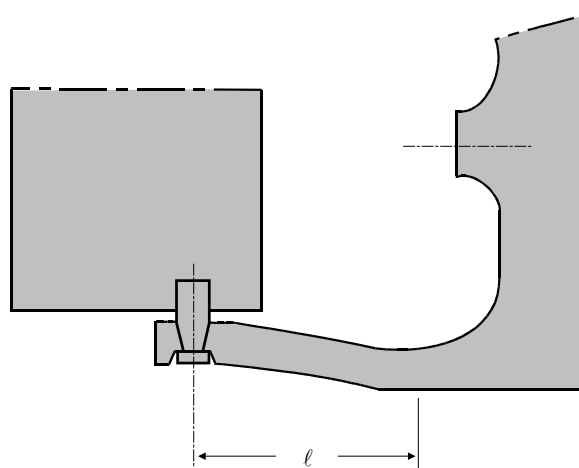
$$\sigma_e = n\sqrt{\sigma_b^2 + 3\tau^2}$$

where

$$\begin{aligned} n &= 1000 \text{ (1000, 2240)} \\ K_g &= K \text{ as defined in 3-2-13/1.3 for castings and forgings} \\ &= 1.0 \text{ for ordinary strength hull steel plate} \end{aligned}$$

- σ_b = bending stress = $0.5C_R\ell/Z_v$
- C_R = rudder force, as defined in 3-2-13/3.1
- ℓ = horizontal distance between centerline of rudder stock and the particular section of the stern frame shoe, in m (in.) (see 3-2-12/Figure 2)
- Z_v = section modulus of shoe-piece about the vertical axis at the particular section under consideration, in cm^3 (in^3)
- τ = shear stress = $0.5C_R/A_s$
- A_s = sectional area at the section of the shoe-piece under consideration, in mm^2 (in^2)

**FIGURE 2
Shoe-piece**



11.5 Minimum Scantlings

In addition, shoe-piece width is to be approximately twice the depth, and vertical and horizontal section modulus and sectional area are in no case less than required by the following equations.

$$Z_z = k_z C_R \ell K_g \quad \text{cm}^3 (\text{in}^3)$$

$$Z_y = 0.5 Z_z \quad \text{cm}^3 (\text{in}^3)$$

$$A'_s = k_a C_R K_g \quad \text{mm}^2 (\text{in}^2)$$

where

Z_z = minimum required section modulus of shoe-piece about the vertical axis at the particular section under consideration

Z_y = minimum required section modulus of shoe-piece about the transverse horizontal axis at the particular section under consideration

A'_s = minimum required sectional area of shoe-piece at the section under consideration

k_z = 6.25 (61.3, 0.0967)

k_a = 10.4 (102, 0.161)

C_R , ℓ and K_g are as defined in 3-2-12/11.3.

13 Rudder Horns

Liftboats that have rudder horns are to meet the requirements in 3-2-13/5 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.

15 Rudder Gudgeons

Rudder gudgeons are to be an integral part of the stern frame. The bearing length of the pintle is to be between 1.0 and 1.2 times the pintle diameter; and the thickness of the pintle housing is not to be less than 25% of the pintle diameter.

17 Shaft Struts

17.1 General

Tail-shaft (propeller-shaft) struts where provided may be of the V or I type. The thickness of the strut barrel or boss is to be at least one-fourth the diameter of the tail shaft. The width to thickness ratio of the struts is not to be greater than 6.25, unless equivalent buckling strength can be demonstrated. The length of the strut barrel or boss is to be adequate to accommodate the required length of propeller-end bearings. The following equations are for struts having streamline cross-sectional or rectangular shapes.

17.3 V Strut

17.3.1 Inertia

The moment of inertia, I , of each strut arm is not to be less than obtained from the following equation:

$$I = 0.0044D^4 \quad \text{mm}^4 \text{ (in}^4\text{)}$$

where

$$D = \text{required diameter of ABS Grade 2 tail shaft, in mm (in.) (see Section 4-3-1)}$$

17.3.2 Section Modulus

The section modulus, SM , of each strut arm is not to be less than obtained from the following equation:

$$SM = 0.024D^3 \quad \text{mm}^3 \text{ (in}^3\text{)}$$

where

$$D = \text{required diameter of ABS Grade 2 tail shaft, in mm (in.)}$$

Where the included angle is less than 45 degrees, the foregoing scantlings are to be specially considered.

17.5 I Strut

17.5.1 Inertia

The moment of inertia, I , of the strut arm is not to be less than obtained from the following equation:

$$I = 0.018D^4 \quad \text{mm}^4 \text{ (in}^4\text{)}$$

where

$$D = \text{required diameter of ABS Grade 2 tail shaft, in mm (in.) (see Section 4-3-1)}$$

17.5.2 Section Modulus

The section modulus, SM , of the strut is not to be less than obtained from the following equation:

$$SM = 0.068D^3 \quad \text{mm}^3 \text{ (in}^3\text{)}$$

where

$$D = \text{required diameter of ABS Grade 2 tail shaft, in mm (in.)}$$

17.7 Strut Length

The length of the longer leg of a V strut or the leg of an I strut, measured from the outside perimeter of the strut barrel or boss to the outside of the shell plating, is not to exceed 10.6 times the diameter of the tail shaft. Where this length is exceeded, the width and thickness of the strut are to be increased, and the strut design will be given special consideration.

19 Propeller Nozzles (2009)

19.1 Application

The requirements in this section are applicable for fixed propeller nozzles with inner diameter d of 5 meters (16.4 feet) or less. Nozzles of larger inner diameter are subject to special consideration with all supporting documents and calculations submitted for review.

19.3 Design Pressure

The design pressure of the nozzle is to be obtained from the following:

$$p_d = 10^{-6} \cdot c \cdot \varepsilon \cdot \left(\frac{N}{A_p} \right) \text{ N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

where

- c = coefficient as indicated in 3-2-12/Table 1
- ε = coefficient as indicated in 3-2-12/Table 2, but not to be taken less than 10
- N = maximum shaft power, in kW (hp)
- A_p = propeller disc area
- = $D^2 \frac{\pi}{4}$, in m² (ft²)
- D = propeller diameter, in m (ft)

TABLE 1
Coefficient c (2009)

Propeller Zone (see 3-2-12/Figure 3)	c		
	p_d in N/mm ²	p_d in kgf/mm ²	p_d in psi
2	10.0	1.02	11.62×10^3
1 & 3	5.0	0.51	5.81×10^3
4	3.5	0.36	4.067×10^3

TABLE 2
Coefficient ε (2009)

	p_d in N/mm ²	p_d in kgf/mm ²	p_d in psi
ε	$21 - 2 \times 10^{-2} \left(\frac{N}{A_p} \right)$	$21 - 2 \times 10^{-2} \left(\frac{N}{A_p} \right)$	$21 - 16 \times 10^{-2} \left(\frac{N}{A_p} \right)$

19.5 Nozzle Cylinder

19.5.1 Shell Plate Thickness

The thickness of the nozzle shell plating, in mm (in.), is not to be less than:

$$t = t_o + t_c, \text{ but not to be taken less than } 7.5 \text{ (0.3) mm (in.)}$$

where

t_o = thickness obtained from the following formula:

$$= c_n \cdot S_p \cdot \sqrt{p_d K_n} \text{ mm (in.)}$$

c_n = coefficient as indicated in 3-2-12/Table 3

S_p = spacing of ring webs in mm (in.)

p_d = nozzle design pressure in N/mm² (kgf/mm², psi), as defined in 3-2-12/19.3

t_c = corrosion allowance determined by 3-2-12/Table 4

K_n = nozzle material factor as defined in 3-2-13/1.3

TABLE 3
Coefficient c_n (2009)

	p_d in N/mm ²	p_d in kgf/mm ²	p_d in psi
c_n	1.58×10^{-1}	4.95×10^{-1}	1.32×10^{-2}

TABLE 4
Corrosion Allowance t_c (2009)

Value of t_o	t_c mm (in.)
If $t_o \leq 10.0$ (0.4)	1.5 (0.06)
If $t_o > 10.0$ (0.4)	the lesser of b_1, b_2
where $b_1 = 3.0$ (0.12) mm (in.) $b_2 = \left(\frac{t_o}{\sqrt{1/K_n}} + 5 \right) \times 10^{-1}$ mm or $b_2 = \left(\frac{t_o}{\sqrt{1/K_n}} + 0.2 \right) \times 10^{-1}$ in.	

19.5.2 Internal Diaphragm Thickness

Thickness of nozzle internal ring web is not to be less than the required nozzle shell plating for Zone 3.

19.7 Nozzle Section Modulus

The minimum requirement for nozzle section modulus is obtained from the following formula:

$$SM = d^2 b V_d^2 Q n \text{ cm}^3 \text{ (in}^3\text{)}$$

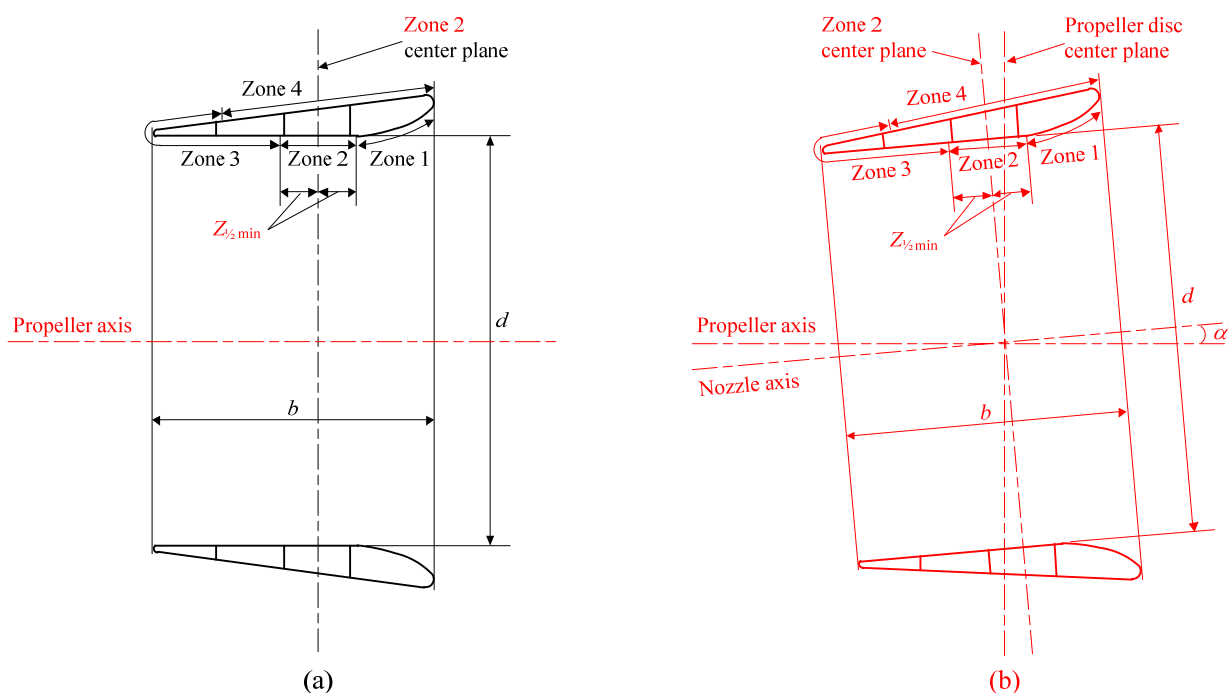
where

d = nozzle inner diameter, in m (ft)

b = nozzle length, in m (ft)

- V_d = design speed in ahead condition, in knots, as defined in 3-2-13/3.1
- Q = reduction factor conditional on material type
- = 1.0 for ordinary strength steel
- = 0.78 for H32 strength steel
- = 0.72 for H36 strength steel
- = 0.68 for H40 strength steel
- Q factor for steel having yield strength other than above is to be specially considered.
- n = nozzle type coefficient taken equal to 0.7 (0.0012) for fixed nozzles

FIGURE 3
Propeller Nozzle Section View (2014)



- b = nozzle length
- d = nozzle inner diameter
- Zone 1 zone of nozzle inner skin from nozzle leading edge to the fore end of Zone 2
- Zone 2 zone of nozzle inner skin in way of propeller tips with two ring webs within the zone
- $z_{1/2 \min}$ = The minimum length on each side of Zone 2 center plane is to be:
- = $\frac{b}{8}$ where Zone 2 center plane and propeller disc center plane coincide as shown in 3-2-12/Figure 3(a);
- = $\frac{b}{8} \cos \alpha + \frac{d}{2} \tan \alpha$ where α is the tilt angle between the Zone 2 and propeller disc center planes, as shown in 3-2-12/Figure 3(b);
- Zone 3 zone of nozzle inner and outer skin covering the tail vicinity, from aft end of Zones 2 to the aft end of Zone 4
- Zone 4 zone of nozzle outer skin from the leading edge to the fore end of Zone 3

19.9 Welding Requirement

The inner and outer nozzle shell plating is to be welded to the internal stiffening ring webs with double continuous welds as far as practicable. Plug/slot welding is prohibited for the inner shell, but may be accepted for the outer shell plating, provided that the nozzle ring web spacing is not greater than 350 mm (13.8 in.).

21 Inspection of Castings

The location of radiographic or other subsurface inspections of large stern-frame and rudder-horn castings is to be indicated on the approved plans. See applicable parts of Chapter 1 of the ABS *Rules for Materials and Welding (Part 2)*.

CHAPTER 2 Hull Structures and Arrangements

SECTION 13 Rudders and Steering Equipment (2009)

1 General

1.1 Application

Requirements specified in this section are applicable to:

- i) Ordinary profile rudders described in 3-2-13/Table 1A;
- ii) High-lift rudders described in 3-2-13/Table 1B;

Rudders not covered in 3-2-13/Table 1A or Table 1B are subject to special consideration, provided that all the required calculations are prepared and submitted for review in full compliance with the requirements in this section.

1.3 Materials for Rudder, Rudder Stock and Steering Equipment (2014)

Rudder stocks, pintles, coupling bolts, keys and other steering equipment components described in this Section are to be made from material in accordance with the requirements of Chapter 1 of the *ABS Rules for Materials and Welding (Part 2)* and particularly:

- i) The Surveyor need not witness material tests for coupling bolts and keys.
- ii) The surfaces of rudder stocks in way of exposed bearings are to be of noncorrosive material.
- iii) Material properties of dissimilar parts and components in direct contact with each other are to be submitted for review of compatibilities, such as galvanic potential.
- iv) Material factors of castings and forgings used for the shoe piece (K_g), horn (K_h), stock (K_s), bolts (K_b), coupling flange (K_p), pintles (K_p), and nozzles (K_n) are to be obtained for their respective material from the following equation:

$$K = (n_y/Y)^e$$

where

- n_y = 235 N/mm² (24 kgf/mm², 34000 psi)
- Y = specified minimum yield strength of the material, in N/mm² (kgf/mm², psi), but is not to be taken as greater than 0.7 U or 450 N/mm² (46 kgf/mm², 65000 psi), whichever is less
- U = minimum tensile strength of material used, in N/mm² (kgf/mm², psi)
- e = 1.0 for $Y \leq 235$ N/mm² (24 kgf/mm², 34000 psi)
= 0.75 for $Y > 235$ N/mm² (24 kgf/mm², 34000 psi)

1.5 Expected Torque

The torque considered necessary to operate the rudder in accordance with 4-3-3/1.9 is to be indicated on the submitted rudder or steering gear plan. See 4-3-3/1.5 and 3-2-13/5.7.

Note that this expected torque is not the design torque for rudder scantlings.

1.7 Rudder Stops

Strong and effective structural rudder stops are to be fitted. Where adequate positive stops are provided within the steering gear in accordance with 4-3-3/5.1, structural stops will not be required.

3 Rudder Design Force

Rudder force, C_R , upon which rudder scantlings are to be based, is to be obtained from equation described either in Section 3-2-13/3.1 or Section 3-2-13/3.3 as applicable. Where for the ordinary rudders the rudder angle, ϕ , exceeds 35° , the rudder force, C_R , is to be increased by a factor of $1.74 \sin(\phi)$.

3.1 Rudder Blades without Cutouts (2014)

Where the rudder profile can be defined by a single quadrilateral, the rudder force is to be obtained from the following equation.

$$C_R = n k_R k_c k_\ell A V_R^2 \quad \text{kN (tf, Ltf)}$$

where

n	=	0.132 (0.0135, 0.00123)
k_R	=	$(b^2/A_t + 2)/3$ but not taken more than 1.33
b	=	mean height of rudder area, in m (ft), as determined from 3-2-13/Figure 1
A_t	=	sum of rudder blade area, A , and the area of rudder post or rudder horn within the extension of rudder profile, in m^2 (ft^2)
A	=	total projected area of rudder as illustrated in 3-2-13/Figure 1, in m^2 (ft^2) For steering nozzles, A is not to be taken less than 1.35 times the projected area of the nozzle.
k_c	=	coefficient depending on rudder cross section (profile type) as indicated in 3-2-13/Table 1A and 1B. For profile types differing from those in 3-2-13/Table 1A and 1B, k_c is subject to special consideration.
k_ℓ	=	coefficient as specified in 3-2-13/Table 2
V_R	=	liftboat speed, in knots = for ahead condition V_R equals V_d or $V_{\min}$, whichever is greater = for astern condition V_R equals V_a or $0.5V_d$, or $0.5V_{\min}$, whichever is greater
V_d	=	design speed in knots with the liftboat running ahead at the maximum continuous rated shaft rpm and at the summer load waterline
V_a	=	maximum astern speed in knots
$V_{\min}$	=	$(V_d + 20)/3$

Where there are any appendages such as rudder bulb fitted on the rudder, its effective areas are to be included in the area of the rudder blade if significant.

3.3 Rudder Blades with Cutouts

This paragraph applies to rudders with cutouts (semi-spade rudders), such that the whole blade area cannot be adequately defined by a single quadrilateral. See 3-2-13/Figure 2. Equations derived in this paragraph are based on a cutout blade with two quadrilaterals. Where more quadrilaterals are needed to define the rudder shape, similar rules apply.

The total rudder force described in 3-2-13/3.1 is applicable for rudders with cutout(s), with A being the summation of sub-quadrilaterals that make up the whole area of the rudder blade. Rudder force distribution over each quadrilateral is to be obtained from the following equations:

$$C_{R1} = C_R A_1/A \quad \text{kN (tf, Ltf)}$$

$$C_{R2} = C_R A_2/A \quad \text{kN (tf, Ltf)}$$

where

C_R and A are as defined in 3-2-13/3.1

A_1 and A_2 are as described in 3-2-13/Figure 2.

3.5 Rudders Blades with Twisted Leading-Edge (2014)

This kind of rudder has the leading edge twisted horizontally on the top and bottom of the section that is an extension of the center of the propeller shaft. For the purpose of calculating design force, twisted rudders may be distinguished in four categories:

Category	Description
1	The projected leading edge of twisted upper and lower blades not lineup to each other
2	The projected leading edge of twisted upper and lower blades form a straight line
3	Rudder with twisted leading-edge combined with tail edge flap or fins
4	The twisted leading edge has a smooth continuous wavy contour (no deflector) or the rudder has multiple section profile types

Design force for rudder with twisted leading edge is obtained according to the following criteria:

- i) For Category 1 rudders as indicated in the above table, design force over upper and lower rudder blades are obtained from the following equations respectively:

$$C_{R1} = nk_R k_c k_\ell A_1 V_R^2 \quad \text{kN (tf, Ltf)} \quad \text{for twisted upper rudder blade;}$$

$$C_{R2} = nk_R k_c k_\ell A_2 V_R^2 \quad \text{kN (tf, Ltf)} \quad \text{for twisted lower rudder blade;}$$

$$C_R = C_{R1} + C_{R2} \quad \text{kN (tf, Ltf)} \quad \text{overall design force;}$$

- ii) For Categories 2, 3, and 4, rudder design force indicated in 3-2-13/3.1 is applicable, that is:

$$C_R = nk_R k_c k_\ell A V_R^2 \quad \text{kN (tf, Ltf)}$$

where

n , k_R , k_c , k_ℓ , A , and V_R are as defined in 3-2-13/3.1, (for rudder has multiple section profile types, A is the whole projected areas).

A_1 and A_2 are the projected areas of upper and lower blades separated at the deflector cross section, respectively. Where the effective projected area of rudder bulb (if present) forward of rudder leading edge is significant and needs to be counted, the proportioned bulb effective areas are added to A_1 and A_2 accordingly

Values of k_c for ahead and astern conditions are determined from one of the methods below as applicable, if the type of basic rudder profile is not provided:

- k_c is taken from 3-2-13/Table 1A for twisted rudders of Categories 1 & 2;
- k_c is taken from 3-2-13/Table 1B for twisted rudders of Category 3;
- k_c is subjected to special considerations for twisted rudders of Category 4;
- Shipyard/rudder manufacturers' submitted k_c obtained from testing data or calculations may be accepted subject to ABS review of all the supporting documents;

TABLE 1A
Coefficient k_c for Ordinary Rudders (2014)

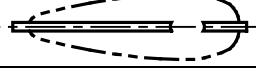
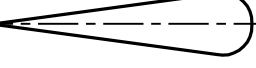
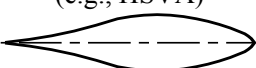
	Profile Type	k_c	
		Ahead Condition	Astern Condition
1	Single plate 	1.0	1.0
2	NACA-OO Göttingen 	1.1	0.80
3	Flat side 	1.1	0.90
4	Mixed (e.g., HSVA) 	1.21	0.90
5	Hollow 	1.35	0.90
6	Twisted rudder of Cat. 1 & 2 	1.2 (if not provided)	0.9 (if not provided)

TABLE 1B
Coefficient k_c for High-Lift/Performance Rudders (2014)

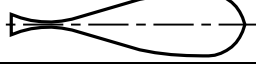
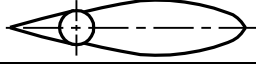
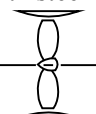
	Profile Type	k_c	
		Ahead Condition	Astern Condition
1	Fish tail (e.g., Schilling high-lift rudder) 	1.4	0.8
2	Flap rudder (or Twisted rudder of Cat. 3) 	1.7	1.3
3	Rudder with steering nozzle 	1.9	1.5

FIGURE 1
Rudder Blade without Cutouts (2009)

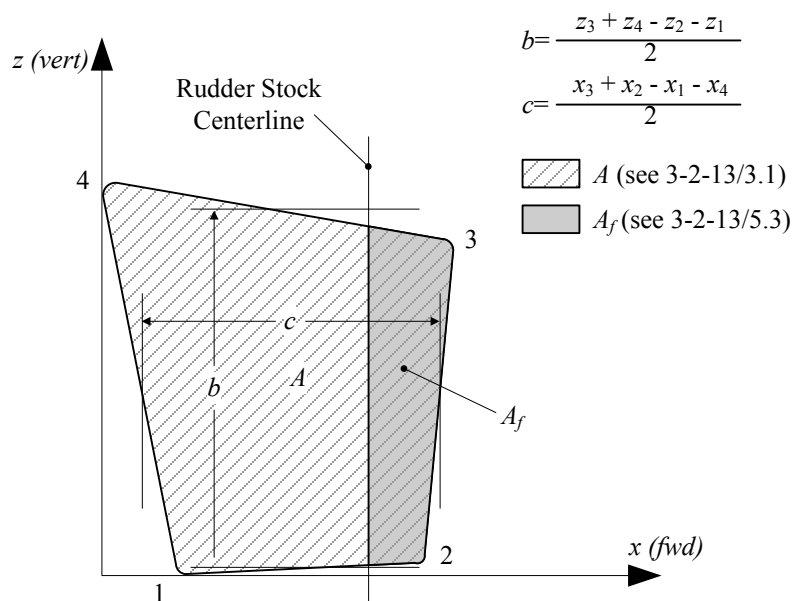
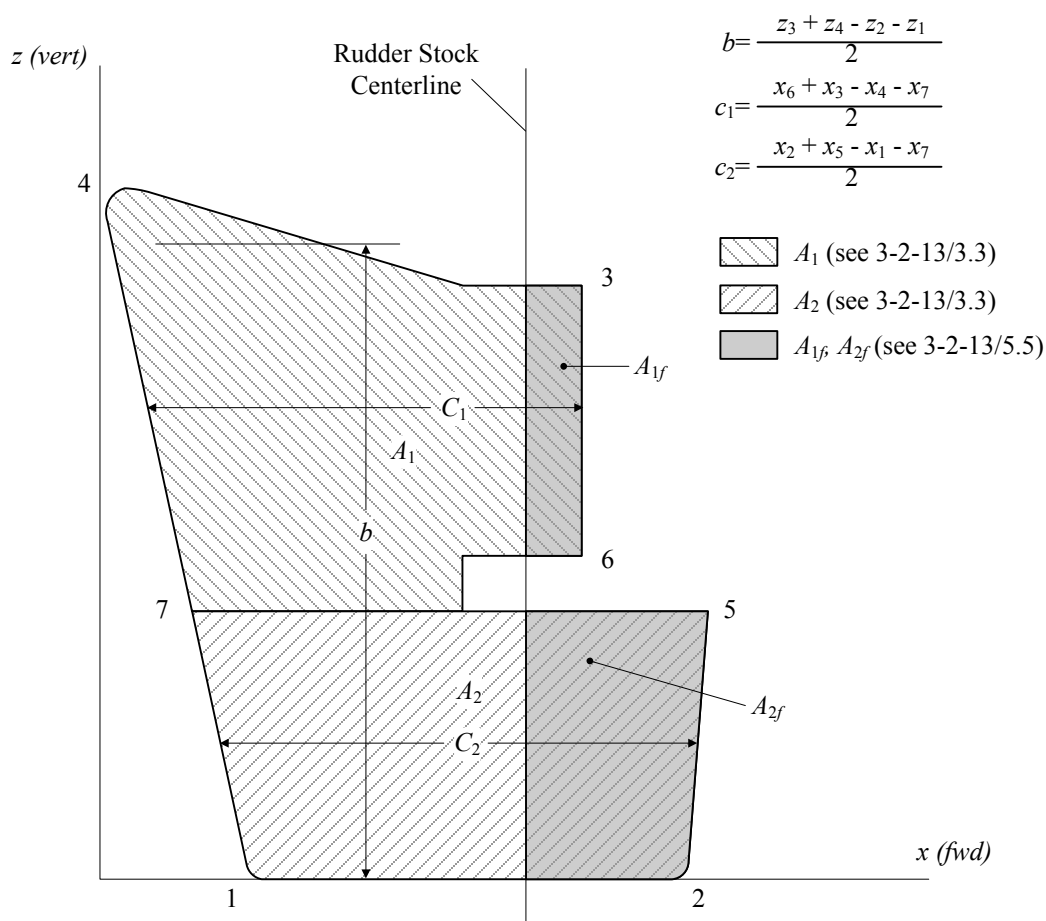


FIGURE 2
Rudder Blade with Cutouts (2009)



5 Rudder Design Torque

5.1 General

The rudder design torque, Q_R , for rudder scantling calculations is to be in accordance with 3-2-13/5.3 or 3-2-13/5.5 as applicable.

5.3 Rudder Blades without Cutouts (2014)

Rudder torque, Q_R , is to be determined from the following equation for both ahead and astern conditions.

$$Q_R = C_R r \text{ kN-m (tf-m, Ltf-ft)}$$

where

C_R = rudder force as calculated in 3-2-13/3.1

r = $c(\alpha - k)$ (but not less than $0.1c$ for ahead condition)

c = mean breadth of rudder area, as shown in 3-2-13/Figure 1, in m (ft)

α = coefficient as indicated in 3-2-13/Table 3

k = A_f/A

A_f = area of rudder blade situated forward of the centerline of the rudder stock, in m² (ft²), as shown in 3-2-13/Figure 1

A = whole rudder area as described in 3-2-13/3.1

Where there are any appendages such as rudder bulb fitted on the rudder, effective areas are to be included in the area of the rudder blade if significant.

TABLE 2
Coefficient k_r (2012)

<i>Rudder/Propeller Layout</i>	k_r
Rudders outside propeller jet	0.8
Rudders behind a fixed propeller nozzle	1.15
Steering nozzles and azimuthing thrusters	1.15
All others	1.0

TABLE 3
Coefficient α (2014)

<i>Rudder Position or High-lift</i>	α	
	<i>Ahead Condition</i>	<i>Astern Condition</i>
Located behind a fixed structure, such as a rudder horn	0.25	0.55
Located where no fixed structure forward of it	0.33	0.75 (hollow profile) 0.66 (non-hollow)
High-Lift Rudders (see 3-2-13/Table 1B)	Special consideration (0.40 if unknown)	Special consideration

5.5 Rudders Blades with Cutouts

This paragraph refers to rudder blades with cutouts (semi-spade rudders) as defined in 3-2-13/3.3. Equations derived in this paragraph are based on a cutout blade with two quadrilaterals. Where more quadrilaterals are needed to define the rudder shape, similar rules apply.

Total rudder torque, Q_R , in ahead and astern conditions is to be obtained from the following equation:

$$Q_R = C_{R1} r_1 + C_{R2} r_2 \quad \text{kN-m (tf-m, Ltf-ft)}$$

but not to be taken less than Q_{Rmin} in the ahead condition

where

$$Q_{Rmin} = 0.1 C_R (A_1 c_1 + A_2 c_2) / A$$

$$r_1 = c_1 (\alpha - k_1) \quad \text{m (ft)}$$

$$r_2 = c_2 (\alpha - k_2) \quad \text{m (ft)}$$

$$c_1, c_2 = \text{mean breadth of partial area } A_1, A_2, \text{ from 3-2-13/Figure 2}$$

$$\alpha = \text{coefficient as indicated in 3-2-13/Table 3}$$

$$k_1, k_2 = A_{1f}/A_1, A_{2f}/A_2 \text{ where } A_{1f}, A_{2f} = \text{area of rudder blade situated forward of the centerline of the rudder stock for each part of the rudder, as shown in 3-2-13/Figure 2}$$

$C_R, C_{R1}, C_{R2}, A_1, A_2$ are as defined in 3-2-13/3.3.

5.7 Rudders with Twisted Leading Edge (2014)

In general, rudder torque, Q_R , indicated in 3-2-13/5.3 is applicable for rudders with twisted leading edge, where C_R is obtained from 3-2-13/3.5.

5.9 Trial Conditions

The above equations for Q_R are intended for the design of rudders and should not be directly compared with the torques expected during the trial (see 3-2-13/1.5) or the rated torque of steering gear (see 4-3-3/1.5).

7 Rudder Stocks

The rudder angle is not to exceed 35° from centerline. Where the angle, ϕ , does exceed 35°, the required upper and lower stock diameters are to be increased by the following proportion:

$$\sqrt[3]{\frac{\sin \phi}{\sin 35^\circ}}$$

7.1 Upper Rudder Stocks (2012)

The upper rudder stock is that part of the rudder stock above the neck bearing or above the top pintle, as applicable.

At the upper bearing or tiller, the upper stock diameter is not to be less than that obtained from the following equation:

$$S = N_u \sqrt[3]{Q_R K_s} \quad \text{mm (in.)}$$

where

$$N_u = 42.0 (89.9, 2.39)$$

$$Q_R = \text{total rudder torque, as defined in 3-2-13/5, in kN-m (tf-m, Ltf-ft)}$$

$$K_s = \text{material factor for upper rudder stock, as defined in 3-2-13/1.3}$$

7.3 Lower Rudder Stocks (2012)

In determining lower rudder stock scantlings, values of rudder design force and torque calculated in 3-2-13/3 and 3-2-13/5 are to be used. Bending moments, shear forces, as well as the reaction forces are to be determined from 3-2-13/7.5 and 3-2-13/13.5, and are to be submitted for review. For rudders supported by shoe pieces or rudder horns, these structures are to be included in the calculation model to account for support of the rudder body. Guidance for calculation of these values is given in Appendix 3-2-A1.

The lower rudder stock diameter is not to be less than obtained from the following equation.

$$S_{\ell} = S \sqrt[6]{1 + (4/3)(M/Q_R)^2} \quad \text{mm (in.)}$$

where

$$\begin{aligned} S &= \text{upper stock required diameter from 3-2-13/7.1, in mm (in.)} \\ M &= \text{bending moment at the section of the rudder stock considered, in kN-m (tf-m, Ltf-ft)} \\ Q_R &= \text{rudder torque from 3-2-13/5, in kN-m (tf-m, Ltf-ft)} \end{aligned}$$

Above the neck bearing a gradual transition is to be provided where there is a change in the diameter of the rudder stock.

The equivalent stress of bending and torsion, σ_c to be assessed from the aforementioned direct calculation in the transition is not to exceed $118/K \text{ N/mm}^2$ ($12.0/K \text{ kgf/mm}^2$, $17100/K \text{ lbs/in}^2$).

$$\sigma_c = K \sqrt{\sigma_b^2 + 3\tau^2}$$

where

$$\begin{aligned} K &= \text{material factor as defined in 3-2-13/1.3.} \\ \sigma_b &= 10.2M/S_{\ell}^3 \\ \tau_t &= 5.1Q_R/S_{\ell}^3 \end{aligned}$$

7.4 Rudder Stock Sealing (2012)

- i) In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier.
- ii) Where the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

7.5 Bending Moments

The bending moment on the rudder and rudder stock may be determined in accordance with Appendix 3-2-A1 or in accordance with the following equations:

7.5.1 Spade Rudders

$$\begin{aligned} M_n &= C_R \ell_n \quad \text{kN-m (Ltf-ft)} \\ M_s &= C_R \frac{A_1}{A} \ell_c \quad \text{kN-m (Ltf-ft)} \end{aligned}$$

where

$$\begin{aligned} M_n &= \text{bending moment at neck bearing} \\ M_s &= \text{bending moment at section under consideration} \\ \ell_n &= \text{distance from center of neck bearing to the centroid of rudder area, m (ft)} \end{aligned}$$

ℓ_c = distance from section under consideration to the centroid of rudder area, A_1 ,
 m^2 (ft^2)

A_1 = area below section under consideration, m^2 (ft^2)

C_R and A are as defined in 3-2-13/3.

7.5.2 Balanced Rudders with Shoe-piece Support

The bending moment at the neck bearing may be taken as indicated below. Bending moments at other locations are to be determined by direct calculation and are to be submitted. See Appendix 3-2-A1 for guidance in calculating bending moments.

$$M_n = NC_R \ell_b \text{ kN-m (Ltf-ft)}$$

where

M_n = bending moment at neck bearing

ℓ_b = distance between center of neck bearing and center of shoe-piece pintle bearing, m (ft)

$$N = \left[\frac{0.5 + \frac{\alpha_1}{8}}{1 + \alpha_1 \left(1 + \frac{\ell_u}{\ell_b} \frac{I_b}{I_u} \right)} \right]$$

$$\alpha_1 = \frac{\ell_b^3 I_d}{\ell_s^3 I_b}$$

I_d = mean moment of inertia of shoe-piece about the vertical axis, cm^4 (in^4)

ℓ_s = distance between center of shoe-piece pintle bearing and the effective support point of the shoe-piece in the hull, m (ft)

I_b = mean moment of inertia of the rudder, cm^4 (in^4), considering a width of rudder plating twice the athwartship dimension of the rudder and excluding welded or bolted cover plates for access to pintles, inc.

ℓ_u = distance between center of the neck bearing and the center of the rudder carrier bearing, m (ft)

I_u = mean moment of inertia of rudder stock, between neck bearing and rudder carrier bearing, cm^4 , (in^4)

C_R is as defined in 3-2-13/3.

9 Flange Couplings

9.1 General

Rudder flange couplings are to comply with the following requirements:

- i) Couplings are to be supported by an ample body of metal worked out from the rudder stock.
- ii) The smallest distance from the edge of the bolt holes to the edge of the flange is not to be less than two-thirds of the bolt diameter.
- iii) Coupling bolts are to be fitted bolts.
- iv) Suitable means are to be provided for locking the nuts in place.

In addition to the above, rudder flange couplings are to meet the type-specific requirements in 3-2-13/9.3 (horizontal couplings) or 3-2-13/9.5 (vertical couplings) as applicable.

9.3 Horizontal Couplings

9.3.1 Coupling Bolts

There are to be at least six coupling bolts in horizontal couplings, and the diameter of each bolt is not to be less than obtained by the following equation:

$$d_b = 0.62 \sqrt{d_s^3 K_b / (nr K_s)} \quad \text{mm (in.)}$$

where

- d_s = required rudder stock diameter, S (3-2-13/7.1) or S_ℓ (3-2-13/7.3) as applicable, in way of the coupling
- n = total number of bolts in the horizontal coupling
- r = mean distance, in mm (in.), of the bolt axes from the center of the bolt system
- K_b = material factor for bolts, as defined in 3-2-13/1.3
- K_s = material factor for stock, as defined in 3-2-13/1.3

9.3.2 Coupling Flange

Coupling flange thickness is not to be less than the greater of the following equations:

$$t_f = d_{bt} \sqrt{K_f / (K_b)} \quad \text{mm (in.)}$$

$$t_f = 0.9 d_{bt} \quad \text{mm (in.)}$$

where

- d_{bt} = calculated bolt diameter as per 3-2-13/9.3.1 based on a number of bolts not exceeding 8
- K_f = material factor for flange, as defined in 3-2-13/1.3
- K_b = material factor of bolts, as defined in 3-2-13/1.3

9.5 Vertical Couplings

9.5.1 Coupling Bolts

There are to be at least eight coupling bolts in vertical couplings and the diameter, d_b , of each bolt is not to be less than obtained from the following equation:

$$d_b = 0.81 d_s \sqrt{K_b / (n K_s)} \quad \text{mm (in.)}$$

where

- n = total number of bolts

d_s , K_b , K_s are as defined in 3-2-13/9.3.

In addition, the first moment of area of the bolts about the center of the coupling is not to be less than given by the following equation:

$$m = 0.00043 d_s^3 \quad \text{mm}^3 (\text{in}^3)$$

where

- d_s = diameter, as defined in 3-2-13/9.3

9.5.2 Coupling Flange

Coupling flange thickness is not to be less than d_b , as defined in 3-2-13/9.5.1.

11 Tapered Stock Couplings

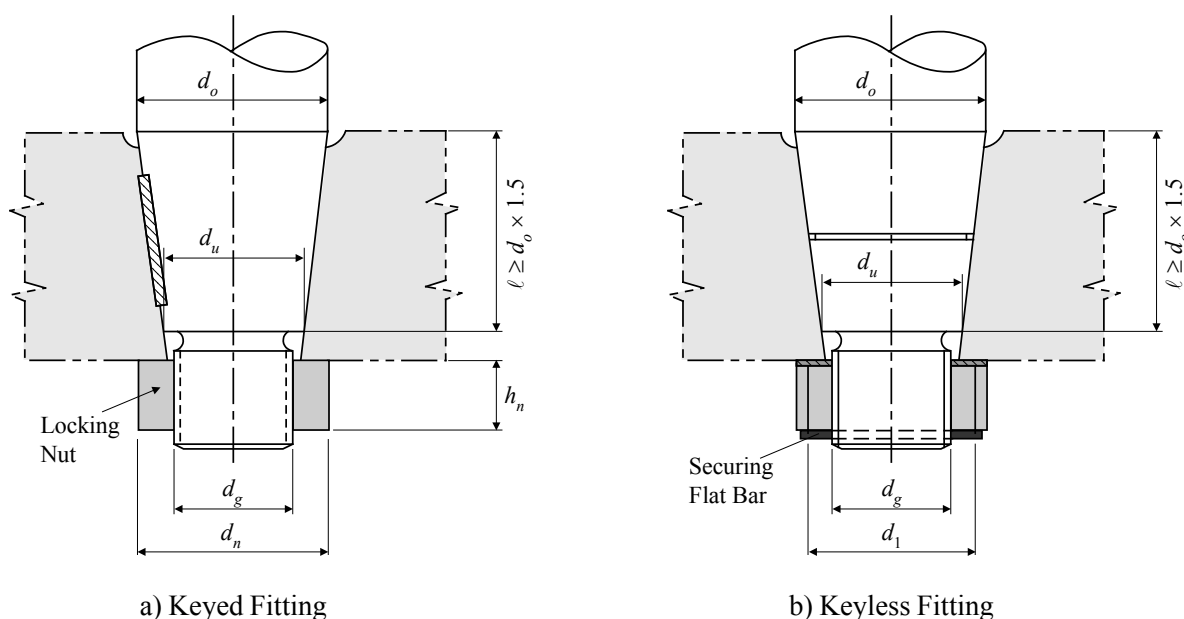
11.1 Coupling Taper (2011)

Tapered stock couplings are to comply with the following general requirements in addition to type-specific requirements given in 3-2-13/13.3 or 3-2-13/11.5 as applicable:

- Tapered stocks, as shown in 3-2-13/Figure 3, are to be effectively secured to the rudder casting by a nut on the end.
- Taper length (ℓ) in the casting is generally not to be less than 1.5 times the stock diameter (d_o) at the top of the rudder.
- The taper on diameter (c) is to be 1/12 to 1/8 for keyed taper couplings and 1/20 to 1/12 for couplings with hydraulic mounting/dismounting arrangements, as shown in the following table.
- Where mounting with an oil injection and hydraulic nut, the push-up oil pressure and the push-up length are to be specially considered upon submission of calculations.
- Means of effective sealing are to be provided to protect against sea water ingress.

Type of Coupling Assembly	$c = \frac{d_o - d_u}{\ell}$
Without hydraulic mounting/dismounting	$1/12 \leq c \leq 1/8$
With hydraulic mounting/dismounting	$1/20 \leq c \leq 1/12$

FIGURE 3
Tapered Couplings (2009)



11.3 Keyed Fitting (2010)

Where the stock is keyed, the key is to be fitted in accordance with the following:

- i) The top of the keyway is to be located well below the top of the rudder.
- ii) Torsional strength of the key equivalent to that of the required upper stock is to be provided.
- iii) The effective shear area* of the key is not to be less than A_k , given below.

$$A_k = \frac{S^3}{5.1r_{md}} \cdot \frac{Y_S}{Y_K}$$

where

- A_k = shear area of key; mm² (in²)
- S = required upper stock diameter; mm (in.); as determined by 3-2-13/7.1
- r_{md} = offered radius of tapered stock at mid length of the bearing surface of the key; mm (in.)
- Y_S = specified minimum yield strength of keyway material; N/mm² (kgf/mm², psi)
- Y_K = specified minimum yield strength of key material; N/mm² (kgf/mm², psi)
- iv) In general, the key material is to be at least of equal strength to the keyway material. For keys of higher strength materials, shear and bearing areas of keys and keyways may be based on the respective material properties of the keys and the keyways, provided that compatibilities in mechanical properties of both components are fully considered. In no case, is the bearing stress of the key on the keyway to exceed 90% of the specified minimum yield strength of the keyway material.

* Note: The effective area is to be the gross area reduced by any area removed by saw cuts, set screw holes, chamfer, etc., and is to exclude the portion of the key in way of spooning of the key way.

11.5 Keyless Fitting

Hydraulic and shrink fit keyless couplings are to be fitted in accordance with the following:

- i) Hydraulic pressure is to be specially considered upon submittal of detailed preloading stress calculations and fitting instructions;
- ii) The calculated torsional holding capacity is to be at least 2.0 times the transmitted torque based on the steering gear relief valve setting;
- iii) Preload stress is not to exceed 70% of the minimum yield strength of either the stock or the bore;
- iv) Prior to applying hydraulic pressure, at least 75% of theoretical contact area of rudder stock and rudder bore is to be achieved in an evenly distributed manner;
- v) The upper edge of the upper main piece bore is to have a slight radius;
- vi) The locking nut is to be fitted in accordance with 3-2-13/11.7.

11.7 Locking Nut

Dimensions of the securing nut, as shown in 3-2-13/Figure 3, are to be proportioned in accordance with the following and the nut is to be fitted with an effective locking device.

Height	$h_n \geq 0.6d_g$
Outer diameter of nut	$d_n \geq 1.2d_u$ or $1.5d_g$ whichever is greater
External thread diameter	$d_g \geq 0.65d_o$

In the case of a hydraulic pressure secured nut, a securing device such as a securing flat bar is to be provided. Calculations proving the effectiveness of the securing device are to be submitted.

13 Pintles

13.1 General

- i) Pintles are to be fitted in the gudgeons by conical attachment to the full extent of the gudgeon depth
- ii) The depth of the pintle boss is not to be less than the required pintle diameter d_p , and bearing length is to be between 1.0 and 1.2 times d_p .
- iii) The taper on the diameter is to be:
 - 1/12 to 1/8 for keyed and other manually assembled pintles with locking nut.
 - 1/20 to 1/12 for pintle mounted with oil injection and hydraulic nut.
- iv) Threads and nuts are to be in accordance with 3-2-13/11.7.
- v) For rudders on horns with two pintles, as shown in 3-2-13/Figure 3b of the *Steel Vessel Rules*, calculations are to include pintle bearing forces with the liftboat running ahead at the maximum continuous rated shaft rpm and at the lightest operating draft.
- vi) The bearing allowable pressure is to be in accordance with 3-2-13/Table 6.

13.3 Diameter

The diameter of the pintles is not to be less than obtained from the following equation.

$$d_p = k_1 \sqrt{BK_p} \quad \text{mm (in.)}$$

where

- k_1 = 11.1 (34.7, 1.38)
- B = bearing force, in kN (tf, Ltf), from 3-2-13/13.5 but not to be taken less than $B_{\min}$ as specified in 3-2-13/Table 4
- K_p = material factor for the pintle, as defined in 3-2-13/1.3

TABLE 4
Minimum Bearing Force $B_{\min}$ (2009)

Pintle Type		$B_{\min}$
Conventional two pintle rudder		$0.5 C_R$
3-2-A1/Figure 2	lower pintle	$0.5 C_R$
3-2-A1/Figure 3	main pintle	$C_R \ell_a / \ell_p^*$
3-2-13/Figure 3 of the <i>Steel Vessel Rules</i>	main pintle	$C_R \ell_a / \ell_p^*$
	upper pintle	$0.25 C_R$

* $B_{\min} = C_R$ where $\ell_a / \ell_p \geq 1$

ℓ_a, ℓ_p as described in 3-2-13/Figure 3 of the *Steel Vessel Rules*

13.5 Shear and Bearing Forces

The shear and bearing forces may be determined in accordance with Appendix 3-2-A1, or by the equations given below.

13.5.1 Spade Rudder

$$\text{Bearing force at rudder carrier: } P_u = \frac{M_n}{\ell_u} \text{ kN (tf, Ltf)}$$

$$\text{Bearing force at neck bearing: } P_n = C_R + P_u \text{ kN (tf, Ltf)}$$

$$\text{Shear force at neck bearing: } F_n = C_R \text{ kN (tf, Ltf)}$$

where C_R is as defined in 3-2-13/3 and ℓ_u is as defined in 3-2-13/7.5.2.

13.5.2 Balanced Rudder with Shoe-piece Support

$$\text{Bearing force at rudder carrier: } P_u = \frac{M_n}{\ell_u} \text{ kN (tf, Ltf)}$$

$$\text{Bearing force at neck bearing: } P_n = P_u \left(1 + \frac{\ell_u}{\ell_b} \right) + \frac{C_R}{\ell_b} \left(\frac{\ell_R}{2} + \ell_p \right) \text{ kN (tf Ltf)}$$

where

ℓ_b = distance between the center of neck bearing support and the center of shoe-piece support, as shown in 3-2-A1/Figure 2

$$= \ell_p + \ell_r + \ell_\ell$$

ℓ_p = distance between bottom of rudder blade and center of support of neck bearing

ℓ_ℓ = distance between top of rudder blade and center of support of neck bearing

$$\text{Bearing force at shoe-piece: } P_p = C_R + P_u - P_n \text{ kN (tf, Ltf) but not less than } 0.5C_R$$

$$\text{Shear force at neck bearing: } F_n = P_n - P_u \text{ kN (tf, Ltf)}$$

where C_R is as defined in 3-2-13/3.

15 Supporting and Anti-Lifting Arrangements

15.1 Bearings (2012)

15.1.1 Bearing Surfaces

Bearing surfaces for rudder stocks, shafts and pintles are to meet the following requirements:

- i) The length/diameter ratio (ℓ_b/d_ℓ) of the bearing surface is not to be greater than 1.2*
- ii) The projected area of the bearing surface ($A_b = d_\ell \ell_b$) is not to be less than A_{bmin} ,

where

d_ℓ = outer diameter of the liner, in mm (in.)

ℓ_b = bearing length, in mm (in.)

$$A_{bmin} = k_1 \frac{P}{q_a} \text{ mm}^2 (\text{in}^2)$$

$$k_1 = 1000 (2240)$$

P = bearing reaction force, in kN (tf, Ltf), as determined from 3-2-13/Table 5

p_a = allowable surface pressure, as indicated in 3-2-13/Table 6, depending on bearing material, in N/mm² (kgf/mm², psi)

* Request for bearing arrangement of length/diameter ratio greater than 1.2 is subject to special consideration provided that calculations are submitted to show acceptable clearance at both ends of the bearing.

15.1.2 Bearing Clearance

i) The clearance for metal bearings is not to be less than $d_i/1000 + 1.0$ mm ($d_i/1000 + 0.04$ in.) on the diameter, where d_i is the inner diameter of the bushing, in mm (in.).

ii) The clearance for non-metallic bearings is to be specially determined considering the material's swelling and thermal expansion properties. This clearance in general is not to be taken less than 1.5 mm (0.06 in.) on diameter*.

* Request of clearance less than 1.5 mm (0.06 in.) for non-metallic bearings is subject to special considerations provided that documented evidence, such as manufacturer's recommendation on acceptable clearance, expansion allowance and satisfactory service history with reduced clearances, are submitted for review.

For spade rudders with a rudder stock diameter of 400 mm (15.75 in.) or less, the clearances on the diameter are not to be less than given below:

Stock Diameter, mm (in.)	Metallic Bushing, mm (in.)	Synthetic Bushing ⁽¹⁾ , mm (in.)
400 (15.75)	1.15 (0.045)	1.15 (0.045) + E ⁽²⁾
300 (11.81)	0.85 (0.033)	0.85 (0.033) + E
200 (7.87)	0.78 (0.031)	0.78 (0.031) + E
100 (3.94)	0.75 (0.030)	0.75 (0.030) + E

Notes

1 The bushing manufacturer's recommended running clearance may be used as an alternative to these clearances.

2 E = expansion allowance provided by bushing manufacturer, mm (in.).

15.1.3 Bearing Pressure

Bearing pressure is to be accordance with 3-2-13/Table 6.

15.1.4 Bearing Material

Where stainless steel or wear-resistant steel is used for liners or bearings, the material properties including chemical composition of both components are to be submitted for review for an approved combination.

15.3 Rudder Carrier (2012)

i) The weight of the rudder assembly is to be supported by a rudder carrier mounted on the hull structure designed for that purpose.

ii) At least half of the rudder carrier's holding-down bolts are to be fitted bolts. Alternative means of preventing horizontal movement of the rudder carrier may be considered.

iii) Rudder carrier bearings are to comply with the requirements in 3-2-13/15.1.

iv) Hull structures in way of the rudder carrier are to be suitably strengthened.

15.5 Anti Lifting Devices

Means are to be provided to prevent accidental unshipping or undue movement of the rudder which may cause damage to the steering gear. There are to be at least two bolts in the joint of the anti-lifting ring.

TABLE 5
Bearing Reaction Force (2009)

<i>Bearing Type</i>	<i>P, Bearing Reaction Force kN (tf, Ltf)</i>
Pintle bearings	$P = B$ as defined in 3-2-13/13
Other bearings	Calculation of P is to be submitted. Guidelines for calculation can be found in Appendix 3-2-A1

TABLE 6
Allowable Bearing Surface Pressure (2012)

<i>Bearing Material</i>	p_a †		
	<i>N/mm²</i>	<i>kgf/mm²</i>	<i>psi</i>
lignum vitae	2.5	0.25	360
white metal, oil lubricated	4.5	0.46	650
synthetic material with hardness between 60 and 70 Shore D *	5.5	0.56	800
steel § and bronze and hot-pressed bronze-graphite materials	7.0	0.71	1000

† Higher values than given in the table may be taken if they are verified by tests.

§ Stainless and wear-resistant steel in an approved combination with stock liner.

* Indentation hardness test at 23°C and with 50% moisture, according to a recognized standard. Synthetic bearing materials to be of approved type.

17 Double Plate Rudder

17.1 Strength

The section modulus and web area of the rudder mainpiece are to be such that the stresses indicated in the following Subparagraphs are not exceeded.

In calculating the section modulus of the rudder, the effective width of side plating is to be taken as not greater than twice the athwartship dimension of the rudder. Welded or bolted cover plates on access openings to pintles are not to be considered effective in determining the section modulus of the rudder. Generous radii are to be provided at abrupt changes in section where there are stress concentrations, including in way of openings and cover plates.

Moments, shear forces and reaction forces are to be as given in 3-2-13/7.5 and 3-2-13/13.5.

17.1.1 Clear of Cut-outs

$$\text{Bending stress} \quad \sigma_b = K/Q \text{ N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

$$\text{Shear stress} \quad \tau = K/Q \text{ N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

$$\text{Equivalent stress} \quad \sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = K/Q \text{ N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

where

	<i>SI units</i>	<i>MKS units</i>	<i>US units</i>
K_{σ}	110	11.2	15,900
K_{τ}	50	5.1	7,300
K_e	120	12.2	17,400

Q = 1.0 for ordinary strength hull steel
= as defined in 3-2-1/9.5 for higher strength steel plate

17.1.2 In way of Cut-outs

Allowable stresses for determining the rudder strength in way of cutouts (see 3-2-13/Figure 4) are as follows:

Bending stress $\sigma_b = K_{\sigma}/Q$ N/mm² (kgf/mm², psi)

Shear stress $\tau = K_{\tau}/Q$ N/mm² (kgf/mm², psi)

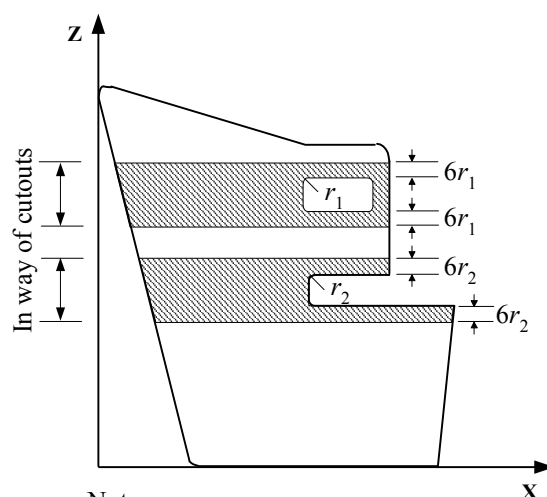
Equivalent stress $\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = K_e/Q$ N/mm² (kgf/mm², psi)

where

	<i>SI units</i>	<i>MKS units</i>	<i>US units</i>
K_{σ}	75	7.65	10,900
K_{τ}	50	5.1	7,300
K_e	100	10.2	14,500

Q = 1.0 for ordinary strength hull steel
= as defined in 3-2-1/9.5 for higher strength steel plate

FIGURE 4 (2009)



Note:

r_1 = corner radius of rudder plate in way of portable bolted inspection hole

r_2 = corner radius of rudder plate

The mainpiece of the rudder is to be formed by the rudder side plating (but not more than the effective width indicated above) and vertical diaphragms extending the length of the rudder or the extension of the rudder stock or a combination of both.

For spade rudders, the section modulus at the bottom of the rudder is not to be less than one-third the required section modulus of the rudder at the top of the rudder or at the center of the lowest pintle.

Where rudders have an unsymmetrical foil section (e.g., reaction rudder) details of the rudder are to be submitted.

Special attention is to be paid in design and construction of rudders with slender foil sections in the vicinity of their trailing edge (e.g., hollow foil sections, fishtail foil sections). Where the width of the rudder blade at the aftermost vertical diaphragm is equal or less than 1/6 of the trailing edge length measured between the diaphragm and the trailing edge, vibration analysis of the rudder blade is also to be submitted for review.

17.3 Side, Top and Bottom Plating

The plating thickness is not to be less than obtained from the following equation:

$$t = 0.0055s\beta\sqrt{k_1d + (k_2 C_R/A)} \times \sqrt{Q} + k_3 \quad \text{mm (in.)}$$

where

Q	=	1.0 for ordinary hull strength steel
	=	as defined in 3-2-1/9.5 for higher strength steel plate
k_1	=	1.0 (1.0, 0.305)
k_2	=	0.1 (0.981, 10.7)
k_3	=	2.5 (2.5, 0.1)
d	=	summer loadline draft of the liftboat, in m (ft)
C_R	=	rudder force according to 3-2-13/3, in kN (tf, Ltf)
A	=	rudder area, in m ² (ft ²)
s	=	smaller unsupported dimension of plating, in mm (in.)
b	=	greater unsupported dimension of plating, in mm (in.)
β	=	$\sqrt{1.1 - 0.5(s/b)^2}$; maximum 1.0 for $b/s \geq 2.5$

The thickness of the rudder side or bottom plating is to be at least 2 mm (0.08 in.) greater than that required by 3-2-10/5 for deep tank plating in association with a head, h , measured to the summer load line.

17.5 Diaphragm Plates

Vertical and horizontal diaphragms are to be fitted within the rudder, effectively attached to each other and to the side plating. Vertical diaphragms are to be spaced approximately 1.5 times the spacing of horizontal diaphragms.

The thickness of diaphragm plates is not to be less than 70% of the required rudder side plate thickness or 8 mm (0.31 in.), whichever is greater. Openings in diaphragms are not to exceed one half their depth.

Welding is to be in accordance with Section 2-4-1 of the *ABS Rules for Materials and Welding (Part 2)* and Section 3-2-15 of this Guide. Where inaccessible for welding inside the rudder, it is recommended that diaphragms be fitted with flat bars and the side plating be connected to these flat bars by continuous welds or by 75 mm (3 in.) slot welds spaced at 150 mm (6 in.) centers. The slots are to be fillet welded around the edge, and filled with a suitable compound.

17.7 Watertightness

The rudder is to be watertight and is to be tested in accordance with 3-6-1/Table 1.

19 Single Plate Rudders

19.1 Mainpiece Diameter

The mainpiece diameter is calculated according to 3-2-13/7.3. For spade rudders the lower third may be tapered down to 0.75 times stock diameter at the bottom of the rudder.

19.3 Blade Thickness

The blade thickness is not to be less than obtained from the following equation:

$$t_b = 0.0015sV_R + 2.5 \text{ mm} \qquad t_b = 0.0015sV_R + 0.1 \text{ in.}$$

where

$$\begin{aligned} s &= \text{spacing of stiffening arms, in mm (in.), not to exceed 1000 mm (39 in.)} \\ V_R &= \text{speed, as defined in 3-2-13/3.1} \end{aligned}$$

19.5 Arms

The thickness of the arms is not to be less than the blade thickness obtained in 3-2-13/19.3. The section modulus of each set of arms about the axis of the rudder stock is not to be less than obtained from the following equation:

$$\begin{aligned} SM &= 0.0005s C_1^2 V_R^2 Q \text{ cm}^3 \\ SM &= 0.0000719s C_1^2 V_R^2 Q \text{ in}^3 \end{aligned}$$

where

$$C_1 = \text{horizontal distance from the aft edge of the rudder to the centerline of the rudder stock, in m (ft.)}$$

s , V_R are as defined in 3-2-13/19.3.

Q is as defined in 3-2-13/17.3.

21 Steering Nozzles (2012)

21.1 Application Scope

Requirements in this Subsection are applicable to conventional steering nozzles, as illustrated in 3-2-13/Figure 5, with the following restrictions:

- i) The inner diameter of 5 meters (16.4 feet) or less, and
- ii) The operating angle ranging not more than -35° to $+35^\circ$ port and starboard
- iii) Nozzles of above features but provided on the vessels for Ice Class are subject to additional requirements specified in Part 6 of the *Steel Vessel Rules*, as applicable

Steering nozzles outside of the application scope are subject to special consideration with all supporting documents and calculations submitted to ABS for review. The submitted documents and calculations are to include, but not limited to, the items listed in the following:

- i) The drawings and plans of steering nozzle with indications of design operating angles and the torque considered necessary to operate the steering nozzle at the design operating angle
- ii) The calculated steering nozzle section modulus
- iii) The calculated maximum water induced pressure of the nozzle under design speed (both ahead and astern conditions) and at the design operating angle, and
- iv) The calculated maximum shear and bending of nozzle support structure under design speed (both ahead and astern conditions) and at the design operating angle

21.3 Design Force

The design force, C_R , for steering nozzles is to be obtained from the following equation:

$$C_R = nk_R k_c k_\ell A V_R^2 \quad \text{kN (tf, Ltf)}$$

where

$$k_R = (d_m^2/A_t + 2)/3 \text{ but not taken more than } 2$$

$$d_m = \text{mean external diameter of the nozzle, in m (ft)}$$

$$= 0.5(d_f + d_a)$$

$$d_f, d_a = \text{fore and aft nozzle external diameters as shown in 3-2-13/Figure 5, in m (ft)}$$

$$A_t = A_{eq} + A_{po} + A_{mf} \text{ in m}^2 \text{ (ft}^2\text{)}$$

$$A_{eq} = \text{nominal projected area of nozzle cylinder, not to be taken less than } 1.35d_m b$$

$$b = \text{nozzle length in m (ft)}$$

$$A_{po} = \text{projected area of nozzle post or horn within the extension of nozzle profile as applicable}$$

$$A_{mf} = \text{projected area of movable flap if present}$$

$$= d_a b_{mf}$$

$$A = A_{eq} + A_{mf} \text{ in m}^2 \text{ (ft}^2\text{)}$$

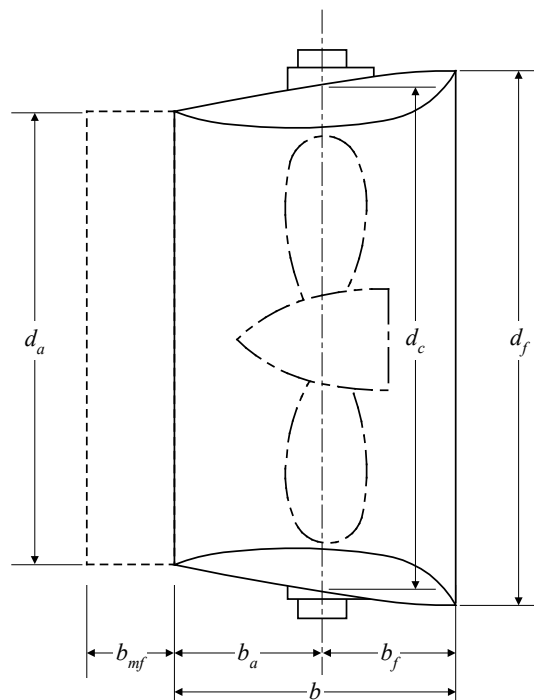
$$k_c = 1.9 \quad \text{for ahead condition}$$

$$= 1.5 \quad \text{for astern condition}$$

$$k_\ell = 1.15, \text{ as specified in 3-2-13/Table 2}$$

n, V_R are as defined in 3-2-13/3.1.

FIGURE 5
Nozzle Geometry (2012)



21.5 Design Torque

Design torque, Q_R , for steering nozzle is to be determined from the following equation for both ahead and astern conditions:

$$Q_R = C_R r \quad \text{kN-m (tf-m, Ltf-ft)}$$

where

$$r = (\alpha - k)\ell, \text{ but not less than } 0.1 \ell \text{ for ahead condition}$$

$$\ell = b \quad \text{without flap, in m (ft)}$$

$$= b + b_{mf} \quad \text{if flap present}$$

$$k = A_f / A$$

$$A_f = A_{eq} b_f / \ell, \text{ in m}^2 \text{ (ft}^2\text{)}$$

$$d_c = \text{nozzle diameter at the section intersecting with nozzle stock axis;}$$

α is as defined in 3-2-12/Table 3.

A , C_R are as defined in 3-2-12/21.3.

21.7 Nozzle Stock

21.7.1 Upper Stock

The upper stock is that part of the nozzle stock above the neck bearing.

At the upper bearing or tiller, the upper stock diameter is not to be less than obtained from the following equation:

$$S = N_u \sqrt[3]{Q_R K_s} \quad \text{mm (in.)}$$

where

$$N_u = 42.0 \text{ (823.9, 2.39)}$$

$$Q_R = \text{as defined in 3-2-12/21.5}$$

$$K_s = \text{material factor for nozzle stock, as defined in 3-2-12/1.3}$$

21.7.2 Lower Stock

In determining lower stock diameters, values of nozzle design force and torque calculated in 3-2-12/21.3 and 3-2-12/21.5 are to be used. Bending moments and shear forces, as well as the reaction forces are to be determined by direct calculation and are to be submitted for review. For nozzles supported by shoe pieces, these structures are to be included in the calculation. Calculation guidance for these values is given in Appendix 3-2-A1.

The lower nozzle stock diameter is not to be less than obtained from the following equation:

$$S_\ell = S \sqrt[6]{1 + 4/3 (M / Q_R)^2} \quad \text{mm (in.)}$$

where

$$S = \text{required upper stock diameter from 3-2-13/21.7.1, in mm (in.)}$$

$$M = \text{bending moment at the cross section of the nozzle stock considered, in kN-m (tf-m, Ltf-ft)}$$

$$Q_R = \text{design torque obtained from 3-2-13/21.5, in kN-m (tf-m, Ltf-ft)}$$

Where there is a change in stock diameter above the neck bearing, a gradual transition is to be provided.

21.9 Design Pressure

The design pressure of the nozzle is to be obtained from the following:

$$p = p_d + p_s \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

where

$$p_s = c_s C_R / A$$

$$c_s = 0.001 \text{ (0.0001, 0.145)}$$

C_R, A as defined in 3-2-13/21.3

p_d as defined in 3-2-12/19.3

21.11 Plate Thickness

21.11.1 Nozzle Shell

The thickness of the nozzle shell plating, in mm (in.), is not to be less than:

$$t = t_o + t_c \quad \text{mm (in.), but not to be taken less than 7.5 mm (0.3 in.)}$$

where

t_o = thickness obtained from the following formula:

$$= c_n \cdot S_p \cdot \sqrt{p K_n} \quad \text{mm (in.)}$$

c_n = coefficient as indicated in 3-2-12/Table 3

S_p = spacing of ring webs, in mm (in.)

p = design pressure, in N/mm² (kgf/mm², psi), as defined in 3-2-13/21.9

t_c = corrosion allowance determined by 3-2-12/Table 4

K_n = nozzle material factor as defined in 3-2-13/1.3

21.11.2 Internal Diaphragm

Thickness of nozzle internal ring web is not to be less than the required nozzle shell plating for Zone 3 as illustrated in 3-2-12/Figure 3.

21.11.3 Movable Flap

Nozzle movable flap plate thickness, if present, is to comply with the following:

- i) For double-plate movable flap, requirements in 3-2-13/17 are to be satisfied as applicable;
- ii) For single-plate movable flap, requirements in 3-2-13/19 are to be satisfied as applicable;

21.13 Section Modulus

Steering nozzle is to have a section modulus at least equal to that specified in 3-2-12/19.7, where n is replaced by 1.0 (0.0017).

21.15 Locking Device

A mechanical locking device is to be provided:

- i) To prevent the steering nozzle from rotating beyond the maximum operating angle at design speed
- ii) To prevent steering nozzle from rotating toward undesired directions in the event of accident or damage

21.17 Welding Requirement

Steering nozzle welding procedures are to comply with 3-2-12/19.9.

23 Azimuthal Thruster (2012)

23.1 Plans and Documents

The following plans and documents are to be submitted to ABS as applicable:

- i) General arrangement of the thruster
- ii) Structural items (nozzle, bracing, etc.)
- iii) Structural connection to hull
- iv) Propeller drawings
- v) Bearing details
- vi) Propeller and intermediate shafts
- vii) Gears
- viii) Rotating mechanism of the thruster
- ix) Thruster control system
- x) Piping systems connected to thruster
- xi) Manufacturer specified/calculated maximum load on the unit for crash stop condition

Note For specific requirements of machinery components, see Part 4 as applicable

23.3 Application Scope

Requirements in this Subsection are applicable to Azimuthal Thrusters (also referred as integrated nozzle propellers), as illustrated in 3-2-13/Figure 6, with the following restrictions:

- i) The inner diameter of thruster's nozzle is of 5 meters (16.5 feet) or less, and
- ii) Azimuthal thrusters of above features but provided on the vessels for Ice Class are subject to additional requirements specified in Part 6 of the *Steel Vessel Rules*, as applicable

Azimuthal thrusters outside of the above application scope are subject to special consideration with all supporting documents and calculations submitted to ABS for review. The submitted documents and calculations include, but are not limited to, the following items:

- i) The drawings and plans of the thruster with indications of design operating angles and the torque considered necessary to operate the thruster at the design operating angle
- ii) The calculated thruster section modulus
- iii) The calculated maximum water induced pressure of the thruster under design speed (both ahead and astern conditions) and at the design operating angle, and
- iv) The calculated maximum shear and bending of thruster support structure under design speed (both ahead and astern conditions) and at the design operating angle

23.5 Locking Device

A locking device is to be provided to prevent the azimuthal thruster from rotating toward undesired directions in the event of accident or damage.

23.7 Design Force

The design force, C_R , for azimuthal thrusters is the maximum load for crash stop condition (3-2-13/23.1) or as obtained from the following equation, whichever is greater:

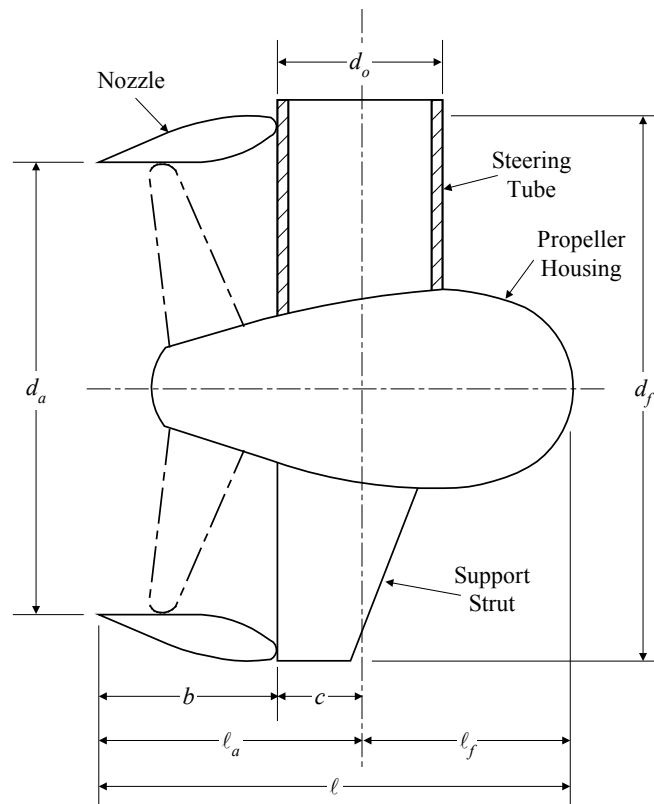
$$C_R = nk_R k_c k_\ell A V_R^2 \quad \text{kN (tf, Ltf)}$$

where

- $k_R = (d_m^2/A + 2)/3$ but not taken more than 1.33
- $d_m =$ mean external diameter of the nozzle, in m (ft)
 $= 0.5(d_f + d_a)$
- $d_f, d_a =$ fore and aft nozzle external diameters as shown in 3-2-13/Figure 6, in m (ft)
- $b =$ nozzle length in m (ft)
- $A = A_{eq} + A_{tb}$, in m^2 (ft^2)
- $A_{eq} =$ equivalent nominal area of nozzle cylinder, not to be taken less than $1.35d_m b$, in m^2 (ft^2)
- $A_{tb} =$ effective projected areas of the azimuthal thruster forward of the nozzle, not to be taken less than $0.707d_j d_o$, in m^2 (ft^2)
- $d_o =$ outer diameter of steering tube, in m (ft)
- $k_c = 1.9$ for ahead condition
 $= 1.5$ for astern condition.
- $k_\ell = 1.15$, as specified in 3-2-13/Table 2

n, V_R are as defined in 3-2-13/3.1.

FIGURE 6
Azimuthal Thruster (2012)



23.9 Design Torque

Design torque, Q_R , for azimuthal thruster is to be determined from the following equation for both ahead and astern conditions:

$$Q_R = C_R r \text{ kN-m (tf-m, Ltf-ft)}$$

where

$$r = (\alpha - k)\ell, \text{ but not less than } 0.1\ell \text{ for ahead condition}$$

$$\ell = \text{length of azimuthal thruster, in m (ft)}$$

$$k = A_f/A$$

$$A_f = \text{effective projected area of azimuthal thrust unit forward of steering centerline (within the extent length of } \ell_p), \text{ not to be taken less than } 0.5 A_{tb}, \text{ in m}^2 \text{ (ft}^2\text{)}$$

α is as defined in 3-2-13/Table 3.

C_R and A are as defined in 3-2-13/23.7.

23.11 Design Pressure

The design pressure of the nozzle is to be obtained from the following:

$$p = p_d + p_s \text{ N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

where

$$p_s = c_s C_R/A \text{ N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

p_d, c_s are as defined in 3-2-13/21.9.

C_R, A are as defined in 3-2-13/23.7.

23.13 Nozzle Scantlings

23.13.1 Nozzle Shell

The thickness of the nozzle shell plating, in mm (in.), is not to be less than the following:

$$t = t_o + t_c \text{ mm (in.), but not to be taken less than } 7.5 \text{ mm (0.3 in.)}$$

where

$$t_o = c_n S_p \sqrt{p K_n} \text{ mm (in.)}$$

$$c_n = \text{coefficient as indicated in 3-2-12/Table 3}$$

$$S_p = \text{nozzle ring web spacing, in mm (in.)}$$

$$p = \text{design pressure as defined in 3-2-13/23.11}$$

$$t_c = \text{corrosion allowance determined by 3-2-12/Table 4}$$

$$K_n = \text{material factor of the nozzle, as defined in 3-2-13/1.3}$$

23.13.2 Internal Diaphragm

Thickness of nozzle internal ring webs and diaphragms are not to be less than that required by 3-2-12/19.5.2.

23.15 Steering Tube

The steering tube of the azimuthal thruster is to have scantlings of at least the same strength against bending moment and shear force as an equivalent stock with diameter calculated in accordance with 3-2-13/7.

where

Q_R is replaced by the design torque as defined in 3-2-13/23.9

K_s is replaced by material factor of the steering tube

M is the bending moment calculated at the section of the steering tube under consideration

23.17 Section Modulus

Azimuthal thruster nozzle is to have a section modulus at least equal to that specified in 3-2-12/19.7, where n is replaced by 1.1 (0.00187).

23.19 Welding Requirement

Integrated nozzle welding procedures are to comply with 3-2-10/19.9 as applicable.

PART 3

CHAPTER 2 Hull Structures and Arrangements

APPENDIX 1 Guidelines for Calculating Bending Moment and Shear Force in Rudders and Rudder Stocks

1 Application

Bending moments, shear forces and reaction forces of rudders, stocks and bearings may be calculated according to this Appendix for the types of rudders indicated. Moments and forces on rudders of different types or shapes than those shown are to be calculated using alternative methods and will be specially considered.

3 Spade Rudders (2014)

3.1 Rudder

3.1.1 Shear Force

For regular spade rudders as shown in 3-2-A1/Figure 1(a), the shear force, $V(z)$, at a horizontal section of the rudder above baseline is given by the following equation:

$$V(z) = \frac{zC_R}{A} \left[c_\ell + \frac{z}{2\ell_R} (c_u - c_\ell) \right] \text{ kN (tf, Ltf)}$$

where

z = distance from the rudder baseline to the horizontal section under consideration, in m (ft)

C_R = rudder force, as defined in 3-2-13/3, in kN (tf, Ltf)

A = total projected area of rudder blade in m^2 (ft^2), as defined in 3-2-13/3

c_ℓ , c_u and ℓ_R are dimensions as indicated in 3-2-A1/Figure 1(a), in m (ft).

For spade rudders with embedded rudder trunks let deep in the rudder blade, as shown in 3-2-A1/Figure 1(b), the shear forces at rudder horizontal sections above rudder baseline in areas A_1 , and A_2 , are given by the following equations:

$$V(z')_1 = \frac{z'C_{R1}}{A_1} \left[c_u - \frac{z'}{2\ell_\ell} (c_u - c_b) \right] \text{ kN (tf, Ltf), over area } A_1$$

$$V(z)_2 = \frac{zC_{R2}}{A_2} \left[c_b + \frac{z}{2\ell_b} (c_b - c_l) \right] \text{ kN (tf, Ltf), over area } A_2$$

where

z' = $\ell_R - z$

C_{R1} = rudder force over rudder area A_1 , in kN (tf, Ltf)

$$= \frac{A_1}{A} C_R$$

C_{R2} = rudder force over rudder area A_2 , in kN (tf, Ltf)

$$= \frac{A_2}{A} C_R$$

A_1 = partial rudder blade area above neck bearing and below rudder top, in mm² (ft²)

A_2 = partial rudder blade area above rudder baseline and below neck bearing, in mm² (ft²)

z , A , and C_R are as indicated in 3-2-A1/3.1.1.

c_ℓ , c_b , c_u , ℓ_u , and ℓ_b are dimensions as illustrated in 3-2-A1/Figure 1(b).

3.1.2 Bending Moment

For regular spade rudders, bending moment, $M(z)$, at a horizontal section z meters (feet) above the baseline of the rudder is given by the following equations:

$$M(z) = \frac{z^2 C_R}{2A} \left[c_\ell + \frac{z}{3\ell_R} (c_u - c_\ell) \right] \text{ kN-m, (tf-m, Ltf-ft)}$$

For spade rudders with embedded rudder trunk, the bending moment at a horizontal section within area A_1 is obtained from the following:

$$M(z')_1 = \frac{(z')^2 C_{R1}}{2A_1} \left[c_u - \frac{z'}{3\ell_u} (c_u - c_b) \right] \text{ kN-m, (tf-m, Ltf-ft)}$$

With the maximum bending moment M_1 over area A_1 equals to:

$$M_1 = C_{R1} \left[1 - \frac{\ell_\ell}{3} (2c_b + c_u) \right] \text{ kN-m, (tf-m, Ltf-ft)}$$

For spade rudders with embedded rudder trunk, the bending moment at a horizontal section within area A_2 is obtained from the following:

$$M(z)_2 = \frac{z^2 C_{R2}}{2A_2} \left[c_\ell + \frac{z}{3\ell_b} (c_u - c_\ell) \right] \text{ kN-m, (tf-m, Ltf-ft)}$$

With the maximum bending moment M_2 over area A_2 equals to:

$$M_2 = C_{R2} \ell_b \frac{2c_\ell + c_b}{3(c_\ell + c_b)} \text{ kN-m, (tf-m, Ltf-ft)}$$

where z , z' , C_{R1} , C_{R2} , A_1 , A_2 , c_ℓ , c_u and ℓ_R are as defined in 3-2-A1/3.1.1.

3.3 Lower Stock

3.3.1 Shear Force

For regular spade rudder, the shear force, V_ℓ , at any section of the lower stock between the top of the rudder and the neck bearing is given by the following equation:

$$V_\ell = C_R \text{ kN (tf, Ltf)}$$

For spade rudder with embedded rudder trunk, the shear force at any section of the stock between the top of the rudder and the neck bearing is given by the following equation:

$$V_\ell = \frac{M_2 - M_1}{\ell_u + \ell_\ell} \text{ kN (tf, Ltf)}$$

where C_R , ℓ_ℓ , and ℓ_u are as defined in 3-2-A1/3.1.1.

3.3.2 Bending Moment at Neck Bearing

For regular spade rudder, the bending moment in the rudder stock at the neck bearing, M_n , is given by the following equation:

$$M_n = C_R \left[\ell_\ell + \frac{\ell_R (2c_\ell + c_u)}{3(c_\ell + c_u)} \right] \text{ kN-m (tf-m, Ltf-ft)}$$

where

C_R = rudder force as defined in 3-2-13/3

c_ℓ , c_u , ℓ_ℓ and ℓ_R are dimensions as indicated in 3-2-A1/Figure 1, in m (ft).

For spade rudder with embedded rudder trunk, the bending moment in the rudder stock at the neck bearing is given by the following equation:

$$M_n = M_2 - M_1 \text{ kN-m (tf-m, Ltf-ft)}$$

where M_1 and M_2 are as defined in 3-2-A1/3.1.2.

3.5 Moment at Top of Upper Stock Taper

For regular spade rudder, the bending moment in the upper rudder stock at the top of the taper, M_t , is given by the following equation:

$$M_t = C_R \left[\ell_\ell + \frac{\ell_R (2c_\ell + c_u)}{3(c_\ell + c_u)} \right] \times \left[\frac{(\ell_u + \ell_R + \ell_\ell - z_t)}{\ell_u} \right] \text{ kN-m (tf-m, Ltf-ft)}$$

For spade rudder with embedded rudder trunk, the bending moment in the upper rudder stock at the top of the taper is given by the following equation:

$$M_t = M_R \left[\frac{(\ell_R + \ell_u - z_t)}{\ell_u} \right] \text{ kN-m (tf-m, Ltf-ft)}$$

where

z_t = distance from the rudder baseline to the top of the upper rudder stock taper in m (ft)

C_R = rudder force, as defined in 3-2-A1/3.1.1

M_R = is the greater of M_1 and M_2 , as defined in 3-2-A1/3.1.2

c_ℓ , c_u , ℓ_ℓ , ℓ_u and ℓ_R are dimensions as indicated in 3-2-A1/Figure 1, in m (ft).

3.7 Bearing Reaction Forces

For regular spade rudder, the reaction forces at the bearings are given by the following equations:

P_u = reaction force at the upper bearing

$$= - \frac{M_n}{\ell_u} \text{ kN (tf, Ltf)}$$

P_n = reaction force at the neck bearing

$$= C_R + \frac{M_n}{\ell_u} \text{ kN (tf, Ltf)}$$

For spade rudder with embedded rudder trunk, the reaction forces at the bearings are given by the following equations:

$$P_u = - \frac{M_n}{\ell_u + \ell_\ell} \text{ kN (tf, Ltf)}$$

$$P_n = C_R + P_u \text{ kN (tf, Ltf)}$$

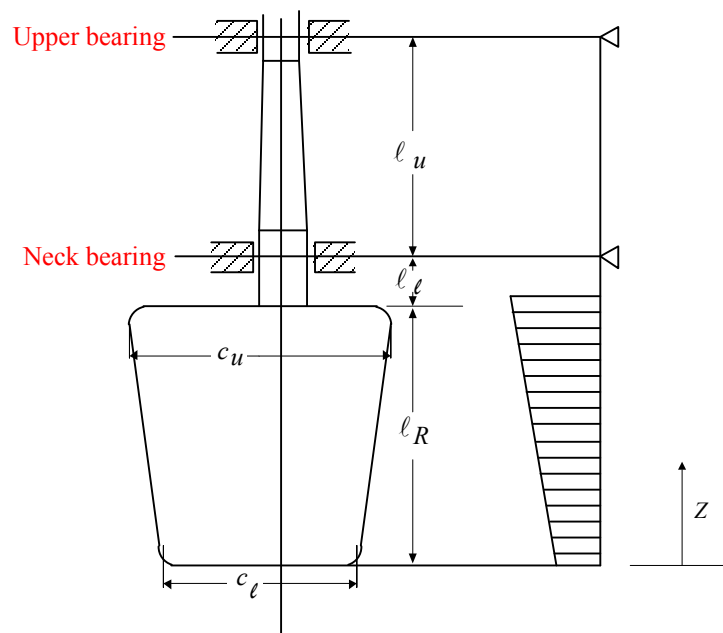
where

M_n = bending moment at the neck bearing, as defined in 3-2-A1/3.3.2

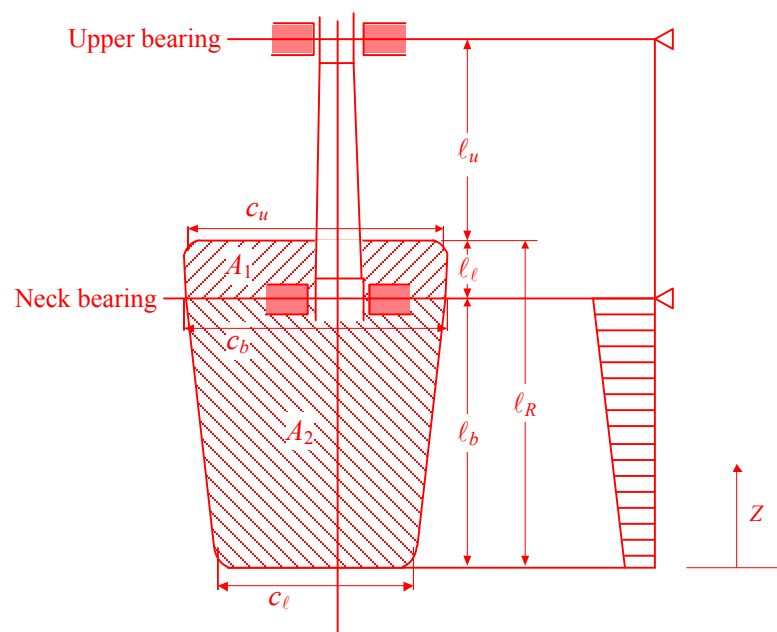
C_R = rudder force, as defined in 3-2-13/3

ℓ_u is as indicated in 3-2-A1/Figure 1, in m (ft).

FIGURE 1
Spade Rudder (2014)



(a) Regular Spade Rudder



(b) Spade Rudder with Embedded Rudder Trunk

5 Rudders Supported by Shoe piece

5.1 Shear Force, Bending Moment and Reaction Forces

Shear force, bending moment and reaction forces may be calculated according to the model given in 3-2-A1/Figure 2.

$$w_R = \text{rudder load per unit length}$$

$$= \frac{C_R}{\ell_R} \text{ kN/m (tf/m, Ltf/ft)}$$

where

$$C_R = \text{rudder force, as defined in 3-2-13/3.1}$$

$$k_s = \text{spring constant reflecting support of the shoe piece}$$

$$= \frac{n_s I_s}{\ell_s^3} \text{ kN/m (tf/m, Ltf/ft)}$$

$$n_s = 6.18 (0.630, 279)$$

$$I_s = \text{moment of inertia of shoe piece about the vertical axis, in cm}^4 (\text{in}^4)$$

$$I_u = \text{moment of inertia of the rudder stock above the neck bearing, in cm}^4 (\text{in}^4)$$

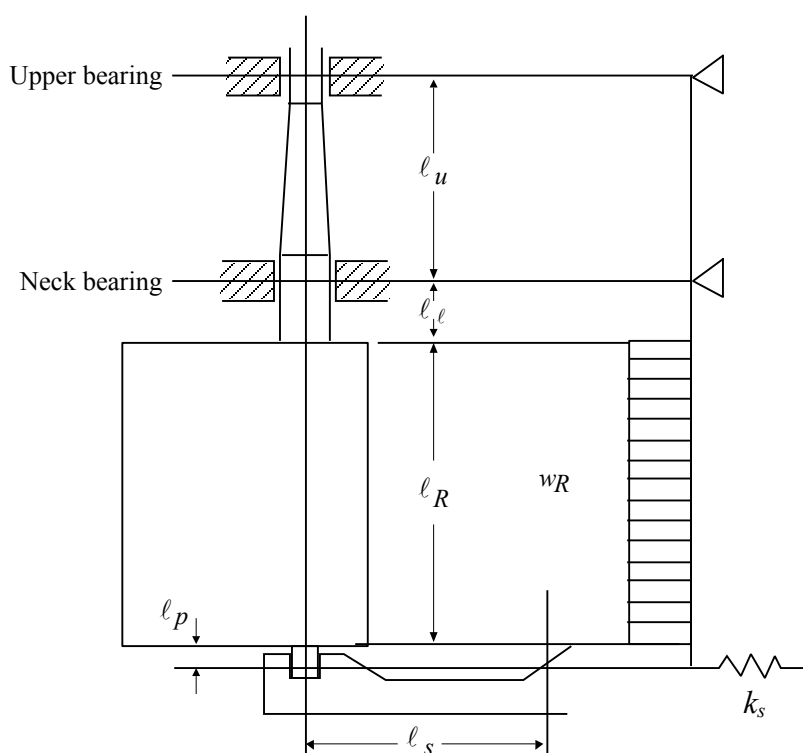
$$I_\ell = \text{moment of inertia of the rudder stock below the neck bearing, in cm}^4 (\text{in}^4)$$

$$I_R = \text{moment of inertia of the rudder about the longitudinal axis, in cm}^4 (\text{in}^4)$$

$$I_p = \text{moment of inertia of the pintle, in cm}^4 (\text{in}^4)$$

ℓ_ℓ , ℓ_s , ℓ_R and ℓ_u are dimensions as indicated in 3-2-A1/Figure 2, in m (ft).

FIGURE 2
Rudder Supported by Shoe piece



7 Rudders Supported by a Horn with One Pintle (2009)

7.1 Shear Force, Bending Moment and Reaction Forces

Shear force, bending moment and reaction forces are to be assessed by the simplified beam model shown in 3-2-A1/Figure 3.

w_{R1} = rudder load per unit length above pintle

$$= \frac{C_{R1}}{\ell_{R1}} \text{ kN/m (tf/m, Ltf/ft)}$$

w_{R2} = rudder load per unit length below pintle

$$= \frac{C_{R2}}{\ell_{R2}} \text{ kN/m (tf/m, Ltf/ft)}$$

where

C_{R1} = rudder force, as defined in 3-2-13/3.3

C_{R2} = rudder force, as defined in 3-2-13/3.3

k_h = spring constant reflecting support of the horn

$$= \frac{1}{\frac{\ell_h^3}{n_b I_h} + \frac{\Sigma \left(\frac{s_i}{t_i} \right) e^2 \ell_h}{n_t a^2}} \text{ kN/m (tf/m, Ltf/ft)}$$

n_b = 4.75 (0.485, 215)

n_t = 3.17 (0.323, 143)

a = mean area enclosed by the outside lines of the rudder horn, in cm² (in²)

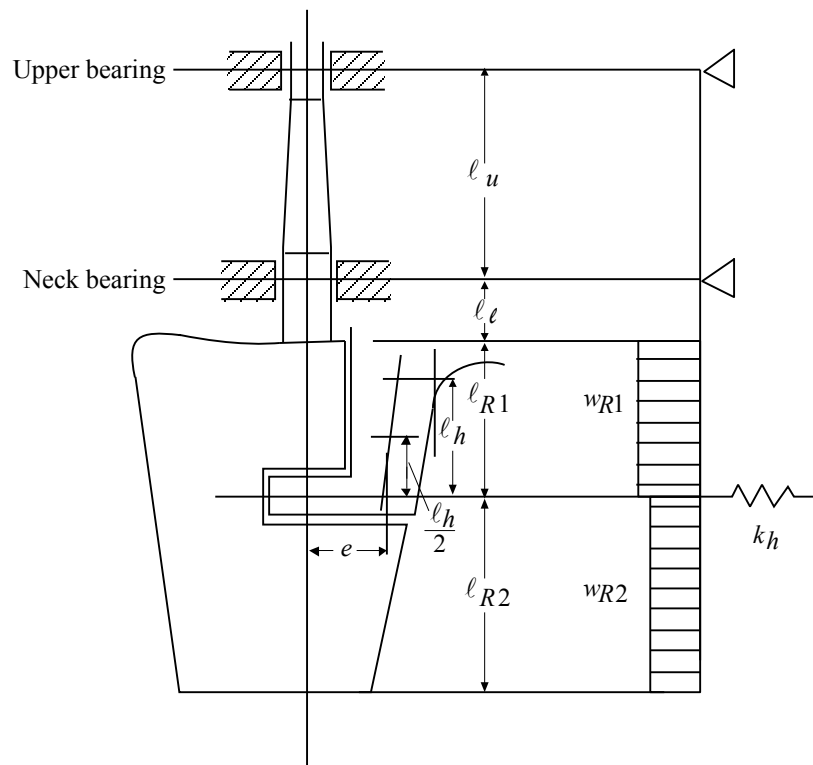
s_i = the girth length of each segment of the horn of thickness t_i , in cm (in.)

t_i = the thickness of each segment of horn outer shell of length s_i , in cm (in.)

I_h = moment of inertia of horn section at ℓ_h about the longitudinal axis, in cm⁴ (in⁴)

e , ℓ_h , ℓ_{R1} and ℓ_{R2} are dimensions as indicated in 3-2-A1/Figure 3, in m (ft).

FIGURE 3
Rudder Supported by a Horn with One Pintle (2009)



PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 14 Bulwarks, Rails, Ports, Portlights, Windows, Ventilators, Tank Vents and Overflows

1 Bulwarks and Guard Rails

1.1 Height

The height of bulwarks and guard rails on exposed freeboard and superstructure decks is to be at least 1 m (39.5 in.). Where this height would interfere with the normal service or operation of a liftboat, a lesser height may be approved if adequate protection is provided. Where approval of a lesser height is requested, justifying information is to be submitted, such as arrangements provided to prevent personnel going over the guard rails or bulwarks.

1.3 Strength of Bulwarks

Bulwarks are to be of ample strength in proportion to their height and efficiently stiffened at the upper edge. The bulwark plating is to be kept clear of the sheerstrake and the lower edge effectively stiffened. For liftboats under 61 m (200 ft) in length, the bulwarks plating on freeboard decks is to be of a thickness adequate for the intended service of the liftboat. For liftboats 61 m (200 ft) in length and over, the bulwark plating on freeboard decks is not to be less than 6.5 mm (0.25 in.) in thickness. Bulwarks are to be supported by efficient stays. Stays on freeboard decks are to be spaced not more than 1.83 m (6 ft) apart, formed of suitably stiffened plate or built-up tee sections, and efficiently attached to the bulwarks and deck plating.

1.5 Spacing of Guard Rails

Where guard rails are installed, the opening below the lowest course is not to exceed 230 mm (9 in.). The other courses are to be spaced not more than 380 mm (15 in.) apart. In the case of liftboats with rounded gunwales, the guard-rail stanchions or supports are to be placed on the flat of the deck. Guard rails are to comply with a recognized national or international standard.

3 Freeing Ports

3.1 Basic Area

Where bulwarks on freeboard decks form wells, ample provision is to be made for rapidly freeing the decks of water and for draining them. The minimum freeing-port area on each side of the liftboat for each well 20 m (66 ft.) or less in length is to be obtained from the following equation:

$$A = 0.7 + 0.035\ell \quad \text{m}^2$$

$$A = 7.6 + 0.115\ell \quad \text{ft}^2$$

Where the bulwark length exceeds 20 m (66 ft.):

$$A = 0.07\ell \quad \text{m}^2$$

$$A = 0.23\ell \quad \text{ft}^2$$

where

$$A = \text{freeing-port area, in m}^2 \text{ (ft}^2\text{)}$$

$$\ell = \text{bulwark length in m (ft), but need not exceed } 0.7L$$

If a bulwark is more than 1.2 m (3.9 ft) in height, the freeing-port area is to be increased by 0.004 m² per meter (0.04 ft² per foot) of length of well for each 0.1 m (1 ft) difference in height. If a bulwark is less than 0.9 m (3 ft) in height, the freeing port area may be decreased by the same ratio. In liftboats with no sheer, the calculated area is to be increased by 50%. Where sheer is less than standard, the percentage is to be obtained by interpolation.

3.3 Details of Freeing Ports

The lower edges of the freeing ports are to be as near the deck as practicable. Two-thirds of the required freeing-port area is to be provided in the half of the well nearest the lowest point of the sheer curve. Freeing-port openings are to be protected by rails or bars in such a manner that the maximum clear vertical or horizontal space is 230 mm (9 in.). Where shutters are fitted, ample clearance is to be provided to prevent them from jamming. Hinges are to have pins and bearings of corrosion resistant material and in general, the hinges are to be located at the top of the shutter. If the shutters are equipped with securing appliances, the appliances are to be of approved construction.

5 Portlights

5.1 Construction

Portlights to spaces within enclosed superstructures and deckhouses protecting openings leading to below the freeboard deck are to be fitted with efficient inside deadlights arranged in such manner that they can be closed and secured watertight. The portlights, together with their glasses and deadlights, are to comply with a recognized National or International Standard. Portlight glazing is to be monolithic tempered or toughened glass. Special consideration will be given to laminated glass, acrylic or polycarbonate materials when test verified mechanical properties are provided. They are to have strong frames (other than cast iron), and if of the opening type are to have noncorrosive hinge pins.

7 Windows

7.1 Construction

Windows to spaces within enclosed superstructure and deckhouses are to be fitted with strong, steel, weathertight storm covers. Windows should generally not be fitted in the end bulkheads of superstructures or deckhouses in Position 1.

Windows on the second tier above the freeboard deck may not require deadlight depending upon the arrangement of the liftboat. Window frames are to be metal or other approval material, and effectively secured to the adjacent structure. Windows are to have a minimum of a 1/4" radius at all corners. The glazing is to be set into the frames in a suitable, approved packing or compound. Special consideration to be given to angled house fronts.

The thickness of the window is not to be less than that obtained from 3-2-14/7.1.1, 3-2-14/7.1.2 or 3-2-14/7.1.3 below, whichever is greater.

7.1.1

$$t = s \left(\sqrt{\frac{pk}{1000\sigma_a}} \right) \text{ mm} \qquad t = s \left(\sqrt{\frac{pk}{\sigma_a}} \right) \text{ in.}$$

7.1.2

$$t = s \left(\sqrt[3]{\frac{pk_1}{20E}} \right) \text{ mm} \qquad t = s \left(\sqrt[3]{\frac{pk_1}{0.02E}} \right) \text{ in.}$$

7.1.3 Minimum Tempered Monolithic Glass Thicknesses:

$$t = 9.5 \text{ mm (0.37 in.)} \quad \text{for front windows}$$

$$t = 6.5 \text{ mm (0.25 in.)} \quad \text{for side and end windows}$$

where

$$t = \text{required window thickness, in mm (in.)}$$

$$s = \text{lesser dimension of window, in mm (in.)}$$

$$h = \text{pressure head, in m (ft), given in 3-2-11/1}$$

$$p = 9.8h \text{ kN/m}^2 (0.44h \text{ psi})$$

$$k = \text{factor given in 3-2-14/Table 1}$$

$$k_1 = \text{factor given in 3-2-14/Table 1}$$

$$\sigma_a = 0.3\sigma_f$$

$$\sigma_f = \text{material flexural strength; see 3-2-14/Table 2}$$

$$E = \text{material flexural modulus; see 3-2-14/Table 2}$$

7.3 Testing

All windows and portlights are to be hose tested after installation.

TABLE 1

ℓ/s	k	k_1
>5	0.750	0.142
5	0.748	0.142
4	0.741	0.140
3	0.713	0.134
2	0.610	0.111
1.8	0.569	0.102
1.6	0.517	0.091
1.4	0.435	0.077
1.2	0.376	0.062
1	0.287	0.044

$$\ell = \text{greater dimension of window panel, in mm (in.)}$$

$$s = \text{lesser dimension of window panel, in mm (in.)}$$

TABLE 2

Glazing	Flexural Strength	Flexural Modulus
Tempered Monolithic	119 MPa (17,200 psi)	73,000 MPa (10,600,000 psi)
Laminated Glass	69 MPa (10,000 psi)	2,620 MPa (380,000 psi)
Polycarbonate*	93 MPa (13,500 psi)	2,345 MPa (340,000 psi)
Acrylic (poly methyl methacrylate)*	110 MPa (16,000 psi)	3,000 MPa (435,000 psi)

* Indicated values are for reference. Aging effects are to be considered for design.

9 Ventilators, Tank Vents and Overflows (2004)

9.1 General (2004)

Ventilators are to comply with the requirements of 3-2-14/9.3. Tank vents and overflows are to comply with the requirements in 3-2-14/9.5. In addition, for those located on the fore deck of liftboats with length L (as defined in 3-1-1/1.1.1) greater than 80 meters (263 feet), the requirements given in 3-2-14/9.7 are to be complied with.

9.3 Ventilators (2004)

9.3.1 Coaming Construction

Ventilators on exposed freeboard decks, superstructure decks, or deckhouses are to have coamings of steel or equivalent material. Coaming plate thicknesses are to be obtained from the following equation:

$$t = 0.01d + 5.5 \text{ mm} \qquad t = 0.01d + 0.22 \text{ in.}$$

where

t = thickness of coaming, in mm (in.)

d = diameter of ventilator, in mm (in.), but not less than 200 mm (7.5 in.)

The maximum coaming plate thickness required is 10 mm (0.40 in.). The coamings are to be effectively secured to the deck. Coamings which are more than 900 mm (35.5 in.) high and which are not supported by adjacent structures are to have additional strength and attachment. Ventilators passing through superstructures other than enclosed superstructures are to have substantially constructed coamings of steel, not less than 0.30 in thick, at the freeboard deck.

9.3.2 Coaming Height

Ventilators in Position 1 are to have coamings at least 900 mm (35.5 in.) high. Ventilators in Position 2 are to have coamings at least 760 mm (30 in.) high. For definitions of Position 1 and Position 2, see Section 3-2-11. Coaming heights may be reduced on liftboats which have freeboard in excess of the minimum geometric freeboard and/or a superstructure deck with height of deck in excess of the standard height of a superstructure.

9.3.3 Means for Closing Ventilators

Except as provided below, ventilator openings are to be provided with efficient, permanently attached closing appliances. In liftboats measuring 24 m (79 ft) or more in length (as defined in the International Convention on Load Lines, 1966) ventilators in Position 1, the coamings of which extend to more than 4.5 m (14.8 ft) above the deck and in Position 2, the coamings of which extend to more than 2.3 m (7.5 ft) above the deck, need not be fitted with closing arrangements.

These coaming height requirements may be modified in liftboats measuring less than 24 m (79 ft) in length.

9.5 Tank Vents and Overflows (2004)

Tank vents and overflows are to be in accordance with the requirements of 4-5-3/9 and 4-5-3/11 of this Guide and, where applicable, the requirements given below in 3-2-14/9.7.

9.7 Ventilators, Tank Vents and Overflows on the Fore Deck (2004)

9.7.1 Application

The requirements of this Paragraph apply to all ventilators, tank vents and overflows located on the exposed fore deck within the forward $0.25L$ on liftboats with length L (as defined in 3-1-1/1.1.1) greater than 80 meters (263 feet) and where the height of the exposed deck in way of the item is less than $0.1L$ or 22 meters (72 ft) above the summer load waterline, whichever is the lesser.

9.7.2 Applied Loading to the Air Pipes and Ventilators

9.7.2(a) *Pressure.* The pressures p , in kN/m^2 (tf/m^2 , Ltf/ft^2), acting on air pipes, ventilator pipes and their closing devices, may be calculated from:

$$p = f \rho V^2 C_d C_s C_p \quad \text{kN/m}^2 \text{ (tf/m}^2, \text{ Ltf/ft}^2\text{)}$$

where:

- f = 0.5 (0.05, 0.0156)
- ρ = density of sea water, 1.025 t/m^3 (1.025 t/m^3 , 0.0286 Lt/ft^3)
- V = velocity of water over the fore deck, 13.5 m/sec (44.3 ft/sec)
- C_d = shape coefficient
 - = 0.5 for pipes,
 - = 1.3 for pipes or ventilator heads in general,
 - = 0.8 for pipes or ventilator heads of cylindrical form with its axis in the vertical direction
- C_s = slamming coefficient, 3.2
- C_p = protection coefficient:
 - = 0.7 for pipes and ventilator heads located immediately behind a breakwater or forecastle,
 - = 1.0 elsewhere including immediately behind a bulwark.

9.7.2(b) *Force.* Forces acting in the horizontal direction on the pipe and its closing device may be calculated from the above pressure using the largest projected area of each component.

9.7.3 Strength Requirements for Ventilators, Tank Vents and Overflows and their Closing Devices

9.7.3(a) *Bending Moment and Stress.* Bending moments and stresses in air pipes and ventilator pipes are to be calculated at critical positions: at penetration pieces, at weld or flange connections, at toes of supporting brackets. Bending stresses in the net section are not to exceed $0.8Y$, where Y is the specified minimum yield stress or 0.2% proof stress of the steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2.0 mm (0.08 in.) is then to be applied.

9.7.3(b) Tank Vents and Overflows

- i) For standard tank vents and overflows of 760 mm (30 in.) height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in 3-2-14/Table 3. Where brackets are required, three or more radial brackets are to be fitted.
- ii) Brackets are to be of gross thickness of 8 mm (0.32 in.) or more, of minimum length of 100 mm (4.0 in.), and height according to 3-2-14/Table 3, but need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported.
- iii) For other configurations, loads according to 3-2-14/9.7.2 are to be applied, and means of support determined in order to comply with the requirements above. Brackets, where fitted, are to be of suitable thickness and length according to their height.
- iv) Final (gross) pipe thickness is not to be taken less than as indicated in 4-5-3/9.3.
- v) The minimum internal diameter of the air pipe or overflow is not to be less than 65 mm.

9.7.3(c) Ventilators

- i) For standard ventilators of 900 mm (35.4 in.) height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in 3-2-14/Table 5. Brackets, where required, are to be as specified in 3-2-14/9.7.3(b)iii).
- ii) For ventilators of height greater than 900 mm (35.4 in.), brackets or alternative means of support are to be provided. Coaming is not to be taken less than as indicated in 3-2-14/9.3 nor in 3-2-14/Table 3.

9.7.3(d) *Components and Connections.* All component parts and connections of the tank vents and overflows or ventilators are to be capable of withstanding the loads defined in 3-2-14/9.7.2.

9.7.3(e) *Rotary Heads.* Rotating type mushroom ventilator heads are not to be used for application in this location.

TABLE 3
760 mm (30 in.) High Tank Vents and Overflows
Thickness and Bracket Standards (2004)

Nominal Pipe Size		Minimum Fitted Gross Thickness mm (in.)		Maximum Projected Area of Head cm ² (in ²)		Height ⁽¹⁾ of Brackets mm (in.)	
A mm	B in.						
65	2½	6.0	---	---	---	480	18.9
80	3	6.3	0.25	---	---	460	18.1
100	4	7.0	0.28	---	---	380	15.0
125	5	7.8	0.31	---	---	300	11.8
150	6	8.5	0.33	---	---	300	11.8
175	7	8.5	0.33	---	---	300	11.8
200	8	8.5 ⁽²⁾	0.33 ⁽²⁾	1900	295	300	11.8
250	10	8.5 ⁽²⁾	0.33 ⁽²⁾	2500	388	300 ⁽²⁾	11.8 ⁽²⁾
300	12	8.5 ⁽²⁾	0.33 ⁽²⁾	3200	496	300 ⁽²⁾	11.8 ⁽²⁾
350	14	8.5 ⁽²⁾	0.33 ⁽²⁾	3800	589	300 ⁽²⁾	11.8 ⁽²⁾
400	16	8.5 ⁽²⁾	0.33 ⁽²⁾	4500	698	300 ⁽²⁾	11.8 ⁽²⁾

Notes:

- 1 Brackets [see 3-2-14/9.7.3(b)] need not extend over the joint flange for the head.
- 2 Brackets are required where the as fitted (gross) thickness is less than 10.5 mm (0.41 in.), or where the tabulated projected head area is exceeded.

Note: For other air pipe heights, the relevant requirements of 3-2-14/9.7.3 are to be applied.

TABLE 4
900 mm (35.4 in.) High Ventilator
Thickness and Bracket Standards (2004)

Nominal Pipe Size		Minimum Fitted Gross Thickness mm (in.)		Maximum Projected Area of Head cm ² (in ²)		Height ⁽¹⁾ of Brackets mm (in.)	
A mm	B in.						
80	3	6.3	0.25	-	-	460	18.1
100	4	7.0	0.28	-	-	380	15.0
150	6	8.5	0.33	-	-	300	11.8
200	8	8.5	0.33	550	85	-	-
250	10	8.5	0.33	880	136	-	-
300	12	8.5	0.33	1200	186	-	-
350	14	8.5	0.33	2000	310	-	-
400	16	8.5	0.33	2700	419	-	-
450	18	8.5	0.33	3300	511	-	-
500	20	8.5	0.33	4000	620	-	-

Note: For other ventilator heights, the relevant requirements of 3-2-14/9.7.3 are to be applied.

CHAPTER 2 Hull Structures and Arrangements**SECTION 15 Weld Design and Production Welding****1 Weld Design – Fillet Welds****1.1 General****1.1.1 Plans and Specifications**

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.

1.1.2 Workmanship

Completed welds are to be to the satisfaction of the attending Surveyor. The gaps between the faying surfaces of members being joined should be kept to a minimum. Where the opening between members being joined exceeds 2.0 mm ($1/16$ in.) and is not greater than 5 mm ($3/16$ in.), the weld leg size is to be increased by the amount of the opening in excess of 2.0 mm ($1/16$ in.). Where the opening between members is greater than 5 mm ($3/16$ in.), corrective procedures are to be specially approved by the Surveyor.

1.1.3 Special Precautions

Special precaution such as the use of preheat or low-hydrogen electrodes or low-hydrogen welding processes may be required where small fillets are used to attach heavy plates or sections. When heavy sections are attached to relatively light plating, the weld size may be required to be modified.

1.3 Tee Connections**1.3.1 Size of Fillet Welds**

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 3-2-15/1. Where it is desirable to substitute continuous welding for intermittent welding as given in 3-2-15/Table 1, a reduction from the required size of fillet may be allowed if equivalent strength is provided.

1.3.2 Intermittent Welding at Intersection

Where beams, stiffeners, frames, etc., are intermittently welded and 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.

1.3.3 Welding of Longitudinal to Plating

Welding of longitudinals to plating is to have double continuous welds at the ends and in way of transverses equal in length to depth of the longitudinal. For deck longitudinals only, a matched pair of welds is required at the transverses.

1.3.4 Stiffeners and Webs to Hatch Covers

Unbracketed stiffeners and webs of hatch covers are to be welded continuously to the plating and to the face plate for a length at ends equal to the end depth of the member.

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 sizes of the welds, w , are not to be less than $\frac{3}{4}$ 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. In certain cases only the webs of girders, beams and stiffeners need be attached. In such cases it is recommended that the unattached face plates or flanges be cut back.

1.7 Tee Joints at Boundary Connections

Tee joints at boundary connections of bulkheads, decks, inner bottoms, etc. are to have continuous welding on both sides where the thinner of the plates is 12.5 mm ($\frac{1}{2}$ in.) thick or greater. In general the size of the welds, w , is to be such that the two together are not less than the thickness of the thinner plate plus 1.5 mm ($\frac{1}{16}$ in.). Where the thickness of the thinner plate is less than 12.5 mm ($\frac{1}{2}$ in.), the attachment may be made by a continuous weld on one side 1.5 mm ($\frac{1}{16}$ in.) less than the thickness of the thinner plate with intermittent welding on the opposite side of the size required by 3-2-15/Table 1 for stiffeners to deep tank bulkheads, except in way of tanks where equivalent continuous welds are to be used.

1.9 Ends of Unbracketed Stiffeners

Unbracketed stiffeners of shell, watertight and oiltight bulkheads and house fronts are to have double continuous welds for one-tenth of their length at each end.

Unbracketed stiffeners of nontight structural bulkheads, deckhouse sides and after ends are to have a pair of matched intermittent welds at each end.

1.11 Reduced Weld Size

Reduction in fillet weld sizes except for slab longitudinals of thickness greater than 25 mm (1.0 in.) may be specially approved by the Surveyor in accordance with either 3-2-15/1.11.1 or 3-2-15/1.11.2 provided the requirements of 3-2-15/1.3 are satisfied.

1.11.1 Controlled Gaps

Where quality control facilitates working to a gap between members being attached of 1 mm (0.04 in.) or less, a reduction in fillet weld leg size w of 0.5 mm (0.02 in.) may be permitted.

1.11.2 Deep Penetration Welds

Where automatic double continuous fillet welding is used and quality control facilitates working to a gap between members being attached of 1 mm (0.04 in.) or less, a reduction in fillet weld leg size of 1.5 mm ($\frac{1}{16}$ in.) may be permitted provided that the penetration at the root is at least 1.5 mm ($\frac{1}{16}$ in.) into the members being attached.

1.13 Lapped Joints

Lapped joints are generally to have overlaps of not less width than twice the thinner plate thickness plus 25 mm (1 in.).

1.13.1 Overlapped End Connections

Overlapped end connections of longitudinal strength members within the midship $0.4L$ 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.

1.13.2 Overlapped Seams

Overlapped seams are to have welds on both edges of the sizes required by 3-2-15/1.7 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 305 mm (12 in.) between centers in both directions.

3 Weld Design – Full or Partial Penetration Corner or Tee Joints

A full or partial penetration weld may be required for highly stressed (75% or more of the yield) critical (e.g., oil/water boundary) joints.

The designer is to give consideration to minimizing the possibility of lamellar tearing in such joints. Ultrasonic inspection of the plate in way of the connection may be required prior to and after fabrication to assure the absence of possible laminations and lamellar tearing.

5 Weld Design – Alternatives

The foregoing are considered minimum requirements for electric-arc welding in hull construction, but alternate methods, arrangements and details will be considered for approval. Fillet weld sizes may be determined from structural analyses based on sound engineering principles provided they meet the overall strength standards of the Guide.

TABLE 1
Weld Sizes and Spacing – Millimeters

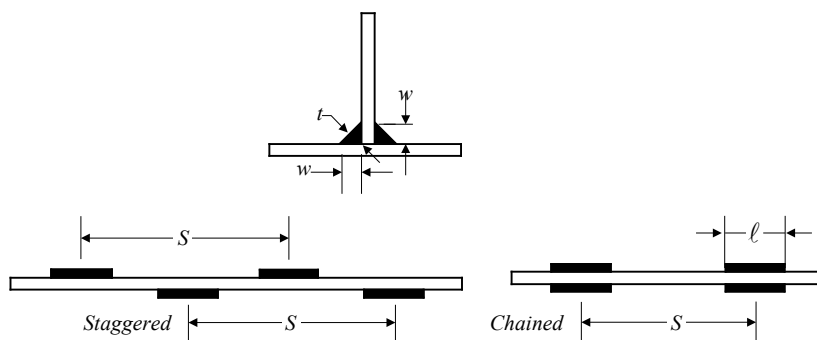
For weld requirements for thicknesses intermediate to those shown in the table use the nearest thickness shown in the table.

Where beams, stiffeners, frames, etc., are intermittently welded and 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.

For slab longitudinals the attachment is to be made by double continuous fillet welds of a size w which is 0.3 times the thickness of the thinner plate but need not be greater than 8.0 mm.

Where automatic double continuous fillet welding is provided, a reduction in fillet size of 1.5 mm will be permitted provided that the specified size of fillet in 3-2-15/Table 1 is 6.5 mm or greater, the gap between the members does not exceed 1.0 mm and the penetration at the root is at least 1.5 mm into the member being attached. This reduction does not apply for slab longitudinals.

For double continuous welding as an alternative to intermittent welding see 3-2-15/1.3.1.



	Weld size for lesser thickness of members joined, mm							
	5	6.5	8	9.5	11	12.5	14.5	16
Nominal leg size of fillet w	3	5	6.5	6.5	8	8	8	8
Nominal throat size of fillet t	2	3.5	5.4	4.5	5.5	5.5	5.5	5.5
Length of fillet weld	40	65	75	75	75	75	75	75

Structural Items	Spacing of Welds S , mm							
Single-Bottom Floors To center keelson <i>Note:</i> Connections elsewhere to take same weld as floors in double bottom	In accordance with 3-2-15/1.7							
Double-Bottom Floors To shell in aft peaks of liftboats having high power and fine form	—	—	150	125	150	150	150	125
To shell flat of bottom forward (fore-end strengthening) and in peaks	—	—	250	225	250	250	225	200
To shell elsewhere	*300	*300	300	275	300	275	250	250
Solid floors to center vertical keel plate in engine room, under boiler bearers, wide-spaced floors with longitudinal frames	In accordance with 3-2-15/1.7							
Solid floors to center vertical keel plate elsewhere, and open-floor brackets to center vertical keel	*250	*250	250	225	250	225	200	175
Solid floors and open-floor brackets to margin plate	In accordance with 3-2-15/1.7							
To inner bottom in engine room	In accordance with 3-2-15/1.7							
To inner bottom at forward end (fore-end strengthening)	*275	*275	275	250	275	250	225	200
To inner bottom elsewhere	*300	*300	300	275	300	275	250	250
Wide spaced with longitudinal framing to shell and inner bottom	In accordance with 3-2-15/1.7							
Solid floor stiffeners at watertight or oiltight boundaries	300	300	300	275	300	275	250	250
Watertight and oiltight periphery connections of floors throughout double bottom	In accordance with 3-2-15/1.7							

TABLE 1 (continued)
Weld Sizes and Spacing – Millimeters

	<i>Weld size for lesser thickness of members joined, mm</i>							
	5	6.5	8	9.5	11	12.5	14.5	16
Nominal leg size of fillet <i>w</i>	3	5	6.5	6.5	8	8	8	8
Nominal throat size of fillet <i>t</i>	2	3.5	5.4	4.5	5.5	5.5	5.5	5.5
Length of fillet weld	40	65	75	75	75	75	75	75

<i>Structural Items</i>	<i>Spacing of Welds S, mm</i>							
Center Girder								
Nontight to inner-bottom or center strake in way of engine and to shell or bar keel	In accordance with 3-2-15/1.7							
Nontight to inner-bottom or center strake clear of engine	150	150	150	125	150	125	125	125
Watertight or oiltight to inner bottom, rider plate, shell or bar keel	In accordance with 3-2-15/1.7							
Intercostals								
Intercostals and continuous longitudinal girders to shell and inner bottom elsewhere and to floors	*275	*275	275	250	275	250	225	225
Watertight and oiltight periphery connections of longitudinal girders in double bottom	In accordance with 3-2-15/1.7							
Frames								
To shell in aft peaks of liftboats having high power and fine form	—	—	150	125	150	150	150	125
To shell for 0.125 <i>L</i> forward and in peaks	—	—	250	225	250	250	225	225
To shell elsewhere—See <i>Note 1</i>	*300	*300	300	275	300	275	250	250
Unbracketed to inner bottom	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	†Dbl. Cont.	†Dbl. Cont.
Frame brackets to frames, decks and inner bottom	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	†Dbl. Cont.
Longitudinals to shell and inner bottom	*300	*300	300	275	300	275	250	250
Longitudinals to shell on flat of bottom forward (fore-end strengthening)	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.
Girders and Webs								
To shell and to bulkheads or decks in tanks	—	200	225	200	225	200	175	150
To bulkheads or decks elsewhere	—	—	250	225	250	225	200	175
Webs to face plate where area of face plate is 64.5 sq. cm. or less	*250	*250	300	275	300	275	250	250
Webs to face plate area of face plate exceeds 64.5 sq. cm	—	—	250	225	250	225	200	175
Bulkheads								
Peripheries of swash bulkheads	—	200	225	200	225	200	175	150
Peripheries of nontight structural bulkheads	—	225	250	225	250	225	200	175
Peripheries of deep tank or watertight bulkheads	In accordance with 3-2-15/1.7							
Stiffeners to deep tank bulkheads—See <i>Note 1</i>	—	*300	300	275	300	275	250	250
Stiffeners to ordinary watertight bulkheads and deckhouse fronts—See <i>Note 1</i>	—	*300	300	275	300	275	250	250
Stiffeners to nontight structural bulkheads; stiffeners on deckhouse sides and after ends—See <i>Note 2</i>	*300	*300	*‡300	300	‡300	300	300	250
Stiffener brackets to beams, decks, etc.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	†Dbl. Cont.
Decks								
Peripheries of platform decks and nontight flats								
Upper Weld	Cont.	Cont.	‡Cont.	Cont.	‡Cont.	Cont.	Cont.	†Cont.
Lower Weld	300	300	‡300	300	‡300	300	300	250
Peripheries of strength decks, exposed decks, and all watertight or oiltight decks, tunnels and flats	In accordance with 3-2-15/1.7							

TABLE 1 (continued)
Weld Sizes and Spacing – Millimeters

	<i>Weld size for lesser thickness of members joined, mm</i>							
	5	6.5	8	9.5	11	12.5	14.5	16
Nominal leg size of fillet <i>w</i>	3	5	6.5	6.5	8	8	8	8
Nominal throat size of fillet <i>t</i>	2	3.5	5.4	4.5	5.5	5.5	5.5	5.5
Length of fillet weld	40	65	75	75	75	75	75	75

<i>Structural Items</i>	<i>Spacing of Welds <i>S</i>, mm</i>							
Decks (continued)								
Beams (transverse or longitudinal) to decks	*300	*300	300	275	300	275	250	250
Beams knees to beams and frames	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.
Hatch coamings to exposed decks	In accordance with 3-2-15/1.7							
Transverses or deep beams to decks in tanks	—	200	225	200	225	200	175	150
Transverse or deep beams to deck elsewhere	—	—	250	225	250	225	200	175
Foundations								
To top plates, shell or inner bottom for main engines and major auxiliaries	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	‡Dbl. Cont.
To top plates, shell or inner bottom for boilers and other auxiliaries	In accordance with 3-2-15/1.7							

See general notes at beginning of table

Notes

- 1 Unbracketed stiffeners of shell, watertight and oiltight bulkheads and house fronts are to have double continuous welds for one-tenth of their length at each end.
- 2 Unbracketed stiffeners of nontight structural bulkheads, deckhouse sides and after ends are to have a pair of matched intermittent welds at each end.
- 3 Where the symbol, — (dash), is shown in place of the spacing of intermittent fillet welds, it is to indicate that the corresponding thickness is not anticipated for that particular structural member.
- ‡ Nominal size of fillet *w* may be reduced 1.5 mm.
- † Nominal size of fillet *w* is increased 1.5 mm.
- * Fillet welds are to be staggered.

TABLE 1
Weld Sizes and Spacing – Inches

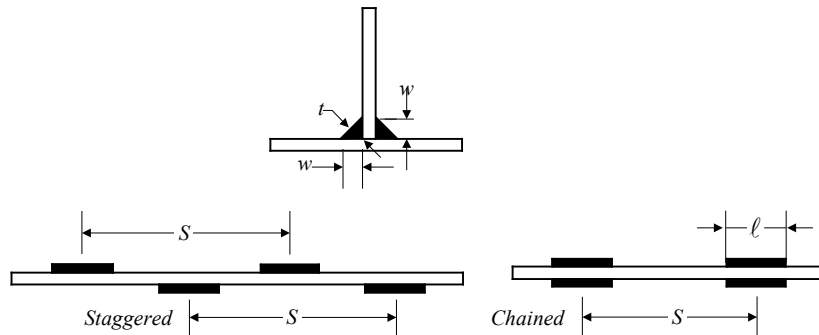
For weld requirements for thicknesses intermediate to those shown in the table use the nearest thickness shown in the table.

Where beams, stiffeners, frames, etc., are intermittently welded and 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.

For slab longitudinals the attachment is to be made by double continuous fillet welds of a size w which is 0.3 times the thickness of the thinner plate but need not be greater than $5/16$ in.

Where automatic double continuous fillet welding is provided, a reduction in fillet size of $1/16$ in. will be permitted provided that the specified size of fillet in 3-2-15/Table 1 is $1/4$ in. or greater, the gap between the members does not exceed 0.04 in. and the penetration at the root is at least $1/16$ in. into the member being attached. This reduction does not apply for slab longitudinals.

For double continuous welding as an alternative to intermittent welding see 3-2-15/1.3.1.



	Leg size for lesser thickness of members joined, in.							
	0.19	0.25	0.32	0.38	0.44	0.50	0.57	0.63
Nominal leg size of fillet w	$1/8$	$3/16$	$1/4$	$1/4$	$5/16$	$5/16$	$5/16$	$5/16$
Length of fillet weld	$1 1/2$	$2 1/2$	3	3	3	3	3	3

Structural Items	Spacing of Welds S , mm							
Single-Bottom Floors To center keelson <i>Note:</i> Connections elsewhere to take same weld as floors in double bottom	In accordance with 3-2-15/1.7							
Double-Bottom Floors To shell in aft peaks of liftboats having high power and fine form	—	—	6	5	6	6	6	5
To shell flat of bottom forward (fore-end strengthening) and in peaks	—	—	10	9	10	10	9	8
To shell elsewhere	*12	*12	12	11	12	11	10	10
Solid floors to center vertical keel plate in engine room, under boiler bearers, wide-spread floors with longitudinal frames	In accordance with 3-2-15/1.7							
Solid floors to center vertical keel plate elsewhere, and open-floor brackets to center vertical keel	*10	*10	10	9	10	9	8	7
Solid floors and open-floor brackets to margin plate	In accordance with 3-2-15/1.7							
To inner bottom in engine room	In accordance with 3-2-15/1.7							
To inner bottom at forward end (fore-end strengthening)	*11	*11	11	10	11	10	9	8
To inner bottom elsewhere	*12	*12	12	11	12	11	10	10
Wide spaced with longitudinal framing to shell and inner bottom	In accordance with 3-2-15/1.7							
Solid floor stiffeners at watertight or oiltight boundaries	—	12	12	11	12	11	10	10
Watertight and oiltight periphery connections of floors throughout double bottom	In accordance with 3-2-15/1.7							

TABLE 1 (continued)
Weld Sizes and Spacing – Inches

	<i>Leg size for lesser thickness of members joined, in.</i>							
	0.19	0.25	0.32	0.38	0.44	0.50	0.57	0.63
Nominal leg size of fillet <i>w</i>	¹ / ₈	³ / ₁₆	¹ / ₄	¹ / ₄	⁵ / ₁₆	⁵ / ₁₆	⁵ / ₁₆	⁵ / ₁₆
Length of fillet weld	1 ¹ / ₂	2 ¹ / ₂	3	3	3	3	3	3

<i>Structural Items</i>	<i>Spacing of Welds S, mm</i>							
Center Girder								
Nontight to inner-bottom or center strake in way of engine and to shell or bar keel	In accordance with 3-2-15/1.7							
Nontight to inner-bottom or center strake clear of engine	6	6	6	5	6	5	5	5
Watertight or oiltight to inner bottom, rider plate, shell or bar keel	In accordance with 3-2-15/1.7							
Intercostals								
Intercostals and continuous longitudinal girders to shell on flat bottom forward (fore-end strengthening) and to inner bottom in way of engines	—	6	6	5	6	5	5	‡Dbl. Cont.
Intercostals and continuous longitudinal girders to shell and inner bottom elsewhere and to floors	*11	*11	11	10	11	10	9	9
Watertight and oiltight periphery connections of longitudinal girders in double bottom	In accordance with 3-2-15/1.7							
Frames								
To shell in aft peaks of liftboats having high power and fine form	—	—	6	5	6	6	6	5
To shell for 0.125 <i>L</i> forward and in peaks	—	—	10	9	10	10	9	9
To shell elsewhere—See <i>Note A</i>	*12	*12	12	11	12	11	10	10
Unbracketed to inner bottom	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	†Dbl. Cont.	†Dbl. Cont.
Frame brackets to frames, decks and inner bottom	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	†Dbl. Cont.
Longitudinals to shell and inner bottom	*12	*12	12	11	12	11	18	18
Longitudinals to shell on flat of bottom forward (fore-end strengthening)	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.
Girders and Webs								
To shell and to bulkheads or decks in tanks	—	8	9	8	9	8	7	6
To bulkheads or decks elsewhere	—	—	10	9	10	9	8	7
Webs to face plate where area of face plate is 10 sq. in. or less	*10	*10	12	11	12	11	10	10
Webs to face plate area of face plate exceeds 10 sq. in.	—	—	10	9	10	9	8	7
Bulkheads								
Peripheries of swash bulkheads	—	8	9	8	9	8	7	6
Peripheries of nontight structural bulkheads	—	9	10	9	10	9	8	7
Peripheries of deep tank or watertight bulkheads	In accordance with 3-2-15/1.7							
Stiffeners to deep tank bulkheads—See <i>Note 1</i>	—	*12	12	11	12	11	10	10
Stiffeners to ordinary watertight bulkheads and deckhouse fronts—See <i>Note 1</i>	—	*12	12	11	12	11	10	10
Stiffeners to nontight structural bulkheads; stiffeners on deckhouse sides and after ends—See <i>Note 2</i>	*12	*12	*‡12	12	‡12	12	12	10
Stiffener brackets to beams, decks, etc.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	†Dbl. Cont.
Decks								
Peripheries of platform decks and nontight flats								
Upper Weld	Cont.	Cont.	‡Cont.	Cont.	‡Cont.	Cont.	Cont.	†Cont.
Lower Weld	12	12	‡12	12	‡12	12	12	10

TABLE 1 (continued)
Weld Sizes and Spacing – Inches

	<i>Leg size for lesser thickness of members joined, in.</i>							
	0.19	0.25	0.32	0.38	0.44	0.50	0.57	0.63
Nominal leg size of fillet <i>w</i>	1/8	3/16	1/4	1/4	5/16	5/16	5/16	5/16
Length of fillet weld	1 1/2	2 1/2	3	3	3	3	3	3

<i>Structural Items</i>	<i>Spacing of Welds S, mm</i>							
Decks (continued)	In accordance with 3-2-15/1.7							
Peripheries of strength decks, exposed decks, and all watertight or oiltight decks, tunnels and flats	*12	*12	12	11	12	11	10	10
Beams (transverse or longitudinal) to decks	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.
Beams knees to beams and frames	—	—	—	In accordance with 3-2-15/1.7				
Hatch coamings to exposed decks	—	8	9	8	9	8	7	6
Transverses or deep beams to decks in tanks	—	—	10	9	10	9	8	7
Transverses or deep beams to decks elsewhere	—	—	10	9	10	9	8	7
Foundations	In accordance with 3-2-15/1.7							
To top plates, shell or inner bottom for main engines and major auxiliaries	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	Dbl. Cont.	‡Dbl. Cont.	‡Dbl. Cont.
To top plates, shell or inner bottom for boilers and other auxiliaries	In accordance with 3-2-15/1.7							

See general notes at beginning of table

Notes

- 1 Unbracketed stiffeners of shell, watertight and oiltight bulkheads and house fronts are to have double continuous welds for one-tenth of their length at each end.
- 2 Unbracketed stiffeners of nontight structural bulkheads, deckhouse sides and after ends are to have a pair of matched intermittent welds at each end.
- 3 Where the symbol, — (dash), is shown in place of the spacing of intermittent fillet welds, it is to indicate that the corresponding thickness is not anticipated for that particular structural member.
- ‡ Nominal size of fillet *w* may be reduced 1/16 in.
- † Nominal size of fillet *w* is increased 1/16 in.
- * Fillet welds are to be staggered.

7 Production Welding

7.1 General

The production welding and forming are to be to the satisfaction of the Surveyor and in accordance with Chapter 4 “Welding & Fabrication” of the *ABS Rules for Materials and Welding (Part 2)*. The following special requirements for Liftboats are also to be complied with.

7.3 Thickness in Excess of 50 mm (2 in.)

Special precautions, with regard to joint preparation, preheat, welding sequence, heat input and interpass temperature, are to be taken for welding thick sections. Ultrasonic inspection to insure the absence of injurious laminations may be required for material used where through-thickness (Z direction) properties are important. Stress relieving, when specified, is to be carried out using an approved method.

7.5 Extent of Inspection of Welds

7.5.1 General

All welds are to be subject to visual inspection. Representative nondestructive testing is to be carried out to the satisfaction of the Surveyor. Such testing is to be carried out after all forming and post weld heat treatment. Welds which are inaccessible or difficult to inspect in service may be subjected to increased levels of nondestructive inspection. A plan for nondestructive testing is to be submitted.

7.5.2 Extent and Method

As a minimum, weld joints of lattice-type leg structure (including chords, braces, racks, and rack attachments), circumferential joints of cylindrical-type legs, structure in way of leg guides and jack house attachments to deck, and attachments of legs to footings are to be subjected to 100% nondestructive testing (radiographic, ultrasonic, magnetic particle, dye-penetrant, or equivalent). In addition to surface nondestructive testing, at least 20% of full penetration welded joints in primary structure and all full penetration welded joints in special application structure are to be subjected to 100% radiographic or ultrasonic inspection. Additional nondestructive testing may be required by the Surveyor.

7.7 Acceptance Criteria

Class A and *Class B* acceptance standards of the *ABS Guide for Nondestructive Inspection of Hull Welds* will be applicable as follows.

Class A acceptance criteria is to be used for special application structure and critical locations within primary application structure such as circumferential welds of cylindrical and built up legs, weld intersections of external plating in decks of platforms, main hull, and footing support structure.

Class B acceptance criteria is to be used for secondary application structure and other locations where *Class A* acceptance criteria do not apply.

Modified procedures and acceptance criteria are to be specified to reflect the application when radiographic or ultrasonic inspection is specified for other type connections such as partial penetration and groove type Tee or corner welds.

7.9 Fillet Welds

7.9.1 Workmanship

Completed welds are to be to the satisfaction of the attending Surveyor. The gaps between the faying surfaces of members being joined should be kept to a minimum. Where the opening between members being joined exceeds 2.0 mm ($1/16$ in.) and is not greater than 5 mm ($3/16$ in.), the weld leg size is to be increased by the amount of the opening. Where the opening between members is greater than 5 mm ($3/16$ in.), corrective procedures are to be specially approved by the Surveyor.

7.9.2 Special Precautions

Special precaution such as the use of preheat or low-hydrogen electrodes or low-hydrogen welding processes may be required where small fillets are used to attach heavy plates or sections. When heavy sections are attached to relatively light plating, the weld size may be required to be modified.

CHAPTER 3 Subdivision and Stability

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PART

3

CHAPTER 3 Subdivision and Stability

SECTION 1 Stability and Watertight/Weathertight Integrity

1 Stability

1.1 General

All liftboats are to have a positive metacentric height for all conditions afloat including temporary conditions when lowering and raising legs.

1.3 Stability Afloat

All liftboats are to meet these stability requirements for all transit and operating conditions afloat.

1.3.1 Intact Stability

All liftboats are to have sufficient stability (righting stability) to withstand the overturning effect of the force produced by a wind from any horizontal direction in accordance with the stability criteria given in 3-3-1/3.3.1 for conditions afloat. All liftboats in unrestricted offshore service are to be capable of withstanding a wind velocity of not less than 36 m/s (70 knots) for transit and a wind velocity of not less than 51.5 m/s (100 knots) for a severe storm condition. Liftboats designed to withstand winds of less than 36 m/s (70 knots) for transit and/or less than 51.5 m/s (100 knots) for severe storm condition, may be considered for restricted service classification. For any restricted service classification, the minimum wind velocity is to be taken at not less than 25.8 m/s (50 knots). In all cases, the wind velocities used for design are to be specified and noted in the Operating Manual.

1.3.2 Damage Stability

All liftboats are to have sufficient buoyancy and stability to satisfy the Damage Stability Criteria in 3-3-1/3.3.2 after the flooding from the sea of any compartment exposed to the following extent of damage.

- i) Horizontal depth of penetration 1.5 m (5 ft) longitudinally, aft of the bow plating, or, 0.75 m (2.5 ft) transversely from the side, or 0.75 m (2.5 ft) longitudinally forward of transom. Appendages are not to be credited as part of the penetration zone.
- ii) Vertical extent of damage from the bottom shell upwards without limit. Footings, mats (if a bottom mat is fitted), and legs, are to be assumed damaged if fitted within the area exposed to the penetration defined above. Simultaneous damage to the hull and footings (or mat) may be disregarded if the top of the footing (or mat) is more than 1.5 m (5 ft) below the lowest waterline. In that case, damage to the footings (or mat) is to be considered separately.
- iii) No vertical bulkhead subdividing the periphery of the liftboat is to be assumed damaged except where such bulkheads are spaced closer than 3 m (10 ft).

The ability to compensate for damage incurred, by pumping out or by ballasting other compartments, etc., is not to be considered as alleviating the requirements specified in 3-3-1/3.3.

1.5 Subdivision Standard

All liftboats are to be subdivided such that the flooding of any one compartment will not cause the immersion of any point on the deck line or any opening that can lead to progressive flooding. For the purpose of this criterion, the flooded compartment is to be considered as free-flooding from the sea. The engine room may be excluded from this standard provided:

- i) Visual and audible flooding alarms are placed locally and in the wheel house, and
- ii) The bilge system will remain in full service after the flooding of the engine room.

See also 3-2-6/1 for double bottoms.

1.7 Lightship Weight and Center of Gravity

An inclining test is required for the first liftboat of a series, when as near to completion as practical, to determine the lightship weight and position of center of gravity. The weight and center of gravity of each independent component of the liftboat (platform, legs, mat, ballast, etc.) is to be determined by an approved method. An inclining test procedure is to be submitted for review prior to the test, which is to be witnessed by a Surveyor. For successive liftboats of a series, which are considered by ABS to be identical, with the exception of minor changes in machinery, outfit, etc., detailed weight calculations showing only the differences of weight and centers of gravity will be satisfactory. The accuracy of the calculations is to be confirmed by a lightweight survey. The results of the inclining test, or lightweight survey and inclining experiment adjusted for weight differences, are to be submitted for review.

3 Stability Criteria

3.1 General

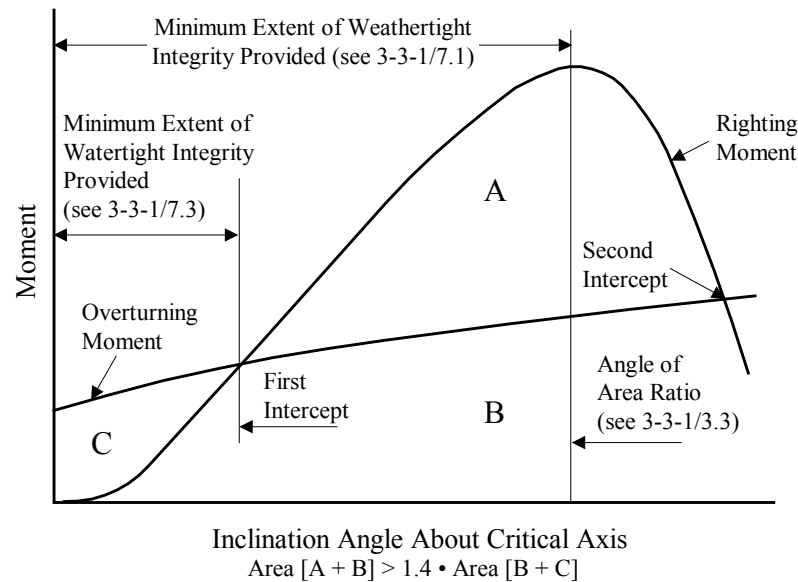
The righting moment curves and wind overturning moment curves with supporting calculations are to be prepared for the full range of drafts and angles of inclination. The calculations are to be performed in a manner to reflect a sustained wind force from any horizontal direction in order to determine the critical stability axis. Documentation demonstrating that the chosen axis of inclination is the most critical for the liftboat is to be submitted. In liftboats that do not have a large independent deck such as a helideck, the overturning moments obtained for the upright hull may be applied to the entire range of inclinations. For purposes of these calculations, the configuration of the liftboat is to reflect the actual condition of the liftboat during afloat operation, for example: deck cargo, position of cranes, and position of legs.

3.3 Righting Moment

3.3.1 Intact Stability Criteria

The area under the righting moment curve at or before the limiting angle (the second intercept or the downflooding angle, whichever is less) is to reach a value of not less than 40% in excess of the area under the wind overturning moment curve to the same limiting angle as indicated in 3-3-1/Figure 1. The righting moment curve is to be positive over the entire range of angles from upright to the limiting angle.

FIGURE 1
Dynamic Stability Curve

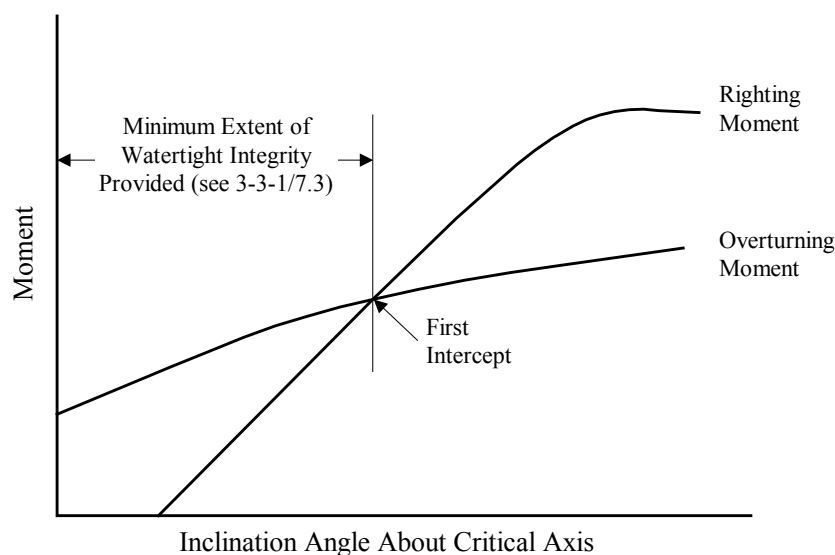


3.3.2 Damage Stability Criteria

One of the following two criteria is to be used to analyze all damage cases:

- i) The final waterline, after assuming damage under 3-3-1/1.3.2 with a 25.8 m/s (50 knots) wind superimposed from any direction (See 3-3-1/Figure 2), is not to exceed the levels to which watertight integrity has been shown on the diagrams submitted in accordance with 1-1-4/1 of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part I)* or a point leading to progressive flooding
- ii) The final waterline, after assuming damage under 3-3-1/1.3.2, is not to exceed any point on the deck edge or a point leading to progressive flooding.

FIGURE 2
Damage Stability Curve



3.5 Wind Overturning Moment

The wind overturning moment is to be calculated per 3-1-2/1.3 at several angles of inclination for the full range of drafts

The lever for the overturning force is to be taken vertically from the center of lateral resistance of the underwater configuration of the liftboat to the center of pressure of the areas subject to wind loading.

3.7 Wind Tunnel Tests

Wind overturning moments derived from wind tunnel tests on a representative model of the liftboat may be considered as alternatives to the method given herein. Such overturning moment determination is to include both lift and drag effects at appropriate inclination angles.

3.9 Stability on Bottom

Liftboats are to have sufficient positive downward gravity loading on the support footings or mat to withstand the overturning moment of the combined environmental forces from any direction. Realistic loads are to be considered in these calculations. Also see 3-2-3/9.1.4.

5 Load Line

Each liftboat is to have load line marks that designate the maximum permissible draft when the liftboat is operating afloat. The marks are to be placed at suitable visible locations on the liftboat hull, to the satisfaction of ABS.

The load line marks are to be established under the terms of the International Convention on Load Lines.

The requirements of the International Convention on Load Lines pertaining to weathertightness and watertightness of hull, decks, superstructures, deckhouses, doors, closing appliances, hatchway covers, other openings, ventilators, air pipes, scuppers, inlets and discharges, and to the heights of sills and coamings, etc., are to be satisfied.

7 Weathertight/Watertight Integrity

A plan identifying the disposition (open or closed) of all non-automatic closing devices and locations of all watertight and weathertight closures for the liftboat when afloat is to be submitted for review prior to delivery. Upon satisfactory review, the plan is to be incorporated into the Operating Manual [See 1-1-5/1.3v) of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*].

7.1 Weathertight Integrity

In addition to the Load Line requirements, external openings whose lower edges are below the levels to which weathertight integrity is to be ensured, as shown by the diagrams to be submitted in accordance with 1-1-4/1 of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, are to have weathertight closing appliances. Openings fitted with appliances to ensure weathertight integrity are to effectively resist the ingress of water due to intermittent immersion of the appliances in complying with the intact stability criteria in 3-3-1/1.3.1.

7.3 Watertight Integrity

All internal and external openings whose lower edges are below the levels to which watertight integrity is to be ensured, as shown by the diagrams submitted in accordance with 1-1-4/1 of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, are to have watertight closing appliances.

The closing appliances are to have strength, tightness and means for securing to remain watertight under the water pressure on the watertight boundary in which they are fitted in complying with the damage stability criteria and subdivision standard in 3-3-1/1.3.2 and 3-3-1/1.5, respectively.

7.3.1 Internal openings

Closing appliances fitted to internal openings to ensure watertight integrity are to comply with the following:

- i)* Doors are to be remotely operated sliding doors or quick acting hinged doors and an indicating system, e.g., light signals, is to be arranged showing personnel, both locally and on the bridge, whether the doors in question are open or secured closed.
- ii)* Hatch covers required for watertight integrity are to have similar indicators. In addition, a sign is to be posted on each side of the appliance stating that the closing appliance is to be secured closed while afloat and opened only during actual use.

7.3.2 External Openings

External openings are to comply with the following:

- i)* The lower edges of all openings including air pipes, ventilators, ventilation intakes and outlets (regardless of closing appliances), non-watertight hatches and weathertight doors are to be above the levels to which watertight integrity is to be ensured.
- ii)* Normally closed openings fitted with appliances to ensure watertight integrity, such as non-opening side scuttle, manholes and small hatches, may be located below the level of watertight integrity.
- iii)* Small hatches are those which are normally used for access by personnel. Such small hatches, which may be submerged in case of damage, are to be closed by approved quick-acting watertight covers of steel or equivalent material. An indicating system, e.g., light signals, is to be arranged showing personnel, both locally and on the bridge, whether the hatch covers in question are open or secured closed. In addition, a sign is to be posted on each side of the appliance stating that the closing appliance is to be secured closed while the liftboat is afloat and opened only during actual use. Such openings are not to be regarded as emergency exits.

7.5 Penetrations

Watertight bulkheads are to be made watertight throughout their extent. Where individual pipes, ducts, or piping systems serve more than one compartment or are within the extent of damage, satisfactory arrangements are to be provided to prevent the possibility of progressive flooding through the pipe, duct or system.

9 Onboard Computers for Stability Calculations (1 July 2007)

The use of onboard computers for stability calculations is not a requirement of class. However, if stability software is installed onboard liftboats contracted on or after 1 July 2005, it should cover all stability requirements applicable to the liftboat and is to be approved by ABS for compliance with the requirements of Appendix 3-3-A1, "Onboard Computers for Stability Calculations".

CHAPTER 3 Subdivision and Stability**APPENDIX 1 Onboard Computers for Stability Calculations**
*(1 July 2007)***1 General****1.1 Scope**

The scope of stability calculation software is to be in accordance with the stability information as approved by the flag Administration or ABS on behalf of the flag Administration. The software is at least to include all information and perform all calculations or checks as necessary to ensure compliance with the applicable stability requirements.

Approved stability software is not a substitute for the approved stability information, and is used as a supplement to the approved stability information to facilitate stability calculations.

1.3 Design

The input/output information is to be easily comparable with approved stability information so as to avoid confusion and possible misinterpretation by the operator relative to the approved stability information.

An operation manual is to be provided for the onboard computer stability software.

The language in which the stability information is displayed and printed out as well as the operation manual is written is to be the same as used in the liftboat's approved stability information. The primary language is to be English.

The onboard computer for stability calculations is liftboat specific equipment and the results of the calculations are only applicable to the liftboat for which it has been approved.

In case of modifications implying changes in the main data or internal arrangement of the liftboat, the specific approval of any original stability calculation software is no longer valid. The software is to be modified accordingly and reapproved.

3 Calculation Systems

This Appendix covers either system, a passive system that requires manual data entry or an active system, which replaces the manual with the automatic entry with sensors reading and entering the contents of tanks, etc., provided the active system is in the off-line operation mode. However, an integrated system, which controls or initiates actions based on the sensor-supplied inputs is not within the scope of this Appendix.

5 Types of Stability Software

Three types of calculations performed by stability software are acceptable depending upon a liftboat's stability requirements:

- Type 1 Software calculating intact stability only (for liftboats not required to meet a damage stability criterion)
- Type 2 Software calculating intact stability and checking damage stability on basis of a limit curve or previously approved operating conditions
- Type 3 Software calculating intact stability and damage stability by direct application of preprogrammed damage cases for each operating condition

7 Functional Requirements

7.1 Calculation Program

The calculation program is to present relevant parameters of each operating condition in order to assist the Master in his judgment on whether the liftboat is loaded within the approval limits. The following parameters are to be presented for a given operating condition:

- Deadweight data
- Lightship data
- Trim
- Draft at the draft marks and perpendiculars
- Summary of operating condition displacement, VCG, LCG and, if applicable, TCG
- Downflooding angle and corresponding downflooding opening
- Compliance with stability criteria: Listing of all calculated stability criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled)

7.3 Direct Damage Stability Calculations

If direct damage stability calculations are performed, the relevant damage cases according to the applicable rules are to be pre-defined for automatic check of a given operating condition.

7.5 Warning

A clear warning is to be given on screen and in hard copy printout if any of the operating limitations are not complied with.

7.7 Data Printout

The data are to be presented on screen and in hard copy printout in a clear unambiguous manner.

7.9 Date and Time

The date and time of a saved calculation are to be part of the screen display and hard copy printout.

7.11 Information of Program

Each hard copy printout is to include identification of the calculation program with version number.

7.13 Units

Units of measurement are to be clearly identified and used consistently within an operating calculation.

9 Acceptable Tolerances

Depending on the type and scope of programs, the acceptable tolerances are to be determined differently, according to 3-3-A1/9.1 or 3-3-A1/9.3. In general, deviation from these tolerances is not to be accepted unless a satisfactory explanation for the difference is submitted for review and the same is satisfactorily confirmed by ABS that there would be no adverse effect on the safety of the liftboat.

Examples of pre-programmed input data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT vs. draft
- Stability data: KN or MS values at appropriate heel/trim angles vs. displacement, stability limits.
- Compartment data: Volume, LCG, VCG, TCG and FSM heeling moments vs. level of the compartment's contents.

Examples of output data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT versus draft, as well as actual drafts, trim.
- Stability data: FSC (free surface correction), GZ-values, KG, GM, KG/GM limits, derived stability criteria (e.g., areas under the GZ curve), weather criteria.
- Compartment data: Calculated Volume, LCG, VCG, TCG and FSM heeling moments vs. level of the compartment's contents

The computational accuracy of the calculation program results is to be within the acceptable tolerances specified in 3-3-A1/9.1 or 3-3-A1/9.3, of the results using an independent program or the approved stability information with identical input.

9.1 Calculation Program of the Approved Stability Information

Programs which use only pre-programmed data from the approved stability information as the basis for stability calculations are to have zero tolerances for the printouts of input data.

Output data tolerances are to be close to zero. However, small differences associated with calculation rounding or abridged input data are acceptable. Additionally differences associated with the use of hydrostatic and stability data for trims that differ from those in the approved stability information are acceptable subject to review by ABS.

9.3 Independent Program for Assessment of Stability

Programs which use hull form models as their basis for stability calculations are to have tolerances for the printouts of basic calculated data established against either data from the approved stability information or data obtained using the approval authority's model. Acceptable tolerances shall be in accordance with 3-3-A1/Table 1.

TABLE 1
Acceptable Tolerances

<i>Hull Form Dependent</i>	<i>Acceptable Tolerance ⁽¹⁾</i>
Displacement	2%
Longitudinal center of buoyancy, from AP	1%/50 cm max
Vertical center of buoyancy	1%/5 cm max
Transverse center of buoyancy	0.5% of B/5 cm max
Longitudinal center of flotation, from AP	1%/50 cm max
Moment to trim 1 cm	2%
Transverse metacentric height	1%/5 cm max
Longitudinal metacentric height	1%/50cm max
Cross curves of stability	5 cm
<i>Compartment Dependent</i>	<i>Acceptable Tolerance ⁽¹⁾</i>
Volume or deadweight	2%
Longitudinal center of gravity, from AP	1%/50 cm max
Vertical center of gravity	1%/5 cm max
Transverse center of gravity	0.5% of B/5 cm max
Free surface moment	2%
Shifting moment	5%
Level of contents	2%
<i>Trim and Stability</i>	<i>Acceptable Tolerance ⁽¹⁾</i>
Drafts (forward, aft, mean)	1%/5 cm max
GMt	1%/5 cm max
GZ values	5%/5 cm max
FS correction	2%
Downflooding angle	2°
Equilibrium angles	1°
Distance to unprotected openings or margin line from WL, if applicable	±5%/5 cm max
Areas under righting arm curve	5% or 0.0012 mrad

Notes:

- 1 Deviation in % = [(base value – applicant’s value)/base value] × 100.
where the “base value” may be from the approved stability information
or the results of master computer suing an independent program.

11 Approval Procedure

11.1 Conditions of Approval of the Onboard Software for Stability Calculations (1 July 2012)

The onboard software used for stability calculations is subject to approval, which is to include:

- Verification of type approval, if any,
- Verification that the data used is consistent with the current condition of the liftboat (see 3-3-A1/11.5),
- Verification and approval of the test conditions, and
- Verification that the software is appropriate for the type of liftboat and stability calculations required.

- Verification that the software is installed so that failure of the primary computer or server does not prevent the stability calculation from being carried out (this is to be demonstrated onboard as noted below)

The satisfactory operation of the software for stability calculations is to be verified by testing upon installation on the primary computer or server and at least one back-up computer or redundant server onboard (see 3-3-A1/15). A copy of the approved test conditions and the operation manual for the computer/software are to be available onboard.

11.3 General Approval (optional)

Upon receipt of application for general approval of the calculation program, ABS may provide the applicant with test data consisting of two or more design data sets, each of which is to include a liftboat's hull form data, compartmentation data, lightship characteristics and deadweight data, in sufficient detail to accurately define the liftboat and its operating condition.

Acceptable hull form and compartmentation data may be in the form of surface coordinates for modeling the hull form and compartment boundaries (e.g., a table of offsets) or in the form of pre-calculated tabular data (e.g., hydrostatic tables, capacity tables) depending upon the form of data used by the software being submitted for approval. Alternatively, the general approval may be given based on at least two test liftboats agreed upon between the applicant and ABS.

In general, the software is to be tested for two types of liftboats for which approval is requested, with at least one design data set for each of the two types. Where approval is requested for only one type of liftboat, a minimum of two data sets for different hull forms of that type of liftboat are required to be tested.

For calculation software which is based on the input of hull form data, design data sets are to be provided for three types of liftboats for which the software is to be approved, or a minimum of three data sets for different hull forms if approval is requested for only one type of liftboat. Representative liftboat types are those which, due to their different hull forms, typical arrangements, and nature of cargo, require different design data sets.

The test data sets are to be used by the applicant to run the calculation program for the test liftboats. The results obtained, together with the hydrostatic data and cross-curve data developed by the program, if appropriate are to be submitted to ABS for the assessment of the program's computational accuracy. ABS is to perform parallel calculations using the same data sets and a comparison of these results will be made against the applicant's submitted program's results.

11.5 Specific Approval

ABS is to verify the accuracy of the computational results and actual liftboat data used by the calculation program for the particular liftboat on which the program will be installed.

Upon receipt of application for data verification, ABS and the applicant are to agree on a minimum of four operating conditions, taken from the liftboat's approved stability information, which are to be used as the test conditions.

For liftboats carrying liquids in bulk, at least one of the conditions is to include partially filled tanks. Within the test conditions each compartment is to be loaded at least once. The test conditions normally are to cover the range of load drafts from the deepest envisaged loaded condition to the light ballast condition and are to include at least one departure and one arrival condition.

ABS is to verify that the following data, submitted by the applicant, is consistent with arrangements and most recently approved lightship characteristics of the liftboat according to current plans and documentation on file with ABS, subject to possible further verification onboard:

- Identification of the calculation program including version number.
- Main dimensions, hydrostatic particulars and, if applicable, the liftboat profile.
- The position of the forward and after perpendiculars, and if appropriate, the calculation method to derive the forward and after drafts at the actual position of the liftboat's draft marks.
- Liftboat lightweight and center of gravity derived from the most recently approved inclining experiment or light weight check.

- Lines plan, offset tables or other suitable presentation of hull form data if necessary for ABS to model the liftboat.
- Compartment definitions, including frame spacing, and centers of volume, together with capacity tables (sounding/ullage tables), free surface corrections, if appropriate
- Cargo and Consumables distribution for each operating condition.

Verification by ABS does not absolve the applicant and liftboat owner of responsibility for ensuring that the information programmed into the onboard computer software is consistent with the current condition of the liftboat.

13 Operation Manual

A simple and straightforward operation manual is to be provided, containing descriptions and instructions, as appropriate, for at least the following:

- Installation
- Function keys
- Menu displays
- Input and output data
- Required minimum hardware to operate the software
- Use of the test operating conditions
- Computer-guided dialogue steps
- List of warnings

15 Installation Testing

To ensure correct working of the computer after the final or updated software has been installed, it is the responsibility of the liftboat's master to have test calculations carried out according to the following pattern in the presence of the Surveyor:

- From the approved test conditions at least one load case (other than lightship) is to be calculated.
Note: Actual operating condition results are not suitable for checking the correct working of the computer.
- Normally, the test conditions are permanently stored in the computer.

Steps to be performed:

- Retrieve the test load case and start a calculation run; compare the stability results with those in the documentation.
- Change several items of deadweight (tank weights and the cargo weight) sufficiently to change the draft or displacement by at least 10%. The results are to be reviewed to ensure that they differ in a logical way from those of the approved test condition.
- Revise the above modified load condition to restore the initial test condition and compare the results. The relevant input and output data of the approved test condition are to be replicated.
- Alternatively, one or more test conditions shall be selected and the test calculation performed by entering all deadweight data for each selected test condition into the program as if it were a proposed loading. The results shall be verified as identical to the results in the approved copy of the test conditions.

17 Periodical Testing

It is the responsibility of the liftboat's master to check the accuracy of the onboard computer for stability calculations at each Annual Survey by applying at least one approved test condition.

If the Surveyor is not present for the computer check, a copy of the test condition results obtained by the computer check is to be retained onboard as documentation of satisfactory testing for the Surveyor's verification.

At each Special Periodical Survey this checking for all approved test operating conditions is to be done in presence of the surveyor.

The testing procedure is to be carried out in accordance with 3-3-A1/15.

19 Other Requirements

The following features are to be provided to the software:

- Protection against unintentional or unauthorized modification of programs and data is to be provided.
- The program is to monitor operations and activate an alarm when the program is incorrectly or abnormally used.
- The program and any data stored in the system are to be protected from corruption by loss of power.
- Error messages with regard to limitations such as filling a compartment beyond capacity, or exceeding the assigned load line, etc. are to be included.

PART

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CHAPTER **4 Fire Safety Measures**

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CHAPTER 4 Fire Safety Measures

SECTION 1 General

1 General

1.1 SOLAS Application

For classification purposes, the fire and safety measures contained in the International Convention for the Safety of Life at Sea, 1974 (1974 SOLAS) as amended, are applicable to liftboats of type, size and service coming under that Convention.

This Section does not relax the requirements in other sections of the Rules.

Gross tonnage is to be taken as defined in 3-1-1/1.13.

1.3 Regulation

Regulation means the regulation contained in 1974 SOLAS as amended. An abbreviated notation is used (e.g., Regulation II-2/55.5 means Regulation 55.5 of Chapter II-2).

1.5 Definitions

See Regulation II-2/3.

1.7 Materials Containing Asbestos (*1 July 2011*)

Installation of materials which contain asbestos is prohibited.

3 Liftboats

For all Liftboats as defined in Regulation I-2(g), the requirements in Parts A through G Chapter II-2 of 1974 SOLAS as amended are applicable.

5 Review Procedures

5.1 Administration Review

When the liftboat is issued a Cargo Ship Safety Equipment Certificate or Cargo Ship Safety Construction Certificate by the flag Administration or its agent other than ABS, such Certificate will be accepted as evidence that the liftboat is in accordance with the applicable criteria in 1974 SOLAS as amended.

Where the Administration undertakes any part of the review and ABS is issuing above Certificate, the acceptance by the Administration will be required before the certificate is issued.

Compliance with the Rule requirements in addition to those in 1974 SOLAS as amended is to be verified by ABS.

5.3 ABS Review

In all other cases, the required information and plans are to be submitted to ABS for review.

CHAPTER 5 Equipment

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PART

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CHAPTER 5 Equipment

SECTION 1 Anchoring and Mooring Equipment

1 General (2012)

All liftboats are to have anchors and chains sized in accordance with 3-5-1/3. The symbol **E** is not required as a condition of classification. When requested by the Owner, the symbol **E** may be placed after the symbols of classification in the *Record*, thus: **A1 E** will signify that the equipment of the liftboat is in compliance with the requirements of the Rules, and the requirements in 3-5-1/5.

The anchors and their cables are to be connected and positioned ready for use. Means are to be provided for stopping each cable as it is paid out and the windlass is to be capable of heaving in either cable. Suitable arrangements are to be provided for securing the anchors and stowing the cables. Cables which are intended to form part of the equipment are not to be used as check chains when the liftboat is launched. The inboard ends of the cables of the bower anchors are to be secured by efficient means.

Equipment Number calculations for unconventional vessels with unique topside arrangements or operational profiles may be specially considered. Such consideration may include accounting for additional wind areas of widely separated deckhouses or superstructures in the equipment number calculations or equipment sizing based on direct calculations. However, in no case may direct calculations be used to reduce the equipment size to be less than that required by 3-5-1/3.

3 Equipment Weight and Size

3.1 Equipment Number for Liftboats in Unrestricted Service (2012)

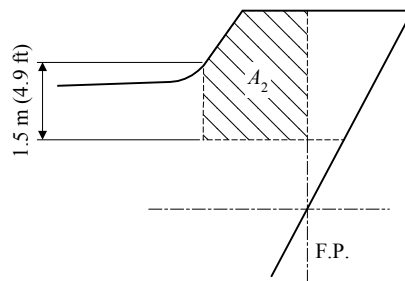
Liftboats anchors and chains are to be in accordance with 3-5-1/Table 1 with their numbers, weight and sizes regulated by the equipment number obtained from the following equation:

$$\text{Equipment Number} = k\Delta^{2/3} + m(Ba + \Sigma bh + A_\ell) + nA$$

where

k	=	1.0 (1.0, 1.012)
m	=	2 (2, 0.186)
n	=	0.1 (0.1, 0.00929)
Δ	=	molded displacement in metric tons (long tons) to the summer load waterline
B	=	molded breadth as defined in 3-1-1/1.1.2 in m (ft)
a	=	freeboard, in m (ft), from the summer load waterline amidships
b	=	breadth, in m (ft), of the widest superstructure or deckhouse on each tier
h	=	height, in m (ft), of each tier of deckhouse or superstructure having a width of $B/4$ or greater. In the calculation of h , sheer, camber and trim may be neglected. See 3-5-1/Figure 1.
A_ℓ	=	half the frontal area of the legs in the full retracted position above the summer load waterline.

A = profile area, in m^2 (ft^2), of the hull, superstructure and houses which are within the Rule length and half the area of the legs in the fully retracted position all being above the summer load waterline. Superstructures or deck houses having a breadth at any point no greater than $0.25B$ may be excluded. Screens and bulwarks more than 1.5 m (4.9 ft) in height are to be regarded as parts of houses when calculating h and A . The height of the hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining h and A . With regard to determining A , when a bulwark is more than 1.5 m (4.9 ft) high, the area shown below as A_2 should be included in A .

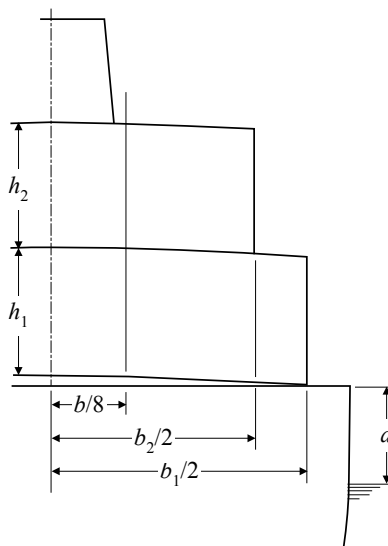


The weight per anchor of bower anchors given in 3-5-1/Table 1 is for anchors of equal weight. The weight of individual anchors may vary 7% plus or minus from the tabular weight.

3.3 Equipment with the Symbol ☹

The equipment weight and size for all liftboats with the symbol ☹ is to be in accordance with 3-5-1/Table 1 in association with the EN calculated by 3-5-1/3.1.

FIGURE 1
Effective Heights of Deckhouses



3.5 Anchors for Liftboats in Restricted Service

For liftboats classed in accordance with 1-1-2/5 and 1-1-2/13 of the Supplement to the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* for restricted service, the requirements applied for sizing anchors and cables will be given special consideration. In lieu of the requirements given in 3-5-1/3.1, the anchor and cable sizing may be calculated by a first principles analysis. The requirements for these calculations are given below. Only one anchor is required and it is to be stowed ready for rapid deployment.

3.5.1 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 3-5-1/3.5.2, they are not to be less than the following:

- *Wind* The highest monthly average value annually for the operating area considered.
- *Current* 1.5 m/sec (3 knots)
- *Water Depth* Maximum still-water anchorage depth within the liftboat's area of operation but not less than 18.3 m (60 ft).

3.5.2 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.

3.5.3 Anchor Weight and Cable Size

The anchor may be selected on the basis of proven holding power ratio (holding force per anchor weight) for the seabed type in the area of operation.

Cable size is to be determined so that the following minimum factor of safety is attained:

Catenary tension vs. breaking strength	2 for chain
	5 for wire

Cables may be either stud link chain or wire rope. Where wire rope is used, a chain fairlead with swivel is to be provided between the anchor and wire rope.

5 Materials and Tests

Material and testing for anchors and chains on liftboats receiving the Ⓔ symbol are to be in accordance with the requirements of Chapter 2 of the *ABS Rules for Materials and Welding (Part 2)* for the respective sizes of anchors and chains. Materials and tests for wire rope are to be in accordance with a national or other recognized standard. See footnotes to 3-5-1/Table 1.

7 Anchor Types

7.1 General

Anchors are in general to be of the stockless type. The weight of the head of a stockless anchor, including pins and fittings, is not to be less than three-fifths of the total weight of the anchor.

7.3 High Holding Power Anchors (HHP)

Where the anchor has a proven holding power of not less than of the *ABS Rules for Materials and Welding (Part 2)* a weight reduction of 25% from the weight specified in 3-5-1/Table 1 will be given. For HHP anchors an appropriate notation will be made in the *Record*.

7.5 Light Weight Anchors

For restricted service, light weight type anchors having a proven holding power of up to three (3) times that of an ordinary stockless anchor may be used. See 3-5-1/3.5.3.

9 Windlass or Winch Support Structure

9.1 General

The windlass is to be of good and substantial make suitable for the size of intended anchor cable. The winch is to be well bolted down to a substantial bed, and deck beams below the windlass are to be of extra strength and additionally supported. Where wire rope is used in lieu of chain cables, a winch capable of controlling the wire rope at all times is to be fitted.

9.3 Windlass or Winch on Liftboats Receiving Ⓔ (2014)

Construction and installation of all windlasses and winches used for anchoring are to be carried out in accordance with the following requirements, to the satisfaction of the Surveyor. In general, the design is to conform to an applicable standard or code of practice. As a minimum, standards or practices are to indicate strength, performance and testing criteria.

The manufacturer or builder is to submit in accordance with 4-1-1/7, the following, as applicable:

9.3.1 Plans

- i) Arrangement and details of the windlass or winch, drums, brakes, shaft, gears, coupling bolts, wildcat, sheaves, pulleys and foundation.
- ii) Electric one line diagram
- iii) Piping system diagrams
- iv) Control arrangements

Plans or data are to show complete details including power ratings, working pressures, welding details, material specifications, pipe and electric cable specifications etc.

9.3.2 Calculations

Detailed stress calculations for the applicable system components listed in 3-5-1/9.3.1i) above. The calculations are to be based on the breaking strength of the chain or wire rope; are to indicate maximum torque or load to which the liftboat will be subjected and also show compliance with either applicable sections of the Rules, such as Section 4-3-1 of the *Steel Vessel Rules* for the gears and shafts, or to other recognized standard or code of practice.

9.5 Support Structure (2004)

The windlass is to be bolted down to a substantial foundation which is to meet the following load cases and associated criteria.

9.5.1 Operating Loads

9.5.1(a) *Load on Windlass Support Structure (2006)*. The following load is to be applied in the direction of the chain.

With cable stopper not attached to windlass: 45% of B.S.

With cable stopper attached to windlass: 80% of B.S.

Without cable stopper: 80% of B.S.

B.S. = minimum breaking strength of the chain, as indicated in 2-2-2/Tables 2 and 3 of the *ABS Rules for Materials and Welding (Part 2)*.

9.5.1(b) *Load on Cable Stopper and Support Structure (2006)*. A load of 80% of B.S. is to be applied in the direction of the chain.

9.5.1(c) *Allowable Stress (2006)*. The stresses in the structures supporting the windlass and cable stopper are not to exceed the yield point.

9.5.2 Sea Loads (2014)

For liftboats with length, L (as defined in 3-1-1/1.1.1), greater than 80 meters (263 feet), where the height of the exposed deck in way of the item is less than $0.1L$ or 22 m above the summer load waterline, whichever is the lesser, the windlass supporting structures located on the exposed fore deck within the forward $0.25L$ are to meet the following requirements. Where the mooring winch is integral with the windlass, it is to be considered as a part of the windlass for the purpose of said paragraph.

9.5.2(a) *Pressures.* The following pressures and associated areas are to be applied (see 3-5-1/Figure 2):

- 200 kN/m² (20.4 tf/m², 4178 lbf/ft²) normal to the shaft axis and away from the forward perpendicular, over the projected area in this direction,
- 150 kN/m² (15.3 tf/m², 3133 lbf/ft²) parallel to the shaft axis and acting both inboard and outboard separately, over the multiple of f times the projected area in this direction,

where f is defined as:

$$\begin{aligned} f &= 1+B/H, \text{ but need not be taken as greater than } 2.5 \\ B &= \text{width of windlass measured parallel to the shaft axis} \\ H &= \text{overall height of windlass.} \end{aligned}$$

9.5.2(b) *Forces.* Forces in the bolts, chocks and stoppers securing the windlass to the deck are to be calculated. The windlass is supported by N groups of bolts, each containing one or more bolts, see 3-5-1/Figure 2.

i) *Axial Forces.* The aggregate axial force R_i in respective group of bolts (or bolt) i , positive in tension, may be calculated from the following equations:

$$\begin{aligned} R_{xi} &= P_x h x_i A_i / I_x \\ R_{yi} &= P_y h y_i A_i / I_y \end{aligned}$$

and

$$R_i = R_{xi} + R_{yi} - R_{si}$$

where

$$\begin{aligned} P_x &= \text{force, kN (tf, lbf), acting normal to the shaft axis} \\ P_y &= \text{force, kN (tf, lbf), acting parallel to the shaft axis, either inboard or outboard, whichever gives the greater force in bolt group } i \\ h &= \text{shaft height above the windlass mounting, cm (in.)} \\ x_i, y_i &= x \text{ and } y \text{ coordinates of bolt group } i \text{ from the centroid of all } N \text{ bolt groups, positive in the direction opposite to that of the applied force, cm (in.)} \\ A_i &= \text{cross sectional area of all bolts in group } i, \text{ cm}^2 \text{ (in}^2\text{)} \\ I_x &= A_i x_i^2 \text{ for } N \text{ bolt groups} \\ I_y &= A_i y_i^2 \text{ for } N \text{ bolt groups} \\ R_{si} &= \text{static reaction at bolt group } i, \text{ due to weight of windlass.} \end{aligned}$$

ii) *Shear forces.* Aggregated shear forces, F_{xi} , F_{yi} , applied to the respective bolt group, i , of bolts, and the resultant combined force, F_i , may be calculated from:

$$\begin{aligned} F_{xi} &= (P_x - \alpha g M) / N \\ F_{yi} &= (P_y - \alpha g M) / N \end{aligned}$$

and

$$F_i = (F_{xi}^2 + F_{yi}^2)^{0.5}$$

where:

- α = coefficient of friction (0.5)
 M = mass of windlass, in tonnes (Ltons)
 g = gravity: 9.81 m/sec² (32.2 ft/sec²)
 N = number of groups of bolt.

The axial tensile/compressive and lateral forces from the above equations are also to be considered in the design of the supporting structure.

9.5.2(c) *Stresses in Bolts.* Tensile axial stresses in the individual bolts in each group of bolts, i , are to be calculated. The horizontal forces, F_{xi} and F_{yi} , are normally to be reacted by shear chocks. Where “fitted” bolts are designed to support these shear forces in one or both directions, the von Mises equivalent stresses in the individual “fitted” bolts are to be calculated, and compared to the stress under proof load. Where pour-able resins are incorporated in the holding down arrangements, due account is to be taken in the calculations.

9.5.2(d) *Allowable Stress*

- i) *Bolts.* The safety factor against bolt proof strength is to be not less than 2.0.
ii) *Supporting Structures.* The stresses in the above deck framing and the hull structure supporting the windlass are not to exceed the following values:

- Bending Stress 85% of the yield strength of the material
Shearing Stress 60% of the yield strength of the material

FIGURE 2
Direction of Forces and Weight (2004)

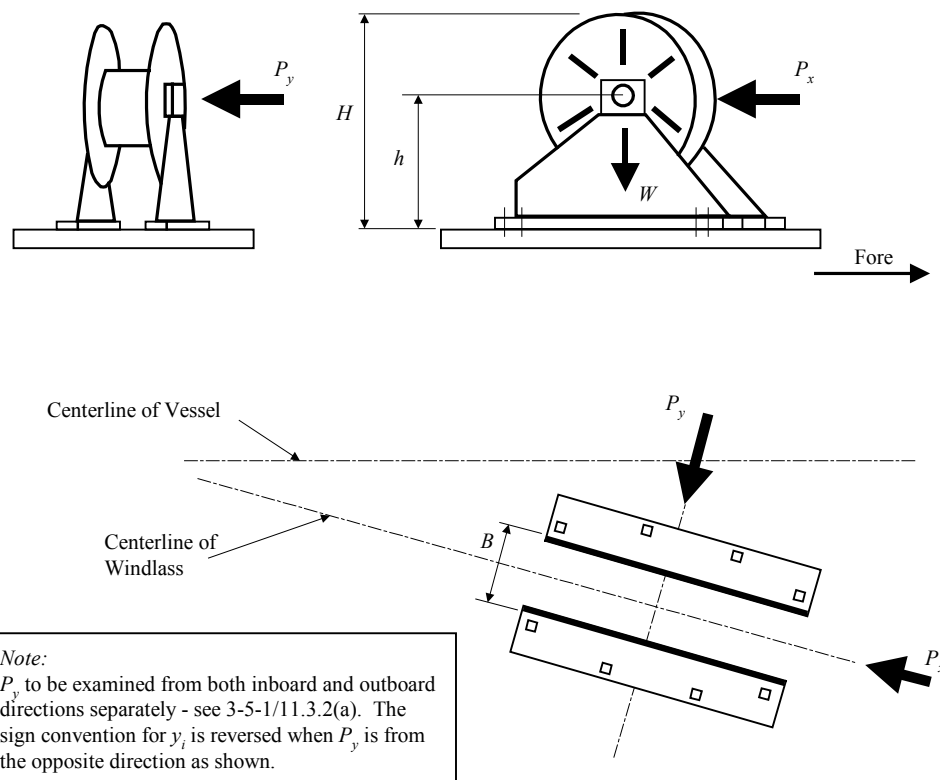
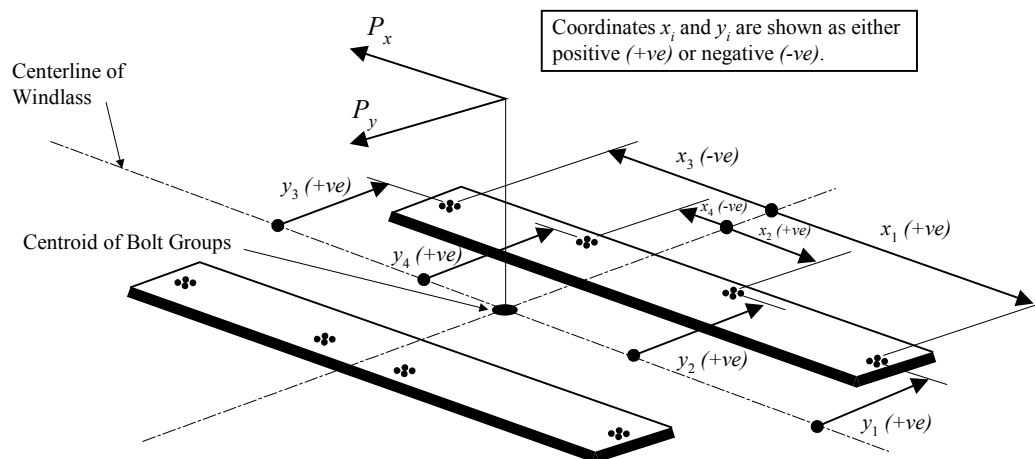


FIGURE 3
Sign Convention (2004)



9.7 Windlass or Winch on Liftboats not Receiving Ⓔ

The windlass or winch is to be provided with a certificate from the manufacturer stating that the equipment has been designed to accommodate the breaking strength of the required chain or wire rope.

11 Trial

See 3-6-2/1.

13 Hawse Pipes

Hawse pipes are to be of ample size and strength; they are to have full rounded flanges and the least possible lead, in order to minimize the nip on the cables; they are to be securely attached to thick doubling or insert plates by continuous welds the size of which are to be in accordance with Section 3-2-15 for the plating thickness and type of joint selected. When in position they are to be thoroughly tested for watertightness by means of a hose in which the water pressure is not to be less than 2.06 bar (2.1 kgf/cm², 30 psi). Hawse pipes for stockless anchors are to provide ample clearances; the anchors are to be shipped and unshipped so that the Surveyor may be satisfied that there is no risk of the anchor jamming in the hawse pipe. Care is to be taken to ensure a fair lead for the chain from the windlass to the hawse pipes and to the chain pipes.

TABLE 1
Equipment for Self-propelled Liftboats

SI, MKS Units							
The weight per anchor of bower anchors given in 3-5-1/Table 1 is for anchors of equal weight. The weight of individual anchors may vary 7% plus or minus from the tabular weight provided that the combined weight of all anchors is not less than that required for anchors of equal weight. The total length of chain required to be carried on board, as given in 3-5-1/Table 1, is to be reasonably divided between the two bower anchors. Where three anchors are given in 3-5-1/Table 1, the third anchor is intended as spare bower anchor and is listed for guidance only; it is not required as a condition of classification.							
Equipment Numeral	Equipment Number*	Stockless Bower Anchors		Chain Cable Stud Link Bower Chain**			
		Number	Mass per Anchor, kg	Length, m	Diameter		
					Normal-Strength Steel (Grade 1), mm	High-Strength Steel (Grade 2), mm	Extra High-Strength Steel (Grade 3), mm
UA1	30	2	75	192.5	12.5	—	—
UA2	40	2	100	192.5	12.5	—	—
UA3	50	2	120	192.5	12.5	—	—
UA4	60	2	140	192.5	12.5	—	—
UA5	70	2	160	220	14	12.5	—
UA6	80	2	180	220	14	12.5	—
UA7	90	2	210	220	16	14	—
UA8	100	2	240	220	16	14	—
UA9	110	2	270	247.5	17.5	16	—
UA10	120	2	300	247.5	17.5	16	—
UA11	130	2	340	275	19	16	—
UA12	140	2	390	275	20.5	17.5	—
U6	150	2	480	275	22	19	—
U7	175	2	570	302.5	24	20.5	—
U8	205	3	660	302.5	26	22	20.5
U9	240	3	780	330	28	24	22
U10	280	3	900	357.5	30	26	24
U11	320	3	1020	357.5	32	28	24
U12	360	3	1140	385	34	30	26
U13	400	3	1290	385	36	32	28
U14	450	3	1440	412.5	38	34	30
U15	500	3	1590	412.5	40	34	30
U16	550	3	1740	440	42	36	32
U17	600	3	1920	440	44	38	34
U18	660	3	2100	440	46	40	36
U19	720	3	2280	467.5	48	42	36
U20	780	3	2460	467.5	50	44	38
U21	840	3	2640	467.5	52	46	40
U22	910	3	2850	495	54	48	42
U23	980	3	3060	495	56	50	44
U24	1060	3	3300	495	58	50	46
U25	1140	3	3540	522.5	60	52	46
U26	1220	3	3780	522.5	62	54	48
U27	1300	3	4050	522.5	64	56	50
U28	1390	3	4320	550	66	58	50
U29	1480	3	4590	550	68	60	52
U30	1570	3	4890	550	70	62	54

TABLE 1 (continued)

SI, MKS Units							
Equipment Numeral	Equipment Number*	Stockless Bower Anchors		Chain Cable Stud Link Bower Chain**			
		Number	Mass per Anchor, kg	Length, m	Diameter		
					Normal- Strength Steel (Grade 1), mm	High- Strength Steel (Grade 2), mm	Extra High- Strength Steel (Grade 3), mm
U31	1670	3	5250	577.5	73	64	56
U32	1790	3	5610	577.5	76	66	58
U33	1930	3	6000	577.5	78	68	60
U34	2080	3	6450	605	81	70	62
U35	2230	3	6900	605	84	73	64
U36	2380	3	7350	605	87	76	66
U37	2530	3	7800	632.5	90	78	68
U38	2700	3	8300	632.5	92	81	70
U39	2870	3	8700	632.5	95	84	73
U40	3040	3	9300	660	97	84	76
U41	3210	3	9900	660	100	87	78
U42	3400	3	10500	600	102	90	78
U43	3600	3	11100	687.5	105	92	81
U44	3800	3	11700	687.5	107	95	84
U45	4000	3	12300	687.5	111	97	87
U46	4200	3	12900	715	114	100	87
U47	4400	3	13500	715	117	102	90
U48	4600	3	14100	715	120	105	92
U49	4800	3	14700	742.5	122	107	95
U50	5000	3	15400	742.5	124	111	97
U51	5200	3	16100	742.5	127	111	97
U52	5500	3	16900	742.5	130	114	100
U53	5800	3	17800	742.5	132	117	102
U54	6100	3	18800	742.5	—	120	107
U55	6500	3	20000	770	—	124	111
U56	6900	3	21500	770	—	127	114
U57	7400	3	23000	770	—	132	117
U58	7900	3	24500	770	—	137	122
U59	8400	3	26000	770	—	142	127
U60	8900	3	27500	770	—	147	132
U61	9400	3	29000	770	—	152	132
U62	10000	3	31000	770	—	—	137
U63	10700	3	33000	770	—	—	142
U64	11500	3	35500	770	—	—	147
U65	12400	3	38500	770	—	—	152
U66	13400	3	42000	770	—	—	157
U67	14600	3	46000	770	—	—	162

* For intermediate values of equipment number use equipment complement in sizes and weights given for the lower equipment number in the table.

** Wire ropes may be used in lieu of chain cables for both anchors on liftboats having an Equipment Number less 150.

The wire is to have a breaking strength not less than the grade 1 chain of required size and a length of at least 1.5 times the chain it is replacing. Material tests are to be witnessed by an ABS Surveyor.

Between the wire rope and anchor, chain cable of the required size having a length of 12.5 m (41.0 ft), or the distance between anchor in stored position and winch, whichever is less, is to be fitted.

For liftboats having an Equipment Number less than 100, nylon rope may be specially considered.

TABLE 1
Equipment for Self-propelled Liftboats

US Units							
The weight per anchor of bower anchors given in 3-5-1/Table 1 is for anchors of equal weight. The weight of individual anchors may vary 7% plus or minus from the tabular weight, provided that the combined weight of all anchors is not less than that required for anchors of equal weight. The total length of chain required to be carried onboard, as given in 3-5-1/Table 1, is to be reasonably divided between the two bower anchors. Where three anchors are given in 3-5-1/Table 1, the third anchor is intended as a spare bower anchor and is listed for guidance only. It is not required as a condition of classification.							
Equipment Numeral	Equipment Number*	Stockless Bower Anchors		Chain Cable Stud Link Bower Chain**			
		Number	Mass per Anchor, pounds	Length, fathoms	Normal-Strength Steel (Grade 1), inches	High-Strength Steel (Grade 2), inches	Extra High-Strength Steel (Grade 3), inches
UA1	30	2	165	105	1/2	—	—
UA2	40	2	220	105	1/2	—	—
UA3	50	2	265	105	1/2	—	—
UA4	60	2	310	105	1/2	—	—
UA5	70	2	350	120	9/16	1/2	—
UA6	80	2	400	120	9/16	1/2	—
UA7	90	2	460	120	5/8	9/16	—
UA8	100	2	530	120	5/8	9/16	—
UA9	110	2	595	135	11/16	5/8	—
UA10	120	2	670	135	11/16	5/8	—
UA11	130	2	750	150	3/4	11/16	—
UA12	140	2	860	150	13/16	11/16	—
U6	150	2	1060	150	7/8	3/4	—
U7	175	2	1255	165	15/16	13/16	—
U8	205	3	1455	165	1	7/8	13/16
U9	240	3	1720	180	1 1/8	15/16	7/8
U10	280	3	1985	195	1 3/16	1	15/16
U11	320	3	2250	195	1 1/4	1 1/8	15/16
U12	360	3	2510	210	1 5/16	1 3/16	1
U13	400	3	2840	210	1 7/16	1 1/4	1 1/8
U14	450	3	3170	225	1 1/2	1 5/16	1 3/16
U15	500	3	3500	225	1 9/16	1 5/16	1 3/16
U16	550	3	3830	240	1 5/8	1 7/16	1 1/4
U17	600	3	4230	240	1 3/4	1 1/2	1 5/16
U18	660	3	4630	240	1 13/16	1 9/16	1 7/16
U19	720	3	5020	255	1 7/8	1 5/8	1 7/16
U20	780	3	5420	255	2	1 3/4	1 1/2
U21	840	3	5820	255	2 1/16	1 13/16	1 9/16
U22	910	3	6280	270	2 1/8	1 7/8	1 5/8
U23	980	3	6740	270	2 3/16	1 15/16	1 3/4
U24	1060	3	7270	270	2 5/16	2	1 13/16
U25	1140	3	7800	285	2 3/8	2 1/16	1 13/16
U26	1220	3	8330	285	2 7/16	2 1/8	1 7/8
U27	1300	3	8930	285	2 1/2	2 3/16	2
U28	1390	3	9520	300	2 5/8	2 5/16	2
U29	1480	3	10120	300	2 11/16	2 3/8	2 1/16
U30	1570	3	10800	300	2 3/4	2 7/16	2 1/8

TABLE 1 (continued)

US Units							
Equipment Numeral	Equipment Number*	Stockless Bower Anchors		Chain Cable Stud Link Bower Chain**			
		Number	Mass per Anchor, pounds	Length, fathoms	Diameter		
					Normal-Strength Steel (Grade 1), inches	High-Strength Steel (Grade 2), inches	Extra High-Strength Steel (Grade 3), inches
U31	1670	3	11600	315	2 ⁷ / ₈	2 ¹ / ₂	2 ³ / ₁₆
U32	1790	3	12400	315	3	2 ⁵ / ₈	2 ⁵ / ₁₆
U33	1930	3	13200	315	3 ¹ / ₁₆	2 ¹¹ / ₁₆	2 ³ / ₈
U34	2080	3	14200	330	3 ³ / ₁₆	2 ³ / ₄	2 ⁷ / ₁₆
U35	2230	3	15200	330	3 ⁵ / ₁₆	2 ⁷ / ₈	2 ¹ / ₂
U36	2380	3	16200	330	3 ⁷ / ₁₆	3	2 ⁵ / ₈
U37	2530	3	17200	345	3 ⁹ / ₁₆	3 ¹ / ₁₆	2 ¹¹ / ₁₆
U38	2700	3	18300	345	3 ⁵ / ₈	3 ³ / ₁₆	2 ³ / ₄
U39	2870	3	19200	345	3 ³ / ₄	3 ⁵ / ₁₆	2 ⁷ / ₈
U40	3040	3	20500	360	3 ⁷ / ₈	3 ⁵ / ₁₆	3
U41	3210	3	21800	360	3 ¹⁵ / ₁₆	3 ⁷ / ₁₆	3 ¹ / ₁₆
U42	3400	3	23100	360	4	3 ⁹ / ₁₆	3 ¹ / ₁₆
U43	3600	3	24500	375	4 ¹ / ₈	3 ⁵ / ₈	3 ³ / ₁₆
U44	3800	3	25800	375	4 ¹ / ₄	3 ³ / ₄	3 ⁵ / ₁₆
U45	4000	3	27100	375	4 ³ / ₈	3 ⁷ / ₈	3 ⁷ / ₁₆
U46	4200	3	28400	390	4 ¹ / ₂	3 ¹⁵ / ₁₆	3 ⁷ / ₁₆
U47	4400	3	29800	390	4 ⁵ / ₈	4	3 ⁹ / ₁₆
U48	4600	3	31100	390	4 ³ / ₄	4 ¹ / ₈	3 ⁵ / ₈
U49	4800	3	32400	405	4 ³ / ₄	4 ¹ / ₄	3 ³ / ₄
U50	5000	3	33900	405	4 ⁷ / ₈	4 ³ / ₈	3 ⁷ / ₈
U51	5200	3	35500	405	5	4 ³ / ₈	3 ⁷ / ₈
U52	5500	3	37200	405	5 ¹ / ₈	4 ¹ / ₂	3 ¹⁵ / ₁₆
U53	5800	3	39200	405	5 ¹ / ₈	4 ⁵ / ₈	4
U54	6100	3	41400	405	—	4 ³ / ₄	4 ¹ / ₄
U55	6500	3	44000	420	—	4 ⁷ / ₈	4 ³ / ₈
U56	6900	3	47400	420	—	5	4 ¹ / ₂
U57	7400	3	50700	420	—	5 ¹ / ₈	4 ⁵ / ₈
U58	7900	3	54000	420	—	5 ³ / ₈	4 ³ / ₄
U59	8400	3	57300	420	—	5 ⁵ / ₈	5
U60	8900	3	60600	420	—	5 ³ / ₄	5 ¹ / ₈
U61	9400	3	63900	420	—	6	5 ¹ / ₈
U62	10000	3	68000	420	—	—	5 ³ / ₈
U63	10700	3	72500	420	—	—	5 ⁵ / ₈
U64	11500	3	78000	420	—	—	5 ³ / ₄
U65	12400	3	85000	420	—	—	6
U66	13400	3	92500	420	—	—	6 ¹ / ₈
U67	14600	3	101500	420	—	—	6 ³ / ₈

* For intermediate values of equipment number use equipment complement in sizes and weights given for the lower equipment number in the table.

** Wire ropes may be used in lieu of chain cables for both anchors on liftboats having an Equipment Number less 150.

The wire is to have a breaking strength not less than the grade 1 chain of required size and a length of at least 1.5 times the chain it is replacing. Material tests are to be witnessed by an ABS Surveyor.

Between the wire rope and anchor, chain cable of the required size having a length of 12.5 m (41.0 ft), or the distance between anchor in stored position and winch, whichever is less, is to be fitted.

For liftboats having an Equipment Number less than 100, nylon rope may be specially considered.

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PART

3

CHAPTER 6 Testing, Trials and Surveys During Construction – Hull

SECTION 1 Tank, Bulkhead and Rudder Tightness Testing

1 General (1 July 2013)

Test procedures are to confirm the watertightness of tanks and watertight boundaries, the structural adequacy of tanks and the weathertightness of structures. The tightness of tanks and tight boundaries is to be confirmed by test procedures for:

- New liftboat, prior to delivery, and
- Structures involved in or affected by major conversions or repairs affecting structural integrity

1.1 Application

All gravity tanks which are subjected to vapor pressure not greater than 0.7 bars (0.7 kgf/cm², 10 psi) and other boundaries required to be watertight or weathertight are to be tested in accordance with this Subsection and proven tight or structurally adequate, as follows:

1.1.1

Gravity Tanks for their structural adequacy and tightness,

1.1.2

Watertight Boundaries Other than Tank Boundaries for their watertightness, and

1.1.3

Weathertight Boundaries for their weathertightness

1.3 Types and Definitions of Test

The following two types of testing are specified in this requirement.

1.3.1

Structural Testing is a test to verify the structural adequacy of the construction of the tank. This may be hydropneumatic testing or hydrostatic testing as specified in 3-6-1/5.1 and 3-6-1/5.3.

1.3.2

Leak Testing is a test to verify the tightness of the boundary. Unless specific testing is indicated, this may be hydrostatic/hydropneumatic testing or air testing as specified in 3-6-1/5.1, 3-6-1/5.3 and 3-6-1/5.5. Leak testing in items 12 to 15 as specified in 3-6-1/Table 1 includes hose test as an acceptable medium of the test.

3 Test Procedures

3.1 General

Tests are to be carried out in the presence of the Surveyor at a stage sufficiently close to completion, after all attachments, outfittings or penetrations which may affect the strength or tightness of the structure have been completed, and before any ceiling and cement work is applied over joints.

Specific test requirements are given in 3-6-1/5 and 3-6-1/Table 1.

For the timing of application of coating in relation to testing, see 3-6-1/7.

3.3 Structural Testing (1 July 2013)

3.3.1 Test Type and Time

Where structural testing is specified by 3-6-1/Table 1, hydrostatic testing in accordance with 3-6-1/5.1 will be acceptable, except where practical limitations (strength of building berth, density of liquid, etc.) prevent it or where air testing is permitted by Note 1 to 3-6-1/Table 1. Hydropneumatic testing in accordance with 3-6-1/5.3 may be approved in lieu of hydrostatic testing. Structural testing may be carried out after the liftboat is launched.

Tank boundaries are to be tested at least from one side. Tanks to be tested for structural adequacy (see Note 1 to 3-6-1/Table 1) are to be selected so that all representative structural members are tested for the expected tension and compression.

3.3.2 Number of Structural Testing

- i) Structural testing is to be carried out for at least one tank of the same construction (i.e. tanks of the same structural design and configuration and same general workmanship as determined by the attending Surveyor) on each liftboat provided all subsequent tanks are tested for leaks by an air test. These relaxations do not apply to tanks for pollutants.

However, where structural adequacy of a tank was verified by structural testing required in 3-6-1/Table 1, the subsequent liftboats in the series may be exempted from such testing for other tanks which have the structural similarity to the tested tank, provided that the water-tightness in all boundaries of exempted tanks are verified by leak tests and thorough inspection. For sister units built several years after the last liftboat of the series, such exemption may be reconsidered. In any case, structural testing is to be carried out for at least one tank for each liftboat in order to verify structural fabrication adequacy.

- ii) For watertight boundaries of spaces other than tanks (excluding chain lockers), structural testing may be exempted, provided that the watertightness in all boundaries of exempted spaces are verified by leak tests and thorough inspection.
- iii) These subsequent tanks may require structural testing if found necessary after the structural testing of the first tank.
- iv) Tanks for structural test are to be selected so that all representative structural members are tested for the expected tension and compression.

3.5 Leak Testing (1 July 2013)

For leak testing specified in 3-6-1/Table 1, air testing, compressed air fillet weld testing, vacuum box testing in accordance with 3-6-1/5.5, 3-6-1/5.9, and 3-6-1/5.11, or their combination will be acceptable. Hydrostatic or hydropneumatic testing may also be accepted as leak testing provided 3-6-1/5.1 and 3-6-1/5.3 are complied with.

Hose testing is applied to structures not subjected to structural or air testing but required to be watertight or weathertight as specified in 3-6-1/Table 1. For the details of hose testing, see 3-6-1/5.7. Air testing or structural testing may be accepted in lieu of hose testing.

Joint air testing may be carried out in the block stage provided all work on the block that may affect the tightness of the joint is completed before the test. See also 3-6-1/7.1 for the application of final coating and 3-6-1/7.4 for safe access to the joint and their summary in 3-6-1/Table 2.

5 Details of Testing (1 July 2013)

5.1 Hydrostatic Testing

Hydrostatic Testing is a test to verify the structural adequacy of the design and the tightness of the tank's structure by means of water pressure. Hydrostatic testing is to consist of a head of water to the level specified in 3-6-1/Table 1.

5.3 Hydropneumatic Testing

Hydropneumatic Testing is a combined hydrostatic and air testing wherein a tank is filled by water with air pressure applied on top. When approved, the combined water level and air pressure used for hydropneumatic testing is to simulate the actual loading as far as practicable. The requirements and recommendations in 3-6-1/5.5 relative to air pressure will also apply.

5.5 Air Testing

Air Testing is a test to verify the tightness of the structure by means of air pressure difference. All boundary welds, erection joints, and penetrations including pipe connections are to be examined in accordance with the approved procedure and under a pressure differential not less than 0.15 bar (0.15 kgf/cm², 2.2 psi) with a leak indicating solution.

It is recommended that the air pressure in the tank be raised to and maintained at 0.20 bar (0.20 kgf/cm², 2.9 psi) for approximately one hour, with a minimum number of personnel around the tank, before being lowered to the test pressure.

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 to be not less than that of the pipe supplying air. In addition to U-tube, a master gauge or other approved means is to be provided to verify the pressure.

Other effective methods of air testing, including compressed air fillet weld testing or vacuum testing, may be considered in accordance with 3-6-1/5.9.

5.7 Hose Testing

Hose Testing is a test to verify the tightness of the joint by a jet of water. Hose testing is to be carried out with the pressure in the hose of at least 2 bar (2 kgf/cm², 30 psi) during test. The nozzle is to have minimum inside diameter of 12 mm (0.5 in.) and is to be located at a distance to the joint not exceeding 1.5 m (5 ft).

For structural welds, where hose testing 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 penetration testing, ultrasonic testing, or an equivalent.

For cable penetrations, where hose testing is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, other methods of testing may be considered upon submission of full particulars to the attending Surveyor.

5.9 Compressed Air Fillet Weld Testing

Compressed Air Fillet Weld Testing is an air test of a fillet welded tee joint with a leak indicating solution applied on the fillet welds. In this air testing, compressed air is injected from one end of fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge on the opposite side. Pressure gauges are to be arranged so that an air pressure of at least 0.15 bar (0.15 kgf/cm², 2.2 psi) can be verified at each end of all passages within the portion being tested.

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.

5.11 Vacuum Box Testing

Vacuum Box Testing is a test to detect any leaks on the structure. A box over a joint with leak indicating solution applied on the fillet or full penetration welds. A vacuum is created inside the box to detect any leaks. A box (vacuum tester) with air connections, gauges and inspection window is placed over the joint with leak indicator applied. The air within the box is removed by an ejector to create a vacuum of 0.20 bar (0.20 kgf/cm², 2.9 psi) – 0.26 bar (0.27 kgf/cm², 3.8 psi) inside the box.

5.13 Ultrasonic Testing

Ultrasonic Testing is a test to verify the tightness of a sealing by means of ultrasound. An arrangement of an ultrasonic echoes transmitter placed inside a compartment and a receiver outside. A location where the sound is detectable by the receiver displays a leakage in the sealing of the compartment.

5.15 Penetration Testing

Penetration Testing is a test to verify that no leakage exist in the boundaries of a compartment by the application of low surface tension liquids. A test of butt welds by applying a low surface tension liquid to one side of a compartment boundary. When no liquid is detected on the opposite side of the boundary after expiration of a definite time, verification of the tightness of the compartment boundary can be assumed.

5.17 Other Methods of Testing

Other methods of testing may be considered upon submission of full particulars.

7 Application of Coating

7.1 Final Coating (1 July 2013)

7.1.1 Structural Testing

For all weld joint types excluding butt joints by automatic process, final coating may be applied prior to the structural testing. See 3-6-1/Table 2.

7.1.2 Leak Testing

For all manual or semi-automatic erection welds and all fillet weld tank boundary connections, including penetrations, the final coating is to be applied after leak testing. For other welds, the final coating may be applied prior to leak testing, provided the Surveyor, after examination prior to the application of coating, is satisfied with the weld. The Surveyor reserves the right to require leak testing prior to the final coating of automatic erection welds and manual or automatic pre-erection welds. See 3-6-1/Table 2.

7.3 Temporary Coating (2012)

Any temporary coating which may conceal defects or leaks is to be applied as specified for the final coating. This requirement applies to shop primers, other than silicate based shop primers, such as epoxy based shop primers.

7.5 Safe Access to Joints (1 July 2013)

For leak testing, a safe access to all joints under examination is to should be provided. See 3-6-1/Table 2.

TABLE 1
Testing Requirements for Tanks and Boundaries (1 July 2013)

	<i>Tank or Boundary to be Tested</i>	<i>Test Type</i>	<i>Test Head or Pressure</i>	<i>Remarks</i>
1	Double bottom tanks ⁽⁴⁾	Leak & Structural ⁽¹⁾	The greater of - top of the overflow, - to 2.4 m (8 ft) above top of tank ⁽²⁾	
2	Double bottom voids ⁽⁵⁾	Leak	See 3-6-1/5.5, 3-6-1/5.9, and 3-6-1/ 5.11, as applicable	
3	Double side tanks	Leak & Structural ⁽¹⁾	The greater of - top of the overflow, - to 2.4 m (8 ft) above top of tank ⁽²⁾	
4	Double side voids	Leak	See 3-6-1/5.5, 3-6-1/5.9, and 3-6-1/ 5.11, as applicable	
5	Deep tanks	Leak & Structural ⁽¹⁾	The greater of - top of the overflow, or - to 2.4 m (8 ft) above top of tank ⁽²⁾	
6	Peak tanks	Leak & Structural ⁽¹⁾	The greater of - top of the overflow, or - to 2.4 m (8 ft) above top of tank ⁽²⁾	After peak to be tested after installation of stern tube
7	a. Fore peak voids	Leak	See 3-6-1/5.5, 3-6-1/5.9, and 3-6-1/ 5.11, as applicable	
	b. Aft peak voids	Leak	See 3-6-1/5.5, 3-6-1/5.9, and 3-6-1/ 5.11, as applicable	After peak to be tested after installation of stern tube
8	Cofferdams	Leak	See 3-6-1/5.5, 3-6-1/5.9, and 3-6-1/ 5.11, as applicable	
9	a. Watertight bulkheads	Leak	See 3-6-1/5.5 through 3-6-1/5.11 as applicable ⁽⁷⁾	
	b. Superstructure end bulkhead	Leak	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	
	c. Cable penetrations in watertight bulkheads	Hose	See 3-6-1/5.7	
10	Watertight doors below freeboard or bulkhead deck	Leak ^(6, 8)	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	See 3-2-9/9.11 of the <i>Steel Vessel Rules</i> for additional test at the manufacturer.
11	Double plate rudder blade	Leak	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	
12	Shaft tunnel clear of deep tanks	Leak ⁽³⁾	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	
13	Shell doors	Leak ⁽³⁾	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	
14	Weathertight hatch covers and closing appliances	Leak ^(3, 8)	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	Hatch covers closed by tarpaulins and battens excluded
15	Dual purpose tank/dry cargo hatch cover	Leak ^(3, 8)	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	
16	Chain locker	Leak & Structural	Top of chain pipe	
17	Independent tanks	Leak & Structural ⁽¹⁾	The greater of - top of the overflow, or - to 0.9 m (3 ft) above top of tank	

TABLE 1 (continued)
Testing Requirements for Tanks and Boundaries (1 July 2013)

	<i>Tank or Boundary to be Tested</i>	<i>Test Type</i>	<i>Test Head or Pressure</i>	<i>Remarks</i>
18	Ballast ducts	Leak & Structural ⁽¹⁾	The greater of - ballast pump maximum pressure, or - setting of any pressure relief valve	
19	Hawse pipes	Leak ⁽³⁾		
20	Skeg	Leak	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	
21	Legs & footings	Leak	See 3-6-1/5.5 through 3-6-1/5.11 as applicable	

Notes:

- 1 Provided the structural similarity of a group of tanks is recognized by ABS and a representative tank as selected by ABS is structurally tested based on the design approval, all subsequent tanks on each liftboat are tested for leaks by an air testing in accordance with 3-6-1/5.5. However, where structural adequacy of a tank was verified by structural testing, the subsequent liftboats of a series of identical new buildings may be exempted from such testing for other tanks which have the structural similarity to the tested tank, provided that the water-tightness in all boundaries of exempted tanks are verified by leak tests and thorough inspection are to be carried out. In any case, structural testing is to be carried out for at least one tank for each liftboat in order to assure structural fabrication adequacy. These relaxations do not apply to tanks for pollutants. (See 3-6-1/3.3.2i.)
- 2 Top of tank is deck forming the top of the tank, excluding any hatchways.
- 3 *Hose Testing* may also be considered as a medium of the test. See 3-6-1/5.7.
- 4 Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4
- 5 Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/9.4
- 6 Where water tightness of 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 Where a hose test is not practicable, other testing methods listed in 3-6-1/5.13 through 3-6-1/5.17 may be applicable subject to adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1.
- 8 As an alternative to the hose testing, other testing methods listed in 3-6-1/5.13 through 3-6-1/5.17 may be applicable subject to adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1.

TABLE 2
Application of Leak Testing, Coating and Provision of Safe Access
for Type of Welded Joints (1 July 2013)

<i>Type of Welded Joints</i>		<i>Leak Testing</i>	<i>Coating</i> ⁽¹⁾		<i>Safe Access</i> ⁽²⁾	
			<i>Before Leak Testing</i>	<i>After Leak Testing & Before Structural Test</i>	<i>Leak Testing</i>	<i>Structural Test</i>
Butt	Automatic	Not required	Allowed ⁽³⁾	N/A	Not required	Not required
	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 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 NDE testing show no significant defects.

PART

3

CHAPTER **6 Testing, Trials and Surveys During Construction - Hull**

SECTION **2 Trials**

1 Anchor Windlass Trials *(1 July 2012)*

Each windlass is to be tested under working conditions after installation onboard to demonstrate satisfactory operation. Each unit is to be independently tested for braking, clutch functioning, lowering and hoisting of chain cable and anchor, proper riding of the chain over the chain lifter, proper transit of the chain through the hawsepipe and the chain pipe, and effecting proper stowage of the chain and the anchor. It is to be confirmed that anchors properly seat in the stored position and that chain stoppers function as designed if fitted. Also, it is to be demonstrated that the windlass is capable of lifting each anchor with 82.5 m (45 fathoms) length of chain submerged and hanging free. The braking capacity is to be tested by intermittently paying out and holding the chain cable by means of the application of the brake. Where the available water depth is insufficient, the proposed test method will be specially considered.

3 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.

5 Steering Trials

Refer to 4-3-3/15.3 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

For surveys of hull construction welding and fabrication, refer to Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)* 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 casting and forgings, refer to Chapter 1 of the *ABS Rules for Materials and Welding (Part 2)*.

5 Pumps and Piping

For surveys in connection with the manufacture and testing of piping, refer to Part 4, Chapter 5. For initial testing of pumps and piping systems refer to sections 4-5-2/1 and 4-5-2/3.

7 Jacking Systems

All jacking or other elevating systems are to be constructed and installed to the satisfaction of the Surveyor in accordance with approved plans. Welded construction is to be in compliance with the applicable requirements of Sections 3-2-7 and 3-2-6 of the *MODU Rules* and Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*. Gears of the climbing pinion gear train are to be examined at the plant of manufacture by an approved crack detection procedure and such an examination is to be witnessed by the Surveyor. Acceptance of components manufactured at a plant which is under an ABS-approved quality assurance program will be subject of special consideration. See 4-4-1/15.

7.1 Operational Trials

An initial trial jacking test of the completed hull is to be carried out up to the limit of designed travel and then down again, to prove alignment of leg racks, pinions and guides, effectiveness of lock or brake arrangements, and proper function of jacking system together with electrical safety system monitoring indicators. Fail-safe arrangement of the jacking system is to be tested to the satisfaction of the attending Surveyor. It shall be demonstrated that the jacking system locking arrangements will activate upon loss of power (hydraulic or electrical) to the jacking unit. See 4-4-1/17.

After the initial trial jacking test, all leg pads are to be visually examined and verified free from damage or permanent deformation. Additionally, leg connections to leg pads are to be nondestructively tested with a suitable surface crack detection method.

7.3 Preload Trial

The liftboat is to be elevated subsequent to the trials per 3-6-3/7.1 and preloaded to demonstrate the capability required by 3-2-3/9.11.

Machinery and Systems

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PART

4

CHAPTER 1 General

SECTION 1 Conditions of Classification of Machinery

1 General

The provisions of Part 1, Chapter 1, “Scope and Conditions of Classification” are applicable to the classification of machinery.

3 Certification of Machinery

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; prototype testing;
- Survey during construction and testing at the plant of manufacture; and
- Survey during installation on board the liftboat 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 on board the liftboat 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 at the request of the designer or manufacturer. . The ABS Type Approval Program generally covers Product Type Approval (1-1-4/9.7.3 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*), but is also applicable for a more expeditious procedure towards Unit-Certification as specified in 1-1-4/9.7.3 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

See the *ABS Type Approval Program* in Appendix 1-1-A2 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (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 categories of Acceptable Quality System (AQS) and 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 *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*. In each instant 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 Shipboard Automatic or Remote Control and Monitoring Systems

Automatic or remote control and monitoring systems associated with propulsion machinery and monitoring systems of propulsion-machinery space installed onboard classed liftboats are to comply with the requirements in Section 4-7-1 through Section 4-7-3 or Section 4-7-6 of the *ABS Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length (Under 90m Rules)*, as applicable. Additionally, where requested by the Owner and provided that compliance with Section 4-7-4 or Section 4-7-5 of the *Under 90m Rules* is met, the aforementioned systems will be assigned the optional notations **ACCU** or **ABCU**, respectively. See Section 4-7-1 of the *Under 90m Rules*.

7 Machinery Plans and Data

The following plans and data, as applicable for each liftboat to be built under survey, are to be submitted and approved before construction is commenced in accordance with Section 1-1-4 of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*. The sizes, dimensions, welding and other details, make and size of standard approved appliances are to be shown on the plans as clearly and fully as possible.

7.1 General

Details of dead ship start arrangements (see 4-1-1/19)

Description of all automatic trips that may affect the liftboat's propulsion system

7.3 Automation and Remote Control Systems

- i) A list of electrical, pneumatic or hydraulic equipment associated with the particular systems including the data listed in 4-7-1/7.1 of the *Under 90m Rules*.
- ii) A list of all major components installed within the particular equipment (i.e., control console, etc.) and the data as required in 4-7-1/7.1 of the *Under 90m Rules*.

- iii) Certificates or test reports attesting to the suitability of the particular equipment in compliance with the environmental criteria set forth in 4-7-2/15 and 4-7-2/17 of the *Under 90m Rules*, as applicable. For equipment already certified by ABS and provided their certification remains valid, the submission of a copy of pertinent certificate will suffice. (see 4-7-2/17.3 of the *Under 90m Rules*)
- iv) Plans showing the location of control and monitoring stations, controlled equipment and piping/cable runs, etc.
- v) Arrangements and details of the control consoles and panels including plan views and elevation details, installation details and wiring data as listed in 4-7-1/7.9 of the *Under 90m Rules*.
- vi) A list of all cables connecting equipment associated with the systems (see 4-7-1/7.11 of the *Under 90m Rules*).
- vii) A complete operational description of the automatic or remote control and monitoring systems (see 4-7-1/7.13 of the *Under 90m Rules*).
- viii) A simplified one-line diagram (electrical and piping) of all power and automatic or remote control and monitoring systems (see 4-7-1/7.15 of the *Under 90m Rules*).
- ix) A schematic diagram of all control, alarm, display and safety systems.
- x) For computer-based systems, the following is to be included:
 - Overall description and specification of the systems and equipment.
 - Block diagrams for the computer hardware showing interfacing between the work stations, input/output (I/O) units, local controllers, traffic controllers, data highways, etc.
 - Logic flow chart or ladder diagrams.
 - Description of the alarm system indicating the ways it is acknowledged, displayed on the monitor or mimic display board, etc.
 - Description of the system redundancy and back-up equipment, if any.
 - Description of the data communication protocol including anticipated data process response delays.
 - Description of the system's security protocol to prevent unauthorized program changes which may compromise the integrity of the automatic or remote systems.
 - Description of the system with regard to the degree of independence or redundancy provided for the control systems alarm/display systems and safety systems.
 - Description of system's task priorities.
 - Where applicable, description of UPS (uninterruptible power supply) and their capacities including system's power consumption.
 - Equipment ratings and environmental parameters.
- xi) Installation methods (electrical, pneumatic and hydraulic) (see 4-7-1/7.21 of the *Under 90m Rules*).
- xii) A matrix chart for each of the systems indicating the information listed in 4-7-1/7.23 of the *Under 90m Rules* upon activation of a given alarm or safety action:

7.5 Pressure Vessels and Heat Exchangers

Arrangements and details of pressure vessels and heat exchangers required by Part 4, Chapter 4 of the *Steel Vessel Rules*.

Plans and data for hydraulic and pneumatic power cylinders as required by 4-5-6/3 and 4-5-6/5.

7.7 Electrical Systems

- i) One line diagrams for the following electrical systems containing the information specified in 4-7-2/1.1.2:
 - Power supply and distribution
 - Lighting including navigating lights
 - Internal communication
 - General emergency alarm
 - Fire detection and alarm
 - Steering gear control
 - Intrinsically-safe equipment
 - Emergency generator starting
 - Semiconductor converters for propulsion
- ii) Short-circuit data (see 4-7-2/1.3)
- iii) Protective device coordination study (see 4-7-2/1.5)
- iv) Electric-plant load analysis (see 4-7-2/1.7)
- v) Booklet of standard wiring practices and details (see 4-7-3/1.1)
- vi) General arrangement plan of electrical equipment showing the location of the equipment listed in 4-7-3/1.3
- vii) Location of splices and cable boxes together with information of their services
- viii) Hazardous area plan (see 4-7-3/1.5)
- ix) List of all equipment in hazardous areas (see 4-7-3/1.5)
- x) Details of electrical components as required by 4-8-1/5.5 of the *Steel Vessel Rules*

7.9 Fire Safety (2010)

- i) Arrangement and details of control station for emergency closing of openings and stopping machinery
- ii) Details and location of fireman's outfits
- iii) Details of fire extinguishing appliances
- iv) Fire control plans (see 4-6-1/1.9)
- v) Plans of the following systems:
 - Fire main system
 - Foam smothering system
 - Fire detection systems
 - Fixed gas extinguishing system
 - Fixed water spraying system
- vi) Other fire extinguishing arrangements
- vii) For liftboats 500 GRT and over, 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.),
- viii) For liftboats 500 GRT and over, calculations and pump data demonstrating that the emergency fire pump system can meet the operational requirements specified in 4-6-2/5.3.3 and 4-6-2/5.3.6 with the proposed pump location and piping arrangements (e.g., adequate suction lift, discharge pressure, capacity, etc.) at the most severe service condition.

7.11 Jacking (Elevating) Systems (2011)

Plans and data related to jacking and associated systems for self-elevating units as outlined in 4-4-1/5.

7.13 Internal Combustion Engines

Plans and particulars as required by Part 4, Chapter 2 of the *Steel Vessel Rules*.

7.15 Piping Systems

- i) Diagrammatic plans of the following piping systems containing the information specified in 4-5-1/3.3
 - Ballast system and preload
 - Bilge system
 - Compressed air systems (including starting air systems and control systems)
 - Cooling water systems
 - Deck drains and scuppers
 - Exhaust gas systems
 - Essential Fresh water service systems
 - Fuel oil filling, transfer and service systems
 - Hydraulic power piping systems
 - Lubricating oil systems
 - Potable water system
 - Sanitary system
 - Essential Sea water service systems
 - Vent, sounding and overflow piping
 - Systems conveying toxic liquids, liquids with a flash point below 60°C (140°F), or flammable gases
 - All Group I piping systems not covered above unless it is part of an independently manufactured unit (such as air conditioning or refrigeration) that does not form part of a liftboat's piping system
- ii) A booklet of standard piping practices and details (see 4-5-1/3.5)
- iii) Plans of molded or built-up flexible expansion joints in seawater piping systems over 150 mm (6 in.), including details of the reinforcement arrangements (see 4-5-1/9.7)
- iv) Specifications for plastic pipes and components, including thermal and mechanical properties and chemical resistance (see 4-5-2/7, 4-5-2/9.11 and 4-5-2/17.7)
- v) Drawings of non-standard valves and fittings showing details of construction, materials and basis for pressure rating (see 4-5-2/11.1.2 and 4-5-2/13.5)
- vi) Valve operating systems for all remote-controlled valves

7.17 Propellers

For all propellers, a propeller plan giving design data and characteristics of the material

For skewed propellers or propeller blades of unusual design, a detailed stress analysis as required by 4-3-2/7.3 or 4-3-2/9.5

For controllable pitch propellers, plans of the propeller hub, propeller blade flange and bolts, internal mechanisms, hydraulic piping control systems, and instrumentation and alarm systems; also strength calculations for the internal mechanism

Detailed stress calculations and fitting instructions for keyless propeller connections

7.19 Reduction Gears

Arrangements, details and data as required by Section 4-3-1 of the *Steel Vessel Rules*

7.21 Shafting (2008)

Detailed plans with material specifications of the propulsion shafting, couplings, coupling bolts*, propulsion shafting arrangement, tail shaft bearings and lubrication system, if oil-lubricated,

Calculations for flexible couplings and demountable couplings (see 4-2-1/17 and 4-3-1/19.9)

Shaft alignment and vibration calculations if required by 4-3-1/21

Detailed preloading and stress calculations and fitting instructions for non-fitted coupling bolts (see 4-3-1/19.3)

* *Note:* Specific details regarding the interference fit of the coupling bolts are to be submitted. In addition, calculations and detail design basis for the sizing of the fitted bolts are to be submitted if the sizing of the bolts as per 4-3-1/19.1 of this Guide is not based on as-built line shaft diameter “D”.

7.23 Steering Gears

General arrangements of the main and auxiliary steering gears and steering compartment

Assembly of upper rudder stock, tiller, tie rod, rudder actuators, etc.

Construction details of all torque-transmitting components such as tiller, tiller pin, tiller/rudder stock interference fit mechanism, tie rod, rudder actuator, etc., including bill of materials, welding procedures, and non-destructive testing, as applicable

Control system incorporating schematic electrical control logic diagram, instrumentation, alarm devices, etc. and including bill of materials

Design calculations for torque-transmitting components such as tiller, tie rod, rudder actuator, etc.

Details of electrical power supply to power units and to steering gear control, including schematic diagram of motor controllers, feeder cables, and feeder cable electrical protection

Rated torque of main steering gear

Schematic hydraulic piping plan incorporating hydraulic logic diagram and including bill of materials, typical pipe to pipe joint details, pipe to valve joint details, pipe to equipment joint details, pressure rating of valves and pipe fittings, and pressure relief valve settings

7.25 Thrusters (Steerable, Athwartship)

Drawings and data as per Section 4-3-5 of the *Steel Vessel Rules*.

7.27 Cranes

Crane certification in accordance with Chapter 2, “Guide for Certification of Cranes”, of the *ABS Guide for Certification of Lifting Appliances* or other recognized standard, where requested.

9 Machinery

Rotating machinery of 100 kilowatts (135 horsepower) and over is to be in accordance with the requirements of Part 4, Chapters 1 through 7, as applicable. Machinery of less than 100 kilowatts (135 horsepower) is to be designed, constructed and equipped in accordance with good commercial practice, and will be accepted subject to satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

11 Machinery Space

Machinery spaces are to be arranged so as to provide access to all machinery and controls as necessary for operation or maintenance.

13 Definitions

For the purpose of machinery installations, electrical installations, periodically unattended machinery spaces, fire protection, fire detection and fire extinction, the following terms are defined:

13.1 Category A Machinery Spaces

Machinery spaces of Category A are those spaces and trunks to such spaces that contain: internal combustion machinery used for main propulsion; internal combustion machinery used for purposes other than main propulsion where such machinery has an aggregate total power output of not less than 375 kW (500 HP); oil fired equipment such as an incinerator, waste disposal unit, etc.; or any oil fuel units.

13.3 Machinery Spaces

Machinery spaces are Category A spaces and all other spaces containing propelling machinery, internal combustion engines, boilers, generators, major electrical equipment, refrigerating, stabilizing, ventilation and air conditioning machinery, similar spaces and trunks to such spaces.

13.5 Oil Fuel Unit

An oil-fuel unit is any equipment, such as pumps, filters and heaters, used for the preparation and delivery of heated fuel oil to internal combustion engines at a pressure of more than 1.8 bar (1.8 kgf/cm², 26 psi).

13.7 Accommodation Spaces

Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, pantries containing no cooking appliances and similar spaces.

13.9 Public Spaces

Public spaces are those portions of the accommodations, which are used for meeting halls, dining rooms, lounges, and similar permanently enclosed spaces.

13.11 Service Spaces

Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, workshops other than those forming part of the machinery spaces, similar spaces and trunks to such spaces.

13.13 Sources of Ignition

Sources of ignition are considered to include a flame, arc, spark and electrical equipment, machinery and other equipment having hot surfaces with the potential of causing a non-intentional explosion or fire when exposed to an explosive or flammable atmosphere or material.

13.15 Vital Systems

Vital systems are those systems necessary for the liftboat's survivability and safety including:

- i) Systems for fill, transfer, and service of fuel oil.
- ii) Fire-main systems, including emergency fire pump
- iii) Other required fire-extinguishing and detection systems.
- iv) Bilge systems, including emergency bilge suction
- v) Ballast/Preload systems.
- vi) Steering systems and steering control systems.
- vii) Propulsion systems and their necessary auxiliaries (fuel oil, lube oil, cooling water, starting system, etc.) and control systems.
- viii) Ship's service and emergency electrical generation systems and their auxiliaries (fuel oil, lube oil, cooling water, starting system, etc.) and control systems.

- ix) Venting and sounding systems
- x) Engine room ventilation systems
- xi) Other required ventilation systems
- xii) Controllable pitch propeller systems including controls
- xiii) Electrical power and lighting systems
- xiv) Systems used for navigation
- xv) Required communication and alarm systems
- xvi) Hydraulic systems for jacking systems
- xvii) Systems necessary due to special characteristics or special service of a liftboat
- xviii) Any other system identified by ABS as crucial to the survival of the liftboat or to the protection of the personnel aboard.

13.17 Dead Ship Condition (2004)

Dead ship condition means a condition under which:

- i) The main propulsion plant, boilers and auxiliary machinery are not in operation due to the loss of the main source of electrical power, and
- ii) In restoring propulsion, the stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliary machinery is assumed to be not available.

13.19 Blackout (2004)

Blackout situation means the loss of the main source of electrical power resulting in the main and auxiliary machinery to be out of operation.

15 Astern Propulsion Power (2005)

15.1 General

Sufficient power for going astern is to be provided to secure proper control of the liftboat in all normal circumstances. The astern power of the main propelling machinery is to be capable of maintaining in free route astern at least 70% of the ahead rpm corresponding to the maximum continuous ahead power. For main propulsion systems with reversing gears, controllable pitch propellers or electric propulsion drive, running astern is not to lead to overload of the propulsion machinery. The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the liftboat to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded during trials.

17 Inclinations

Machinery installations are to be designed to operate under the conditions as shown in 4-1-1/Table 1.

19 Dead Ship Start (2005)

Means are to be provided to bring the machinery into operation from a “dead ship” condition as defined in 4-1-1/13.17. See 4-7-2/3.1.3 and 4-7-3/3.27 for the required starting arrangements.

21 Machinery Equations

The equations for rotating parts of the machinery in the following Sections are based upon strength considerations only. Their application does not relieve the manufacturer from responsibility for the presence of dangerous vibrations in the installation at speeds within the operating range. See also 4-3-1/21.

23 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.

25 Engineers' Alarm

See 4-7-2/17.3.

27 Automatic Trips

A description of all automatic trips that may affect the liftboat's propulsion system is to be submitted for review.

29 Thrusters and Dynamic Positioning Systems

Compliance with Section 4-3-5 of the *Steel Vessel Rules* is required as a condition for Class for main propulsion thrusters and is optional for propulsion-assist thrusters and athwartship thrusters. Dynamic positioning systems, including their thrusters, are to comply with the *ABS Guide for Dynamic Positioning Systems*.

31 Pressure Vessels

When fitted, pressure vessels are to be designed and constructed in accordance with Part 4, Chapter 4, of the *Steel Vessel Rules*.

33 Materials Containing Asbestos (2011)

Installation of materials which contain asbestos is prohibited.

35 Sea Trial

35.1 General

A final underway trial is to be made of all machinery, including the steering gear. The entire installation is to be operated in the presence of the Surveyor to demonstrate its reliability and capability to function satisfactorily under operating conditions and its freedom from harmful vibrations within the operating range. The ability of the machinery to reverse the direction of thrust of the propeller from maximum ahead speed and bring the liftboat to rest is to be demonstrated on sea trials to the satisfaction of the Surveyor.

All automatic controls, including trips which may affect the liftboat's propulsion system, are to be tested underway or alongside the pier, to the satisfaction of the Surveyor.

See also 4-3-3/15.3, 4-2-1/19 and 4-2-1/21.

37 Units

This Guide is written in three systems of units (i.e., SI units, MKS units and US customary units). Each system is to be used independently of any other system. Unless indicated otherwise, the format presentation in this Guide of the three systems of units is as follows:

SI units (MKS units, US customary units)

39 Ambient Temperature (2008)

For liftboats of unrestricted service, ambient temperature, as indicated in 4-1-1/Table 2, is to be considered in the selection and installation of machinery, equipment and appliances. For liftboats of restricted or special service, the ambient temperature appropriate to the special nature is to be considered.

TABLE 1
Machine Installations – Inclinations

<i>Installations, Components</i>	<i>Angle of Inclination, Degrees ⁽¹⁾</i>			
	<i>Athwartships</i>		<i>Fore & Aft</i>	
	<i>Static</i>	<i>Dynamic</i>	<i>Static</i>	<i>Dynamic</i>
Main and auxiliary machinery	15	22.5	5	7.5
Safety Equipment				
Emergency power installations ⁽³⁾	22.5	22.5	10	10
Emergency fire pumps and their drives	22.5	22.5	10	10
Switchgear				
Electrical and electronic appliances and remote control systems	22.5 ⁽²⁾	22.5 ⁽²⁾	10	10

Notes:

- 1 Athwartships and fore-aft inclinations occur simultaneously.
- 2 Up to an angle of inclination of 45 degrees, switches and controls are to remain in their last set position.
- 3 In liftboats designed for the carriage of liquefied gases and of chemicals, the emergency power installation is to remain operable with the liftboat flooded to its permissible athwartships inclination up to a maximum of 30 degrees.

TABLE 2
Ambient Temperatures for Unrestricted Service (2014)

Air		
<i>Installations, Components</i>	<i>Location, Arrangement ^(1, 2)</i>	<i>Temperature Range (°C)</i>
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		
	<i>Coolant</i>	<i>Temperature (°C)</i>
Seawater		+32

Notes:

- 1 (2014) Electronic equipment is to be suitable for operations up to 55°C. See also 4-7-1/17.3.
- 2 (2014) For environmentally controlled spaces, see 4-7-1/17.3.

CHAPTER 2 Prime Movers

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PART

4

CHAPTER **2 Prime Movers**

SECTION **1 Internal Combustion Engines and Reduction Gears**

1 General

1.1 Construction and Installation

Internal combustion engines of 100 kW [135 horsepower (hp)] and over and associated reduction gears are to be constructed in accordance with Part 4, Chapters 2 and 3 of the *Steel Vessel Rules* and installed in accordance with the following requirements, to the satisfaction of the Surveyor. Engines of less than 100 kW (135 hp) and associated reduction gears are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

For engines driving generators refer to the applicable requirements of 4-7-4/3.17.

1.3 Piping Systems

In addition to requirements for specific system in this Section, piping systems are to comply with the applicable requirements in Chapter 4, Section 5.

1.5 Pressure Vessels and Heat Exchangers

Pressure vessels and heat exchangers are to be in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*.

1.7 Torsional Vibration Stresses

Refer to 4-3-1/21.

1.9 Crankcase Ventilation

1.9.1 General

Provision is to be made for ventilation of an enclosed crankcase by means of a small breather or by means of a slight suction not exceeding 25.4 mm (1 in.) of water. Crankcases are not to be ventilated by a blast of air. Otherwise, the general arrangements and installation are to be such as to preclude the possibility of free entry of air to the crankcase.

1.9.2 Piping Arrangement

Crankcase ventilation piping is not to be directly connected with any other piping system. Crankcase ventilation pipes from each engine are normally to be led independently to the weather and fitted with corrosion resistant flame screens; however, crankcase ventilation pipes from two or more engines may lead to a common oil mist manifold.

Where a common oil mist manifold is employed, the vent pipes from each engine are to be led independently to the manifold and fitted with a corrosion resistant flame screen within the manifold. The arrangement is not to violate the engine manufacturer's recommendations for crankcase ventilation. The common oil mist manifold is to be accessible at all times under normal conditions and effectively vented to the weather. Where venting of the manifold to the weather is accomplished by means of a common vent pipe, the location of the manifold is to be as close as practicable to the weather such that the length of the common vent pipe is no greater than one deck height. The clear open area of the common vent pipe is not to be less than the aggregate cross-sectional area of the individual vent pipes entering the manifold, and the outlet to the weather is to be fitted with a corrosion resistant flame screen. The manifold is also to be fitted with an appropriate draining arrangement.

1.11 Warning Notices

Suitable warning notices are to be attached in a conspicuous place on each engine and are to caution against the opening of a hot crankcase for a specified period of time after shutdown based upon the size of the engine, but not less than 10 minutes in any case. Such notice is also to warn against restarting an overheated engine until the cause of overheating has been remedied.

1.13 Bedplate

The bedplate or crankcase is to be of rigid construction, oiltight, and provided with a sufficient number of bolts to secure the same to the liftboat's structure. The structural arrangements for supporting and securing the main engines are to be submitted for approval. Refer to 3-2-6/11 for structural requirements. For welded construction see also Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

3 Fuel Oil Pumps

3.1 Transfer Pumps

Refer to 4-5-4/3.

3.3 Booster Pumps (2014)

A stand-by fuel-oil booster pump is to be provided for main engines having independently driven booster pumps. For main engines having attached fuel pumps, a complete pump may be carried as a spare in lieu of the standby pump.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

5 Fuel Oil Pressure Piping

Pipes from booster pumps to injection systems are to be at least standard seamless steel. Pipes conveying heated oil are to be at least standard seamless or electric-resistance-welded steel. ERW pipe is to be straight seam and fabricated with no filler metal (e.g., ABS Grade 2 or 3 ERW). Valves and fittings may be screwed in sizes up to and including 60 mm OD (2 in. N.P.S.), but screwed unions are not to be used on pressure lines in sizes 33 mm OD (1 in.) and over. Valves are to be so constructed as to permit packing under pressure.

7 Fuel Oil Injection System

7.1 General

Strainers are to be provided in the fuel oil injection pump suction line.

For main propulsion engines, the arrangement is to be such that the strainers may be cleaned without interrupting the fuel supply to the engine. However, where multiple engines are provided, a dedicated simplex strainer may be fitted for each engine provided the liftboat can maintain at least one-half of the design speed, while operating with one engine temporarily out of service until its strainer can be cleaned.

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 change over 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 being opened inadvertently. Strainers are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Strainers are to be so located that in the event of leakage oil cannot be sprayed on to the exhaust manifold or surfaces with temperatures in excess of 220°C (428°F).

The injection lines are to be of seamless drawn pipe. Fittings are to be extra heavy. The material used may be either steel or nonferrous as approved in connection with the design. Also refer to 4-5-4/3.7.

7.3 Piping Between Injection Pump and Injectors (2005)

7.3.1 Injection Piping

All external high pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high-pressure line failure. A jacketed pipe incorporates an outer pipe into which the high-pressure fuel pipe is placed, forming a permanent assembly. Metallic hose of an approved type may be accepted as the outer pipe, where outer piping flexibility is required for the manufacturing process of the permanent assembly. The jacketed piping system is to include means for collection of leakages and arrangements are to be provided for an alarm to be given of a fuel line failure.

7.3.2 Fuel oil Return Piping

When the peak to peak pressure pulsation in the fuel oil return piping from the injectors exceeds 20 bar (20.5 kgf/cm², 285 psi), jacketing of the return pipes is also required.

7.3.3 High Pressure Common Rail System (2011)

Where a high pressure common rail system is fitted to an engine, the high pressure common rail is to be in accordance with Section 4-4-1 of the *Steel Vessels Rules* for pressure vessels, or a recognized standard as listed in 4-4-1/1.5 of the *Steel Vessels Rules*. Alternatively, the design may be verified by certified burst tests. Components are to be made of steel or cast steel. Components made of steel, other than cast steel, are to withstand not less than 4 times the maximum allowable working pressure. The cast steel common rails are to withstand not less than 5 times the maximum allowable working pressure. The use of non-ferrous materials, cast iron and nodular iron is prohibited. Materials are to comply with Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*.

The high pressure common rail system is required to be properly enclosed and provided with arrangement for leak collection and alarm in case of a failure of high pressure common rail system, see 4-2-1/7.3.1.

7.5 Piping Between Booster Pump and Injection Pumps (2005)

Spray shields are to be fitted around flanged joints, flanged bonnets and any other flanged or threaded connections in fuel oil piping systems under pressure exceeding 1.8 bar (1.84 kgf/cm², 26 psi) which are located above or near units of high temperature, including boilers, steam pipes, exhaust manifolds, silencers or other equipment required to be insulated by 4-5-4/1.1.2, and to avoid as far as practicable oil spray or oil leakage into machinery air intakes or other sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

9 Lubricating Oil Systems

9.1 General

The following requirements are applicable for main and auxiliary diesel engines and for reduction gears associated with diesel propulsion. See also 4-1-1/17 and 4-5-4/9.

9.3 Low Oil Pressure Alarms, Temperature and Level Indicators

An alarm device with audible and visual signals for failure of the lubricating oil system is to be fitted. Pressure and temperature indicators are to be installed in lubricating oil systems indicating that the proper circulation is being maintained.

9.5 Drain Pipes

Lubricating oil drainpipes from the sump to the drain tank are to be submerged at their outlet ends. No interconnection is to be made between the drainpipes from the crankcases of two or more engines.

9.7 Lubricating Oil Pumps (2014)

In cases where forced lubrication is used for propulsion engines, one independently driven standby pump is to be provided in addition to the necessary pumps for normal operation. Where the size and design of an engine is such that lubrication before starting is not necessary and an attached lubricating pump is normally used, an independently driven standby pump is not required if a complete duplicate of the attached pump is carried as a spare.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

9.9 Filters

Oil filters are to be provided. 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. However, where multiple engines are provided, a dedicated simplex filter may be fitted for each engine provided the liftboat can maintain at least one-half of the design speed, while operating with one engine temporarily out of service until its filter can be cleaned.

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 change over to a standby unit can be accomplished without loss of propulsion capability, will be acceptable for this purpose.

The arrangement of the valving is to be such as to avoid release of debris into the lubricating-oil system upon activation of the relieving mechanism.

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 and cocks with drainpipes led to a safe location are to be used for this purpose. Filters are to be so arranged as to prevent, in the event of leakage, spraying of oil onto the exhaust manifold and surfaces with temperatures in excess of 220°C (428°F).

9.11 Lubricating-Oil Systems for Reduction Gears

Where a reduction gear is driven by a single engine and a common lubricating-oil system is used for both the engine and gear, the requirements in 4-2-1/9.1 through 4-2-1/9.9 are applicable.

Where a reduction gear is driven by more than one engine and any other case where a separate lubricating-oil system is provided for the reduction gear, the following requirements are applicable.

9.11.1 Pumps

Two lubricating-oil pumps are to be provided, at least one of which is to be independently driven. The capacity of each pump is to be sufficient for continuous operation of the main propulsion plant at its maximum rated power.

9.11.2 Coolers

One or more lubricated-oil coolers with means for controlling the oil temperature is to be provided together with two separate cooling water pumps, at least one of which is to be independently driven. The coolers are to have sufficient capacity to maintain the required oil temperature while the main propulsion plant is operating continuously at its maximum rated power.

9.11.3 Indicators

Indicators are to be fitted by which the pressure and temperature of the water inlet and oil outlet may be determined. Gravity tanks are to be fitted with a low-level alarm and a sight glass is to be fitted in the overflow line to the sump. Pressure systems are to be fitted with a low-pressure alarm. Sump and gravity tanks are to be provided with suitable gauges for determining the level of oil within the tank.

9.11.4 Filters

A filter is to be provided in the lubricating-oil piping to each reduction gear. The requirements in 4-2-1/9.9 are applicable.

11 Cooling Water Systems

11.1 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. For relief valves, see 4-5-1/9.15.

11.3 Sea Suctions

At least two independent sea suction are to be provided for supplying water to the engine jackets or to the heat exchangers. The sea suction are to be located as to minimize the possibility of blanking off the cooling water.

11.5 Strainers

Where seawater is used for direct cooling of the engines, unless other equivalent arrangements are specially approved, suitable strainers are to be fitted between the sea valves and the pump suction. The strainers are to be either of the duplex type or otherwise arranged so they can be cleaned without interrupting the cooling water supply.

11.7 Circulating Water Pumps (2014)

There are to be at least two means for supplying cooling water to main and auxiliary engines, compressors, coolers, reduction gears, etc. One of these means is to be independently driven and may consist of a connection from a suitable pump of adequate size normally used for other purposes, such as a general service pump, or in the case of fresh-water circulation, one of the liftboat's fresh-water pumps. Where, due to the design of the engine, the connection of an independent pump is impracticable, the independently driven stand-by pump will not be required if a complete duplicate of the attached pump is carried as a spare. For multiple propulsion engines using identical attached pumps, only one complete pump needs to be carried as a spare.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

13 Starting Systems

13.1 Starting Air Systems (2013)

The design and construction of all air reservoirs are to be in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*. The piping system is to be in accordance with the applicable requirements of Part 4, Chapter 5 of this Guide. The air reservoirs are to be so installed as to make the drain connections effective under extreme conditions of trim. Compressed air systems are to be fitted with relief valves and each air reservoir, which can be isolated from a relief valve, is to be provided with its own safety valves or equivalent. Connections are also to be provided for cleaning the air reservoir and pipelines.

All discharge pipes from starting air compressors are to be led directly to the starting air reservoirs and all starting pipes from the air reservoirs to main or auxiliary engines are to be entirely separate from the compressor discharge piping system.

13.3 Starting Air Capacity (2013)

Liftboats having main 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 starts stated below.

If other compressed air systems, such as control air, are supplied from starting air reservoirs, the capacity of the air reservoirs is to be sufficient for continued operation of these systems after the air necessary for the required number of consecutive starts has been used.

13.3.1 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 Liftboats		Multiple Propeller Liftboats	
	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
Non-reversible	6	8	8	8

For arrangements of engine 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.

13.3.2 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.

13.5 Starting Air Compressors (2013)

For liftboats having internal-combustion engines arranged for air starting, there are to be two or more air compressors, at least one of which is to be driven independently of the main propulsion unit, and the total capacity of air compressors driven independently of the main propulsion unit is to be not less than 50% of the total required.

The total capacity of the air compressors is to be sufficient to supply within one hour the quantity of the air need to satisfy 4-2-1/13.3 by charging the reservoirs from atmospheric pressure. The capacity is to be approximately equally divided between the number of compressors fitted, excluding an emergency compressor where fitted.

The arrangement for dead ship air starting is to be such that the necessary air for the first charge can be produced on board without external aid. See 4-1-1/19.

13.7 Protective Devices for Starting-air Mains

In order to protect starting air mains against explosions arising from improper functioning of starting valves, an isolation non-return valve or equivalent is to be installed at the starting air supply connection to each engine. Where engine bores exceed 230 mm (9¹/₁₆ in.), a bursting disc or flame arrester is to be fitted in way of the starting valve of each cylinder for direct reversing engines having a main starting manifold or at the supply inlet to the starting-air manifold for non-reversing engines.

The above requirement is applicable to engines where the air is directly injected into the cylinder. It is not intended to apply to engines utilizing air start motors.

13.9 Electrical Starting

13.9.1 Main Engine

Where the main engine is arranged for electric starting, at least two separate batteries (or separate set of batteries) are to be fitted. The arrangement is to be such that the batteries (or set of batteries) cannot be connected simultaneously in parallel. Each battery (or set) is to be capable of starting the main engine when in cold and ready to start conditions. The combined capacity of the batteries is to be sufficient without recharging to provide within 30 minutes the number of starts of main engines as required for air starting in 4-2-1/13.3, and if arranged also to supply starting for auxiliary engines the number of starts required in 4-2-1/13.9.2. See also 4-2-1/13.9.3.

13.9.2 Auxiliary Engine

Electric starting arrangements for auxiliary engines are to have at least two separate batteries (or separate set of batteries) or may be supplied by separate circuits from the main engine batteries when such are provided. Where one auxiliary engine is arranged for electric starting, one battery (or set) may be accepted in lieu of two separate batteries (or sets). The capacity of the batteries for starting the auxiliary engines is to be sufficient for at least three starts for each engine.

13.9.3 Other Requirements

The starting batteries (or set of batteries) are to be used only for starting and for engine's own control and monitoring purpose. When the starting batteries are used for engine's own control and monitoring purpose, the aggregate capacity of the batteries is to be sufficient for continued operation of such system in addition to the required number of starting capacity. Provisions are to be made to maintain continuously the stored energy at all times. See also 4-7-2/5.17 and 4-7-3/3.7.

13.11 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 4-2-1/13.3.

15 Engine Exhaust Systems

15.1 General

The exhaust pipes are to be effectively insulated. Engine exhaust systems are to be so installed that the liftboat's structure cannot be damaged by heat from the systems. 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 the water passing inboard.

15.3 Exhaust System Materials

Materials used in the exhaust system are to be resistant to saltwater corrosion, galvanically compatible to each other and resistant to exhaust products. Plate flanges will be considered where the specified material is suitable for exhaust piping pressures and temperatures.

15.5 Exhaust Gas Temperature

Propulsion engines with bores exceeding 200 mm (7.87 in.) are to be fitted with a means to display the exhaust gas temperature of each cylinder.

17 Couplings

17.1 Flexible Shaft Couplings (2014)

Details of the various components of flexible couplings for main propulsion machinery and ship's service generator sets are to be submitted for approval.

17.1.1 Design

Flexible couplings intended for use in propulsion shafting are to be of approved designs. Couplings are to be designed for the rated torque, fatigue and avoidance of overheating. Where elastomeric material is used as a torque-transmitting component, it is to withstand environmental and service conditions over the design life of the coupling, taking into consideration the full range of maximum to minimum vibratory torque. Flexible coupling design will be evaluated, based on submitted engineering analyses.

17.1.2 Torsional Displacement Limiter

Flexible couplings with elastomer or spring type flexible members, whose failure will lead to total loss of propulsion capability of the liftboat, such as that used in the line shaft of a single propeller liftboat, are to be provided with a torsional displacement limiter. The device is to lock the coupling or prevent excessive torsional displacement when a pre-determined torsional displacement limit is exceeded. Operation of the liftboat under such circumstances may be at reduced power. Warning notices for such reduced power are to be posted at all propulsion control stations.

17.1.3 Barred Range

Conditions where the allowable vibratory torque or the allowable dissipated power may be exceeded under the normal operating range of the engine are to be identified and are to be marked as a barred range in order to avoid continuous operation within this range.

17.1.4 Diesel Generators

Flexible couplings for diesel generator sets are to be capable of absorbing short time impact torque due to electrical short-circuit conditions up to 6 (six) times the nominal torque.

17.3 Flanged Couplings and Coupling Bolts

Refer to 4-3-1/19.5, for flanged couplings.

Elongation for auxiliary machinery coupling bolts made of steel having an ultimate tensile strength over 690 N/mm² (70 kgf/mm², 100,000 psi) will be subject to special consideration. Also refer to 4-3-1/19.1 and 4-3-1/19.3.

19 Testing of Pumps Associated with Engine and Reduction Gear Operation

Pumps associated with engine and reduction gear operation (oil, water, fuel) utilized with engines having bores exceeding 300 mm (11.8 in.) are to be provided with certificates issued by the Surveyor. The following tests are to be conducted to the Surveyor's satisfaction:

19.1 Pumps Hydrostatic Tests

Independently driven pumps are to be hydrostatically tested to 4 bar (4 kgf/cm², 57 psi) but not less than 1.5P, where P is the maximum working pressure in the part concerned.

19.3 Capacity Tests

Tests of pump capacities are to be conducted to the satisfaction of the Surveyor with the pump operating at design conditions. Capacity tests will not be required for individual pumps produced on a production line basis, provided the Surveyor is satisfied from periodic inspections and the manufacturer's quality assurance procedures that the pump capacities are acceptable.

21 Trial

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 vibration at speeds within the operating range. See also 4-1-1/33.

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 5-1-6/1ii).

The gear-tooth examination for conventional gear units 1120 kW (1500 HP) and below and all epicyclical gear units will be subject to special consideration. The gear manufacturer's recommendations will be considered.

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PART

4

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 1 Propulsion Shafting

1 General

The construction of the propellers and propulsion shafting for liftboats is to be carried out in accordance with the following requirements and to the satisfaction of the Surveyor. Upon satisfactory compliance with the requirements, a notation will be made in the *Record* indicating the type of propeller and the material of which it is made.

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 liftboat.

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 Plans and Data to be Submitted

Plans and specifications are to be submitted in accordance with Section 1-1-4 of the Supplement to the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* as indicated in the following:

Detailed plans together with material specifications of the propulsion shafting, couplings, coupling bolts, propulsion shafting arrangement, tail shaft bearings and lubrication system, if oil-lubricated, are to be submitted. Calculations are to be included for flexible couplings and demountable couplings, see 4-2-1/17 and 4-3-1/19.9. See also 4-3-1/21.

5 Materials and Testing

5.1 Material (2004)

Materials for propulsion shafts, couplings and coupling bolts, keys and clutches are to be of forged steel or rolled bars, as appropriate, in accordance with Section 2-3-7 and Section 2-3-8 of the ABS *Rules for Materials and Welding (Part 2)* or other specifications as may be specially approved with a specific design. Where materials other than those specified in the Rules are proposed, full details of chemical composition, heat treatment and mechanical properties, as appropriate, are to be submitted for approval.

5.1.1 Ultimate Tensile Strength

In general, the minimum specified ultimate tensile strength of steel used for propulsion shafting is to be between 400 N/mm² (40.7 kgf/mm², 58,000 psi) and 930 N/mm² (95.0 kgf/mm², 135,000 psi).

5.1.2 Elongation (2012)

Carbon Steel with elongation ($L_o/d = 4$) of less than 16% or ($L_o/d = 5$) of less than 15% is not to be used for any shafting component, with the exception that material for non-fitted alloy steel coupling bolts manufactured to a recognized standard may have elongation ($L_o/d = 4$) of not less than 10% or ($L_o/d = 5$) of not less than 9%.

Alloy steels with elongation less than ($L_o/d = 4$) 16% or ($L_o/d = 5$) 15% may be applied subject to approval.

5.3 Alternative Test Requirements

Materials for shafting, couplings, and coupling bolts, transmitting 373 kW (500 HP) or less, will be accepted based on the manufacturer's certified mill tests and hardness check witnessed by the Surveyor. Bolts manufactured to a recognized standard and used as coupling bolts will not require material testing.

5.5 Inspection

Shafting and couplings are to be surface examined at the manufacturer. Tail shafts in the finished machine condition are to be subjected to a nondestructive examination such as magnetic particle, dye penetrant or other nondestructive methods and are to be free of linear discontinuities greater than 3.2 mm (1/8 in.) except that in the following locations the shafts are to be free of all linear discontinuities:

5.5.1 Tapered Tail Shafts

The forward one-third length of the taper, including the forward end of any keyway and an equal length of the parallel part of the shaft immediately forward of the taper.

5.5.2 Flanged Tail Shafts

The flange fillet area.

5.7 Weldability (2008)

Steel used for tail shafts is to have carbon content in accordance with 2-3-7/1.1.2 of the *ABS Rules for Materials and Welding (Part 2)*.

7 Design and Construction (2004)

7.1 Shaft Diameters (2012)

The least diameter of propulsion shafting is to be determined by the following equation:

$$D = 100K \sqrt[3]{(H/R)[c_1/(U + c_2)]}$$

where

c_1	=	560 (41.95, 3.695)	for liftboats 45.7 m (150 ft) in length and over
	=	472.5 (35.4, 3.12)	for liftboats 20 m (65 ft) and over but below 45.7 m (150 ft), where the material of the shaft is Grade 2 and the shaft is protected
	=	540 (40.3, 3.55)	for liftboats 20 m (65 ft) and over but below 45.7 m (150 ft), for all other materials and unprotected Grade 2 shaft material
	=	416.4 (31.22, 2.75)	for liftboats below 20 m (65 ft)
c_2	=	160 (16.3, 23180)	
D	=	greater of the required solid shaft diameter, in mm (in.), as required by 4-3-1/7.1, or 4-3-1/21 reflective of static and dynamic stresses, except hollow shaft in 4-3-1/7.3	

- K = shaft design factor (see 4-3-1/Table 1 and 4-3-1/Table 2)
- H = power at rated speed, kW (PS, HP), [(MKS units: 1 PS = 0.735 kW), (US units: 1 HP = 0.746 kW)]
- R = rpm at rated speed
- U = minimum specified ultimate tensile strength of the material, in N/mm² (kgf/mm², psi). For calculation purposes, U is not to be taken as more than the following:
- = 415 N/mm² (42.2 kgf/mm², 60,000 psi) for carbon, and alloy steel tail shafts fitted with salt-water lubricated bearings and non-continuous shaft liners.
 - = 600 N/mm² (61.2 kgf/mm², 87,000 psi) for carbon, alloy and austenitic stainless steel tail shafts fitted with oil lubricated bearings or with continuous shaft liners or equivalent.
 - = 930 N/mm² (95.0 kgf/mm², 135,000 psi) for other shaft sections and for tail shafts manufactured of age-hardened martensitic stainless steels, higher-strength austenitic stainless steels such as ASTM Type XM-19, XM-21, or XM-28, or other high strength alloy materials.

Note: In general, the minimum specified ultimate tensile strength of steel used for propulsion shafting is to be between 400 N/mm² (40.7 kgf/mm², 58,000 psi) and 930 N/mm² (95.0 kgf/mm², 135,000 psi). See also 4-3-1/5.1.

TABLE 1
Shaft Design Factor K for Line Shafts, Thrust Shafts, and Oil Distribution Shafts

<i>Propulsion Type</i>	<i>Design Features</i> ⁽¹⁾							
	<i>Integral flange</i>	<i>Shrink fit coupling</i>	<i>Keyways</i> ⁽²⁾	<i>Radial holes, transverse holes</i> ⁽³⁾	<i>Longitudinal slots</i> ⁽⁴⁾	<i>On both sides of thrust collars</i>	<i>In way of axial bearings used as thrust bearings</i>	<i>Straight sections</i>
Electric Drives	0.95	0.95	1.045	1.045	1.14	1.045	1.045	0.95
Diesel Drives through slip couplings (electric or hydraulic)								
All Other Diesel Drives	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.0

Notes:

- 1 Geometric features other than those listed will be specially considered.
- 2 After a length of not less than $0.2D$ from the end of the keyway, the shaft diameter may be reduced to the diameter calculated for straight sections.
Fillet radii in the transverse section of the bottom of the keyway are to be not less than $0.0125D$.
- 3 Diameter of bore not more than $0.3D$.
- 4 Length of the slot not more than $1.4D$, width of the slot not more than $0.2D$, whereby D is calculated with $k = 1.0$.

TABLE 2
Shaft Design Factor K for Tail Shafts and Stern Tube Shafts (See Note 1)

Propulsion Type	Stern Tube Configuration	Propeller Attachment Method ⁽²⁾			
		Keyed ⁽³⁾	Keyless Attachment by Shrink Fit ⁽⁴⁾	Flanged ⁽⁵⁾	Stern Tube Shafts ^{(6),(7)}
All	Oil lubricated bearings	1.26	1.22	1.22	1.15
All	Water lubricated bearings with continuous shaft liners or equivalent	1.26	1.22	1.22	1.15
All	Water lubricated bearings with non-continuous shaft liners	1.29	1.25	1.25	1.18

Notes:

- 1 The tail shaft diameter may be reduced to the stern tube shaft diameter forward of the bearing supporting the propeller, and the stern tube shaft diameter reduced to the line shaft diameter inboard of the forward stern tube seal. The inboard end of tail shafts or tube shafts within the liftboat, as applicable, is to be designed the same as line shafts, with shaft design factors in accordance with 4-3-1/Table 1.
- 2 Other attachments are subject to special consideration.
- 3 Fillet radii in the transverse section at the bottom of the keyway are not to be less than $0.0125D$.
- 4 See also 4-3-1/15.
- 5 The fillet radius in the base of the flange, for the tail shaft supporting the propeller, is to be at least $0.125D$. Special consideration will be given to fillets of multiple radii design. The fillet radius is to be accessible for nondestructive examination during tail shaft surveys. See 5-1-9/5. For other fillet radii, see 4-3-1/19.5.
- 6 K factor applies to shafting between the forward edge of the propeller-end bearing and the inboard stern tube seal.
- 7 Where keyed couplings are fitted on stern tube shaft, the shaft diameters are to be increased by 10% in way of the coupling. See Note 2 of 4-3-1/Table 1.

7.3 Hollow Shafts

For hollow shafts where the bore exceeds 40% of the outside diameter, the minimum shaft diameter is not to be less than that given by the following equation:

$$D_o = D \sqrt[3]{1/[1 - (D_i / D_o)^4]}$$

where

- D_o = required outside diameter, in mm (in.)
 D = solid shaft diameter required by 4-3-1/7, as applicable, in mm (in.)
 D_i = actual shaft bore, in mm (in.)

9 Key (2004)

In general, the key material is to be of equal or higher strength than the shaft material. The effective area of the key in shear is to be not less than A given below. The effective area is to be the gross area subtracted by materials removed by saw cuts, set screw holes, chamfer, etc., and is to exclude the portion of the key in way of spooning of the key way.

$$A = \frac{D^3}{5.1r_m} \cdot \frac{Y_s}{Y_K}$$

where

A	=	shear area of key; mm ² (in ²)
D	=	line shaft diameter; mm (in.); as determined by 4-3-1/7.1
r_m	=	shaft radius at mid-length of the key; mm (in.).
Y_S	=	specified yield strength of shaft material; N/mm ² (kgf/mm ² , psi)
Y_K	=	specified yield strength of key material; N/mm ² (kgf/mm ² , psi)

11 Tail Shaft Liners

11.1 Thickness at Bearings (2009)

11.1.1 Bronze Liner

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.)

11.1.2 Stainless Steel Liner

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 inches) whichever is greater.

11.3 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.

11.5 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.

11.7 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.

11.9 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/cm², 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.

11.11 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. Prior to coating, the shaft is to be cleaned with a suitable solvent and grit blasted. The shaft is to be examined prior to coating and the first layer is to be applied in the presence of the Surveyor. Subsequent to coating, the finished shaft is to be subjected to a spark test or equivalent to verify freedom from porosity to the satisfaction of the Surveyor. 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 over-lapping and adequately bonding the coating to fitted or clad liners. The end of the liner is to be stepped and tapered as required to protect the end of the wrapping.

11.13 Stainless Steel Cladding

Stainless steel cladding of shafts is to be carried out in accordance with an approved procedure. See latest edition of Appendix 7-A-11, "Repair and Cladding of Shafts" of the *ABS Rules for Survey After Construction (Part 7)*.

13 Tail Shaft Bearings

13.1 Water Lubricated Bearings

13.1.1 Wood Bearings (resinous, dense hardwoods)

The length of the bearing, next to and supporting the propeller, is to be not less than four times the required tail shaft diameter.

13.1.2 Synthetic Bearings (rubber, reinforced resins, plastic materials)

The length of the bearing, next to and supporting the propeller, is to be not less than four times the required tail shaft diameter.

For a bearing design substantiated by experimental tests to the satisfaction of ABS, consideration may be given to a bearing length of less than four times but not less than two times the required tail shaft diameter.

13.3 Oil Lubricated Bearings

13.3.1 White Metal Lined

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. The length of the bearing may be less provided the nominal bearing pressure is not more than 0.80 N/mm² (0.0815 kgf/mm², 116 psi) as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing, divided by the projected area of the shaft. The minimum length, however, is not to be less than 1.5 times the actual diameter.

13.3.2 Synthetic Bearings (rubber, reinforced resins, plastic etc.)

The length of synthetic rubber, reinforced resin or plastic oil lubricated propeller end bearings fitted with an approved oil-seal gland is to be on order of two time the required tail shaft diameter. The length of bearing may be less provided the nominal bearing pressure is not more than 0.60 N/mm² (0.0611 kgf/mm², 87 psi) as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing, divided by the projected area of the shaft. The minimum length, however, is not to be less than 1.5 times the actual diameter. Where the material has demonstrated satisfactory testing and operating experience, consideration may be given to increased bearing pressure.

15 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.

15.1 Keyed

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 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.

15.3 Keyless

Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for review.

17 Flexible Couplings

See 4-2-1/17.1.

19 Solid Couplings

19.1 Fitted Bolts (2008)

The minimum diameter of fitted shaft coupling bolts is to be determined by the following equation.

$$d_b = 0.65 \sqrt{D^3 (U + c) / NBU_b} \quad \text{mm (in.)}$$

where

- d_b = diameter of bolts at joints, in mm (in.)
- D = minimum required shaft diameter designed considering the largest combined torque (static and dynamic), acting at the shaft in vicinity of the respective coupling flanges; mm (in), see 4-3-1/21, but not less than the minimum required line shaft diameter (see 4-3-1/7), in mm (in.)
- U = minimum specific tensile strength of shaft material, in N/mm², (kgf/mm², psi)
- c = 160 (16.3, 23180)
- N = number of bolts fitted in one coupling
- B = bolt circle diameter, in mm (in.)
- U_b = minimum specific tensile strength of bolt material, in N/mm², (kgf/mm², psi). To be not less than U . U_b is to be taken not more than 1.7 U or 1000 N/mm² (102 kgf/mm², 145,000 psi), whichever is less, for calculation purposes.

Notes: (2008)

- 1 The bolts are to be assembled with an interference fit.
- 2 The use of other materials will be subject to special consideration based on submitted engineering analyses.

19.3 Non-fitted Bolts

The diameter of pre-stressed non-fitted coupling bolts will be considered upon the submittal of detailed preloading and stress calculations and fitting instructions. The tensile stress on the bolt due to prestressing and astern pull is not to exceed 90% of the minimum specified yield strength of the bolt material. In addition, the bearing stress on any member such as the shaft, bolt, threads or nut is not to exceed 90% of the minimum specified yield strength of the material for that member.

19.3.1 Power Transmitted by Prestress Only

Where bolts are under pure tension, the factor of safety against slip under the worst of the operating conditions, including mean transmitted torque plus vibratory torque due to torsional loads, is to be at least as follows:

- i) Inaccessible couplings (external to the hull or not readily accessible) 2.8
- ii) Accessible couplings (internal to the hull) 2.0

19.3.2 Power Transmitted by Combination Prestress and Shear

Where the power is transmitted by a combination of fitted bolts and prestressed non-fitted bolts, the components are to meet the following criteria:

19.3.2(a) Fitted Bolts. The shear stress under the maximum torque corresponding to the worst loaded condition, is to be not more than 50% of the minimum specified tensile yield strength of the bolt material.

19.3.2(b) Non-Fitted Bolts. The factor of safety against slip, under the maximum torque corresponding to the worst loaded condition and the specified bolt tension, is to be at least 1.6 for inaccessible couplings and 1.1 for accessible couplings.

19.3.3 Dowels Used for Transmitting Power

Dowels connecting the tail shaft flange to the controllable pitch propeller hub, utilized with non-fitted bolts to transmit power, are considered equivalent to fitted coupling bolts and are to comply with 4-3-1/19.1 and, if applicable, 4-3-1/19.3.2(a). The dowels are to be accurately fitted and effectively secured against axial movement. The coupling is to be satisfactory for astern condition.

19.5 Flanges

The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts or 0.2 times D (as defined in 4-3-1/7), whichever is greater. The fillet radius at the base of an integral flange is not to be less than 0.08 times the actual shaft diameter. Consideration of a recognized shaft coupling standard will be given to fillets of multiple radii design. In general, the surface finish for fillet radii is not to be rougher than 1.6 μmeters (63 $\mu\text{in.}$) RMS. For the fillet radius for tail shaft to propeller coupling flange, see Note 4 in 4-3-1/Table 2.

19.7 Locking Arrangement (2014)

After assembly, all coupling bolts and associated nuts are to be fitted with locking arrangement.

19.9 Demountable Couplings

Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft. Where necessary, provisions for resisting thrust loading are to be provided.

Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed preloading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted mean torque plus vibratory torque due to torsionals for inaccessible couplings (external to the hull or not readily accessible) and at least 2.0 times for accessible couplings (internal to the hull). The preload stress is not to exceed 70% of the minimum specified yield strength.

21 Propulsion Shaft Alignment and Vibrations

21.1 General

Propulsion shafting is to be aligned with the location and spacing of the shaft bearings being such as to give acceptable bearing reactions and shaft bending moments and also acceptable amplitudes of vibration for all conditions of ship loading and operation.

The designer or the builder is to evaluate the propulsion shafting system taking into consideration any forces or factors which may affect the reliability of the propulsion shafting system including weight of the propeller and shafts, hydrodynamic forces acting on the propeller, number of propeller blades in relation to diesel engine cylinders, misalignment forces, thermal expansion, flexibility of engine and thrust bearing foundations, engine induced vibrations, gear tooth loadings, flexible couplings, effect of power take-off arrangements from the propulsion shafting system driving auxiliaries, etc., as applicable, as well as any limits for vibrations and loadings specified by the equipment manufacturers.

21.3 Liftboats 61 m (200 ft) in Length and Over

21.3.1 Shaft Alignment Calculations

The requirements in 4-3-2/7.3 of the *Steel Vessel Rules* are to be complied with.

21.3.2 Torsional Vibrations

The requirements in 4-3-2/7.5.1 of the *Steel Vessel Rules* are to be complied with.

21.3.3 Axial Vibrations

The requirements in 4-3-2/7.7 of the *Steel Vessel Rules* are to be complied with.

21.3.4 Lateral (Whirling) Vibrations

The requirements in 4-3-2/7.9 of *Steel Vessel Rules* are to be complied with.

21.3.5 Cast Resin Chocks (2009)

Resin chocks and their installation are to comply with the requirements in 4-3-2/11.1.2 of the *Steel Vessel Rules*.

21.5 Liftboats Below 61 m (200 ft) in Length

21.5.1 Torsional Vibration

For liftboats fitted with unusual propulsion arrangement or without vibration dampers, a torsional vibration analysis of the propulsion system showing compliance with 4-3-2/7.5.1 of the *Steel Vessel Rules* is to be submitted. This is not required for liftboats under 20 m (65 ft) in length or where the installation is essentially the same as previous designs which have been proven satisfactory.

23 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.

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 2 Propellers

1 General

The construction of the propellers and propulsion shafting for liftboats is to be carried out in accordance with the following requirements and to the satisfaction of the Surveyor. Upon satisfactory compliance with the requirements, a notation will be made in the *Record* indicating the type of propeller and the material of which it is made.

1.1 Definitions (2014)

For purpose of this section, the following definitions apply.

1.1.1 Skew Angle

Skew Angle (θ) of a propeller is the angle measured from ray 'A' passing through the tip of blade at mid-chord line to ray 'B' tangent to the mid-chord line on the projected blade outline. See 4-3-2/Figure 1.

1.1.2 Highly Skewed Propeller

A *Highly Skewed Propeller* is one whose skew angle is more than 25° .

1.1.3 Propeller Rake

1.1.3(a) Rake. Rake is the distance at the blade tip between the generating line and the line perpendicular to the propeller axis that meets the generating line at the propeller axis. See 4-3-2/Figure 2.

1.1.3(b) Rake Angle (ϕ). Rake Angle of a propeller is the angle measured from the plane perpendicular to shaft centerline to the tangent to the generating line at a specified radius ($0.6 \times$ radius for the purpose of this section). See 4-3-2/Figure 2.

1.1.4 Wide Tipped Blade Propeller

A propeller blade is to be considered as a wide tipped blade if the maximum expanded blade cord length occurs at or above $0.8R$, with R being the distance measured from the centerline of the propeller hub.

3 Plans and Data to be Submitted

Plans and specifications are to be submitted in accordance with Section 1-1-4 of the Supplement to the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* as indicated in the following:

3.1 Fixed-Pitch Propellers

Where the propeller blades are of conventional design, a propeller plan, giving the design data and characteristics of the material, as required by 4-3-2/7.1, is to be submitted. For skewed propellers or propeller blades of unusual design, a detailed stress analysis is also to be submitted as required by 4-3-2/7.3 or 4-3-2/9.3. For keyless propellers see 4-3-2/17.3.

3.3 Controllable-Pitch Propellers

In addition to the plan and data required in 4-3-2/3.1 for the propeller blade; plans of the propeller hub, propeller blade flange and bolts, internal mechanisms, hydraulic piping control systems, and instrumentation and alarm system are to be submitted. Strength calculations are to be included for the internal mechanism, see 4-3-2/13.

5 Materials and Testing

5.1 Propeller Material

5.1.1 General

For propellers required to be of an approved design, the material of the propeller 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 to be inspected by the Surveyor.

5.3 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)*.

7 Blade Design

7.1 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:

7.1.1 Fixed-Pitch Propellers

$$t_{0.25} = S \left[K_1 \sqrt{\frac{AH}{C_n CRN}} \pm \left(\frac{C_s}{C_n} \right) \left(\frac{BK}{4C} \right) \right] \text{ mm (in.)}$$

where

$$A = 1.0 + (6.0/P_{0.70}) + 4.3P_{0.25}$$

$$B = (4300wa/N) (R/100)^2 (D/20)^3$$

$$C = (1 + 1.5P_{0.25}) (Wf - B)$$

$$S = 1.0 \quad \text{for all propellers with } D \leq 6.1 \text{ m (20 ft)}$$

$$= \sqrt{(D + 24.0) / 30.1} \quad \text{SI, MKS units or}$$

$$= \sqrt{(D + 79) / 99} \quad \text{US units for solid propellers with } D > 6.1 \text{ m (20 ft) and weighing in excess of 20 tons. } S \text{ is not to exceed 1.025.}$$

$$t_{0.25} = \text{required thickness at the one-quarter radius, in mm (in.)}$$

$$K_1 = 337 (289, 13)$$

$$H = \text{power at rated speed, kW (hp, HP)}$$

$$hp = \text{metric horsepower}$$

$$HP = \text{US horsepower}$$

$$R = \text{rpm at rated speed}$$

$$N = \text{number of blades}$$

- $P_{0.25}$ = 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 (in.) (positive for aft rake and negative for forward rake)
- C_s = a_s/WT (section area coefficient at the 0.25 or 0.35 radius). Also see below.
- C_n = $I_o/U_f WT^2$ (section modulus coefficient at the 0.25 or 0.35 radius). Also see below.
- I_o = moment of inertia of the expanded cylindrical section at 0.25 or 0.35 radius about a straight line through the center of gravity parallel to the pitch line or to the nose-tail line, in mm⁴ (in⁴)
- a_s = area of expanded cylindrical section at the 0.25 or 0.35 radius, in mm² (in²)
- U_f = maximum normal distance from the moment of inertia axis to points on the face boundary (tension side) of the section, in mm (in.)
- T = maximum thickness at the 0.25 or 0.35 radius, in mm (in.), from propeller drawing
- 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	8.31	68	0.30
3	Nickel-manganese bronze	2.13	8.01	69	0.29
4	Nickel-aluminum bronze	2.62	7.51	85	0.27
5	Mn-Ni-Al bronze	2.37	7.51	77	0.27
	Cast steel	2.10	8.30	68	0.30
CF-3	Austenitic stainless steel	2.10	7.75	68	0.28

Note: The f values of materials not covered will be specially considered upon submittal of complete material specifications including corrosion fatigue data to 10^8 cycles.

The values of C_s and C_n computed as stipulated above are to be indicated on the propeller drawing. If the C_n value exceeds 0.10, the required thickness is to be computed with $C_n = 0.10$.

For liftboats below 61 m (200 ft) in length, the required thickness may be computed with the assumed values of $C_n = 0.10$ and $C_s = 0.69$.

7.1.2 Controllable-Pitch Propellers

$$t_{0.35} = K_2 \sqrt{\frac{AH}{C_n CRN}} \pm \left(\frac{C_s}{C_n} \right) \left(\frac{BK}{6.3C} \right) \text{ mm (in.)}$$

where

$$\begin{aligned} A &= 1.0 + (6.0/P_{0.7}) + 3P_{0.35} && \text{(free running)} \\ &= 7.2 + (2.0/P_{0.7}) + 3P_{0.35} && \text{(bollard, APS, dynamic positioning)} \\ B &= (4900wa/N) (R/100)^2 (D/20)^3 \\ C &= (1 + 0.6P_{0.35}) (Wf - B) \end{aligned}$$

$t_{0.35}$ = required thickness at the 0.35 radius, in mm (in.)

K_2 = 271 (232, 10.4)

$P_{0.35}$ = 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.)

$H, R, N, P_{0.7}, a, D, K, C_s, C_n, f$, and w are as defined in 4-3-2/7.1.1.

7.1.3 Nozzle Propellers (Wide Tip Blades) (2014)

$$t_{0.35} = K_3 \sqrt{\left(\frac{AH}{C_n CRN} \right) \pm \left(\frac{C_s}{C_n} \right) \left(\frac{BK}{5.6C} \right)} \text{ mm (in.)}$$

where

A = $1.0 + (6.0/P_{0.7}) + 2.8P_{0.35}$ (free running)

= $7.2 + (2.0/P_{0.7}) + 2.8P_{0.35}$ (bollard, APS, dynamic positioning)

B = $(4625wa/N) (R/100)^2 (D/20)^3$

C = $(1 + 0.6P_{0.35}) (Wf - B)$

$t_{0.35}$ = required thickness at the 0.35 radius, in mm (in.)

K_3 = 288 (247, 11.1)

$P_{0.35}$ = 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.)

$H, R, N, P_{0.7}, a, D, K, C_s, C_n, f$, and w are as defined in 4-3-2/7.1.1.

A propeller blade is to be considered as a wide tipped blade if the maximum expanded blade cord length occurs at or above $0.8R$, with R being the distance measured from the centerline of the propeller hub.

7.3 Blades of Unusual Design

Propellers of unusual design or application will be subject to special consideration upon submittal of detailed stress calculations.

7.5 Blade-root Fillets

Fillets at the root of the blades are not to be considered in the determination of blade thickness.

7.7 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.

9 Skewed Propeller Blades

9.1 Definitions

9.1.1 Maximum Skew Angle

Maximum skew angle (θ) is measured from ray A passing through the tip of blade to ray B tangent to the mid-chord line of the projected blade outline. See 4-3-2/Figure 2.

9.1.2 Rake Angle

Rake angle (ϕ) for the purpose of this Subsection is the angle measured from the plane perpendicular to shaft centerline to the tangent to generating line at 0.6 radius. See 4-3-2/Figure 3.

9.3 Application

9.3.1 $\theta \leq 25^\circ$

The requirements in 4-3-2/7.1 are applicable where the maximum skew angle is 25 degrees or less.

9.3.2 $25^\circ < \theta \leq 50^\circ$

The requirements in 4-3-2/9.5 may be used for fixed pitch propellers of ABS Type 4 material having skew angle over 25 degrees but not exceeding 50 degrees. For other material/type propellers, calculations as required in 4-3-2/9.3.3 are to be submitted.

9.3.3 $\theta > 50^\circ$

Propellers with the maximum skew angle exceeding 50 degrees will be subject to special consideration upon submittal of detailed stress calculations.

The maximum stress occurring during steady or transient astern operations is not to exceed seventy per cent of the minimum specified yield strength of the propeller material.

9.5 Propellers Over 25° up to 50° Skew Angle

This Paragraph applies to fixed pitch propellers of ABS Type 4 material having a maximum skew angle over 25 degrees but not exceeding 50 degrees.

9.5.1 Blade Thickness at 0.25 Radius

The maximum thickness at 0.25 radius is not to be less than the thickness required in 4-3-2/7.1.1 multiplied by the factor m as given below:

$$m = \sqrt{1 + 0.0065(\theta - 25)}$$

9.5.2 Blade Thickness at 0.6 Radius

The maximum thickness at 0.6 radius is to be not less than that obtained from the following equation:

$$T_{0.6} = K \sqrt{(1 + C_{0.9})(1 + 2C_{0.9} / C_{0.6})[(HDI\Gamma) / (Rp_{0.6}Y)]^{0.5}}$$

where

$t_{0.6}$	=	required thickness at the 0.6 radius in mm (in.)
K_3	=	12.6 (6.58, 1.19)
$C_{0.9}$	=	expanded chord length at the 0.9 radius divided by propeller diameter
$C_{0.6}$	=	expanded chord length at the 0.6 radius divided by propeller diameter
Γ	=	$[1 + (\theta - 25)/\theta][\phi^2 + 0.16\phi\theta P_{0.9} + 100]$
θ	=	skew angle in degrees (see 4-3-2/9.1.1 and 4-3-2/Figure 2)
ϕ	=	rake angle in degrees (see 4-3-2/9.1.2 and 4-3-2/Figure 3), positive for rake aft
$P_{0.6}$	=	pitch at the 0.6 radius divided by propeller diameter
$P_{0.9}$	=	pitch at the 0.9 radius divided by propeller diameter
Y	=	minimum specified yield strength of ABS Type 4 propeller material in N/mm ² (kgf/m ² , psi)

H, D, R are as defined in 4-3-2/7.1.

9.5.3 Blade Thickness Between 0.6 and 0.9 Radius

9.5.3(a) *Maximum Thickness.* The maximum thickness between 0.6 and 0.9 radius is not to be less than that obtained from the following equation:

$$t_x = 3.3D + 2.5(1 - x)(t_{0.6} - 3.3D) \quad \text{mm}$$

$$t_x = 0.04D + 2.5(1 - x)(t_{0.6} - 0.04) \quad \text{in.}$$

where

t_x = required maximum blade thickness at radius x

$t_{0.6}$ = blade thickness at 0.6 radius as required by 4-3-2/9.5.2

x = ratio of the radius under consideration to $D/2$, $0.6 < x \leq 0.9$

9.5.3(b) *Trailing Edge Thickness at 0.9 Radius.* The edge thickness measured at 5% of chord length from the trailing edge is to be not less than 30% of the maximum blade thickness required by 4-3-2/9.5.3(a) above at that radius.

FIGURE 1
Maximum Skew Angle

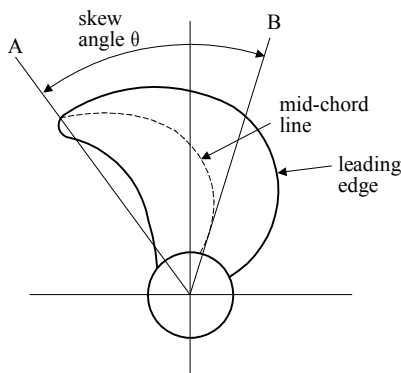
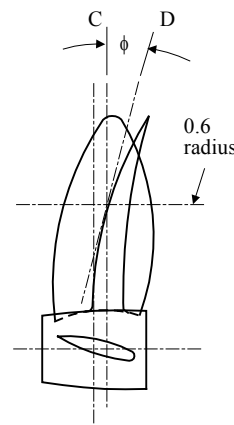


FIGURE 2
Rake Angle at the 0.6 Radius, Positive Aft



The rake angle ϕ , measured at 0.6 radius, is formed between line D , which is tangent to the generating line, and the line C , which is perpendicular to the propeller shaft centerline.

11 Studs

11.1 Stud Area

$$s = 0.056kW t_{0.35}^2 f/rn \quad \text{mm}^2$$

$$s = 0.0018kW t_{0.35}^2 f/rn \quad \text{in}^2$$

where

k = $C/(U + C_1)$ material correction factor

C = 621 (63.3, 90,000)

C_1 = 207 (21.1, 30,000)

U = ultimate tensile strength of the stud material, kg/mm² (psi)

s = area of one stud at bottom of thread, in mm² (in²)

n = number of studs on driving side of blade

r = radius of pitch circle of the studs, in mm (in.)

W, f and $t_{0.35}$ are as defined in 4-3-2/7.1.

11.3 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.

13 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.

15 Controllable Pitch Propeller System

15.1 Blade Pitch Control

15.1.1 Bridge Control

Where the navigation bridge is provided with direct control of propulsion machinery, it is to be fitted with means to control the pitch of the propeller.

15.1.2 Duplication of Power Unit

At least two hydraulic power pump units are to be provided for the pitch actuating system and arranged so that transfer between the pump units can be readily effected. For propulsion machinery spaces intended for unattended operation (**ACCU** notation), automatic start of the standby pump unit is to be provided.

15.1.3 Emergency Provisions

To safeguard the propulsion and maneuvering capability of the liftboat in the event of any single failure in either the remote pitch control system or the pitch actuating system external to the propeller shaft and oil transfer device (also known as oil distribution box), the following are to be provided:

- i) Manual control of pitch at or near the pitch-actuating control valve (usually the directional valve or similar).
- ii) The pitch is to remain in the last ordered position, or to revert to a preset position which still permits propulsion and maneuvering.

15.1.4 Integral Oil Systems

Where the pitch actuating hydraulic system is integral with the reduction gear lubricating oil system and/or clutch hydraulic system, the piping is to be arranged such that any failure in the pitch actuating system will not leave the other system(s) non-operational.

15.1.5 Provisions for Testing

Means are to be provided in the pitch actuating system to simulate system behavior in the event of loss of system pressure. Hydraulic pump units driven by main propulsion machinery are to be fitted with a suitable by-pass for this purpose.

15.1.6 Hydraulic Piping

Hydraulic piping is to meet the requirements of 4-5-6/1.

15.3 Instrumentation and Alarms

The following instruments and alarms are to be provided:

15.3.1 Pitch Indicators

Each station capable of controlling the propeller pitch is to be fitted with a pitch indicator. In addition, a pitch indicator is to be fitted on the navigation bridge for liftboats 500 gross tons and above.

15.3.2 Low Oil Pressure

Visual and audible alarms are to be provided in the engine room control station to indicate low hydraulic oil pressure.

15.3.3 High Oil Pressure

Visual and audible alarms are to be provided in the engine room control station to indicate high hydraulic oil pressure. The alarm is to be set below relief valve pressure.

15.3.4 High Temperature

Visual and audible alarms are to be provided in the engine room control station to indicate high hydraulic oil temperature.

15.5 Electrical Components

Electrical components are to meet the applicable requirements of Part 4, Chapter 7.

17 Propeller Fitting

17.1 Keyed Fitting

For shape of the keyway in the shaft and the size of the key, see 4-3-1/15.1

17.3 Keyless

The formulas specified below apply to the ahead condition, but they will also provide adequate safety margin for the astern condition. The astern condition is to be considered if the astern torque exceeds the ahead torque. The formulas are applicable for solid propeller shafts only.

17.3.1 Design Criteria at 35°C (95°F)

The minimum required contact surface (grip) pressure, $P_{\min}$, at 35°C (95°F) and corresponding minimum pull-up length, $\delta_{\min}$, are to be determined by the following equations:

$$P_{\min} = \frac{ST}{AB} \left[-S\tau + \sqrt{\mu^2 + B \left(\frac{F_v}{T} \right)^2} \right] \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

$$\delta_{\min} = P_{\min} \frac{D_s}{2\tau} \left[\frac{1}{E_b} \left(\frac{K^2 + 1}{K^2 - 1} + \nu_b \right) + \frac{1}{E_s} (1 - \nu_s) \right] \text{ mm (in.)}$$

If the rated propeller thrust, T , is not known, it can be estimated as the thrust of a free running liftboat, using the following equations, whichever yields the greater value:

$$T = \frac{c_1 H}{V} \quad \text{or} \quad T = \frac{c_2 \times 10^6 H}{PR} \quad \text{N (kgf, lbf)}$$

17.3.2 Design Criteria at 0°C (32°F)

The maximum permissible contact surface (grip) pressure, $P_{\max}$, at 0°C (32°F), and corresponding maximum permissible pull-up length, $\delta_{\max}$, are to be determined from the following equations:

$$P_{\max} = \frac{\sigma_E (K^2 - 1)}{\sqrt{3K^4 + 1}} \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

$$\delta_{\max} = \frac{P_{\max}}{P_{\min}} \delta_{\min} \quad \text{mm (in.)}$$

17.3.3 Design Criteria at Fitting Temperature

The pull-up length, δ_p , at temperature t , where $t < 35^\circ\text{C}$ (95°F), and corresponding contact surface (grip) pressure, P_p , are to be determined by the following equations.

$$\delta_t = \delta_{\min} + \frac{D_s}{2\tau} (\alpha_b - \alpha_s)(t_{\text{ref}} - t) \quad \text{mm (in.)}$$

$$P_t = P_{\min} \frac{\delta_t}{\delta_{\min}} \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

The minimum push-up load, W_p , at temperature t is to be as follows:

$$W_t = AP_t (\mu + \tau) \quad \text{N (kgf, lbf)}$$

The variables and constants used in 4-3-2/17.3.1, 4-3-2/17.3.2 and 4-3-2/17.3.3 are defined as follows:

- c = coefficient, dependent on the type of propulsion drive
 - = 1.0 for turbines, geared diesel drives, electric drives, and direct diesel with a hydraulic, electromagnetic or high elasticity coupling.
 - = 1.2 for a direct diesel drive.

Higher values may be necessary for cases where extremely high pulsating torque is expected in service.
- c_1 = constant = 1760 (132, 295)
- c_2 = constant = 57.3 (4.3, 0.38)
- t = fitting temperature; $^\circ\text{C}$ ($^\circ\text{F}$); $t < t_{\text{ref}}$
- t_{ref} = 35°C (95°F)
- A = 100% theoretical contact surface area between propeller boss and shaft; disregarding oil grooves (i.e., $A = \pi D_s L$); mm^2 (in^2). Typically, the propeller boss forward and aft counterbore lengths (ℓ_1 and ℓ_2 in 4-3-2/Figure 1) and the forward and aft inner edge radii (r_1 and r_2 in 4-3-2/Figure 1), if any, are to be excluded.
- B = $\mu^2 - S^2 \tau^2$
- D_b = mean outer diameter of propeller boss; mm (in.). D_b is to be calculated as the mean of
$$D_{bm}, D_{bf} \text{ and } D_{ba} \text{ (i.e., } D_b = \frac{D_{ba} + D_{bm} + D_{bf}}{3} \text{),}$$

which are the outer diameters of boss corresponding to D_s , the forward point of contact and the aft point of contact, respectively (see 4-3-2/Figure 1).
- D_s = diameter of tail shaft at mid-point of the taper in axial direction; mm (in.), taking into account the exclusion of forward and aft counterbore length and the forward and aft edge radii (see 4-3-2/Figure 1).
- E_b = modulus of elasticity for boss material; N/mm^2 ($\text{kgf/mm}^2, \text{ psi}$). Material properties are given below.
- E_s = modulus of elasticity of shaft material; N/mm^2 ($\text{kgf/mm}^2, \text{ psi}$). Material properties are given below.
- F_v = shear force at propeller/shaft interface = $\frac{2cQ}{D_s}$; N (kgf, lbf)
- H = rated power; kW (PS, hp)

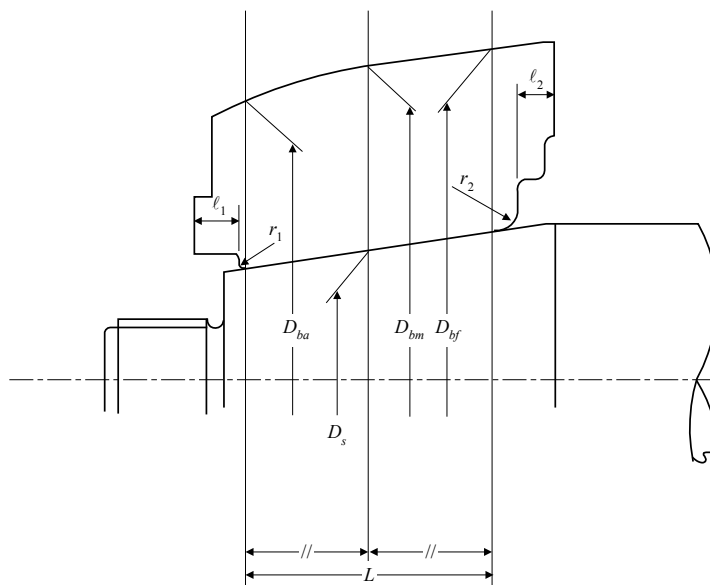
- $K = \frac{D_b}{D_s}$
- $L =$ contact length; mm (in.) See 4-3-2/Figure 1.
- $P =$ mean propeller pitch; mm (in.)
- $Q =$ rated torque corresponding to the rated power, H , and the propeller speed, R ; N-mm (kgf-mm, lbf-in)
- $= 9550 \times 10^3 \frac{H}{R}$ N-mm
- $= 716,200 \frac{H}{R}$ kgf-mm
- $= 63,025 \frac{H}{R}$ lbf-in
- $R =$ propeller speed at rated power; rpm
- $S =$ factor of safety against slip at 35°C (95°F). S is to be at least 2.8 under the action of rated torque (based on maximum continuous rating) plus torque due to torsional vibrations.
- $T =$ rated propeller thrust; N (kgf, lbf)
- $V =$ liftboat speed at rated power; knots
- $\alpha_b =$ coefficient of linear expansion of shaft material; mm/mm-°C (in./in.-°F). Material properties are given below.
- $\alpha_s =$ coefficient of linear expansion of shaft material; mm/mm-°C (in./in.-°F). Material properties are given below.
- $\mu =$ coefficient of friction between contact surfaces. For oil injection method of fit, μ is to be taken as no greater than 0.13 for bronze/steel propeller bosses on steel shafts. For dry method of fit using cast iron on steel shafts, μ is to be taken as no greater than 0.18.
- $\nu_b =$ Poisson's ratio for boss material. Material properties are given below.
- $\nu_s =$ Poisson's ratio for shaft material. Material properties are given below.
- $\tau =$ taper of tail shaft on radius (e.g., if taper = 1/15 on diameter, $\tau = 1/30$ on radius). τ is not to exceed 1/30.
- $\sigma_E =$ maximum equivalent uniaxial stress in the boss at 0°F (32°F) based on the von Mises-Hencky criterion; N/mm² (kgf/mm², psi). For the purposes of these calculations, σ_E is to be taken as 70% of the minimum specified yield strength of the material as defined in 2-3-1/13.3 of the *ABS Rules for Materials and Welding (Part 2)*. For cast iron, σ_E is to be taken as 30% of the minimum specified tensile strength.

The following material constants may be used:

Material	Modulus of Elasticity, E			Poisson's Ratio, ν	Coefficient of Expansion, α	
	N/mm ²	kgf/mm ²	psi		mm/mm°C	in./in.°F
Cast and forged steel	20.6×10^4	2.1×10^4	29.8×10^6	0.29	12.0×10^{-6}	6.67×10^{-6}
Cast iron	29.8×10^4	1.0×10^4	14.2×10^6	0.26	12.0×10^{-6}	6.67×10^{-6}
Bronzes, Types 1 & 2	10.8×10^4	1.1×10^4	15.6×10^6	0.33	17.5×10^{-6}	9.72×10^{-6}
Bronzes, Types 3 & 4	11.8×10^4	1.2×10^4	17.1×10^6	0.33	17.5×10^{-6}	9.72×10^{-6}

FIGURE 3
Keyless Propeller – Theoretical Contact Surface Area
Between Propeller Boss and Shaft

(Refer to 4-3-1/15.3 and 4-3-2/17.3)



19 Protection Against Corrosion

19.1 Propeller Aft End

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 is to be fitted with a fairwater cap, acorn nut, or other suitable after end sealing arrangements which prevents sea water from having contact with the shaft taper area. See 4-3-2/Figure 4 for typical sealing arrangement.

19.3 Propeller Forward End

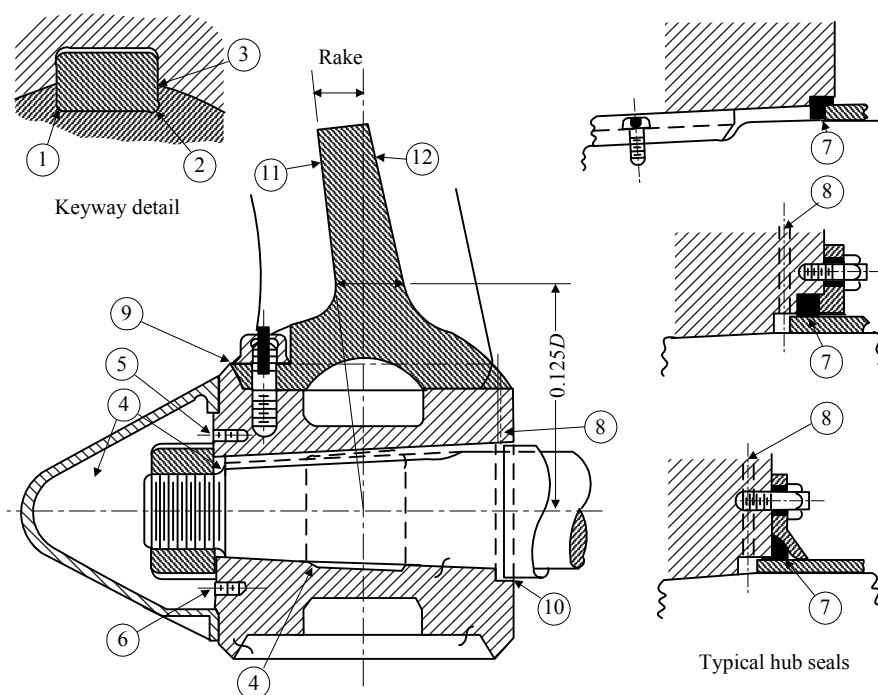
The propeller assembly is to be sealed at the forward end with a well-fitted soft-rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When 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; and, 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 a rust preventive compound before the propeller nut is put on.

19.5 Non-Corrosive, Non-Pitting Alloys

The sealing arrangements above are not required where the tail shaft is fabricated of corrosion-resistant, pitting-resistant alloy unless required by the manufacturer.

FIGURE 4
Propeller Hub Details



1 Liberal Fillet	7 Soft rubber ring
2 Chamfer corners of key	8 Fill and vent holes. One to be centered on keyway
3 Break sharp corners of keyway in shaft	9 See 4-3-2/3.3.4
4 Fill with suitable sealing material	10 See typical hub seals
5 Locking device	11 Face (tension side)
6 Threaded holes for jack bolts	12 Back (compression side)

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 3 Steering Gear

1 General

1.1 Application

These requirements apply to liftboats, which have Rule required upper rudder stock diameter less than 230 mm (9 in.). Where the Rule required upper rudder stock diameter is 230 mm (9 in.) or above, the *Steel Vessel Rules* are to be applied.

Where a rudder is not fitted and steering is achieved by change of setting of the propulsion units, such as the use of cycloidal, azimuthing or similar type propulsion systems, Section 4-3-5 of the *Steel Vessel Rules* is to be applied.

1.3 Definitions

1.3.1 Main Steering Gear

Main steering gear is the machinery, rudder actuators, power units, ancillary equipment and the means of applying torque to the rudder stock (e.g., tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the liftboat.

1.3.2 Auxiliary Steering Gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the liftboat in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.3.3 Steering Gear Control System (1 July 2011)

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power actuating system. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables required to control the steering gear power actuating system. For the purpose of the Rules, steering wheels, steering levers, and rudder angle feedback linkages are not considered to be part of the control system.

1.3.4 Power Units

A steering gear power unit is:

- i) In the case of electric steering gears, an electric motor and its associated electrical equipment,
- ii) In the case of electro-hydraulic steering gears, an electric motor and its associated electrical equipment and connected pump(s), and
- iii) In the case of other hydraulic steering gears, a driving engine and connected pump(s).

1.3.5 Power Actuating System

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components (i.e., tiller, quadrant, rudderstock or components serving the same purpose).

1.3.6 Rudder Actuator

Rudder actuator is the component, which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.7 Maximum Working Pressure

Maximum working pressure is the expected pressure in the system when the steering gear is operated to comply with 4-3-3/1.9.

1.5 Plans and Data

Plans and data of the steering gear system to be submitted are as follows:

1.5.1 Plans

General arrangements of the main and auxiliary steering gears, and of the steering gear compartment.

Assembly of upper rudderstock, tiller, tie rod, rudder actuators, etc. as applicable.

Construction details of all torque-transmitting components of steering gear, such as tiller, tiller pin, tiller/rudder stock interference fit mechanism, tie rod, rudder actuator, etc., including bill of materials, welding procedures, non-destructive testing, as applicable.

Schematic hydraulic piping diagram, incorporating hydraulic logic diagram, and including bill of materials, typical pipe to pipe joint details, pipe to valve joint details, pipe to equipment joint details, pressure rating of valves and pipe fittings, and pressure relief valve settings.

Steering gear control system incorporating schematic electrical control logic diagram, instrumentation, alarm devices, etc., and including bill of materials.

Electrical power supply to power units and to steering gear control, including schematic diagram of motor controllers, feeder cables, feeder cable electrical protection.

1.5.2 Data

Rated torque of main steering gear.

Calculations of torque-transmitting components such as tiller, tie rod, rudder actuator, etc.

1.7 Power Operation

The main steering gear is to be power operated, by one or more power units, if the Rule required upper rudder stock diameter is 120 mm (4.7 in.) or greater.

Notwithstanding the above, the performance requirements stated in 4-3-3/1.9 and 4-3-3/1.11 are to be used to determine if it is necessary for the main and auxiliary steering gears to be power operated.

1.9 Main Steering Gear

The main steering gear is to be capable of putting the rudder from 35° on one side to 35° on the other side with the liftboat running ahead at maximum continuous shaft rpm and at the summer load waterline; and under the same conditions, the travel time from 35° on either side to 30° on the other side is not to be more than 28 seconds. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated RPM.

1.11 Auxiliary Steering Gear

The auxiliary steering gear is to be capable of putting the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the liftboat running ahead at half speed.

The auxiliary steering gear is to be so arranged that the failure of the main steering gear will not render it inoperative. Likewise, failure of auxiliary steering gear is not to affect the main steering gear.

An auxiliary steering gear is not required under the following conditions.

1.11.1

When the main steering gear comprises two or more power units, and is so arranged that after a single failure in its piping system or in one of the power units the defect can be isolated so that the steering capability can be maintained or regained; and provided that the main steering gear is to be capable of operating the rudder as required by 4-3-3/1.9 while all the power units are in operation.

1.11.2

When the main steering gear is non-power operated such as an orbitrol system or consists solely of mechanical components such as sheaves, blocks, wires, chains, etc.

1.13 Steering Gear Compartment Unit Location

The main and the auxiliary steering gears are to be protected from weather. The power units may be located either within or outside the compartment containing the rudder actuators. In the event of loss of hydraulic fluid and of the need to restore the operation of the main or the auxiliary steering gear, the steering gear compartment is to be provided with handrails and gratings, or other non-slip surfaces, to ensure suitable working condition.

In the event of control system failure, or the need to operate the main or the auxiliary steering gear from within the steering gear compartment or from positions other than the navigation bridge, liftboats of 500 gross tons and above are to be provided with a means to indicate the position of the rudder at these positions where emergency steering is to be conducted.

3 Materials

3.1 General

All steering gear components transmitting a force to the rudder and pressure retaining components of hydraulic rudder actuator 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.

3.3 Material Testing (2010)

Except as modified below, materials for the parts and components mentioned in 4-3-3/3.3 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)*.

Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor.

Material tests for commercially supplied tie-rod nuts need not be witnessed by the Surveyor provided the nuts are in compliance with the approved steering gear drawings and are appropriately marked and identified in accordance with a recognized industry standard. Mill test reports for the tie-rod nuts are to be made available to the Surveyor upon request. For all non-standard tie-rod nuts, material testing is required to be performed in the presence of the Surveyor.

Material tests for forged, welded or seamless steel parts (including the internal components) and all non-ferrous parts 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 above referenced *Part 2*, or such other appropriate material specifications as may be approved in connection with a particular design, and will be accepted on the basis of presentation of mill certificates to the Surveyor for verification.

5 Design

5.1 Power Gear Stops (2010)

Power operated steering gears are to be provided with arrangements, such as limit switches, for stopping the steering gear before the structural rudder stops (see 3-2-13/1.7) or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the rudder stock or position of the steering gear itself and may be an integral part of the rudder actuator. Arrangements to satisfy this requirement through the steering gear control system are not permitted

5.3 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 to have strength equivalent to that of the Rule required upper rudder stock diameter.

5.4 Steering Gear Torque (2003)

5.4.1 Minimum Required Rated Torque

The rated torque of the steering gear is not to be less than the expected torque as defined in 3-2-13/1.5.

5.4.2 Maximum Allowable Torque

The transmitted torque, $T_{\max}$, of the steering gear is not to be greater than the maximum allowable torque, T_{ar} , based on the actual rudder stock diameter.

5.4.2(a) *Transmitted torque.* The transmitted torque, $T_{\max}$, is to be based on the relief valve setting and to be determined in accordance with the following equations:

For ram type actuator:

$$T_{\max} = P \cdot N \cdot A \cdot L_2 / (C \cdot \cos^2 \theta) \quad \text{kN-m (tf-m, Ltf-ft)}$$

For rotary vane type actuator:

$$T_{\max} = P \cdot N \cdot A \cdot L_2 / C \quad \text{kN-m (tf-m, Ltf-ft)}$$

For linked cylinder type actuator:

$$T_{\max} = P \cdot N \cdot A \cdot L_2 \cos \theta / C \quad \text{kN-m (tf-m, Ltf-ft)}$$

where

P	=	steering gear relief valve setting pressure, bar (kgf/cm ² , psi)
N	=	number of active pistons or vanes
A	=	area of piston or vane, mm ² (cm ² , in ²)
L_2	=	torque arm, equal the distance from the point of application of the force on the arm to the center of the rudder stock at 0 deg of the rudder angle, m (ft)
C	=	factor, 10000 (1000, 2240)
θ	=	maximum permissible rudder angle (normally 35 degrees)

5.4.2(b) *Maximum allowable torque for rudder stock.* The maximum allowable torque " T_{ar} " for the actual rudder stock diameter is to be determined in accordance with the following equation:

$$T_{ar} = 2.0(D_r/N_u)^3/K_s \quad \text{kN-m (tf-m, Ltf-ft)}$$

where

K_s	=	material factor for rudder stock (see 3-2-13/1.3)
D_r	=	actual rudder stock diameter at minimum point below the tiller or the rotor, mm (in.)
N_u	=	factor, 42.0 (89.9, 2.39)

5.5 Tiller

Tillers are to comply with the following requirements. All terms in the formulae are to have consistent units.

5.5.1

Depth of tiller hub is not to be less than Rule required upper rudder stock diameter.

5.5.2

Thickness of tiller hub is not to be less than one third of the Rule required upper rudder stock diameter.

5.5.3

Notwithstanding 4-3-3/5.5.2 above, polar section modulus of the tiller hub is not to be less than:

$$0.196S^3 \frac{K_h}{K_s}$$

where

- S = Rule required upper rudder stock diameter.
 K_s = material factor of rudder stock (see 3-2-13/1.3)
 K_h = material factor of hub (see 3-2-13/1.3)

5.5.4

The shear area of the tiller key is not to be less than:

$$\frac{0.196S^3}{r} \cdot \frac{K_k}{K_s}$$

where

- r = mean radius of the rudder stock in way of the key
 K_k = material factor of the key (see 3-2-13/1.3)

Other symbols are defined above.

5.5.5

Bearing stress of the tiller and rudder stock keyways is not to be less than 0.9 times the material yield stress.

5.5.6

If tiller is shrink fitted to the rudderstock, preloading and stress calculations and fitting instructions are to be submitted. The calculated torsional holding capacity is to be at least 2.0 times the transmitted torque based on the steering gear relief valve setting. Preload stress is not to exceed 70% of the minimum yield strength.

5.5.7

Section modulus of tiller arm at any point within its length is not to be less than:

$$\frac{0.167S^3 (L_2 - L_1)}{L_2} \cdot \frac{K_t}{K_s}$$

where

- L_2 = distance from the point of application of the force on the tiller to the center of rudder stock
 L_1 = distance between the section of the tiller arm under consideration and the center of the rudder stock
 K_t = material factor of tiller or quadrant arm (see 3-2-13/1.3)

Other symbols are defined above.

5.5.8 (2009)

Split or semi-circular tiller or quadrant hubs assembled by bolting are to have bolts on each side having a total cross-sectional area not less than that given below (use a consistent system of units):

$$\frac{0.196S^3}{L_3} \cdot \frac{K_b}{K_s}$$

where

$$\begin{aligned} L_3 &= \text{distance between the center of the bolts and the center of the rudder stock} \\ K_b &= \text{material factor of bolt (see 3-2-13/1.3)} \end{aligned}$$

Other symbols are as defined above.

The thickness of the bolting flange is not to be less than the minimum required diameter of the bolt.

5.5.9

Where tiller is of welded construction, weld design and weld sizes are to be proportioned such that they are commensurate with the strength of the tiller.

5.7 Pin

Shear area of tiller pin is not to be less than:

$$\frac{0.196S^3}{L_2} \cdot \frac{K_p}{K_s}$$

where K_p is the material factor of the pin (see 3-2-13/1.3)

Other symbols are defined above.

5.9 Tie Rod (Jockey Bar)

The buckling strength of the tie rod is not to be less than:

$$\frac{0.113S^3U_R}{L_2}$$

where

$$U_R = \text{ultimate tensile strength of the rudder stock}$$

Other symbols are defined above.

5.11 Rudder Actuators

5.11.1 General

Rudder actuators are to meet the requirements in 4-3-3/3 for materials and material tests and 2-4-2/1 of the *ABS Rules for Materials and Welding (Part 2)* for welding. They are also to meet the requirements for pressure vessels in the *Steel Vessel Rules*, specifically 4-4-1A1/3.1 (for malleable cast iron, use $y = 0.5$), 4-4-1A1/5 and 4-4-1A1/7 (in association with S as defined below) for design and 4-4-1A1/21 for hydrostatic tests. The maximum allowable stress S is not to exceed the lower of the following:

$$\frac{U}{A} \quad \text{or} \quad \frac{Y}{B}$$

where

$$\begin{aligned} U &= \text{minimum specified tensile strength of material at room temperature} \\ Y &= \text{minimum specified yield point or yield strength} \\ A, B &= \text{factors as given in the following table.} \end{aligned}$$

<i>Factor</i>	<i>Rolled or Forged Steel</i>	<i>Cast Steel</i>	<i>Nodular Cast Iron</i>
A	3.5	4	5
B	1.7	2	3

5.11.2 Oil Seals

Oil seals between non-moving parts forming the external 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 arrangement may be acceptable provided equivalent protection against leakage can be ensured.

5.13 Mechanical Steering Gear

Where mechanical steering systems are permitted, the following are applicable.

5.13.1 Steering Chains and Wire Ropes

Steering chains and wire rope are to be tested as required by Sections 2-2-1 and 2-2-2 of the *ABS Rules for Materials and Welding (Part 2)*, respectively.

5.13.2 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. Guards are to be placed around the sheaves to protect against injury. For sheaves intended to use with ropes, the radius of the grooves is to be equal to that of the rope plus 0.8 mm ($1/32$ in.), and the sheave diameter is to be determined on the basis of wire rope flexibility. For 6×37 -wire rope, the sheave diameter is to be not less than 18 times that of the rope. For wire ropes 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.

5.13.3 Buffers

Steering gears other than hydraulic type are to be designed with suitable buffer arrangement to relieve the gear from shocks to the rudder.

7 Hydraulic System

7.1 Pipes, Valves and Fittings

Pipes, valves and fittings are to meet the requirements of 4-5-6/1, as applicable. The design pressure of piping components subject to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure of the system. Arrangements for bleeding air from hydraulic system are to be provided, where necessary.

7.3 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 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 but is not to exceed the design pressure.

7.5 Filtration

A means is to be provided to maintain cleanliness of the hydraulic fluid.

7.7 Single Failure Criteria

Where multiple power units are provided and an auxiliary steering gear is not fitted, the steering gear hydraulic system is to be designed so that after a single failure in its piping system, one of the power units, or mechanical connection 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 regained. For this purpose, piping system associated with each power unit is to be independent of that of the other units as far as practicable and connections are made only where necessary. Isolation valves are to be fitted, as necessary, to allow for any single failure in the piping system to be isolated so the steering gear can be operated with the remaining intact part of the system. Isolation valves are to be fitted at the pipe connections to rudder actuators. Where non-duplicated rudder actuator is employed, the isolation valves are to be mounted directly on the actuator. Piping systems are to be so arranged that transfer between power units can be readily effected.

7.9 Reservoir and Storage Tank

All open-loop hydraulic systems are to be provided with an oil reservoir of suitable capacity. In addition, for liftboats of 500 gross tons and above, a fixed storage tank having sufficient capacity to recharge at least one hydraulic power system including the reservoir 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.

9 Power Units

If the Rule required upper rudder stock diameter is 120 mm (4.7 in.) or greater, power units are to be tested and certified in accordance with the following requirements. If the Rule required upper rudder stock diameter is less than 120 mm (4.7 in.), and if the liftboat is 500 gross tons or greater, power units are to be tested and certified in accordance with 4-3-3/9.3 only. For liftboats less than 500 gross tons, power units may be accepted based on manufacturer's guarantee for suitability for the intended purpose and subject to satisfactory functional tests after installation.

9.1 Prototype Test

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.

9.1.1

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.

9.1.2

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.

9.3 Production Unit Test

Each power unit pump is to meet the hydrostatic and capacity tests in accordance with 4-5-2/1, as applicable.

11 Steering Gear Control System

11.1 Locations of Control (1 July 2011)

11.1.1 Main Steering Gear

The main steering gear is to be provided with control from the navigation bridge and local control from within the steering gear compartment. However, if the power unit is located in a space other than the steering compartment, the local control is to be provided in that space instead of the steering compartment. For the purpose of local control from the steering gear compartment (or the space containing the power unit), a means is to be provided in the steering compartment (or the space containing the power unit) to disconnect any control system from the navigation bridge. Such means for disconnecting are to be operable by a single person without the need for tools.

11.1.2 Auxiliary Steering Gear

The auxiliary steering gear is to be operable from a space in which the operation of the auxiliary steering gear can be effectively carried out, or from within the steering compartment. However, if power operated, it is to be provided with control from the navigation bridge also.

11.1.3 Duplicate Power Units

Where duplicate (or more) power units are provided and an auxiliary steering gear is not fitted, two independent systems of control are to be provided. Each of these systems is to meet the requirements of the control system of the main steering gear (See 4-3-3/11.1.1). Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

11.1.4 Manual Means

If the steering gear is operated by manual means only, such as by means of a steering wheel through a mechanical or a non-power-operated hydraulic system, only the requirements of 4-3-3/11.7 and 4-3-3/11.9.1 are applicable.

11.3 General (1 July 2011)

11.3.1 Main and Auxiliary Steering Gears

Control systems of the main and the auxiliary steering gears are to be independent of each other in all respects. The independent control systems are to meet the following requirements.

11.3.1(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.

11.3.1(b) 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.

11.3.1(c) 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.

11.3.1(d) 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.

11.3.1(e) Additional Control Systems. Control circuits for additional control systems (e.g., steering lever or autopilot) are to be designed for all-pole disconnection.

11.3.1(f) 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.

11.3.1(g) 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.

11.3.2 Duplicate Power Units

If the main steering gear consists of duplicated (or more) power units and an auxiliary steering is not fitted, the two independent means of control are to comply with the requirements of 4-3-3/11.3.1.

11.3.3 Single Power Units

If the main steering gear consists of a single power unit and the auxiliary steering gear is not power operated, only one control system for the main steering gear need be provided.

11.3.4 Computer-based Systems

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.

11.5 Control System Power Supply

Electrical power for steering gear control system is to be derived from the motor controller of the power unit it is controlling, or from the main switchboard at a point adjacent to the supply to the power unit.

11.7 Communication

A means of communication is to be provided between the navigation bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable.

11.9 Instrumentation and Alarms

The following instruments and alarms are to be provided. The audible and visual alarms are to have provisions for testing.

11.9.1 Rudder Position Indicator

The angular position of the rudder is to be indicated on the navigation bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable. The rudder angle indication is to be independent of the steering gear control system.

11.9.2 Autopilot

Where autopilot is fitted, a visual and audible alarm is to be provided on the navigation bridge to indicate its failure.

Where power unit is provided and steering is controlled from navigation bridge, the following are applicable:

11.9.3 Motor Alarm

A visual and audible alarm is to be given on the navigation bridge and the engine room control station to indicate an overload condition of the steering gear power unit motor. Where three-phase electrical power is used a visual audible alarm is to be installed which indicates failure of any one of the supply phases. The operation of these alarms is not to interrupt the circuit.

11.9.4 Motor Running Indicators

Indicators for running indication of motors are to be installed on the navigation bridge and the engine room control station.

11.9.5 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.

11.9.6 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.

In addition, hydraulic power operated steering gear is to be provided with the following:

11.9.7 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.

11.9.8 Hydraulic Lock (2006)

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, an independent steering failure alarm for follow-up control systems complying with the following requirements may be provided in lieu of a hydraulic lock alarm.

Where an independent steering failure alarm is installed for follow-up control systems, it is to comply with the following:

11.9.8(a) 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

11.9.8(b) 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.

11.9.8(c) Each steering failure alarm system is to be supplied by a circuit that:

- i) Is independent of other steering gear system and steering alarm circuits.
- ii) Is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and
- iii) Has no overcurrent protection except short circuit protection

11.9.9 Autopilot Override

11.9.9(a) Steering gear systems provided with an autopilot system are to have a device at the primary steering station to completely disconnect the autopilot control to permit change over to manual operation of the steering gear control system. A display is to be provided at the steering station to ensure that the helmsman can readily and clearly recognize which mode of steering control (autopilot or manual) is in operation.

11.9.9(b) In addition to the changeover device as in 4-3-3/11.9.9(a), for primary steering stations, where fitted with an automatic autopilot override to change over from autopilot control to manual operation, the following are to be provided.

- i) The automatic override of the autopilot is to occur when the manual helm order is 5 degrees of rudder angle or greater.
- ii) An audible and visual alarm is to be provided at the primary steering station in the event that the automatic autopilot override fails to respond when the manual helm order is 5 degrees of rudder angle or greater. The alarm is to be separate and distinct from other bridge alarms, and is to continue to sound until it is acknowledged.
- iii) An audible and visual alarm, that is immediately activated upon automatic autopilot override actuation, is to be provided at the primary steering station. The alarm is to be distinct from other bridge alarms, and is to continue to sound until it is acknowledged.

The following instrumentation and alarms are to be provided.

11.9.10 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 4-3-3/11.9.8(a), (b) and (c).

11.9.11 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 4-3-3/11.9.8(a), (b) and (c).

11.11 Operating Instructions

Appropriate operating instructions with a block diagram showing the change-over procedures for steering control systems and steering gear power units are to be permanently posted at a conspicuous location on the navigation bridge and in or near the steering gear compartment. Where system failure alarms in 4-3-3/11.9.8 are provided, appropriate instructions are to be permanently posted on the navigation bridge to shut down the failed system.

13 Electrical Power Supply

Electrical power circuits are to meet the requirements of 4-7-2/11 and 4-7-2/5.3.5.

15 Testing and Trials

15.1 Testing of Piping System

The following tests are to be performed in the presence of the Surveyor.

15.1.1 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.

15.1.2 Installation Tests

After installation in the liftboat, 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.

15.3 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 the Rules have been met. The trial is to include the operation of the following:

15.3.1 (1 July 2012)

The main steering gear, including demonstration of the performance requirements of 4-3-3/1.9 or 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 the rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition, or the rudder load and torque at the specified trial loading condition have been predicted and extrapolated to the full load condition.

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.

Trials are to be carried out with the vessel running ahead at 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 RPM.

15.3.2

The auxiliary steering gear, if required, including demonstration to the performance requirements of 4-3-3/1.11 and transfer between main and auxiliary steering gear.

15.3.3

The power units, including transfer between power units.

15.3.4

The emergency power supply required by 4-7-2/5.3.5.

15.3.5

The steering gear controls, including transfer of control, and local control.

15.3.6

The means of communications as required by 4-3-3/11.7.

15.3.7

The alarms and indicators required by 4-3-3/11.9 (test may be done at dockside).

15.3.8

The storage and recharging system contained in 4-3-3/7.9 (test may be done at dockside).

15.3.9

The isolating of one power actuating system, and checking for regaining steering capability are required by 4-3-3/7.7, if applicable (test may be done at dockside).

15.3.10

Where the steering gear is designed to avoid hydraulic locking, this feature is to be demonstrated.

CHAPTER 4 Jacking or Other Elevating Systems

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CHAPTER 4 **Jacking or Other Elevating Systems**SECTION 1 **General (2011)****1 General**

Jacking systems are used to elevate and lower the hull of liftboats in the elevated condition and to raise and lower the legs in the afloat condition.

The hull of the liftboat is maintained stationary in the elevated condition by means of a holding mechanism. The same mechanism is used to maintain the legs stationary in the afloat condition.

The jacking system and holding mechanism on liftboats are to be designed and constructed with sufficient redundancy so that upon failure of any one component, the system will prevent an uncontrolled descent of the liftboat. This is to be accomplished either by continuing to jack to a safe position or holding in place. Approved procedures are to be provided to allow emergency raising or lowering of the liftboat after failure in the case the liftboat is holding in an unsafe position.

Jacking systems are to be considered as machinery to provide the vertical movement of the legs as well as structural elements transmitting the loads between hull and legs, as applicable to the particular system design.

3 Definitions

The following definitions apply for the purpose of this Section.

3.1 Jacking System

A mechanical system used for raising the hull of a liftboat above the surface of the sea by simultaneously applying a downward force on the movable legs of the liftboat. The same system is used for lowering the hull from the elevated condition in a controlled manner and for raising and lowering the legs relative to the hull in the afloat condition. The most commonly used jacking systems are the rack and pinion type and the yoke and pin type.

3.3 Holding Mechanism

A mechanism used for maintaining the hull of a liftboat stationary in the elevated condition and/or maintaining the legs of the liftboat stationary in the afloat condition. The holding mechanism may be either the jacking system in a static position or a separate fixation system or a combination of both.

3.5 Rack and Pinion Jacking System

A jacking system using climbing pinions, most commonly driven by electric or hydraulic motors through a jacking gearbox, to engage with racks attached to the legs of the unit in order to raise or lower the hull in relation to the legs in the elevated condition or to raise or lower the legs in relation to the hull in the afloat condition.

3.7 Yoke and Pin Jacking System

A jacking system using yokes with pins, both operated by hydraulic cylinders, to engage with holes on the legs of the liftboat in order to raise or lower the hull in relation to the legs in the elevated condition or to raise or lower the legs in relation to the hull in the afloat condition.

3.9 Fixation System

A holding mechanism, independent from the jacking system, using a device attached to the hull to engage a counterpart device in the legs in order to establish a rigid connection between the hull and the legs of the liftboat.

3.11 Specified Service Temperature

Minimum atmospheric temperature identified for the liftboat in association with 1-1-4/1 of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* and documented in the liftboat's Operations Manual as per 1-1-5/1 of the Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

3.13 Jacking Unit Rated Capacity

Vertical effective force delivered to the leg by the jacking system per jacking unit when raising or lowering the hull. Effective force is inclusive of all frictional effects directly rated to the jacking unit including leg interfaces such as a rack and pinion mesh.

3.15 Lifting Capacity per Leg

Vertical force per leg by the combination of jacking units attached to the leg, including the leg guide friction effect.

5 Plans and Data to be Submitted

The following plans and data are generally to be submitted:

- A description of the jacking system, holding mechanism and associated systems
- Failure Modes and Effects Analysis (FMEA)
- Design plans showing the following arrangements and details, as applicable:
 - Jacking system, including mechanical and hydraulic components such as rack and pinion, bearings, reduction gears, brakes, hydraulic power units, hydraulic cylinders, etc.
 - Fixation system
 - Jackcase (fixed or floating frame)
 - Electric system diagrams
 - Jacking motor and brake specifications and operating characteristics
 - Electric and/or hydraulic controls
 - Monitoring and alarm systems
 - Lubrication methods
 - Heating arrangements for low temperature operation
- Material specifications
- Design calculations, including strength, fatigue, buckling, rigidity and critical speed (resonance) analyses, as applicable to the particular system
- Specified service temperature

7 Failure Modes and Effects Analysis (FMEA)

A failure modes and effects analysis (FMEA) is to be carried out on the jacking system and holding mechanism with the purpose of demonstrating that a single failure of any component will not cause an uncontrolled descent of the unit. The FMEA methodology has to ensure that any predictable failure mode relevant to the purpose of the FMEA has been considered and is to be sufficiently detailed to cover all systems associated with the jacking and holding operations. The FMEA is to be submitted for review and is to include but not be limited to the following information:

- A description of all the systems associated with the jacking and holding operations of the liftboat and a functional block diagram showing their interaction with each other. Such systems would include the jacking systems, the fixation systems, jackcase, electrical power distribution system, hydraulic power system, control systems (including programmable systems), monitoring and alarm systems, etc. and their subcomponents.
- All significant failure modes relevant to the purpose of the FMEA
- Each predictable cause associated with each failure mode
- The method of detecting that the failure has occurred
- The effect of the failure upon the rest of the system's ability to jack the liftboat
- An analysis of possible common failure mode

Where parts of the system are identified as non-redundant and where redundancy is not possible, these parts are to be further studied with consideration given to their reliability and mechanical protection. The results of this further study are to be submitted for review.

9 Material

The material specifications for the components of the jacking system, holding mechanism and associated systems, including structural load carrying components (such as rack and jackcase for rack and pinion units or jacking pins and yoke for hydraulically actuated units), torque transmitting parts (such as climbing pinion, gears, pinions, planet carriers, pins, shafts, torque supports, couplings, coupling bolts, shafts, torque flanges and brakes of rack and pinion units), fixation system components and hydraulic components (such as hydraulic cylinders and actuators), as applicable to the particular system design, will be subject to approval and are to be submitted by the designer. These specifications are to include as a minimum, chemical composition, yield strength, ultimate tensile strength, percent elongation and reduction of area, and hardness for gears and coupling teeth, and where required, impact values.

Load bearing/torque transmitting components in the direct load path are to be constructed of steel, or other acceptable ductile materials with an elongation not less than 12%. Other materials suitable for the intended purpose may be specially considered.

Note: Materials for bushing, shim plates and other components under compressive loads only need not be ductile.

Materials for the load-bearing components of the fixation system in the direct load path are to comply with 3-1-3/5.5 and 3-1-3/5.7, as applicable.

9.1 Toughness

The following toughness requirements refer to the core material after all thermal treatments.

For rack and pinion units, steel for the rack and rack attachments and the frame which attaches to the hull structure is to meet the toughness requirements for primary application (see 3-1-3/5.3.2) at the specified service temperature in accordance with 3-1-3/5.5 and 3-1-3/5.7, as applicable to the steel grade. Steel for the frame which will be used in cases of floating jacking systems is to meet the toughness criteria for secondary application (see 3-1-3/5.3.1) at the specified service temperature.

For systems actuated by hydraulic cylinders, steel for jacking pins and yoke is to meet the toughness criteria for primary application (see 3-1-3/5.3.2) at the specified service temperature in accordance with 3-1-3/5.5 and 3-1-3/5.7, as applicable to the steel grade.

Steel for torque transmitting parts for rack and pinion units is to meet the Charpy V-Notch (CVN) impact requirements specified in 4-4-1/Table 1.

Materials other than steel are to exhibit fracture toughness which is satisfactory for the intended application, as evidenced by previous satisfactory service experience or appropriate toughness tests.

TABLE 1
Charpy V-Notch (CVN) Impact Requirements for Steel Materials (2011)

Application	Charpy V-Notch (CVN) Minimum Average Values at Specified Service Temperature (SST)								
	Forgings Longitudinal CVN Test			Forgings Tangential CVN Test			Castings		
	J	kgf-m	ft-lbf	J	kgf-m	ft-lbf	J	kgf-m	ft-lbf
Climbing Pinion	27	2.8	20	20	2.0	15	20	2.0	15
Low Speed Gears and Pinions ⁽¹⁾	20	2.0	15	15	1.5	11	15	1.5	11
Other ⁽²⁾	SST of -20°C (-4°F) and above Not Required								
	SST below -20°C (-4°F) Subject to Special Consideration								

Notes:

- As defined in 4-4-1/9, mesh rate MR < 100 Teeth / Minute
- Torque transmitting/load bearing components in the load path (other than climbing pinion and low speed gears and pinions), such as high speed pinions and gears, planetary ring gears, planetary carriers, torque supports, shafts, pins, couplings and coupling bolts.

11 Strength Analysis

Strength calculations of the jacking system and holding mechanism are to be submitted in accordance with 4-4-1/5. Strength calculations are to consider at least the maximum loads of the following loading conditions, as applicable to the liftboat:

- Normal raising of hull
- Normal holding of hull
- Normal lowering of hull
- Pre-load raising
- Pre-load holding
- Pre-load lowering
- Normal raising of legs
- Normal holding of legs
- Normal lowering of legs
- Severe storm holding (elevated or afloat)

Maximum rated loads associated with severe storm conditions (elevated or afloat) and pre-load holding condition are to be considered as combined loadings, in accordance with 3-2-2/1.1.2 and 3-2-3/9.1.3. Maximum rated loads associated with the normal jacking, pre-load jacking and normal holding conditions may be considered as static loadings only, as defined in 3-2-2/1.1.1.

When establishing the loads imposed on a jacking system during lifting operations, friction losses at leg guides are to be considered, as defined in 3-2-3/9.3.

For the purpose of strength calculation of the jacking system and for designing mechanical components (including pins), the factor of safety, F.S. is to comply with 3-2-2/3.3 as applicable, except that gear reducers are to comply with a recognized standard such as American Gear Manufacturers Association (AGMA) standards. Alternative design methods for low speed gears with a mesh rate MR less than 100 teeth/minute (where MR = RPM × Number of teeth) may be specially considered, subject to the submission of adequate evidence to validate the design method, such as first principles calculations, experimental data and satisfactory operation experience for the intended application. The alternative design methods are to take into account all the various degradation factors, such as dynamic factor, non-uniform load distribution or misalignment.

When recognized standards are not applicable, structural and mechanical components may be designed according to the von Mises equivalent stress criterion. Except for components under compressive loads only, the equivalent stress is not to exceed $F_y/F.S.$ where:

$$F_y = \text{as defined in 3-2-2/3.3}$$

$$F.S. = 1.43 \quad \text{for static loading, as defined in 3-2-2/1.1.1}$$

$$= 1.11 \quad \text{for combined loading, as defined in 3-2-2/1.1.2}$$

The scantlings of the load-bearing components of the fixation system in the direct load path are to be determined on the basis of the allowable stresses specified in 3-2-2/3.

As applicable to the design, the buckling strength of structures is to be verified according to the latest version of the *ABS Guide for Buckling and Ultimate Strength Assessment for Offshore Structures*, or other recognized standard acceptable to ABS.

Fatigue damage of jacking system components due to cyclic loading is to be considered. A fatigue analysis is to be performed using an appropriate loading spectrum. The fatigue analysis is to be based on recognized fatigue assessment methodologies such as those shown in the latest editions of AGMA and ISO gear standards or the Miner's Rule for cumulative fatigue. For gears, both tooth surface contact and tooth root bending fatigue strength are to be considered. The calculated fatigue life is to be at least the design life of the liftboat, but not less than 20 years. Safety factors against maximum fatigue life in hours or cycles are to be as follows:

1. Tooth root bending: $F.S. = 1.5$ for cumulative fatigue due to all lifting and lowering operations and all other applicable cyclic loads
2. Tooth surface contact: $F.S. = 1.0$ for cumulative fatigue due to all lifting and lowering operations and all other applicable cyclic loads

In the calculation of the tooth surface contact fatigue, the magnitude/effect of non-uniform face load distribution is to be considered. Inspectable low speed, through hardened pinions and gears may not need to comply with the above safety factor for tooth surface contact fatigue, subject to past satisfactory experience with material and design for this purpose.

Jacking system design may be accepted based on full life-cycle fatigue load test results in lieu of theoretical fatigue calculations. Acceptability of test results is to be governed by the type and the extent of the testing. When testing for fatigue, the jacking system or parts are to be subject to all the applicable maximum cyclic loading conditions and each applicable load level is to be multiplied with relevant safety factors. The safety factors applied in case of full life-cycle fatigue load test will be specially considered.

Note: Full-life cycle fatigue load test does not exclude the required mandatory prototype test.

Where applicable, critical speed (resonance) analysis of rotating components is to be submitted to demonstrate that there are no harmful vibrations at operating speeds. Test results in lieu of theoretical analysis may be considered.

For rack and pinion systems, the alignment between the rack and pinion is to be maintained within specified limits throughout the life of the liftboat. Documentation in this regard is to be submitted to ABS.

13 Mechanical Components

In addition to the strength requirements for mechanical components in accordance with 4-4-1/11, the following requirements are to be complied with:

13.1 Bearings

Bearings are to be designed for the operational static and dynamic loads in accordance with applicable recognized standards such as the latest editions of ISO 76 and ISO 281. Design calculations are to be submitted for bearings not covered by recognized standards. Adequate bearing lubrication is to be provided. Manufacturer's documentation is to be submitted to confirm the suitability of the bearings for operation at the design temperature of the unit.

13.3 Brakes

Brakes are to be designed to engage automatically in the event of failure of power supply to the motor (fail-safe type). The brake holding capacity is to be at least equal to 120% of the maximum required brake torque associated with the maximum rated load applied to the climbing pinion from all loading conditions specified in 4-4-1/11.

13.5 Flexible Shock Pads

Jackcase shock pads are to be designed for the maximum severe storm loads and suitable for operation at the design temperature of the unit. Shock pads are to be suitably protected against adverse effects of the marine and working environment which may lead to degradation. Manufacturer's technical specification or similar documentation is to be submitted to verify the suitability of the shock pads for the intended service.

15 Electrical Power System

Jacking gear motor installations are to be in accordance with Part 4, Chapter 7 except group motor installations will be permitted as follows:

- On each leg, two or more motors of any horsepower may be connected to a single branch circuit.
- The branch circuit is to be provided with short circuit protection set at not greater than ten times the sum of the full load currents of the motors.
- A visual and audible alarm is to be given at the Jacking Control Station to indicate overload condition in any of the jacking motors, (see 4-4-1/19).

17 Hydraulic System

The hydraulic system for jacking units and holding mechanisms is to be in accordance with 4-5-6/1. Design of hydraulic cylinders and actuators, including materials, is to be in accordance with 4-5-6/3. Hydraulic cylinders are to be considered both as pressure containing and load bearing units.

Sufficient redundancy of the hydraulic power unit or units servicing the jacking systems is to be provided to maintain continuous jacking operation in the event of a single failure in the hydraulic power system.

19 Control, Monitoring and Alarm System

Operation of the jacking system and holding mechanism is to be possible from a central jacking control station, except that the operation of a fixation system is to be from a local control station in visual proximity to the system at each leg chord. The central jacking control station is to be provided with the following alarms and indications, as applicable to the particular system design:

- i) Audible and visual alarms for:
 - Motor overload or over temperature for each motor
 - Unit out-of-level (elevated condition)
 - Significant differences in the currents or torque in the motors on one rack
 - Rack phase differential, where applicable to the design
- ii) Indication of:
 - Availability of power
 - Current or torque in each motor (during raising and lowering operations)
 - Brake release status
 - Hydraulic pressure
 - Air pressure

- Pin position
- Position of yoke
- Inclination of the unit, in two horizontal, perpendicular axes (elevated condition)

Upon failure of the jacking system controls in the central control station, emergency controls to operate the jacking system are to be available.

An emergency stop is to be provided at each jack house. Emergency stop circuits are to be independent from the jacking control circuits. A communication system as defined in 4-7-2/15.5.3 is to be provided.

21 Inspection and Material Testing

All jacking systems, holding mechanisms and associated systems are to be constructed and installed to the satisfaction of the Surveyor in accordance with approved plans.

Welded construction is to be in compliance with the applicable requirements of Section 3-2-15 of this Guide and Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*. Material tests for the components of the jacking systems, holding mechanisms and associated systems are to be carried out in accordance with 4-4-1/9 and Chapters 1 to 3 of the above referenced *Part 2*.

Gears of the climbing pinion gear train are to be examined at the plant of the manufacturer by an approved crack detection procedure and such an examination is to be witnessed by the Surveyor. Acceptance of components manufactured at a plant which is under an ABS-approved quality assurance program will be subject to special consideration.

Where it is intended to surface harden climbing pinion teeth, full details of the proposed procedure and specification are to be submitted for approval. The manufacturer/heat treater will be required to demonstrate by test that the proposed procedure gives a uniform surface layer of the required hardness and depth and that it does not impair the soundness and properties of the steel. Test specimens are to be representative of the climbing pinion and in accordance with Chapter 3 of the above referenced *Part 2*. Representative specimens are to be of the same material grade, from the same heat and heat treatment batch, and are to be of sufficient size and mass to represent the heat transfer experienced in the pinion itself during the complete heat treatment cycle.

23 Low Temperature Operation

Jacking systems, holding mechanisms and associated systems intended for operation at a specified service temperature below -20°C (-4°F) will be subject to special consideration.

25 Jacking Systems of Novel Design

Jacking systems other than rack and pinion type or yoke and pin type will be subject to special consideration. Compliance with Section 4-4-1 is required, as applicable. The suitability of the novel features will be considered on the basis of first principles, applicable recognized standards and experimental test results, depending on the particular characteristics of the jacking system and type of unit.

27 Prototype Test

A prototype test is to be performed on one unit of a newly designed rack and pinion system as part of the design approval procedure.

The prototype test procedure is to be submitted for review and as a minimum is to include the following.

27.1

Prior to the test, all pinions and gears of the climbing pinion gear train are to be examined using an approved crack detection procedure. (ABS material certificates as per 4-4-1/9 are to be provided for the prototype unit).

27.3

The prototype test is to be carried out at 150% of the maximum normal holding capacity rating or 10% above maximum storm holding load of the jacking unit, whichever is higher. As a minimum the test is to be carried out for one complete revolution of the climbing pinion.

27.5

Subsequent to the test, the unit is to be disassembled and examined. All pinions and gears of the climbing pinion gear train are to be examined using an approved crack detection procedure. The above testing and examination are to be carried out in the presence of and to the satisfaction of the Surveyor.

29 Initial Jacking Test

The test should include a trial jacking of the completed hull up to limit of designed travel and then down again, to prove alignment of leg racks, pinions and guides, effectiveness of lock or brake arrangements, and proper function of jacking system together with electrical safety system monitoring indicators.

CHAPTER 5 Pumps and Piping Systems

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CHAPTER 5 Pumps and Piping Systems

SECTION 1 General

1 Construction and Installation

1.1 General Requirements

All liftboats 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 which are applicable to all oceangoing liftboats but which may be modified for liftboats classed for limited service.

1.3 Piping Groups

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:

<i>Service</i>	<i>Pressure bar (kgf/cm², psi)</i>	<i>Temperature °C (°F)</i>
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 piping and open-ended lines such as drains, overflows, engine exhausts and vents.

3 Plans and Data to Be Submitted

3.1 Plans

Before proceeding with the work, plans in accordance with 4-1-1/7 are to be submitted, showing clearly the diagrammatic details or arrangement of the equipment.

3.3 All Piping Systems

The plans are to consist of a diagrammatic drawing of each system accompanied by lists of material giving size, wall thickness, maximum working pressure and material of all pipes and the type, size, pressure rating and material of valves and fittings.

3.5 Booklet of Standard Details

A booklet of standard piping practices and details including such items as bulkhead, deck and shell penetrations, welding details including dimensions, pipe joining details, etc. is to be submitted. Pipe welding details are to comply with Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

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 this Section. The material is to be made in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*, except that tests of material for valves, fittings, fluid power cylinders, and Group II piping need not be witnessed by the Surveyor. Where electric resistance welding is used, the requirements of Chapter 4 of the above *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 Surveyor.

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 Definitions

7.1 Piping/Piping Systems

The terms *piping* and *piping systems* include the pipe, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria. For example, if the basic material needs a fire protective coating to comply with the fire endurance requirements, then the piping should be manufactured and tested with both the basic material and coating attached and details are to be submitted to ABS for approval.

7.3 Joints

The term *joint* refers to the method of connecting pipes by adhesive bonding, brazing, welding, bolted flanging, threading, etc.

7.5 Fittings

The term *fittings* refers to bends, elbows, fabricated branch pieces, etc.

7.7 Positive Closing Valves

Positive closing valves are valves that are capable of maintaining a set position under all operating conditions.

7.9 Recognized Standard of Construction

Recognized standards of construction are published construction standards from organizations, such as but not limited to the American Society of Mechanical Engineers (ASME), American Society of Testing and Materials (ASTM), Department of Transportation (DOT), Japanese Industrial Standard (JIS), German Design Standard (DIN), British Standard Code of Practice (BSI), which are recognized by ABS as being acceptable standards for a specific purpose or service. Each standard is to be used independently and in a consistent manner.

7.11 Standard or Extra-Heavy Pipe

Pipe thickness 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.

9 General Installation Details

9.1 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 protected.

9.3 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.

9.5 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. Alignment is to be within tolerances specified by the expansion joint manufacturer.
- *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.

9.7 Molded Expansion Joints (2004)

Molded expansion joints may be Type Approved; see 1-1-A2/1 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

9.7.1 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.

9.7.2 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:

9.7.2(a) Expansion joint ratings for temperature, pressure, movements and selection of materials are to be suitable for the intended service.

9.7.2(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 joints. Results of the burst test are to be submitted.

9.7.2(c) The expansion joints are to pass the fire resistant test specified in 4-5-1/9.7.3, below.

9.7.2(d) The expansion joints are to be permanently marked with the manufacturer's name and the month and year of manufacture.

9.7.3 Fire Resistant Test

In order for a molded expansion joint of composite construction utilizing metallic material, as referenced in 4-5-1/9.7.2, 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/cm², 72.5 lb/in²), and with a subsequent pressure test to twice the design pressure.

9.9 Bulkhead, Deck or Tank Top Penetrations (2013)

9.9.1 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.

9.9.2 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.

9.10 Damage Stability Consideration (2012)

Piping serving tanks and dry spaces, where installed within zones of assumed damage under damage stability conditions, is also to be considered damaged. Damage to such piping is not to lead to progressive flooding of spaces not assumed damaged. If it is not practicable to route piping outside the zone of assumed damage, then means are to be provided to prevent progressive flooding. Such means, for example, may be the provision of a remotely operated valve in the affected piping. Alternatively, intact spaces that can be so flooded are to be assumed flooded in the damage stability conditions.

In addition, where open ended piping systems are located below the bulkhead deck and penetrate watertight subdivision bulkheads, means operable from above the bulkhead deck are to be provided to prevent progressive flooding through those piping systems which remain intact following damage to the liftboat.

9.11 Collision-Bulkhead Penetrations (2014)

- i) Except as provided in 4-5-1/9.11ii), the collision bulkhead may be pierced below the bulkhead deck by not more than one pipe for dealing with fluid in the forepeak tank, provided that the pipe is fitted with a screwdown or butterfly valve capable of being operated from above the bulkhead deck; and the valve chest being secured to the collision bulkhead inside the forepeak.
- ii) 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 4-5-1/9.11.i), 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 craft is maintained.
- iii) The valve in 4-5-1/9.11.i) may be fitted of on the after side of the collision bulkhead provided that the valve is readily accessible under all service conditions and the space in which they are located is not a cargo space. Local operation of the valve is acceptable.
- iv) Cast iron is not to be used for these valves. 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.).
- v) Tanks forward of the collision bulkhead are not to be arranged for the carriage of oil or other liquid substances that are flammable.

9.13 Sluice Valves and Cocks

No valve or cock for sluicing purposes is to be fitted on a collision bulkhead. Sluice valves or cocks may be fitted only on other watertight bulkheads, when they are at all times accessible for examination. The control rods are to be operable from the bulkhead deck and are to be provided with an indicator to show whether the valve or cock is open or closed. The control rods are also to be properly protected from injury and their weight is not to be supported by the valve or cock.

9.15 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, and 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.

9.15.1 Exceptions

In pumping systems such as oil piping and fire main, where ordinarily relief valves are 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.

9.17 Instruments

9.17.1 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.

9.17.2 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.

9.17.3 Tanks (2006)

Pressure, temperature and level sensing devices installed on tanks at locations where they are subjected to a static head of liquid are to be fitted with valves or arranged such that they may be removed without emptying the tank.

9.19 Flexible Hoses (2006)

9.19.1 Definition

A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation.

9.19.2 Scope

The requirements 4-5-1/9.19 apply to flexible hoses of metallic or non-metallic material intended for a permanent connection between a fixed piping system and items of machinery. The requirements may also be applied to temporary connected flexible hoses or hoses of portable equipment.

Flexible hose assemblies as defined in 4-5-1/9.19.1 are acceptable for use in oil fuel, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems. The flexible hoses are acceptable for steam systems with pressure below 7 bar (7.1 kgf/cm², 101.5 psi) and temperature below 150°C (302°F), where they comply with 4-5-1/9.19.

Flexible hoses are not acceptable in high pressure fuel oil injection systems.

These requirements for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire extinguishing systems.

9.19.3 Design and Construction

9.19.3(a) Hose material. Flexible hoses are to be designed and constructed in accordance with recognized National or International standards acceptable to ABS. Flexible hoses constructed of rubber or plastics materials and intended for use in bilge, ballast, compressed air, oil fuel, lubricating, hydraulic and thermal oil systems are to incorporate a single or double closely woven integral wire braid or other suitable material reinforcement. Where rubber or plastics materials hoses are to be used in oil supply lines to burners, the hoses are to have external wire braid protection in addition to the integral reinforcement. Flexible hoses for use in steam systems are to be of metallic construction.

9.19.3(b) Hose end fittings. Flexible hoses are to be complete with approved end fittings in accordance with manufacturer's specification. Flanged end connections are to comply with 4-5-2/17 and threaded end connections with 4-5-2/13.1, as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

The use of hose clamps and similar types of end attachments is not acceptable for flexible hoses in piping systems for steam, flammable media, starting air or for sea water, where failure may result in flooding*. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 5 bar (5.1 kgf/cm², 72.5 psi) and provided there are double clamps at each end connection. The hose clamps are to be at least 12 mm (0.5 in.) wide and are not to be dependent upon spring tension to remain fastened.

* *Note:* For sea water systems, where flooding can be prevented by the installation of a readily accessible shutoff valve immediately upstream of the hose, double clamps at each end connection may be accepted.

9.19.3(c) Fire resistance. Flexible hose assemblies constructed of non-metallic materials intended for installation in piping systems for flammable media and sea water systems where failure may result in flooding are to be of a fire-resistant type**. Fire resistance is to be demonstrated by testing to ISO 15540 and ISO 15541.

** *Note:* The installation of a shutoff valve immediately upstream of a sea water hose does not satisfy the requirement for fire resistant type hose.

9.19.3(d) Hose application. Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions and other relevant requirements of this Section.

Flexible hose assemblies intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service, are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required by 4-5-1/9.19.5 are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

9.19.4 Installation

In general, flexible hoses are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery, equipment or systems.

Flexible hose assemblies are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

The number of flexible hoses, in piping systems is to be kept to minimum and is to be limited for the purpose stated in 4-5-1/9.19.2.

Where flexible hoses are intended to be used in piping systems conveying flammable fluids that are in close proximity of heated surfaces the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other similar protection.

Flexible hoses are to be installed in clearly visible and readily accessible locations.

The installation of flexible hose assemblies is to be in accordance with the manufacturer's instructions and use limitations with particular attention to the following:

- Orientation
- End connection support (where necessary)
- Avoidance of hose contact that could cause rubbing and abrasion
- Minimum bend radii

9.19.5 Tests

9.19.5(a) Test procedures. Acceptance of flexible hose assemblies is subject to satisfactory prototype testing. Prototype test programs for flexible hose assemblies are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

The tests are, as applicable, to be carried out on different nominal diameters of hose type complete with end fittings for pressure, burst, impulse resistance and fire resistance in accordance with the requirements of the relevant standard. The following standards are to be used as applicable.

- ISO 6802 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test without flexing.
- ISO 6803 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test with flexing.
- ISO 15540 – Ships and marine technology – Fire resistance of hose assemblies – Test methods.
- ISO 15541 – Ships and marine technology – Fire resistance of hose assemblies – Requirements for test bench.
- ISO 10380 – Pipework – Corrugated metal hoses and hose assemblies.

Other standards may be accepted where agreed.

9.19.5(b) Burst test. All flexible hose assemblies are to be satisfactorily prototype burst tested to an international standard to demonstrate they are able to withstand a pressure not less than four (4) times its design pressure without indication of failure or leakage.

Note: The international standards (e.g., EN or SAE) for burst testing of non-metallic hoses, require the pressure to be increased until burst without any holding period at $4 \times \text{MWP}$.

9.19.6 Marking

Flexible hoses are to be permanently marked by the manufacturer with the following details:

- Hose manufacturer's name or trademark
- Date of manufacture (month/year)
- Designation type reference
- Nominal diameter
- Pressure rating
- Temperature rating

Where a flexible hose assembly is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

9.21 Leakage Containment

For areas where leakage may be expected such as oil burners, purifiers, oil drains, valves under day tanks, etc., means of containing the leakage are to be provided. Where drain pipes are fitted for collected leakages, they are to be led to a suitable oil drain tank not forming part of an overflow system.

PART

4

CHAPTER 5 Pumps and Piping Systems

SECTION 2 Pumps, Pipes, Valves and Fittings

1 Pumps

1.1 General

For self-propelled liftboats 500 gross tons and above, the following pumps are to meet the test requirements of 4-5-2/1.3 and 4-5-2/1.5:

- Fire pump
- Bilge pump
- Ballast pump
- Hydraulic pumps for steering gears, anchor windlasses, and variable pitch propellers

The tests are to be carried out at the manufacturer's plant in the presence of the Surveyor. The capacity test will not be required nor will the hydrostatic test need to be witnessed by the Surveyor for individual pumps assembled on a production line basis, provided the Surveyor is satisfied from periodic inspections and the manufacturer's quality assurance procedures that the pump capacities are acceptable and that hydrostatic testing is being performed. See 4-1-1/3. For pumps associated with reciprocating internal combustion engines and reduction gears, see 4-2-1/19.

1.3 Hydrostatic Test

All pumps are to be hydrostatically tested to $1.5P$, but not less than 3.9 bar (4 kgf/cm², 57 psi), where P is the maximum working pressure of the part concerned. When the suction and discharge sides of the pump are tested independently, the pump suction is to be tested to 1.5 times P_s , but not less than 3.9 bar (4 kgf/cm², 57 psi), where P_s is the maximum pressure available from the system at the suction inlet. For steering gear pumps, also see 4-3-3/15.1.

1.5 Capacity Test

Pump capacities are to be checked with the pump operating at design conditions (rated speed and pressure head). For centrifugal pumps, the pump characteristic (head capacity) design curve is to be verified to the satisfaction of the Surveyor.

1.7 Relief Valve Capacity Test (2005)

For positive displacement pumps with an integrated relief valve, the valve's setting and full flow capacity corresponding to the pump maximum rating is to be verified. The operational test for relief valve capacity may be waived if previous satisfactory tests have been carried out on similar pumps.

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.

Small bore pipes and tubes of less than 15 mm outside diameter may be exempted from the required hydrostatic tests.

3.3 Fuel Oil Service System

Pressure lines are to be tested before installation to 1.5 times the design pressure of the system, but not less than 3.4 bar (3.5 kgf/cm², 50 psi).

3.5 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/cm², 50 psi).

3.7 Starting Air Piping

Piping in starting-air systems is to be tested, preferably before installation, to 1.5 times the design pressure of the system.

3.9 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 4-3-3/15 and for controllable pitch propeller system piping tests see 4-3-2/15.1.3.

3.11 All Piping

After installation all piping is to be tested under working conditions.

Where it is not possible to carry out the required hydrostatic tests for all segments of pipes and integral fittings before installation, the remaining segments, including the closing seams, may be so tested after installation. Or, where it is intended to carry out all the required hydrostatic tests after installation, such tests may be conducted in conjunction with those required by this Paragraph. In both these respects, testing procedures are to be submitted to the Surveyor for acceptance.

3.13 Hydrostatic Tests of Shell Valves

All valves intended for installation on the side shell at or below the load waterline, including those at the sea chests, are to be hydrostatically tested before installation and in the presence of the Surveyor to a pressure of at least 5 bar (5.1 kgf/cm², 72.5 psi).

3.15 Pneumatic Tests in Lieu of Hydrostatic Tests (1 July 2012)

In general, a pneumatic test in lieu of a hydrostatic test is not permitted. Where it is impracticable to carry out the required hydrostatic test, a pneumatic test may be considered. In such cases, the procedure for carrying out the pneumatic test, having regard to safety of personnel, is to be submitted to the applicable ABS Divisional Assistant Chief Surveyor's Office for special consideration.

5 Metallic Pipes

5.1 Test and Inspection 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. See 4-5-6/1.5 for pipe used in hydraulic systems.

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 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) and within the limitations specified in the material specification.

5.7 Brass Pipe

Seamless-drawn brass pipe, unless otherwise prohibited, may be used where the temperature does not exceed 208°C (406°F).

5.8 Other Materials (2014)

Piping containing flammable fluids is to be constructed of steel or other materials approved by ABS. Other equivalent material with a melting point above 930°C (1706°F) and with an elongation above 12% may be accepted. Aluminum and aluminum alloys which are characterized by low melting points, below 930°C (1706°F), are considered heat sensitive materials and are not to be used to convey flammable fluids, except for such piping as arranged inside cargo tanks or heat exchangers or as otherwise permitted for engine attached filters, see 4-2-1/7.7 of the *Steel Vessel Rules*.

5.9 Design

5.9.1 Maximum Allowable Working Pressure and Minimum Thickness

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:

$$W = \frac{KS(t - c)}{D - M(t - c)} \quad t = \frac{WD}{KS + MW} + C$$

where

- W = maximum allowable working pressure, in bar, kgf/cm² (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/mm² (kgf/mm², psi) from 4-5-2/Table 1. See Note 2.
- M = factor from 4-5-2/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.) and smaller
 - = depth of thread h for all threaded pipe over 17 mm O.D. (3/8 in.). 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/cm², 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/cm², 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.

5.9.2 Pipe Bending (2005)

Pipe bending is to be in accordance with 2-3-12/25 of the *ABS Rules for Materials and Welding (Part 2)*. Alternatively, bending in accordance with a recognized standard (e.g. ASME B31.1 – Section 129.1 and 129.3) or other approved specification to a radius that will result in a surface free of cracks and substantially free of buckles may be acceptable.

5.11 Working Pressure and Thickness – Alternative Consideration

Consideration will be given to the maximum allowable working pressure and the minimum thickness of piping determined from criteria of applicable recognized standards.

TABLE 1
Allowable Stress Values S for Steel Piping N/mm^2 (kgf/mm², psi)

Part 2, Chapter 3 Par. & Grade Nominal Composition	Tensile Strength	Service Temperature—Degrees C (F)			
		–29°C (–20°F) to 334°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 Elec. res. Carbon Steel	310 (31.5, 45000)	46.9 (4.78, 6800)	46.6 (4.75, 6500)		
2-3-12/5-2 Elec. res. Carbon Steel	330 (33.7, 48000)	70.3 (7.17, 10200)	68.3 (6.96, 9900)	62.8 (6.40, 9100)	53.1 (5.41, 7700)
Seamless Carbon Steel	330 (33.7, 48000)	82.8 (8.44, 12000)	80.6 (8.22, 11700)	73.7 (7.52, 10700)	62.1 (6.33, 9000)
2-3-12/5-3 Elec. res. Carbon Steel	415 (42, 60000)	88.3 (9.0, 12800)	84.1 (8.58, 12200)	75.8 (7.73, 11000)	63.4 (6.47, 9200)
Seamless Carbon Steel	415 (42, 60000)	103.5 (10.55, 15000)	99.2 (10.12, 14400)	89.6 (9.14, 13000)	74.4 (7.59, 10800)
2-3-12/5-4 Carbon Steel	330 (33.7, 48000)	82.8 (8.44, 12000)	80.7 (8.23, 11700)	73.7 (7.52, 10700)	62.1 (6.33, 9000)
2-3-12/5-5 Carbon Steel	415 (42, 60000)	103.5 (10.55, 15000)	99.2 (10.12, 14400)	89.6 (9.14, 13000)	74.4 (7.59, 10800)

Notes:

- 1 Intermediate values of S may be determined by interpolation.
- 2 For grades of piping other than those given in 4-5-2/Table 1, S values are not to exceed those permitted by ASTM B31.1 Code for Pressure Piping. See 4-5-2/5.11.
- 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

7.1 General

Pipes and piping components made of thermoplastic or thermosetting plastic materials, with or without reinforcement, may be used in piping systems referred to in 4-5-2/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).

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.

TABLE 2
Fire Endurance Requirements Matrix for Plastic Pipes

PIPING SYSTEMS		LOCATION										
		A	B	C	D	E	F	G	H	I	J	K
FLAMMABLE LIQUIDS (flash point > 60°C (140°F))												
11	Fuel oil	X	X	L1	X	X	NA ⁽²⁾	0	0	0	L1	L1
12	Lubricating oil	X	X	L1	X	X	NA	NA	NA	0	L1	L1
13	Hydraulic oil	X	X	L1	X	X	0	0	0	0	L1	L1
SEA WATER (See Note 1)												
14	Bilge main and branches	L1 ⁽⁵⁾	L1 ⁽⁵⁾	L1	X	X	NA	0	0	0	NA	L1
15	Fire main and water spray	L1	L1	L1	X	NA	NA	NA	0	0	X	L1
16	Foam system	L1	L1	L1	NA	NA	NA	NA	NA	0	L1	L1
17	Sprinkler system	L1	L1	L3	X	NA	NA	NA	0	0	L3	L3
18	Ballast	L3	L3	L3	L3	X	0	0	0	0	L2	L2
19	Cooling water, essential services	L3	L3	NA	NA	NA	NA	NA	0	0	NA	L2
10	Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
FRESH WATER												
11	Cooling water, essential services	L3	L3	NA	NA	NA	NA	0	0	0	L3	L3
12	Condensate return	L3	L3	L3	0	0	NA	NA	NA	0	0	0
13	Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
SANITARY/DRAINS/SCUPPERS												
14	Deck drains (internal)	L1 ⁽³⁾	L1 ⁽³⁾	NA	L1 ⁽³⁾	0	NA	0	0	0	0	0
15	Sanitary drains (internal)	0	0	NA	0	0	NA	0	0	0	0	0
16	Scuppers and discharges (overboard)	0 ^(1,6)	0 ^(1,6)	0 ^(1,6)	0 ^(1,6)	0 ^(1,6)	0	0	0	0	0 ^(1,6)	0
VENTS/SOUNDING												
17	Water tanks/dry spaces	0	0	0	0	0	0	0	0	0	0	0
18	Oil tanks (flashpoint 60°C (140°F))	X	X	X	X	X	X ⁽²⁾	0	0	0	X	X
MISCELLANEOUS												
19	Control air	L1 ⁽⁴⁾	L1 ⁽⁴⁾	L1 ⁽⁴⁾	L1 ⁽⁴⁾	L1 ⁽⁴⁾	NA	0	0	0	L1 ⁽⁴⁾	L1 ⁽⁴⁾
20	Service air (non-essential)	0	0	0	0	0	NA	0	0	0	0	0
21	Brine	0	0	NA	0	0	NA	NA	NA	0	0	0

Locations

A Category A machinery spaces
B Other machinery spaces
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 4-5-2/7.13
L2 Fire endurance test in dry conditions, 30 minutes, in accordance with 4-5-2/7.13
L3 Fire endurance test in wet conditions, 30 minutes, in accordance with 4-5-2/7.15
0 No fire endurance test required
NA Not applicable
X Metallic materials having a melting point greater than 925°C (1700°F)

Notes:

- Where non-metallic piping is used, remotely controlled valves are to be provided at the ship's side. These valves are to be controlled from outside the space.
- When cargo tanks contain flammable liquids with a flash point greater than 60°C (140°F), "0" may replace "NA" or "X".
- For drains serving only the space concerned, "0" may replace "L1".
- When controlling functions are not required by statutory requirements, "0" may replace "L1".
- Scuppers serving open decks in positions 1 and 2, as defined in Regulation 13 of the International Convention on Load Lines, 1966, are to be "X" throughout unless fitted at the upper end with the means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.
- For essential services, such as fuel oil tank heating and ship's whistle, "X" is to replace "0".

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:

$$P_{int} = \frac{P_{sth}}{4}$$

$$P_{int} = \frac{P_{lth}}{2.5}$$

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/cm², 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/cm², 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 4-5-2/7.5.1, 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 the 2.5 times the design pressure for at least one hour.

7.5.6 Fire Endurance

4-5-2/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 liftboat 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 4-5-2/7.13 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).
- ii) *Level 2* intends to ensure the availability of systems essential to the safe operation of the ship, 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 4-5-2/7.13 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).
- 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 4-5-2/7.15 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 4-5-2/7.7.7 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

7.5.7(a) Plastic Pipes. 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 4-5-2/7.17, 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) 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.

7.5.7(b) *Multi-core Metallic Tubes Sheathed by Plastic Materials (2005)*. The multi-core tubes in “bundles” made of stainless steel or copper tubes covered by an outer sheath of plastic material are to comply with the flammability test criteria of IEC 60332, Part 3, Category A/F or A/F/R. Alternatively, the tube bundles complying with at least the flammability test criteria of IEC 60332, Part 1 or a test procedure equivalent thereto are acceptable provided they are installed in compliance with approved fire stop arrangements.

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 1×10^5 Ohm/m (3×10^4 Ohm/ft). See also 4-5-2/7.7.4.

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) Selection and spacing of pipe supports in shipboard systems is 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, 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 liftboat’s structure, having due regard to the difference in the coefficients of thermal expansion and deformations of the liftboat’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 4-5-2/7.11.

7.7.4 Electrical Conductivity

Where electrically conductive pipe is required by 4-5-2/7.5.8, 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 megohm. The resistance is to be checked in the presence of the Surveyor.

7.7.4(b) Pipes and fittings with conductive layers are to be protected against a possibility of spark damage caused by a different conductivity of the conductive layers.

7.7.4(c) 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 liftboat, 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 4-5-2/19.

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 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 4-5-2/7.5.6, after performing hydrostatic pressure tests of the piping system (see 4-5-2/7.19). 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-A2/5.3 and 1-1-A2/5.5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (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 4-5-2/7.5.1 through 4-5-2/7.5.8 and 4-5-2/7.19, as applicable.

Where the manufacturer does not have a certified quality system in accordance with 1-1-A2/5.3 and 1-1-A2/5.5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* or ISO 9001 (or equivalent), the tests in with 4-5-2/7.5.1 through 4-5-2/7.5.8 and 4-5-2/7.19, as applicable, will be required using samples from each batch of pipes being supplied for use aboard the liftboat 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 4-5-2/7.5.1. 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-A2/5.3 and 1-1-A2/5.5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (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 Section 4-5-2.

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 longitudinal and circumferential direction.

7.11.2(b) Selection of the pipes used for 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 $\pm 15\%$ 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 $\pm 10\%$ 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 $\pm 5\%$ 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 $\pm 100^\circ\text{C}$ ($\pm 180^\circ\text{F}$).

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 $20 \pm 5^\circ\text{C}$ ($68 \pm 9^\circ\text{F}$). 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/cm², 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) 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 4-5-2/7.5.1 and 4-5-2/7.5.2. The pressure is to be held for a minimum of 15 minutes without leakage. 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 5 burners as shown in 4-5-2/Figure 1. A constant heat flux averaging 113.6 kW/m^2 ($36,000 \text{ BTU/hr-ft}^2$) $\pm 10\%$ is to be maintained $12.5 \pm 1 \text{ cm}$ ($5 \pm 0.4 \text{ in.}$) 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 $\pm 3\%$ 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 ($36,000 \text{ BTU/hr-ft}^2$) $\pm 10\%$ is still to be maintained at the $12.5 \pm 1 \text{ cm}$ ($5 \pm 0.4 \text{ in.}$) 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 4-5-2/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 $12.5 \pm 1 \text{ cm}$ ($5 \pm 0.4 \text{ in.}$) during the test. The free length of the pipe between its supports is to be $0.8 \pm 0.05 \text{ m}$ ($31.5 \pm 2 \text{ in.}$). See 4-5-2/Figure 2.

FIGURE 1
Fire Endurance Test Burner Assembly

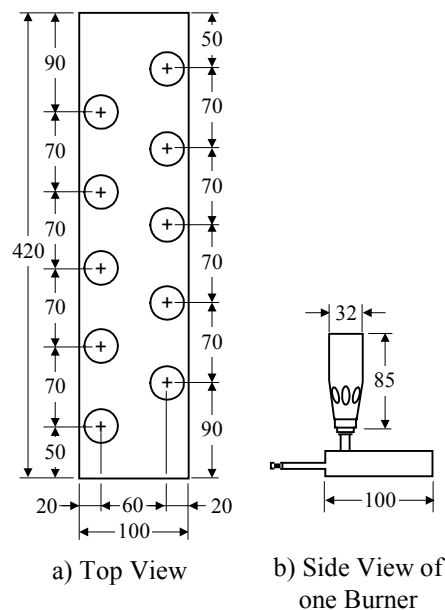
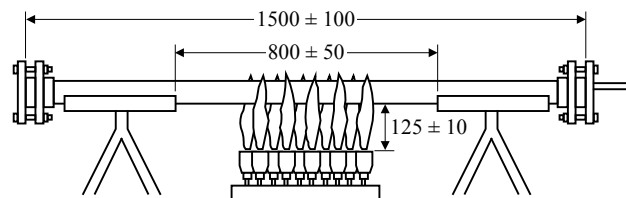


FIGURE 2
Fire Endurance Test Stand With Mounted Sample



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 $20 \pm 5^\circ\text{C}$ ($68 \pm 9^\circ\text{F}$). 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 4-5-2/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/cm², 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 4-5-2/7.5.1 and 4-5-2/7.5.2. The pressure is to be held for a minimum of 15 minutes without significant leakage [i.e., not exceeding 0.2 l/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 Section 4-5-2, is requested. These tests are to be in compliance with the requirements of relevant standards as per 4-5-2/Table 3 and 4-5-2/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 3
Standards for Plastic Pipes – Typical Requirements for All Systems (2007)

	<i>Test</i>	<i>Typical Standard</i>	<i>Notes</i>
1	Internal pressure ⁽¹⁾	4-5-2/7.5.1 ASTM D 1599 ASTM D 2992 ISO 15493 or equivalent	Top, Middle, Bottom (of each pressure range) Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections.
2	External pressure ⁽¹⁾	4-5-2/7.5.2 ISO 15493 or equivalent	As above, for straight pipes only.
3	Axial strength ⁽¹⁾	4-5-2/7.5.3	As above.
4	Load deformation	ASTM D 2412 or equivalent	Top, Middle, Bottom (of each pressure range)
5	Temperature limitations ⁽¹⁾	4-5-2/7.5.4 ISO 75 Method A GRP piping system: HDT test on each type of resin acc. to ISO 75 method A. Thermoplastic piping systems: ISO 75 Method AISO 306 Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST) VICAT test according to ISO 2507 Polyesters with an HDT below 80°C should not be used.	Each type of resin
6	Impact resistance ⁽¹⁾	4-5-2/7.5.5 ISO 9854: 1994, ISO 9653: 1991 ISO 15493 ASTM D 2444, or equivalent	Representative sample of each type of construction
7	Ageing	Manufacturer's standard 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 Manufacturer's standard	

Notes:

- 1 Where the manufacturer does not have a certified quality system, test to be witnessed by the Surveyor. See 4-5-2/7.9.
- 2 If applicable.

TABLE 4
Standards for Plastic Pipes – Additional Requirements Depending on Service and/or Location of Piping (2007)

	<i>Test</i>	<i>Typical Standard</i>	<i>Notes</i>
1	Fire endurance ^(1,2)	4-5-2/7.5.6	Representative samples of each type of construction and type of pipe connection.
2	Flame spread ^(1,2)	4-5-2/7.5.7	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)	4-5-2/7.5.8 ASTM F1173-95 or ASTM 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 4-5-2/7.9.
- 2 If applicable.

Note: Test items 1, 2 and 5 in 4-5-2/Table 4 are optional. However, if not carried out, the range of approved applications for the pipes will be limited accordingly (see 4-5-2/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. Consideration is to be given to the possibility of graphite formation in the following steels: Carbon steel above 425°C (800°F); carbon-molybdenum steel above 468°C (875°F); chrome-molybdenum steel (with chromium under 0.60%) above 524°C (975°F).

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 in locations for which it is specifically prohibited elsewhere in the Rules.

9.7 Ductile (Nodular) Iron

Nodular-iron applications for valves will be specially considered when the material has an elongation of not less than 12% in 50 mm (2 in.) and where the temperature does not exceed 343°C (650°F). See Section 2-3-5 of the *ABS Rules for Materials and Welding (Part 2)*.

9.9 Brass and Bronze

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/cm², 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

Rigid plastic compounds for valves and fittings in plastic piping systems will be considered for Group II piping systems. The design pressure and temperature together with the physical characteristics of the material verifying compliance with the requirements of 4-5-2/7 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 4-5-2/11.5.

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 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/cm²) 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/cm²) 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 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 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/cm², 50 psi). Valves used in open systems, such as vent and drain lines, (for example, level gauge and drain cocks) may be designed for a pressure below 3.4 bar (3.5 kgf/cm², 50 psi) subject to the requirements of 4-5-2/11.1. Large fabricated ballast manifolds which connect lines exceeding 200 mm (8 in.) nominal pipe size may be used when the maximum pressure to which they will be subjected does not exceed 1.7 bar (1.75 kgf/cm², 25 psi).

All valves for Group I piping systems and valves intended for use in 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. N.P.S.). 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.

<i>Pipe Size mm O.D. (in N.P.S.)</i>	<i>Maximum Pressure bar (kgf/cm², psi)</i>
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. See 4-5-6/1.7 for hydraulic systems.

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 Non-Standard Fittings

Fittings which are 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 include testing or analysis demonstrating adequacy including both structural and material capability aspects. Drawings of such fittings showing details of construction, material and design calculations or test results are to be submitted for review.

13.7 Mechanical Joints (2005)

The installation of mechanical pipe joints, as covered by 4-5-2/13.1 and 4-5-2/13.5, is to be in accordance with the manufacturer's assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be specified and supplied as necessary by the manufacturer. These special tools are to be kept onboard.

15 Welded Non-Standard Valves and Fittings

Non-Standard steel valves and fittings fabricated by means of fusion welding are to comply also 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 for other valves and fittings which conform to standards of the American National Standards Institute or other recognized standards.

17 Flanges

17.1 General

Flanges are to be designed and fabricated in accordance with a recognized 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 2-4-2/9.1 of the *ABS Rules for Materials and Welding (Part 2)*. Smaller pipes may be screwed without seal-welding but oil lines are, in addition, to be expanded into the flanges in order to insure 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.

17.7 Group II Plastic Piping Flanges

Rigid plastic compounds for flanges in plastic piping systems will be considered for Group II piping systems. The design pressure and temperature together with the physical characteristics of the material are to be submitted in all cases.

19 Sea Inlets and Overboard Discharges

19.1 Installation (2006)

Piping 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. For compensation in way of holes in the shell plating see 3-2-4/7.

Threaded connections outboard of the shell valves are not considered an acceptable method of connection of pipe to the shell.

19.3 Valve Connections to Shell (2014)

Wafer type valves are not to be used for any connections to the liftboat's shell unless specially approved. Lug type butterfly valves used as shell valves are to have a separate set of bolts on each end of the valve so that the inboard end may be disconnected with the valve closed to maintain its watertight integrity.

Where a distance piece is fitted between the shell and the shell valves, the pipe is to be as short as possible and of wall thickness not less than that specified below:

<i>Nominal Size, d</i>	<i>Min. Wall Thickness</i>
$d \leq 65 \text{ mm (2.5 in.)}$	7 mm (0.276 in.)
$d = 150 \text{ mm (6 in.)}$	10 mm (0.394 in.)
$d \geq 200 \text{ mm (8 in.)}$	12.5 mm (0.492 in.)

For intermediate nominal pipe sizes, the wall thicknesses are to be obtained by linear interpolation as follows:

For $65 < d < 150$: $7 + 0.035(d - 65) \text{ mm}$ or $0.28 + 0.034(d - 2.5) \text{ in.}$

For $150 < d < 200$: $10 + 0.05(d - 150) \text{ mm}$ or $0.39 + 0.05(d - 6.0) \text{ in.}$

19.5 Materials

All shell fittings and valves required by 4-5-2/21 and 4-5-2/23 are to be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable. 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.). All pipes to which this Subsection refers are to be of steel or other equivalent material, subject to special approval.

19.7 Shell Reinforcement

Overboard discharges are to have spigots extending through the shell plate and doubling plate where fitted but need not project beyond the outside surface of the liftboat.

19.9 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, gravity drains, etc., are not to have a common overboard discharge

19.11 Preload Tank Overboard Discharges (Dump)

Preload tank gravity drainage systems are to generally be located wholly within the tank being served. Shell connections are to comply with 4-5-2/19.3 and are to be fitted with a stop-check positive closing valve complying with 4-5-2/19.5 which is remotely operable from a readily accessible location above the freeboard deck. Alternatively, the stop-check valve may be replaced with a positive closing valve and a separate check valve. The positive closing valve may be located in the inboard position relative to the check valve. The remote operator is to indicate whether the valve is open or closed.

21 Machinery and Pumping Systems

21.1 Valves Required (2006)

Positive closing valves are to be fitted at the shell in inlet and discharge piping. The controls are to be readily accessible and are to be provided with indicators showing whether the valves are open or closed. In order to be considered readily accessible, the controls, during normal operating conditions, are to be:

- i) Located in a space normally entered without using tools,
- ii) Clear of or protected from obstructions, moving equipment and hot surfaces that prevent operation or servicing, and
- iii) Within operator's reach.

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.

21.3 Sea Chests

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.

21.3.1 Strainer Plates

Sea chests are to be fitted with strainer plates at the hull'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.

21.3.2 Ice Strengthening

For liftboats with ice strengthening, see Part 6, Chapter 1 of the *Steel Vessel Rules*.

23 Scuppers and Drains

23.1 Discharges through the Shell (2012)

23.1.1 General

Discharges led through the shell either from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck are to be fitted with efficient and accessible means for preventing water from passing inboard.

Normally, each separate discharge is to have one automatic non-return valve with a positive means of closing it from a position above the freeboard deck, except as below. Alternatively, one automatic non-return valve and one positive closing valve controlled from above the freeboard deck may be accepted.

Where the vertical distance from the summer loadline (SLWL) to the inboard end of the discharge pipe exceeds $0.01L$, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions. The inboard valve is to be above the tropical load waterline (TLWL). If this is not practicable, then, provided a locally controlled stop valve is interposed between the two non-return valves, the inboard valve need not be fitted above the tropical load waterline.

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds $0.02L$, a single automatic non-return valve without positive means of closing may be accepted, provided it is located above the tropical load waterline (or, where assigned, timber tropical load waterline). If this is impracticable, a locally operated positive closing valve may be provided below the single non-return valve, in which case, the non-return valve need not be located above the specified tropical load waterline.

L is defined in 3-1-1/1.1.1. The means for operating the positive-action valve is to be readily accessible and provided with an indicator showing whether the valve is open or closed. See 4-5-2/Figure 3.

23.1.2 Manned Machinery Space

Where sanitary discharges and scuppers lead overboard through the shell in way of manned machinery spaces, the fitting to the shell of a locally operated positive closing valve, together with a non-return valve inboard, will be acceptable

See 4-5-2/Figure 3 for the acceptable arrangements of scuppers, inlets and discharges.

FIGURE 3

Discharges coming from enclosed spaces below the freeboard deck or on the freeboard deck				Discharges coming from other spaces	
General requirement where inboard end < 0.01L above SWL	Discharges through manned machinery space	Alternatives where inboard end		outboard end > 450 mm below FB deck or < 600 mm above SWL	otherwise
		> 0.01L above SWL	> 0.02L above SWL		
Superstructure or Deckhouse Deck FB Deck SWL	FB Deck SWL */	FB Deck SWL	FB Deck SWL	FB Deck SWL	FB Deck SWL
*/ control of the valves are to be in an approved position					

Symbols:

- inboard end of pipes
- outboard end of pipes
- pipes terminating on the open deck

- non return valve without positive means of closing
- non return valve with positive means of closing controlled locally
- valve controlled locally

- remote control
- normal thickness
- substantial thickness

23.3 Scuppers and Discharges below the Freeboard Deck

Scuppers and discharge pipes originating at any level and penetrating the shell either more than 450 mm (17.5 in.) below the freeboard deck or less than 600 mm (23.5 in.) above the summer load waterline are to be provided with a non-return valve at the shell. This valve, unless required by 4-5-2/23.1, may be omitted if the piping has a wall thickness at least equal to the thickness of the shell plating or extra-heavy pipe, whichever is less.

23.5 Scuppers from Superstructures or Deckhouses

23.5.1 Enclosed Cargo Spaces

Drainage of enclosed cargo spaces situated on the bulkhead deck or the freeboard deck is to be provided with the following:

23.5.1(a) Where the summer freeboard is such that the deck edge of the space being drained is not immersed when the liftboat heels 5 degrees, the drainage is to be by means of a sufficient number of scuppers of suitable size discharging directly overboard in accordance with 4-5-2/23.1.

23.5.1(b) Where the summer freeboard is such that the deck edge of the space being drained is immersed when the lifboat heels 5 degrees, the drainage of the enclosed cargo spaces is to be led to a suitable space, or spaces, of adequate capacity, having a high water level alarm and provided with suitable arrangements for discharge overboard. In addition the system is to be designed such that:

- i) The number, size and disposition of the scuppers are to prevent unreasonable accumulation of free water;
- ii) The pumping arrangements are to take into account the requirements for any fixed, pressurized, water spraying, fire extinguishing system;
- iii) Water contaminated with oil or other dangerous substances is not drained to machinery spaces or other spaces where sources of ignition may be present; and
- iv) Where the enclosed cargo space is protected by a carbon dioxide fire extinguishing system the deck scuppers are fitted with means to prevent the escape of the smothering gas.

23.7 Liftboats Receiving Subdivision Loadlines

For liftboats receiving subdivision loadlines, the bulkhead deck is to apply to provisions given in 4-5-2/23.1 when it is higher than the freeboard deck.

23.9 Required Minimum Wall Thicknesses for Pipes (2012)

For pipes in the gravity drain systems covered by 4-5-2/23, the wall thickness of steel piping are not be less than given below:

23.9.1 Piping where Substantial Thickness is Required

For scupper and discharge pipes between hull plating and the closeable or non-return valve, where substantial thickness is required:

- i) External diameter of pipes equal to or less than 80 mm (3.15 in.): thickness not less than 7.0 mm (0.276 in.)
- ii) External diameter of pipes 180 mm (7.1 in.): thickness not less than 10.0 mm (0.394 in.)
- iii) External diameter of pipes equal to or more than 220 mm (8.7 in.): thickness not less than 12.5 mm (0.5 in.)

Intermediate sizes are to be determined by linear interpolation.

23.9.2 Piping where Substantial Thickness is not Required

For scupper and discharge pipes inboard of a closeable or non-return valve, where substantial thickness is not required;

- i) External diameter of pipes equal to or less than 155 mm (6.1 in.): thickness not less than 4.5 mm (0.177 in.)
- ii) External diameter of pipes equal to or more than 230 mm (9.1 in.): thickness not Less than 6.0 mm (0.236 in.)

Intermediate sizes are to be determined by linear interpolation.

25 Cooler Installations External to the Hull

25.1 General

The inlet and discharge connections of external cooler installations are to be in accordance with 4-5-2/19.1 through 4-5-2/19.5 and 4-5-2/21.1, except that wafer type valves will be acceptable.

25.3 Integral Keel Cooler Installations

The positive closing valves required by 4-5-2/25.1 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.

25.5 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 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 5 Pumps and Piping Systems

SECTION 3 Bilge and Ballast Systems and Tanks

1 General Arrangement of Bilge Systems (2011)

A pumping system is to be provided in all liftboats capable of pumping from and draining any compartment when the liftboat is on an even keel and either upright or listed 5 degrees. For this purpose wing suctions will often be necessary, except in narrow compartments at the ends of the liftboat. 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 and comparatively small compartments, such as chain lockers, echo sounder spaces and decks over peak tanks, etc., may be drained by ejectors or hand pumps. Where ejectors are used for this purpose, the overboard discharge arrangements are to comply with 4-5-2/23.

3 Bilge Pumps

3.1 Number of Pumps

All self-propelled liftboats 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. Liftboats under 20 m (65 ft) in length are to be provided with one fixed power driven pump, which may be an attached unit, and one portable hand pump.

3.3 Capacity

The capacity of each pump is to be in accordance with the following:

<i>Liftboat Length</i>	<i>Minimum Capacity per Pump</i>
Below 20 m (65 ft)	5.5 m ³ /hr (25 gpm) (hand pump 5 gpm, 1.13 m ³ /hr)
20 m (65 ft) or greater but below 30.5 m (100 ft)	11 m ³ /hr (50 gpm)
30.5 m (100 ft) or greater but below 45.7 m (150 ft)	14.33 m ³ /hr (66.6 gpm)
45.7 m (150 ft) and greater	$Q = 5.66d^2/103$ m ³ /hr $Q = 16.1d^2$ gpm

Q = pump capacity

d = required diameter of main bilge line suction, mm (in.) See 4-5-3/5.9.

When more than two pumps are connected to the bilge system, their arrangement and aggregate capacity are not to be less effective.

3.5 Centrifugal Pumps

Where centrifugal pumps are installed, suitable means for priming are to be provided.

3.7 Independent Power Bilge Pumps (2007)

Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps, provided they are of the required capacity and are fitted with stop valves so that when a pump is used for one service, the other services can be isolated.

5 Bilge and Ballast Piping

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.

5.3 Installation

Bilge or ballast pipes, where permitted to pass through compartments intended for the carriage of oil, are to be of either steel or wrought iron.

Where bilge pipes in way of deep tanks are not led through a watertight or oiltight tunnel, the bilge lines are to be of steel and extra heavy. Similarly, where ballast pipes in way of deep tanks, other than ballast tanks, are not led through a watertight or oiltight tunnel, the ballast lines are to be of steel and extra heavy. For both bilge and ballast piping, the number of joints is to be kept to a minimum and to be arc welded or extra heavy flanged. The piping within a deep tank is to be installed to take care of expansion. A non-return valve is to be fitted at the open end of bilge pipes.

5.5 Manifolds, Cocks and Valves

5.5.1 General

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.

5.5.2 Common-main-type Bilge Systems (2005)

A common-main bilge system normally consists of one or more main lines installed along the length of the liftboat fitted with branch bilge suction connections to various compartments. Where only one fore-and-aft bilge main is installed, the bilge main is to be located inboard of 20% of the molded beam of the liftboat, measured inboard from the side of the liftboat perpendicular to the centerline at the level of the summer load line. If there is at least one bilge main on each side of the liftboat, then those bilge mains may be installed within 20% of the molded beam, measured inboard from the side of the liftboat perpendicular to the centerline at the level of the summer load line, provided they are fitted with branch lines and control valves arranged such that it is possible to effectively pump out each compartment using the main(s) on either side of the liftboat.

For all common-main-type bilge systems, the control valves required in the branches from the bilge main are to be accessible at all times and are to be of the stop-check type with an approved type of remote operator. Remote operators may be located in a manned machinery space, or from an accessible position above the freeboard deck, or from underdeck walkways. Remote operators may be of the hydraulic, pneumatic, electric or reach-rod type.

5.5.3 Controls for Ballast Tank Valves

Ballast tank valves are to be arranged so they will remain closed at all times except when ballasting. For this purpose, manual screw thread operated valves, positive holding arrangements for butterfly type valves or other equivalent arrangements may be used. Where installed, remote controlled valves are to be arranged so they will close and remain closed upon loss of control power, or will remain in their last position and are provided with a readily accessible manual means of operation in case of loss of power to the valve control system. Remote control of bilge and ballast valves is to be clearly marked at the control station and means are to be provided to indicate whether the valve is open or closed.

5.7 Strainers (2005)

Bilge lines in machinery spaces other than emergency suction 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.

5.9 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.

5.9.1 Main Line

For the diameter of main bilge line suction and direct bilge suction to the pumps:

$$d = 25 + 1.68 \sqrt{L(B + D)} \quad \text{mm} \qquad d = 1 + \sqrt{L(B + D) / 2500} \quad \text{in.}$$

5.9.2 Branch Lines

For the equivalent diameter of the combined branch suction to a compartment:

$$d = 25 + 216 \sqrt{c(B + D)} \quad \text{mm} \qquad d = 1 + \sqrt{c(B + D) / 1500} \quad \text{in.}$$

where

- d = internal diameter of pipe, in mm (in.)
- L = length of liftboat as defined in 3-1-1/1.1.1, in m (ft)
- B = breadth of liftboat as defined in 3-1-1/1.1.2, in m (ft)
- c = length of compartment, in m (ft)
- D = molded depth to bulkhead or freeboard deck, in m (ft), except that, for the main line, in a liftboat having an enclosed cargo space on the bulkhead or freeboard deck which is internally drained in accordance with 4-5-2/23.5.1(b)ii) and which extends for the full length of the liftboat, D is to be measured to the next deck above the bulkhead or freeboard deck. Where the enclosed cargo spaces cover a lesser length, D is to be taken as a molded depth to the bulkhead or freeboard deck plus $\ell h/L$ where ℓ and h are aggregate length and height respectively of the enclosed cargo spaces.

5.9.3 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.

5.9.4 Alternate Size Requirements

For liftboats below 30.5 m (100 ft) in length the bilge pipe sizes may be in accordance with the following in lieu of 4-5-3/5.9.1.

<i>Liftboat Length</i>	<i>Minimum Pipe Size (I.D.)</i>
Below 20 m (65 ft)	25 mm (1 in.)
20 m (65 ft) or greater but below 30.5 m (100 ft)	38 mm (1.5 in.)

5.9.5 Size Limits

For liftboats of 30.5 m (100 ft) in length or greater, no main suction piping is to be less than 63 mm (2.5 in.) internal diameter. No branch piping need be more than 100 mm (4 in.) I.D., nor is it to be less than 50 mm (2 in.) I.D., except that for drainage of small pockets or spaces 38 mm (1.5 in.) I.D. pipe may be used.

5.9.6 Bilge Common-main (2005)

The diameter of each common-main bilge line may be determined by the equation for bilge branches given in 4-5-3/5.9.2 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 liftboat is not representative of the breadth of the compartment, B may be appropriately modified to the breadth of the compartment. However, no common-main bilge pipe needs to be more than the diameter for the bilge main given in 4-5-3/5.9.1.

5.11 Gravity Drains

Gravity drains that penetrate the main machinery space watertight bulkheads below the freeboard deck and terminate within the main machinery space are to be fitted with a valve operable from above the freeboard deck or with quick-acting, self-closing valves. The valve should preferably be located in the main machinery space. When gravity drains from other spaces are terminated in cargo holds, the cargo hold bilge well is to be fitted with a high level alarm. Gravity drains which terminate in spaces which are protected by fixed gas extinguishing systems are to be fitted with means to prevent the escape of extinguishing medium.

5.13 Ballast Water Treatment Systems (1 July 2012)

Where a ballast water treatment system is to be installed, it is to comply with the requirements in Sections 4 and 5 of the *ABS Guide for Ballast Water Treatment* and the same is to be verified by ABS.

5.15 Oil Pollution Prevention Measures (2014)

5.15.1 General

Means are to be provided to process oil contaminated water from machinery space bilges prior to discharging it overboard for every vessel of 400 gross tonnage and above. In general, the discharge criteria of MARPOL ANNEX 1, Regulation 15 are to be complied with.

5.15.2 Oily Water Filtering or Separating Equipment

Oily water filtering equipment capable of processing oily mixtures to produce an effluent with oil content not exceeding 15 parts per millions (PPM) and complying with IMO Resolution MEPC.107(49) is to be provided to allow oily water from the bilges to be processed prior to discharging overboard. For vessels of 10,000 tons gross tonnage and above, the equipment is to be fitted with an alarm and an arrangement to automatically stop the discharge when 15 PPM cannot be maintained.

5.15.3 Sludge Tank

A tank or tanks of adequate capacity is to be provided to receive oily residues such as those resulting from the oily water filtering or separating equipment and from the purification of fuel and lubricating oils. The minimum sludge tank capacity V_1 is to be calculated by the following formula:

$$V_1 = K_1 CD \quad \text{m}^3 \text{ (ft}^3\text{)}$$

where

K_1	=	0.015 for vessels where heavy fuel oil is purified for main engine use or
	=	0.005 for vessels using diesel oil or heavy fuel oil which does not require purification before use
C	=	daily fuel oil consumption, $\text{m}^3 \text{ (ft}^3\text{)}$
D	=	maximum period of voyage between ports where sludge can be discharged ashore (days). In the absence of precise data, a figure of 30 days is to be used.

The sludge tank is to be so designed as to facilitate cleaning. Where heavy fuel oil residue is expected to be received by the sludge tank, heating arrangements are to be provided to facilitate the discharge of the sludge tank.

5.15.4 Sludge Piping System

5.15.4(a) Sludge Pump. The sludge tank is to be provided with a designated pump of a suitable type, capacity and discharge head for the discharge of the tank content to shore reception facilities.

5.15.4(b) Standard Discharge Connection. To enable the discharge of sludge to shore reception facilities, the sludge piping is to be provided with a standard discharge connection, in accordance with 4-4-3/Table 1.

TABLE 1
Dimensions and Details of Standard Discharge Connection Flange (2014)

	<i>Dimension</i>
Outside diameter	215 mm
Inner diameter	According to pipe outside diameter
Bolt circle diameter	183 mm
Slots in flange	6 holes 22 mm in diameter equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery. The slot width to be 22 mm
Flange thickness	20 mm
Bolts and nuts:	6 sets, each of 20 mm in diameter and of suitable length
The flange is designed to accept pipes up to a maximum internal diameter of 125 mm and is to be of steel or other equivalent material having a flat face. This flange, together with a gasket of oil-proof material, is to be suitable for a service pressure of 6 kg/cm ²	

5.15.4(c) Sludge Piping. There is to be no interconnection between the sludge tank discharge piping and bilge piping other than the possible common piping, with appropriate valves, leading to the standard discharge connection. Piping to and from sludge tanks is to have no direct connection overboard other than the standard discharge connection referred to in 4-5-3/5.15.4(b).

7 Independent and Emergency Bilge Suctions

7.1 Independent Bilge Suction

For liftboats 20 m (65 ft) in length and greater, one of the independent power pumps is to be fitted with a direct bilge suction, led directly from the main machinery space bilge to the suction valve chest of the pump and arranged so that it can be operated independently of the bilge system. The size of this line is to be such that the pump will deliver its full capacity.

If watertight bulkheads separate the main machinery space into compartments, a direct suction is to be fitted to each compartment unless the pumps available for bilge service are distributed throughout these compartments. At least one pump in each such compartment is to be fitted with a direct suction for its compartment.

7.3 Emergency Bilge Suctions

In addition to the independent bilge suction in 4-5-3/7.1, an emergency bilge suction is to be fitted for all oceangoing liftboats 55 m (180 ft) in length and over. A direct bilge suction for the engine room is to be provided from the largest suitable pump in the engine room except a required bilge pump. The area of the direct bilge suction pipe is to be equal to the full suction inlet of the pump selected. A suitable overboard discharge line is to be provided and the means of control of the direct bilge suction is to be readily accessible and so located to provide rapid operation.

7.5 Direct Bilge Suction

The direct bilge suctions are to be fitted with suitable non-return valves.

9 Vent Pipes

9.1 General (2011)

Except for comparatively small compartments that are not fitted with a fixed means of drainage, vent pipes are to be fitted to all tanks, cofferdams, voids, tunnels and compartments which are not fitted with other ventilation arrangements. In all liftboats 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. Each tank is to be fitted with at least one vent pipe, 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. No shutoff valve or a closing device that can prevent the venting from a tank is to be installed in vent piping.

9.3 Height and Wall Thickness (2010)

9.3.1 Vents Exposed to Weather

Vent pipes on decks exposed to the weather are to have the following heights:

- i) 760 mm (30 in.) for those on the freeboard deck; and
- ii) 450 mm (17.5 in.) for those on the superstructure deck.

The height is to be measured from the deck to the point where water may have access below. Where these heights may interfere with the working of the liftboat, a lower height may be accepted, provided that ABS is satisfied that the closing arrangements and other circumstances justify a lower height.

The wall thicknesses of vent pipes where exposed to the weather are to be not less than that specified below. For vent pipes located on the fore deck, as defined in 3-2-14/9.7.1, the strength and wall thickness requirements are to also comply with 3-2-14/9.7.2 and 3-2-14/9.7.3:

Nominal Size, d	Min. Wall Thickness
$d \leq 65 \text{ mm (2.5 in.)}$	6.0 mm (0.24 in.)
$65 \text{ mm (2.5 in.)} < d < 150 \text{ mm (6 in.)}$	by interpolation ⁽¹⁾
$d \geq 150 \text{ mm (6 in.)}$	8.5 mm (0.33 in.)

Note:

$$1 \quad 6 + 0.029(d - 65) \text{ mm or } 0.24 + 0.026(d - 2.5) \text{ in.}$$

9.3.2 Vents not Exposed to Weather

Vent pipes not exposed to the weather need not comply with the height and wall thickness required by 4-5-3/9.3.1.

9.5 Size

Vent pipes are to have a minimum internal diameter not less than 38 mm (1.5 in.) and not less than the internal diameter of the fill line. 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 size. The minimum diameter of vent pipes on the fore deck is not to be less than 65 mm [see 3-2-14/9.7.3(b)].

Notwithstanding the above, the pump capacity and pressure head are to be considered in the sizing of vents, and overflows; when high capacity and/or high head pumps are used, calculations demonstrating the adequacy of the vent and overflows are to be submitted.

9.7 Location

Vents for compartments required for subdivision (such as double bottom or wing spaces) are to be led above the freeboard or bulkhead deck. In addition, vents for ballast tanks, fuel oil tanks, cargo tanks, thermal oil tanks and those cofferdams adjacent to cargo oil tanks are to be led to the weather. Vents for other tanks may terminate within the machinery space provided that the open ends are situated to prevent the possibility of overflowing on electric equipment, engines or heated surfaces.

Vent pipes for fuel oil service tanks, fuel oil settling tanks and lubricating oil tanks which directly serve the engines are to be located and arranged and/or suitably protected from mechanical damage in order to minimize the possibility of being broken and allowing the ingress of seawater splashes or rainwater into the above mentioned tanks.

9.9 Vent Outlets

All vent and overflow pipes on the open deck are to terminate by way of return bends.

9.9.1 Fuel Oil Tank Vents (2007)

Vent outlets from 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. 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: Mash 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.

9.9.2 Vent Closure (2010)

All vents terminating in the weather are to be fitted with return bends (gooseneck), or equivalent, and the vent outlet is to be provided with an automatic means of closure type i.e., close automatically upon submergence (e.g., ball float or equivalent), complying with 4-5-3/9.9.3.

9.9.3 Vent Outlet Closing Devices (2008)

9.9.3(a) General. Where vent outlets required by 4-5-3/9.9.2 are to be fitted with automatic closing devices, they are to comply with the following:

9.9.3(b) Design.

- i) Vent outlet automatic closing devices are to be so designed that they will withstand both ambient and working conditions, and be suitable for use at inclinations up to and including $\pm 40^\circ$.
- ii) Vent outlet automatic closing devices are to be constructed to allow inspection of the closure and the inside of the casing as well as changing the seals.
- iii) Efficient ball or float seating arrangements are to be provided for the closures. Bars, cage or other devices are to be provided to prevent the ball or float from contacting the inner chamber in its normal state and made in such a way that the ball or float is not damaged when subjected to water impact due to a tank being overfilled.
- iv) Vent outlet automatic closing devices are to be self-draining.
- v) The clear area through a vent outlet closing device in the open position is to be at least equal to the area of the inlet.
- vi) An automatic closing device is to:
 - Prevent the free entry of water into the tanks,
 - Allow the passage of air or liquid to prevent excessive pressure or vacuum developing in the tank.
- vii) In the case of vent outlet closing devices of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim. [see 4-5-3/9.9.3(b)i)]

- viii) The maximum allowable tolerances for wall thickness of floats should not exceed $\pm 10\%$ of thickness.
- ix) The inner and outer chambers of an automatic air pipe head is to be of a minimum thickness of 6 mm (0.24 inch).

9.9.3(c) *Materials.*

- i) Casings of vent outlet closing devices are to be of approved metallic materials adequately protected against corrosion.
- ii) For galvanized steel air pipe heads, the zinc coating is to be applied by the hot method and the thickness is to be 70 to 100 micrometers (2.756 to 3.937 mil).
- iii) For areas of the head susceptible to erosion (e.g., those parts directly subjected to ballast water impact when the tank is being pressed up, for example the inner chamber area above the air pipe, plus an overlap of 10° or more to either side) an additional harder coating should be applied. This is to be an aluminum bearing epoxy, or other equivalent coating, applied over the zinc.
- iv) Closures and seats made of non-metallic materials are to be compatible with the media intended to be carried in the tank and to seawater and suitable for operating at ambient temperatures between -25°C and 85°C (-13°F and 185°F).

9.9.3(d) *Type Testing.*

- i) *Testing of Vent Outlet Automatic Closing Devices.* Each type and size of vent outlet automatic closing device is to be surveyed and type tested at the manufacturer's works or other acceptable location.

The minimum test requirements for a vent outlet automatic closing device are to include the determination of the flow characteristics of the vent outlet closing device, the measurement of the pressure drop versus the rate of volume flow using water and with any intended flame or insect screens in place and also tightness tests during immersion/emerging in water, whereby the automatic closing device is to be subjected to a series of tightness tests involving not less than two (2) immersion cycles under each of the following conditions:

- The automatic closing device is to be submerged slightly below the water surface at a velocity of approximately 4 m/min. (13.12 ft/min) and then returned to the original position immediately. The quantity of leakage is to be recorded.
- The automatic closing device is to be submerged to a point slightly below the surface of the water. The submerging velocity is to be approximately 8 m/min and the air pipe vent head is to remain submerged for not less than 5 minutes. The quantity of leakage is to be recorded.
- (2014) Each of the above tightness tests are to be carried out in the normal position as well as at an inclination of 40 degrees **under the strictest conditions for the device. In cases where such strictest conditions are not clear, tests shall be carried out at an inclination of 40 degrees with the device opening facing in three different directions: upward, downward, sideways (left or right). See 4-5-3/Figures 1 to 4.**

The maximum allowable leakage per cycle is not to exceed 2 ml/mm (1.312×10^{-2} gal/inch) of nominal diameter of inlet pipe during any individual test.

- ii) ***Discharge/Reverse Flow Test (2014).* The air pipe head shall allow the passage of air to prevent excessive vacuum developing in the tank. A reverse flow test shall be performed. A vacuum pump or another suitable device shall be connected to the opening of the air pipe leading to the tank. The flow velocity shall be applied gradually at a constant rate until the float gets sucked and blocks the flow. The velocity at the point of blocking shall be recorded. 80% of the value recorded will be stated in the certificate. Each type and size of vent outlet automatic closing device is to be surveyed and type tested at the manufacturer's works or other acceptable location.**

- iii) *Testing of Non-Metallic Floats.* Impact and compression loading tests are to be carried out on the floats before and after pre-conditioning as follows:

Test Temperature °C (°F):	−25°C (−13°F)	20°C (68°F)	85°C (185°F)
Test Conditions			
Dry	Yes	Yes	Yes
After immersing in water	Yes	Yes	Yes
After immersing in fuel oil	NA	Yes	NA

Immersing in water and fuel oil is to be for at least 48 hours.

- a) *Impact Test.* The test may be conducted on a pendulum type testing machine. The floats are to be subjected to 5 impacts of 2.5 N-m (1.844 lbf-ft) each and are not to suffer permanent deformation, cracking or surface deterioration at this impact loading.

Subsequently the floats are to be subjected to 5 impacts of 25 N-m (18.44 lbf-ft) each. At this impact energy level some localized surface damage at the impact point may occur. No permanent deformation or cracking of the floats is to appear.

- b) *Compression Loading Test.* Compression tests are to be conducted with the floats mounted on a supporting ring of a diameter and bearing area corresponding to those of the float seating with which it is intended that float shall be used. For ball type float, loads are to be applied through a concave cap of the same internal radius as the test float and bearing on an area of the same diameter as the seating. For a disc type float, loads are to be applied through a disc of equal diameter as the float.

A load of 3430 N (350 kgf, 770 lbf) is to be applied over one minute and maintained for 60 minutes. The deflection is to be measured at intervals of 10 minutes after attachment of the full load.

The record of deflection against time is to show no continuing increase in deflection and, after release of the load, there is to be no permanent deflection.

- iii) *Testing of Metallic Floats.* The above described impact tests are to be carried out at room temperature and in the dry condition.

FIGURE 1
Example of Normal Position (2014)

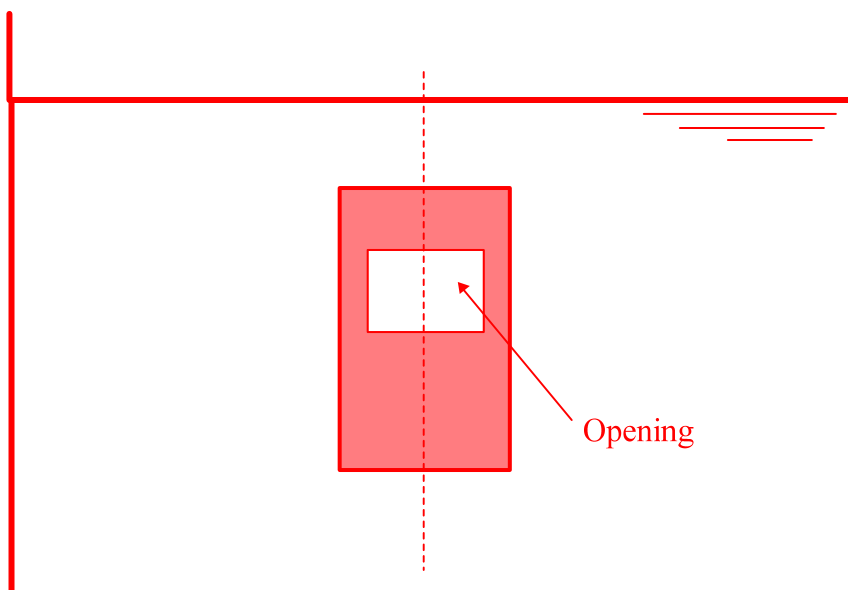


FIGURE 2
Example of Inclination 40 Degrees Opening Facing Upward (2014)

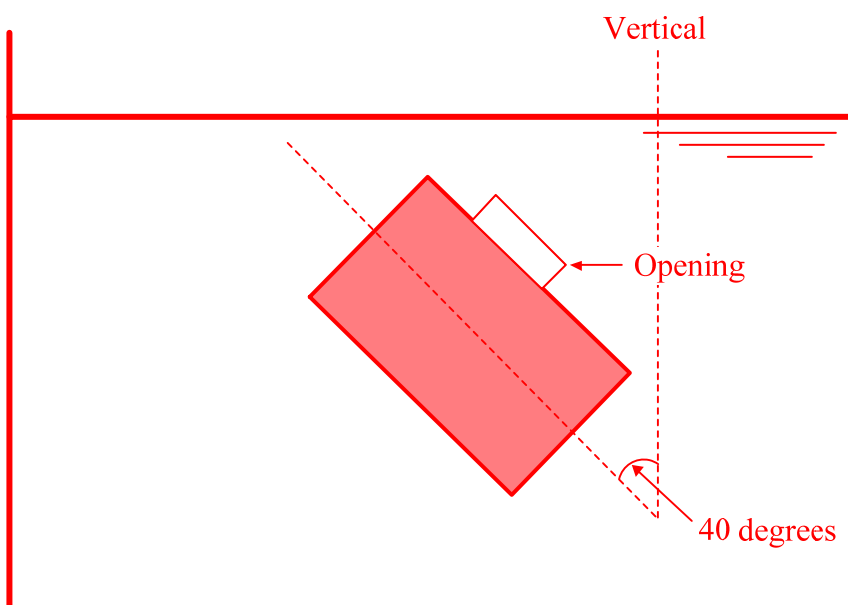


FIGURE 3
Example of Inclination 40 Degrees Opening Facing Downward (2014)

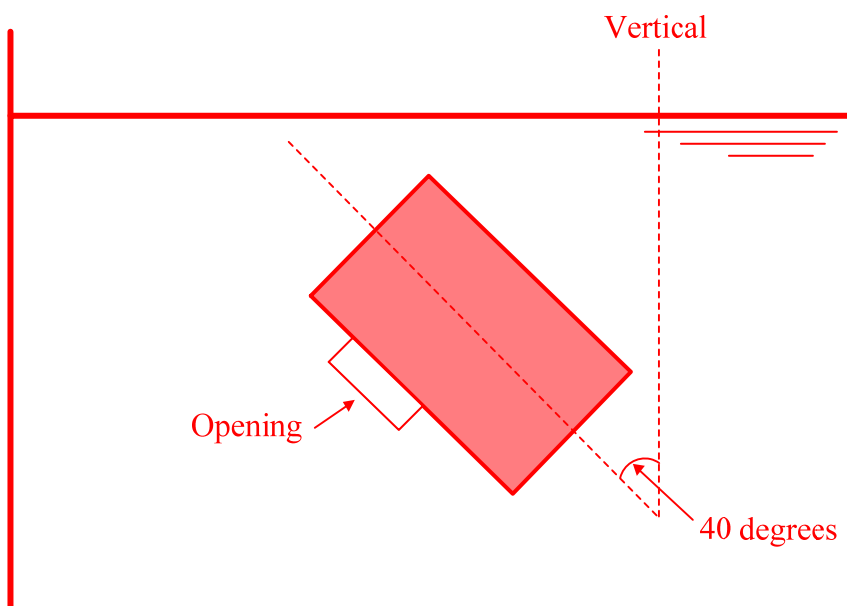
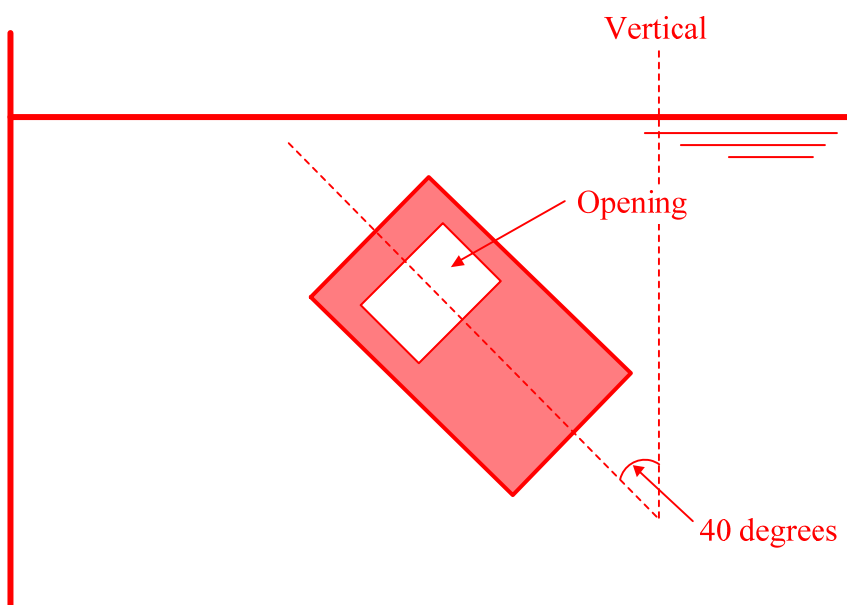


FIGURE 4
Example of Inclination 40 Degrees Opening Facing Sideways (2014)



11 Overflow Pipes

Overflow pipes discharging through the hull's side are to be located as far above the deepest load line as practicable and are to be provided with nonreturn valves located on the liftboat's side. Where the overflow does not extend above the freeboard deck, there is to be provided in addition an efficient and accessible means for preventing water from passing inboard. Such means may consist of another nonreturn valve located in an accessible position above the deepest load line.

Where it is impracticable to locate the inner valve in an accessible position, one nonreturn valve with positive means for closing from an accessible position above the freeboard or bulkhead deck will be acceptable, provided there are suitable arrangements to insure the valve not being closed by unauthorized persons and provided a notice is posted in a conspicuous place at the operating station to the effect that the valve is never to be closed except as may be required in an emergency.

Overflow pipes from combustible and flammable liquid tanks are to be led to an overflow tank of adequate capacity or to a storage tank having space reserved for overflow purposes. An alarm device is to be provided to give warning when the liquid reaches a predetermined level in the overflow tank. If a sight flow glass is also provided in the overflow pipe, then such sight glasses are to be fitted only in vertical sections of overflow pipes and be in readily visible positions.

Where overflows from the tanks in more than one watertight subdivision are connected to a common header below the freeboard or bulkhead deck, the arrangement is to be such as to prevent fore-and-aft flooding of one watertight bulkhead subdivision from another in the event of damage.

13 Sounding

13.1 General

All tanks are to be fitted with a suitable means of determining the level of the liquid therein. Such means may be sounding pipes, gauge glasses, or other approved level indicating systems or devices.

All compartments, including cofferdams and pipe tunnels, which are not readily accessible are to be fitted with sounding pipes if the compartment is adjacent to the sea or has pipes carrying liquids passing through it.

13.3 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:

13.3.1 Oil Tanks

Quick-acting, self-closing gate valves are required.

13.3.2 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 hull 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. Sounding pipes for combustible or flammable fluids are not to terminate in accommodation spaces.

13.3.3 Ignition of Spillage

13.3.3(a) Fuel Oil Tanks. Sounding pipes for fuel oil tanks are not to terminate in any space where the risk of ignition of spillage may exist. In particular, they are not to terminate in machinery spaces or in close proximity to internal combustion engines, generators, electric equipment or surfaces with temperatures in excess of 220°C (428°F) in other spaces. Where it is impracticable to do otherwise, sounding pipes from fuel oil tanks may terminate in machinery spaces provided the following are met:

- i) The sounding pipes terminate in locations remote from ignition hazards or effective precautions such as shielding are taken to prevent fuel oil spillage from coming into contact with a source of ignition; and
- ii) The terminations of sounding pipes are fitted with quick-acting, self-closing gate valves and with a small diameter self-closing test cock or equivalent located below the gate valve is to be provided for the purpose of ascertaining that fuel oil is not present in the sounding pipe before the gate valve is opened. Provisions are to be made so as to prevent spillage of fuel oil through the test cock from creating an ignition hazard; and
- iii) (2005) An approved level gauge is provided. However, short sounding pipes may be used for oil tanks other than double bottom tanks without the additional closed level gauge, provided an overflow system is fitted, see 4-5-3/11. The oil level gauge may also be omitted for liftboats less than 500 gross tons.

13.3.3(b) *Lubricating Oil Tanks (2005)*. Sounding pipes from lubricating oil tanks may terminate in machinery spaces provided that the following are met:

- i) The sounding pipes are to terminate in locations remote from the ignition hazards, or effective precautions, such as shielding, are taken to prevent oil spillage from coming into contact with a source of ignition.
- ii) The termination of sounding pipes is fitted with a quick-acting self-closing gate valve. Alternatively, for lubricating oil tanks that cannot be filled by a pump, the sounding pipes may be fitted with an appropriate means of closure such as a shut-off valve or a screw cap attached by chain to the pipe.

13.5 Gauge Glasses (2006)

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.

Gauge glasses for tanks containing flammable or combustible liquids are to be of the flat glass type having approved self-closing valves at each end. For hydraulic oil tanks located in spaces other than category A machinery spaces, cylindrical gauge glasses with approved self-closing valves at each end will be acceptable provided such spaces do not contain internal combustion engines, generators, major electrical equipment or piping having a surface temperature in excess of 220°C (428°F).

Gauge glasses for tanks integral with the shell which are located below the deepest load waterline are to be of the flat glass type and have approved self-closing valves at each end.

Isolation valves are to be fitted to allow for gauges removal without emptying the tank, see 4-5-1/9.17.3.

13.7 Level Indicating Systems and Devices (2005)

Where a level indicating device or system is provided for determining the level in a tank containing flammable or combustible liquid, failure of the device/system is not to result in the release of the contents of the tank through the device. Level switches, which penetrate below the tank top, may be used, provided they are contained in a steel enclosure or other enclosures not being capable of being destroyed by fire. If an overflow is not fitted, means are also to be provided to prevent overfilling of the tank in the event of malfunction of the indicating device/system.

CHAPTER 5 Pumps and Piping Systems

SECTION 4 Fuel Oil and Lubricating Oil Systems and Tanks

1 Fuel Oil Piping Systems

1.1 General Arrangement

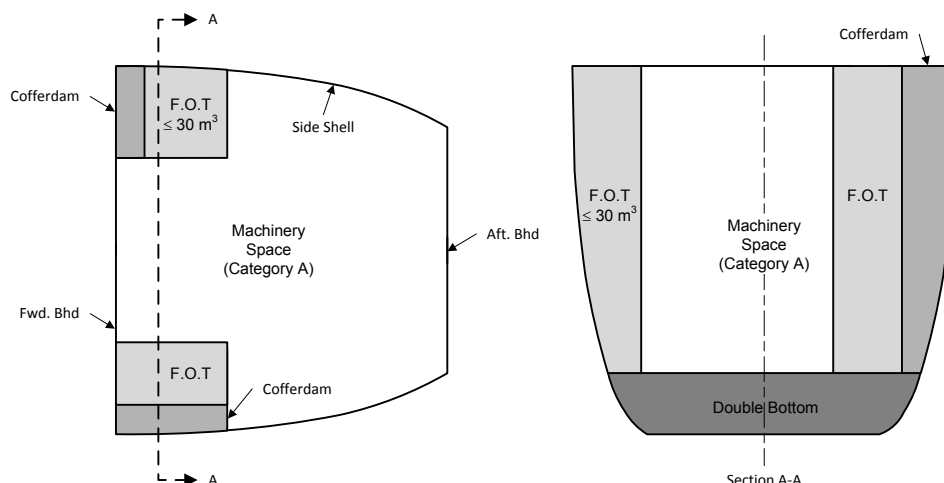
1.1.1 Tanks (2011)

1.1.1(a) Structural Tanks. As far as practicable, fuel oil tanks are to be part of the hull structure and located outside of Category A machinery spaces. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within a Category A machinery space, the arrangements are to reduce the area of the tank boundary common with the machinery space of category A to a minimum, and to comply with the following:

- i) Fuel tanks having boundaries common with machinery spaces of category A are not to contain fuel oils having flash point of 60°C (140°F) or less.
- ii) At least one of their vertical sides is to be contiguous to the machinery space boundaries. The arrangements in 4-5-4/Figure 1 are acceptable for structural tanks. (The side shell is not being included in contiguous boundary of the category A machinery space.)
- iii) The bottom of the fuel oil tank is not to be so exposed that it will be in direct contact with flame should there be a fire in a Category A machinery space. The fuel tank is to extend to the double bottom. Alternatively, the bottom of the fuel oil tank is to be fitted with a cofferdam. The cofferdam is to be fitted with suitable drainage arrangements to prevent accumulation of oil in the event of oil leakage from the tank.

FIGURE 1

Acceptable Fuel Oil Tanks Arrangements Inside Category A Machinery Spaces (2013)



1.1.1(b) Free-standing Tanks. In general, the use of free standing fuel oil tanks is to be avoided. Where permitted, they are to be placed in an oil tight spill tray of ample size with adequate means of drainage in accordance with 4-5-1/9.21.

1.1.2 Spillage (2011)

No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces or electrical equipment. Precautions are to be taken to prevent any oil that may escape under pressure during inspection or maintenance of any pump, filter or heater from coming into contact with a source of ignition as defined in 4-1-1/13.13.

To prevent the ignition of fuel oil, all hot surfaces likely to reach a temperature above 220°C (428°F) during service are to be insulated with non-combustible, and preferably non-oil-absorbent materials. Such insulation materials, if not impervious to oil, are to be encased in oil-tight steel sheathing or equivalent. The insulation assembly is to be well-installed and supported having regard to its possible deterioration due to vibration.

1.3 Piping, Valves and Fittings (2014)

Fuel oil pipes, valves and fittings are to be of steel or other approved materials. *See also 4-5-2/5.8.*

1.5 Multiple Internal Combustion Engine Installations

In multi-engine propulsion installations on liftboats 500 gross tons and above, which are supplied from the same fuel source, means of isolating the fuel supply and spill (return) piping to individual engines is to be provided. The means of isolation is not to affect the operation of the other engines and is to be operable from a position not rendered inaccessible by a fire on any of the engines.

Similarly, for multi-engine auxiliary diesel installations on liftboats 500 gross tons and above, the same requirements are applicable.

3 Fuel-oil Transfer and Filling

3.1 General

Where fuel oil transfer arrangements are furnished, two transfer pumps are to be provided and one of them is to be independent of the main engine. 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.

3.3 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.

3.5 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 deep and settling tanks. Pumps, strainers, etc., requiring occasional examination are to have drip pans.

3.7 Valves on Oil Tanks (2013)

Where pipe lines emanate from fuel 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. The valves are to be secured at the tank. A short length of Extra Strong pipe connecting the valve to the tank is also acceptable. Where the fuel oil piping passes through adjacent tanks, the valve required above may be located where the pipe run exits the adjacent tank(s) provided the piping in the adjacent tanks is extra-heavy and has all welded connections. However, if the adjacent tank is a fuel oil tank, the pipe run within the oil tank is to be at least Standard thickness.

If the valves are installed on the outside of the tank, they are not to be of cast iron. The use of nodular iron, also known as ductile iron or spheroidal-graphite iron, may be used provided the material has an elongation not less than 12% in 50 mm (2 in.). Arrangements are to be provided for closing them at the valve and for tanks having a capacity of 500 liters (132 US gal.) or greater, from a readily accessible and safe location outside of the compartment in which the valve is located.

If the positive closing valve required above is situated in a shaft tunnel or pipe tunnel or similar space, arrangements for closing may be effected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such additional valve is fitted in the machinery space, it is to be operated from a position outside this space.

If the valves are located inside of 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.

Where independent filling lines are fitted, they are to enter at or near the top of the tank; but if this be impracticable, they are to be fitted with non-return valves at the tank.

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 valves 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 an electric, hydraulic or pneumatic system is not acceptable to keep directly the valve in the open position.

Materials readily rendered ineffective by heat are not to be used in the construction of the valves or the closure mechanism within the space 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. Hydraulic systems are to be in accordance with 4-5-6/1 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.

3.9 Remote Shutdown of Pumps

Machinery driving fuel oil transfer pumps, oil fuel unit pumps and other similar fuel pumps are to be fitted with remote shutdowns complying with 4-6-1/5.3.

3.11 Oil Drain Tanks

Drain tanks, where fitted, for waste oil, fuel oil overflows, drains, all oil drip pans, and fuel injection piping, etc., are to have air and sounding pipes. Non-return valves are to be fitted in drain lines entering the drain tanks except where backflow would not present a hazard. Suitable means are to be provided for pumping out these drain tanks.

Oil tanks not forming a part of the liftboat's structure, where permitted by 4-5-4/1.1.1, are to have suitable drip pans with adequate means of drainage in accordance with 4-5-1/9.21.

5 Fuel-Oil Service and Injection Systems

Fuel oil service and injection systems for internal-combustion engines are to be in accordance with 4-2-1/3, 4-2-1/5 and 4-2-1/7.

7 Low-Flash Point Fuels

7.1 General

Fuel oils with a flash point of 60°C (140°F) closed-cup or below may be accepted for the following:

7.1.1

Liftboats classed for restrictive service within areas having a climate ensuring that ambient temperatures of spaces where such fuel oil is stored will not rise within 10°C (18°F) below its flash point, may use fuel oil with flash point of 60°C (140°F) or below but not less than 43°C (110°F).

7.1.2

For emergency generators fuel oil with a flash point of not less than 43°C (110°F) may be used. See 4-7-2/5.5.2.

7.3 Fuel Oil Tank Vents

Vent pipes are to extend at least 2.4 m (8 ft) above the weather deck or other effective arrangements which have been approved are to be provided.

9 Lubricating Oil Systems

9.1 General

The lubricating systems are to be so arranged that they will function satisfactorily under the conditions specified in 4-1-1/17. The lubricating-oil piping is to be entirely separated from other piping systems. In addition, the requirements of 4-5-4/1.1.2, 4-5-4/1.3, and 4-5-4/1.5 are applicable.

The requirements in 4-5-4/3.7 are also applicable for lubricating-oil tanks; however, arrangements for remotely closing the valve from a position outside the compartment need not be provided if inadvertent valve closure could result in damage to the running machinery due to lack of lubricating-oil. Where the machinery is arranged for automatic shutdown upon loss of lubricating-oil, the valve required by 4-5-4/3.7 is to be provided with means to close it from a readily accessible and safe location outside the compartment in which the valve is located.

9.3 Sight Flow Glasses

Sight flow glasses may be used in lubricating systems provided they are fire resistant.

9.5 Internal-Combustion Engines

For internal-combustion engines, see also 4-2-1/9.

9.7 Reduction Gears

For reduction gears, see also 4-2-1/9.11.

9.9 Electrical Machinery

For electrical machinery see also 4-7-3/3.3, 4-7-3/3.5 and 4-7-4/3.15.

9.11 Hose Reels

Where hose reels are used for filling engine or reduction gear sumps with oil, a self-closing valve is to be provided at the end of the filling hose to prevent spillage. Suitable arrangements are to be provided to properly drain and store the hose and reel when not in use. Hoses are to be approved for oil service and in accordance with the requirements for burst pressure, fire resistance, reinforcement, and end fittings in 4-5-1/9.19.

PART

4

CHAPTER **5 Pumps and Piping Systems**

SECTION **5 Internal Combustion Engine Systems**

1 Fuel Oil System

Fuel oil systems for internal-combustion engines are to comply with 4-2-1/3.

3 Lubricating Oil System

Lubricating oil systems for internal-combustion engines are to comply with 4-2-1/9.

5 Cooling Water System

Cooling water systems for internal-combustion engines are to comply with 4-2-1/11.

7 Exhaust Piping

Exhaust piping for internal-combustion engines is to comply with 4-2-1/15.

9 Starting-Air Systems

Starting-air systems for internal-combustion engines are to comply with 4-2-1/13.

PART

4

CHAPTER **5 Pumps and Piping Systems**

SECTION **6 Hydraulic and Pneumatic Systems**

1 Hydraulic Systems

1.1 General

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 liftboat's piping system (such as a crane) are not covered by this Section.

Plans showing clearly the arrangements and details are to be submitted for review.

Hydraulic pumps, actuators, motors and accessories are to be suitable for the intended duty, compatible with the working fluid and are to be designed to operate safely at full power conditions. In general, the hydraulic fluid is to be non-flammable or have a flash point above 157°C (315°F).

The requirements for fuel oil tanks contained in 4-5-4/1.1.2 and 4-5-4/1.3 are applicable to tanks containing hydraulic fluid. See also 4-3-3/7 and 4-3-2/15.

1.3 Valves

1.3.1 General

In general, valves are to comply with the requirements of 4-5-2/9 and 4-5-2/11.

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 4-5-1/5 and 4-5-2/5, except that mill tests need not be witnessed by the Surveyor. In such cases, mill certificates are to be provided which verify the chemical and mechanical properties for the pipe.

1.7 Pipe Fittings

Fittings and flanges are to meet the requirements of 4-5-2/9, 4-5-2/13, and 4-5-2/17, except as follows:

1.7.1 Split Flanges (2004)

Split flanges are not to be used in steering gear systems, certified thruster systems, nor in systems which are vital to the propulsion or safety of the liftboat. Split flanges may be considered for use in other systems. Where split flanges are permitted they are not to be used to join sections of piping, but may be used for connections to machinery provided the materials and construction are suitable for the system design pressure.

1.7.2 Straight-Thread "O"-Ring Connections

Straight-thread "O"-ring type connections may be used for connections to equipment such as pumps, valves, cylinders, accumulators, gages, and hoses. Such connections are not to be used for joining sections of pipe.

1.7.3 Tapered Threaded Connections

Tapered threaded connections up to and including 89 mm O.D. (3 in. NPS) may be used without limitation for connections to equipment such as pumps, valves, cylinders, accumulators, gages, 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 4-5-2/13.1. Such connections are not to be used for joining sections of pipe except where permitted by 4-5-2/13.1.

1.9 Accumulators and Fluid Power Cylinders

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.

Fluid Power Cylinders are to meet the requirements of 4-5-6/3.

1.11 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.

1.13 Segregation of High Pressure Hydraulic Units

Hydraulic units with working pressures above 15.5 bar (15.8 kgf/cm², 225 psi) installed within a machinery space 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 purpose of this requirement, a hydraulic unit includes the power pack and all components of the hydraulic piping system.

3 Fluid Power Cylinders (1 July 2009)

3.1 General

Fluid power cylinders subject to pressures or temperatures greater than those indicated below are to be designed, constructed and tested in accordance with a recognized standard for fluid power cylinders.

- *Hydraulic fluid – flammable*: 7 bar (7.1 kgf/cm², 101.5 psi) or 60°C (140°F)
- *Hydraulic fluid – non-flammable*: 16 bar (16.3 kgf/cm², 232 psi) or 200°C (392°F)
- *Air*: 16 bar (16.3 kgf/cm², 232 psi) or 200°C (392°F)

Acceptance will be based on the manufacturer's certification of compliance and on verification of permanent identification on each cylinder bearing the manufacturer's name or trademark, standard of compliance and maximum allowable working pressure and temperature.

3.3 Non-compliance with a Recognized Standard

Cylinders subject to pressures or temperatures higher than those indicated above which are not constructed to a recognized standard may be accepted based on the following:

- i) Regardless of diameter, the design of the cylinder is to be shown to comply with one of the following:
 - A recognized pressure vessel code,
 - Section 4-4-1 of the *Steel Vessel Rules*. For instance, the cylinder is to have a wall thickness not less than that given by equation 2 of 4-4-1A1/3.1, and the cylinder ends are to meet the requirements of flat heads in 4-4-1A1/5.7, or
 - Verification through burst tests. Steel cylinders (other than cast steel) are to withstand not less than 4 times the maximum allowable working pressure, while cast steel, cast iron and nodular iron cylinders are to withstand not less than 5 times the maximum allowable working pressure.

Documentation in this regard is to be submitted for review.

- ii) Each individual unit is to be hydrostatically tested to 1.5 times the maximum allowable working pressure (2 times, for cast iron and nodular iron cylinders) by the manufacturer. A test certificate is to be submitted.
- iii) Each cylinder is to be affixed with a permanent nameplate or marking bearing the manufacturer's name or trademark and the maximum allowable working pressure and temperature.

3.5 Materials

- i) The materials of the cylinders are to comply with the requirements of the standard or code to which they are designed and constructed. Where the design is verified through burst tests, the materials of the cylinder are to comply with 4-4-1/3 of the *Steel Vessel Rules* or other acceptable standards.
- ii) Ordinary cast iron having an elongation of less than 12% is not to be used for cylinders expected to be subjected to shock loading.
- iii) Copies of certified mill test reports are to be made available to the Surveyor upon request.

3.7 Rudder Actuators

Rudder actuators are to be in accordance with the requirements of 4-3-3/5.11.

3.9 Cylinders below Pressures or Temperatures Indicated in 4-5-6/3.1

Cylinders subject to pressures and temperatures at or below those indicated in 4-5-6/3.1 may be used in accordance with the manufacturer's rating and verification of suitability for the intended service.

3.11 Exemptions (2013)

Fluid power cylinders that do not form part of the liftboat's piping systems, machinery or equipment covered in Part 4 of these Rules are exempt from the requirements of 4-5-6/3. However, those fluid power cylinders which are integrated into piping systems associated with optional classification notations are to comply with the requirements of 4-5-6/3 and the applicable requirements specified in the pertinent ABS Rules and Guides.

5 Pneumatic Systems (2005)

5.1 Application

Requirements of 4-5-6/5 apply to shipboard pneumatic systems for control and actuation services. Requirements for starting air systems are in 4-2-1/13. Pneumatic systems fitted in self-contained equipment not associated with propulsion and maneuvering of the liftboat and completely assembled by the equipment manufacturer need not comply with this Subsection. Such pneumatic systems, however, are to comply with the accepted practice of the industry.

5.3 Pneumatic System Components

5.3.1 Air Reservoirs

The design and construction of all air receivers are to be in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*.

5.3.2 Pipe Fittings and Joints

The piping system and its components are to be in accordance with the applicable requirements of Part 4, Chapter 5 of this Guide.

5.5 Pneumatic System Requirements

5.5.1 Pneumatic Air Source

Compressed air for general pneumatic control and actuation services may be drawn from engine starting air reservoirs. In which case, the aggregate capacity of the starting air reservoirs is to be sufficient for continued operation of these services after the air necessary for the required number of engine starts (as specified in 4-2-1/13.3.1) has been used.

For propulsion remote control purposes, pneumatic air is to be available from at least two air compressors. The starting air system, where consisting of two air compressors, may be used for this purpose. The required air pressure is to be automatically maintained. Pneumatic air supplies to safety and control systems may be derived from the same source but are to be by means of separate lines.

5.5.2 Air Quality (2010)

5.5.2(a) General. Provisions are to be made to minimize the entry of oil or water into the compressed air system. Suitable separation and drainage arrangements are to be provided before the air enters the reservoirs.

5.5.2(b) Safety and Control Air Systems. For requirements regarding the quality of the air supplied to safety and control air systems, see 4-7-2/11.1.4 of the *Under 90m Rules*.

5.5.3 Overpressure Protection

Means are to be provided to prevent overpressure in any part of the pneumatic system. This includes the water jackets or casings of the air compressors and coolers which may be subjected to dangerous over-pressure due to leakage into them from the air pressure parts.

CHAPTER 5 Pumps and Piping Systems

SECTION 7 Other Piping Systems and Tanks

1 Fuel Storage and Refueling Systems for Helicopter Facilities

1.1 Fuels with Flash Point Above 60°C (140°F)

When fixed helicopter fuel storage and pumping systems are provided and the flash point of the fuel is above 60°C (140°F) closed cup test, the installation is to comply with 4-5-4/1, 4-5-4/3 and 4-5-7/1.3.5.

1.3 Fuels with Flash Point at or Below 60°C (140°F) – Installations on an Open Deck

1.3.1 General

The designated fuel storage and refueling areas are to be suitably isolated from areas which contain a source of vapor ignition, escape routes and embarkation stations and are not to be located on landing areas. The storage and refueling areas are to be permanently marked as an area where smoking and open flames are not permitted.

1.3.2 Tanks

Fixed fuel storage tanks are to be of metal construction. Mounting, securing arrangements, and electrical bonding of the storage tank and refueling system are to be approved.

1.3.3 Vents and Sounding

Fuel storage tank venting and sounding arrangements are to comply with 4-5-3/9.5, 4-5-3/9.7, 4-5-4/7.3 and 4-5-3/13.

1.3.4 Tank Valves

Fuel storage tank outlet valves are to be provided with a means of remote closure. Means are also to be provided for remote shutdown of the refueling pumps.

1.3.5 Spill Containment (2013)

To contain spillage and retain fire extinguishing agents, a coaming of at least 150 mm (6 in.) in height is to be provided. The coaming is to surround the fuel storage area which consists of the fuel tank, associated piping and any pumping unit adjacent to the storage tank. Where the pumping unit is remote from the tank, a separate coaming is to be provided around the pumping unit.

Drainage is to be provided for the area enclosed by the coaming complying with the following:

- i) The area within the coaming is to be sloped toward the drain line.
- ii) Drainage from the area within the coaming is to be led through a valve designed for selective output (e.g., 3-way valve) either to a holding tank complying with 4-5-7/1.3.2 and 4-5-7/1.3.3 above or directly overboard. No other valves may be fitted in the drain line.
- iii) The cross sectional area of the drain line from the fuel tank coaming is to be at least twice that of the fuel storage tank outlet connection.

Fuel tank coamings not provided with drainage arrangements in accordance with the above are to be sized to contain the full volume of the fuel storage tank plus 150 mm (6 in.) of foam.

1.3.6 Electrical Equipment (2008)

All electrical equipment installed within 3 meters (10 ft) of either the tank vent outlet or the pumping/refueling equipment is to be of a certified safe type. Electrical equipment installed may be any of the types indicated in 4-7-3/9.1.1 and is to be IEC Publication 60079 group IIA class T3.

1.5 Fuels with Flash Points at or Below 60°C (140°F) – Installation Within Enclosed Spaces

1.5.1 Independent Tanks

Fuel storage tanks and their venting and sounding arrangements are to comply with 4-5-7/1.3.2 and 4-5-7/1.3.3. The valving arrangements on the tanks are to comply with 4-5-4/3.7.

1.5.2 Integral Tanks

The venting and sounding arrangements for integral tanks are to comply with 4-5-7/1.3.3. Overflow and valving arrangements are to comply with 4-5-3/11 and 4-5-4/3.7, respectively. Cofferdams meeting the requirements of 5C-2-1/5.3 of the *Steel Vessel Rules* are to be provided to separate fuel tanks from the spaces mentioned therein.

1.5.3 Access Arrangements

The access to the fuel storage and refueling compartment is to be from the open deck by means of a trunk, if necessary. The compartment is to be bounded by gas tight bulkheads/decks and there is to be no direct access from any other compartment to the fuel storage and refueling compartment or access trunk.

1.5.4 Electrical Equipment (2008)

Electrical equipment installed in the refueling pump room and the space in which an independent helicopter fuel tank storage is located is to be of a certified safe type. All electrical equipment installed within three (3) meters (10 ft) of the tank vent outlet is to be of a certified safe type. Electrical equipment installed may be any of the types indicated in 4-7-3/9.1.1 and is to be IEC Publication 60079 group IIA class T3.

1.5.5 Pumps

Fuel pumps for helicopter refueling are to comply with 4-4-7/1 of the *Under 90m Rules* and are to be provided with remote shut-down.

1.5.6 Piping

Helicopter refueling piping systems are to comply with 4-4-7/3.1 of the *Under 90m Rules*.

1.5.7 Bilge/Drainage System

Provision is to be made for drainage of the refueling pump room and cofferdams. A separate bilge pump, ejector or a bilge suction from a refueling pump may be provided for this purpose. The arrangements are to be in accordance with 4-4-7/5.1 of the *Under 90m Rules*.

1.5.8 Ventilation

Systems for the refueling pump room and the space in which an independent helicopter fuel tank is located are to comply with 4-6-6/1.13.1 of the *Under 90m Rules*.

3 Fixed Oxygen-Acetylene Installations

3.1 Application (2005)

Provisions of 4-5-7/3 apply to fixed oxygen-acetylene installations that have two or more cylinders of oxygen and acetylene respectively. Spare cylinders of gases need not be counted for this purpose. Provisions of 4-5-7/3.5 and 4-5-7/3.7, as applicable, are to be complied with for fixed installations regardless of the number of cylinders.

3.3 Gas Storage

3.3.1 Storage of Gas Cylinders

3.3.1(a) Storage room. The gas cylinders are to be stored in rooms dedicated for this purpose only. A separate room is to be provided for each gas. The rooms are to be on or above the upper-most continuous deck and are to be constructed of steel. Access to the rooms is to be from the open deck and the door is to open outwards. The boundaries between the rooms and other enclosed spaces are to be gastight. Suitable drainage of the storage room is to be provided.

3.3.1(b) Open area. Where no storage room is provided, the gas cylinders may be placed in an open storage area. In such cases, they are to be provided with weather protection (particularly from heavy seas and heat) and effectively protected from mechanical damage. Suitable drainage of the open storage area is to be provided.

3.3.1(c) Piping passing through storage room or area. Piping systems containing flammable fluids are not to run through the storage room or open storage area

3.3.2 Ventilation of Storage Room

Gas cylinder storage rooms are to be fitted with ventilation systems capable of providing at least six air changes per hour based on the gross volume of the room. The ventilation system is to be independent of ventilation systems of other spaces. The space within 3 m (10 ft) from the power ventilation exhaust, or 1 m (3 ft) from the natural ventilation exhaust is to be considered a hazardous area. The fan is to be of the non-sparking construction, see 4-7-3/9.7. Small storage spaces provided with sufficiently large openings for natural ventilation need not be fitted with mechanical ventilation.

3.3.3 Electrical Installation in Storage Room (2008)

Electrical equipment installed within the storage room, including the ventilation fan motor, is to be of the certified safe type. Electrical equipment installed within the storage room may be any of the types indicated in 4-7-3/9.1.1 and is to be IEC Publication 60079 group IIC class T2.

3.5 Piping System Components

3.5.1 Pipe and Fittings

3.5.1(a) General (2011). In general, all oxygen and acetylene pipes, pipe fittings, pipe joints and valves are to be in accordance with the provisions of Section 4-5-2 for Group I piping systems, except as modified below. Further, only high pressure oxygen and acetylene piping is to be certified as Group I piping, see 4-5-1/5.1 for the materials testing.

3.5.1(b) Piping Materials (2010). Materials for acetylene on the high-pressure side between the cylinders and the regulator are to be steel. Copper or copper alloys containing more than 65% copper are not to be used in acetylene piping (high or low pressure). Materials for oxygen on the high-pressure side are to be steel or copper. All pipes, both high- and low-pressure sides, are to be seamless.

3.5.1(c) Design Pressure (2006). Pipes, pipe fittings and valves on the oxygen high-pressure side are to be designed for not less than 207 bar (211 kgf/cm², 3000 psi). Pipes used on the low-pressure side are to be at least of standard wall thickness.

3.5.1(d) Pipe Joints. All pipe joints outside the storage room or open storage area are to be welded.

3.5.1(e) Flexible Hoses (2009). Flexible hoses used to connect oxygen or acetylene gas cylinders to a fixed piping system or manifold are to comply with an acceptable standard and be suitable for the intended pressure and service. Further, the internal surface of a hose used to connect an acetylene tank is to be of a material that is resistant to acetone and dimethylformamide decomposition*.

Where a flexible hose is connected from an oxygen cylinder to the piping system or manifold directly (i.e. no intervening pressure regulator), the internal liner of the oxygen hose is to be of a material that has an autoignition temperature of not less than 400°C (752°F) in oxygen*.

* *Note:* Criteria based on ISO 14113:1997 Gas welding equipment – rubber and plastic hoses assembled for compressed or liquefied gases up to a maximum design pressure of 450 bar

3.5.2 Pressure Relief Devices

Pressure relief devices are to be provided in the gas piping if the maximum design pressure of the piping system can be exceeded. These devices are to be set to discharge at not more than the maximum design pressure of the piping system to a location in the weather remote from sources of vapor ignition or openings to spaces or tanks. The area within 3 m (10 ft) of the pressure relief device discharge outlet is to be regarded as a hazardous area. The pressure relief devices may be either a relief valve or a rupture disc.

3.5.3 System Arrangements

Where two or more gas cylinders are connected to a manifold, high pressure piping between each gas cylinder and the manifold is to be fitted with a non-return valve. The piping is not to run through unventilated spaces or accommodation spaces. Outlet stations are to be fitted with shut-off valves. Outlet stations are to be provided with suitable protective devices to prevent back flow of gas and the passage of flame into the supply lines.

3.5.4 Gas Cylinders

Gas cylinders are to be designed, constructed and certified in accordance with the provisions of 4-4-1/1.11.4 of the *Steel Vessel Rules*. Each cylinder is to be fitted with a suitable pressure relief device such as a fusible plug or a rupture disc.

The area within 3 m (10 ft) of the pressure relief device discharge outlet is to be regarded as a hazardous area.

3.7 Testing (2006)

Piping on the oxygen high-pressure side is to be tested before installation to at least 207 bar (211 kgf/cm², 3000 psi) and the piping on the acetylene high-pressure side is to be tested in accordance with Section 4-5-2.

The entire system is to be leak-tested with nitrogen or a suitable inert gas after installation. Care is to be taken to cleanse the piping with suitable medium to remove oil, grease and dirt and to blow-through with oil-free nitrogen or other suitable medium before putting the system in service. The system is to be operationally tested in the presence of the Surveyor under working conditions after installation.

CHAPTER 6 Fire Extinguishing Systems

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PART

4

CHAPTER 6 Fire Extinguishing Systems

SECTION 1 All Liftboats

1 General

1.1 Classification Requirements

The following are the minimum classification requirements for all self-propelled oceangoing liftboats under 90 meters (295 feet) in length. For liftboats classed with restricted service, the requirements may be modified and the proposed fire extinguishing arrangements are to be submitted for consideration.

1.3 Governmental Authority

Attention is directed to the appropriate governmental authority. In each case there may be additional requirements depending on the gross tonnage, length, type and intended service of the liftboat 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 of the country in which the liftboat is to be registered.

1.5 Automated Propulsion Machinery Spaces

Where automatic controls for propulsion machinery spaces are installed and it is intended that the propulsion machinery spaces are either not continuously manned at sea or only one person is required on watch, the requirements of Part 4, Chapter 7 of the *Under 90m Rules* are to be met.

1.7 Plans and Specifications

The plans together with supporting data and particulars listed in 4-1-1/7 are to be submitted for review.

1.9 Fire Control Plans

1.9.1 Required Information

Fire control plans are to be general arrangement plans showing for each deck the provision, location, controls and particulars, as applicable, of fixed fire detection, alarm and extinguishing systems, portable fire fighting appliances and equipment, controls for shutdowns of the ventilation system, fuel oil pumps and valves, along with details of the means provided for the closing of openings, and locations of accesses to critical spaces (such as fire control stations, Category A machinery spaces, etc.). For liftboats where structural fire protection is required by the Rules, locations and type of fire retarding bulkheads are to be specified on the plan.

1.9.2 Plan Location

The fire control plans are to be conspicuously posted in the liftboat for the guidance of the crew.

1.11 Additional Fixed Fire Fighting Systems (2009)

Where a fixed fire extinguishing system not required by Sections 4-6-2 and 4-6-3 is installed, such system is to meet the applicable requirements of 4-6-2/11 and is to be submitted for approval.

3 Fire Pumps, Fire Main, Hydrants and Hoses

3.1 Materials

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.

3.3 Fire Pumps

3.3.1 Number of Pumps

All liftboats are to have at least two fire pumps, one of which is to be available for use on the fire system at all times. Refer to 4-6-2/5 for liftboats of 500 gross tons or over, or 4-6-3/1 for liftboats under 500 gross tons.

3.3.2 Type of Pumps

Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil. If the pumps are subject to occasional duty for the transfer or pumping of fuel oil, change over arrangements that prevent operation for fire fighting when configured for fuel transfer are to be fitted.

3.3.3 Pressure

Power-driven fire pumps are to have sufficient pressure to produce 12 m (40 ft.) jet throw through any two adjacent hydrants located in accordance with 4-6-1/3.7.1. Also refer to 4-6-2/5.1 or 4-6-3/1.

3.3.4 Relief Valves

In conjunction with all fire pumps, relief valves are to be provided if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system. In general, the relief valve is to be set to relieve at no greater than 1.7 bar (1.75 kgf/cm², 25 psi) in excess of the pump pressure necessary to maintain the requirements of 4-6-1/3.3.3.

3.3.5 Intermediate Tank Water Supply (2009)

Where intermediate tanks are used to maintain a constant supply of water to the fire pump suction, the following requirements apply.

3.3.5(a) Tank Capacity. The intermediate tanks are to be of such size and automatically maintained so that the lowest water level permitted will assure that the supply of water is adequate for two hoses at a minimum of 3.5 bar (3.5 kgf/cm², 50 psi). Pitot pressure at the uppermost hydrant for at least 15 minutes, with minimum tank capacity of 10,000 liters (2,640 gallons).

3.3.5(b) Features. The following features are to be incorporated in a system using an intermediate tank:

- i) A low water level alarm;
- ii) Two means to replenish water in the intermediate tank are to be provided. Each pump is to be arranged to deliver at least the amount of water expended under the conditions of 4-6-1/3.3.3. At least one of the replenishment pumps is to be arranged for automatic operation. The arrangement of such pumps is to comply with 4-6-1/3.3.1.
- iii) If the liftboat is intended to operate where the atmospheric temperature is expected to be 0°C (32°F) or less, the entire fire-fighting system, including tanks used as water reservoirs, is to be protected from freezing

3.5 Fire Main

3.5.1 Size

Refer to 4-6-2/3 for liftboats of 500 gross tons and over. For liftboats under 500 gross tons, the diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from the pump(s). Refer to 4-6-3/1 and 4-6-3/Table 1.

3.5.2 Cocks or Valve

A valve is to be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work.

3.5.3 Cold Weather Protection

Fire main systems are to be provided with drains, circulation loops or other means for cold weather protection.

3.7 Hydrants

3.7.1 Number and Position of Hydrants

The number and position of the hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the liftboat normally accessible to the passengers or crew while the liftboat is being navigated. In addition, the arrangements are to be such that at least two jets of water can reach any part of any space.

3.7.2 Materials

Materials readily rendered ineffective by heat are not to be used for fire protection systems unless adequately protected. See 4-6-1/3.1.

3.7.3 Installation

The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. In liftboats 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 to avoid risk of damage by such cargo.

3.9 Hoses (2009)

3.9.1 General

Fire hoses are to be of a type certified by a competent independent testing laboratory as being constructed of non-perishable material to a recognized standard. 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.

Fire hoses are to have a length of at least 10 m (33 ft), but not more than:

- 15 m (50 ft) in machinery spaces;
- 20 m (66 ft) in other spaces and open decks; and
- 25 m (82 ft) for open deck on liftboats with a maximum breadth in excess of 30 m (98 ft)

Each hose is to have a nozzle and the necessary couplings. Fire hoses together with any necessary fittings and tools are to be kept ready for use in conspicuous positions near the hydrants.

3.9.2 Diameter

For liftboats less than 500 gross tons, hoses are not to have a diameter greater than 38 mm (1.5 in.).

Hoses for liftboats under 20 m (65 ft) in length may be of a good commercial grade having a diameter of not less than 16 mm ($\frac{5}{8}$ in.) and are to have a minimum test pressure of 10.3 bar (10.5 kgf/cm², 150 psi) and a minimum burst pressure of 31.0 bar (31.6 kgf/cm², 450 psi).

3.9.3 Number of Fire Hoses

In liftboats of 1,000 gross tonnage and upwards, the number of fire hoses to be provided is to be at least one for each 30 m (100 ft) length of the liftboat and one spare, but in no case less than five in all. This number does not include any hoses required in any engine or boiler room.

In liftboats of less than 1,000 gross tonnage, the number of fire hoses to be provided is to be at least one for each 30 m (100 ft) length of the liftboat and one spare. However, the number of hoses is to be in no case less than three.

Unless one hose and nozzle is provided for each hydrant in the liftboat, there are to be complete interchangeability of hose couplings and nozzles.

3.11 Nozzles

3.11.1 Size

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. Larger diameter nozzles may be permitted subject to compliance with 4-6-1/3.3.3. 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 pressure mentioned in 4-6-1/3.3.3 from the smallest pump; however, a nozzle size greater than 19 mm (0.75 in.) need not be used.

3.11.2 Type

All nozzles are to be of an approved dual-purpose type (i.e., spray and jet type) incorporating a shut-off. 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.

5 Means for Closing of Openings, Stopping of Machinery and Oil Containment

5.1 Ventilation Fans and Openings

Means are to be provided for stopping ventilation 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 operated from outside such spaces in case of fire. See 4-7-2/19.1.1.

5.3 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 4-7-2/19.1.2.

In addition to the remote shutdowns required above, a means to shut down the equipment is to be provided within the space itself.

5.5 Oil Tank Suction Pipes

Except for small independent tanks, having a capacity less than 500 liters (132 gal.) every oil suction pipe from a storage, settling, daily service tank or lube oil tank situated above the double bottom is to be fitted with a valve capable of being closed from outside the space where such tanks are located in the event of a fire. In the special case of deep tanks situated in any shaft or pipe tunnel, control may be effected by means of an additional valve on the pipeline outside the tunnel. See 4-5-4/3.7.

Where inadvertent valve closure could result in damage to the running machinery due to lack of lubricating-oil, a valve is to be fitted on the lubricating oil tank, but remote control of the valve from outside the space is not required. See 4-5-4/1.1.

7 Helicopter Facilities (2005)

7.1 Application

For each helicopter deck on board a liftboat designated for helicopter operations, fire fighting system and equipment complying with 4-6-1/7.3.2 and 4-6-1/7.3.3, as applicable, are to be provided.

Helicopter deck (helideck) is a purpose-built helicopter landing area, on a liftboat including all structure, fire fighting appliances and other equipment necessary for the safe operation of helicopters, but not those areas for occasional or emergency helicopter operations (e.g., circle H marked on hatch covers for drop-off/pickup of pilot). Helicopter facility is a helideck including any refueling and hangar facility.

7.3 Provisions for Helicopter Deck

7.3.1 Hoses and Nozzles

At least two combination solid stream and water spray nozzles and hoses sufficient in length to reach any part of the helicopter deck are to be provided.

7.3.2 Portable Extinguishers

The helicopter deck is to be protected by at least two dry powder extinguishers of a total capacity of not less than 45 kg (100 lb).

7.3.3 Back-up System

A back-up fire fighting system is to be provided consisting of CO₂ extinguishers of a total capacity of not less than 18 kg (40 lb) or equivalent, one of these extinguishers being equipped so as to enable it to reach the engine area of any helicopter using the helicopter deck. The back-up system is to be located so that the equipment would not be vulnerable to the same damage as the dry powder extinguisher required by 4-6-1/7.3.2.

7.3.4 Fixed Foam System

A suitable fixed foam fire extinguishing system, consisting of monitors or hose streams or both, is to be installed to protect the helicopter landing area in all weather conditions in which helicopters can operate. The system is to be capable of delivering foam solution at a discharge rate in accordance with the following table for at least five minutes. The operation of the foam system is not to interfere with the simultaneous operation of the fire main.

Category	Helicopter Overall Length, L_H	Discharge Rate	
		Liters/min.	gpm
H1	$L_H < 15 \text{ m (49 ft)}$	250	66
H2	$15 \text{ m (49 ft)} \leq L_H < 24 \text{ m (79 ft)}$	500	132
H3	$24 \text{ m (79 ft)} \leq L_H < 35 \text{ m (115 ft)}$	800	211

The foam agent is to meet the performance standards for Level B foam in the International Civil Aviation Organization's Airport Services Manual (Part 1 Chapter 8, Paragraph 8.1.5, Table 8-1) and be suitable for use with sea water.

7.3.5 Fireman's Outfits

In addition to the fireman's outfits required in 4-6-2/15, two additional sets of fireman's outfits are to be provided and stored near the helicopter deck.

7.3.6 Other Equipment

The following equipment is to be provided near the helicopter deck and is to be stored in a manner that provides for immediate use and protection from the elements:

- Adjustable wrench
- Fire resistant blanket

- Bolt cutters with arm length of 60 cm (24 in.) or more
- Grab hook or salving hook
- Heavy duty hack saw, complete with six spare blades
- Ladder
- Lifeline of 5 mm ($\frac{3}{16}$ in.) diameter $\times$ 15 m (50 ft) length
- Side cutting pliers
- Set of assorted screw drivers
- Harness knife complete with sheath

7.5 Provisions for Enclosed Helicopter Facilities

Hangars, refueling and maintenance facilities are to be treated as machinery space of category A with regard to structural fire protection, fixed fire-extinguishing system and fire detection system requirements. See 4-6-2/11 and 4-6-2/21.

7.7 Operation Manual

Each helicopter facility is to have an operation manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the liftboat's emergency response procedures.

9 Portable Extinguishers

Portable extinguishers are to be provided in the quantities and locations indicated in 4-6-1/Table 1 and 4-6-1/Table 2.

11 Paint and Flammable Liquid Lockers

Paint and flammable liquid lockers or any similar service spaces used for the storage of flammable liquids (such as solvents, adhesives, lubricants, etc.) are to be protected by a fire extinguishing arrangement enabling the crew to extinguish a fire without entering the space. Unless required or permitted otherwise by the flag Administration, one of the following systems is to be provided:

11.1 Lockers of 4 m² (43 ft²) or More Floor Area and Lockers with Access to Accommodation Spaces

Paint lockers and flammable liquid lockers of floor area 4 m² (43 ft²) or more and also such lockers of any floor area with access to accommodation spaces are to be provided with one of the fixed fire extinguishing systems specified below:

- CO₂ system, designed for 40 % of the gross volume of the space.
- Dry powder system, designed for at least 0.5 kg/m³ (0.03 lb/ft³).
- Water spraying system, designed for 5 liters/m²/minute (0.12 gpm/ft²). The water spraying system may be connected to the liftboat's fire main system, in which case the fire pump capacity is to be sufficient for simultaneous operation of the fire main system as required in 4-6-2/5.1 and the water spray system. Precautions are to be taken to prevent the nozzles from being clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.
- Systems or arrangements other than those referenced above may be also considered, provided they are not less effective.

11.3 Lockers of Less Than 4 m² (43 ft²) Floor Area Having no Access to Accommodation Spaces

For paint lockers and flammable liquid lockers of floor area less than 4 m² (43 ft²) having no access to accommodation spaces, portable fire extinguisher(s) sized in accordance with 4-6-1/9 and which can be discharged through a port in the boundary of the lockers may be accepted. The required portable fire extinguishers are to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided for this purpose to facilitate the use of water from the fire main.

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 size I is the smallest. Sizes I and II are hand portable extinguishers and sizes III and V are semi-portable extinguishers.

Classification		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	V	—	152 (40)	45 (100) ⁽²⁾	22.5 (50) ⁽²⁾
C	I	—	—	1.8 (4)	0.9 (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 Extinguishers (1 July 2009)

Space	Classification	Quantity and Location ⁽⁵⁾
Safety Areas		
Communicating corridors	A-II	1 in each main corridor not more than 46 m (150 ft) apart. (May be located in stairways.)
Pilothouse	C-II	2 in vicinity of exit. See Note 4.
Radio room	C-II	1 in vicinity of exit. See Note 4.
Accommodations		
Sleeping Accommodations	A-II	1 in each sleeping accommodation space. (Where occupied by more than four persons.)
Service Spaces		
Galleys	B-II or C-II	1 for each 230 m ² (2500 ft ²) or fraction thereof for hazards involved.
Storerooms	A-II	1 for each 230 m ² (2500 ft ²) or fraction thereof located in vicinity of exits, either inside or outside of spaces. See Note 4.
Workshops	A-II	1 outside the space in vicinity of exit. See Note 4.
Machinery Spaces		
Internal combustion or gas turbine-engines	B-II and B-III	1 for each 746 kW (1000 hp), but not less than 2 nor more than 6. See Note 1. 1 required. See Note 3.
Electric motors or generators of the open type	C-II	1 for each motor or generator unit. See Note 2.

Notes:

- 1 When installation is on weather deck or open to atmosphere at all times, one B-II for every three engines is allowable.
- 2 Small electrical appliances, such as fans, etc., are not to be counted or used as basis for determining number of extinguishers required.
- 3 Not required on liftboats of less than 500 gross tons.
- 4 Vicinity is intended to mean within 1 m (3 ft).
- 5 For liftboats of 1000 gross tons and above, at least five extinguishers are to be provided for accommodation spaces, service spaces, spaces where the liftboat's radio, main navigation equipment or emergency source of power is located, and locations where the fire recording or fire control equipment is located.

CHAPTER 6 Fire Extinguishing Systems

SECTION 2 Requirements for Liftboats 500 Gross Tons and Over

1 Fire Safety Measures

The applicable requirements of Section 3-4-1 of the *Under 90m Rules* are to be complied with.

3 Size of Fire Main

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously except that the diameter need only be sufficient for the discharge of 140 m³/hr (616 gpm).

5 Main and Emergency Fire Pumps

5.1 Main Fire Pumps

5.1.1 Number of Pumps

For liftboats of 1000 gross tons and above, the pumps are to be independently power-driven. For liftboats less than 1000 gross tons, only one of the pumps need be independently power-driven and one of the pumps may be attached to the propulsion unit.

5.1.2 Total Pump Capacity

The fire pumps required by 4-6-2/5.1.1 are to be capable of delivering for fire-fighting purposes a quantity of water, at the appropriate pressure prescribed, not less than four-thirds of the quantity required under 4-5-3/3.3 to be dealt with by each of the independent bilge pumps when employed on bilge pumping, using in all cases L = length of liftboat as defined in 3-1-1/1.1.1, except that the total required capacity of the fire pumps need not exceed 180 m³/hr (792 gpm).

5.1.3 Individual Pump Capacity

Each of the fire pumps required by 4-6-2/5.1.1 is to have a capacity of not less than 40% of the total required capacity but not less than 25 m³/hr (110 gpm) and in any event is to be capable of delivering at least the two required jets of water. These pumps are to be capable of supplying the water under the required conditions. Where more pumps than required are installed, their capacity will be subject to special consideration.

5.1.4 Pressure

For liftboats 1000 gross tons and over, with the two power-driven pumps simultaneously delivering through the nozzles specified in 4-6-1/3.11 the quantity of water specified in 4-6-1/3.5.1, through any adjacent hydrants, a pressure of 2.5 bar (2.6 kgf/cm², 37 psi) is to be maintained at all hydrants.

For liftboats less than 1000 gross tons, the power-driven fire pumps are to have sufficient pressure to produce 12 m (40 ft) jet throw through any two adjacent hydrants located in accordance with 4-6-1/3.5.1.

5.1.5 Arrangement

Unless an emergency fire pump complying with 4-6-2/5.3 is provided, the two main fire pumps including their power source, fuel supply, electric cables, and lighting and ventilation for the spaces in which they are located are to be in separate compartments so that a fire in any one compartment will not render both main pumps inoperable. Only one common boundary is allowed between the compartments in which case the single common boundary is to be at least to A-0 standard.

No direct access is allowed between the compartments except that where this is impracticable, an access meeting the requirements in 4-6-2/5.1.6 may be considered.

5.1.6 Alternative Arrangement

Where it is impracticable to do otherwise, a direct access between the compartments containing the main fire pumps may be considered provided:

- i) A watertight door capable of being operated locally from both sides of the bulkhead, and from a safe and accessible location outside of these spaces is provided. The means for the latter operation is expected to be available in the event of fire in these spaces; or
- ii) An air lock consisting of two gastight steel doors. The doors are to be self-closing without any hold back arrangements.
- iii) In addition to the arrangements specified in 4-6-2/5.1.6i) or 4-6-2/5.1.6ii) above, a second protected means of access is to be provided to the space containing the fire pumps.

5.1.7 Isolation

Isolating valves and other arrangements, as necessary, are to be provided so that if a fire pump and its associated piping within its compartment are rendered inoperable, the fire main can be pressurized with a fire pump located in another compartment.

5.3 Emergency Fire Pumps

5.3.1 When required

If a fire in any one compartment could put all main pumps out of action (see 4-6-2/5.1.2) an independently power-driven and self-priming emergency fire pump complying with this Paragraph is to be provided.

5.3.2 Arrangement

An emergency fire pump system, including power source, fuel supply, electric cables, and lighting, as well as lighting and ventilation for the emergency fire pump space is to be in a separate compartment than the main fire pumps so that a fire in any one compartment will not render both the main and the emergency fire pumps inoperable.

No direct access is permitted between the main machinery space and the spaces containing the emergency fire pump and its source of power. Where this is impracticable, access between the space containing the emergency fire pump and the main machinery space in accordance with 4-6-2/5.1.6 may be considered

The space containing the emergency fire pump is not to be contiguous to the boundaries of machinery spaces of Category A or the spaces containing the main fire pumps. Where this is impracticable, the common bulkhead between the two spaces is to be constructed to A-60 standard. The insulation is to extend at least 450 mm (18 in.) outside the area of the joint bulkheads and decks.

5.3.3 Capacity

The emergency fire pump is to be capable of supplying at least two jets of water required by 4-6-1/3.5.1 using the available hydrants, hoses and nozzles and is to have a capacity of at least 40% of the total capacity of the fire pumps required by 4-6-2/5.1.2 or 25 m³/hr (110 gpm) whichever is greater.

When the pump is delivering the quantity of water, as above, the pressure at the hydrant is to be not less than the pressure given in 4-6-2/5.1.4.

In addition, the emergency fire pump is also to be capable of supplying simultaneously the amount of water needed for any fixed extinguishing system protecting the space containing the main pumps.

5.3.4 Starting

Internal combustion engines larger than 15 kW (20 hp) are to be provided with power starting systems having a capacity sufficient for at least six starts within 30 minutes including at least two within the first ten minutes. For engines of 15 kW (20 hp) and smaller, manual means of starting is sufficient.

Any internal-combustion engine driving an emergency fire pump is to be capable of readily being started in its cold condition down to a temperature of 0°C (32°F). If this is impracticable, or if lower temperatures are likely to be encountered, consideration is to be given to the provision and maintenance of heating arrangements.

5.3.5 Fuel Supply

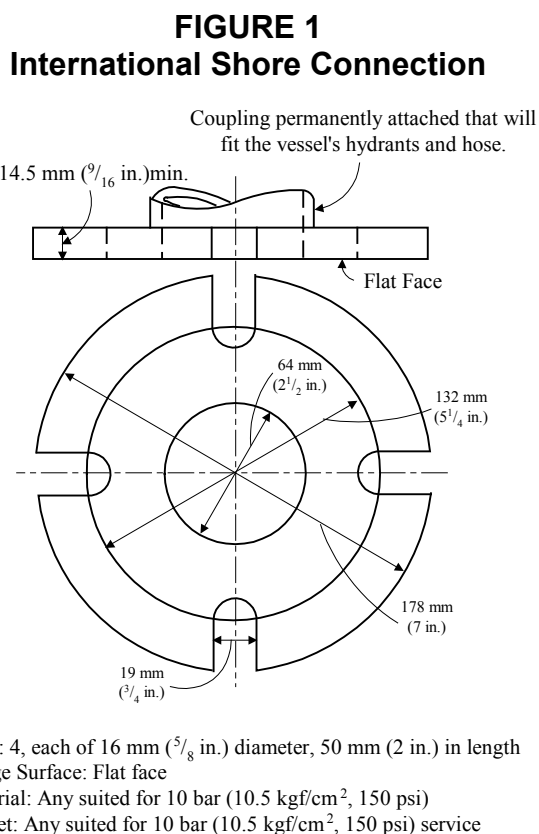
Any service fuel tank is to contain sufficient fuel to enable the pump to run on full load for at least three hours and sufficient reserves of fuel are to be available outside the main machinery space to enable the pump to be run on full load for an additional 15 hours.

5.3.6 Suction

The total suction head and the net positive suction head of the pump is to be such that the requirements of 4-6-2/5.3.3 and 4-6-2/5.1.4 will be satisfied under all conditions of list, trim, roll and pitch likely to be encountered in service. The sea valve is to be operable from a position near the pump or locked in the open position (provided possible flooding can be detected).

7 International Shore Connection

At least one international shore connection as shown in 4-6-2/Figure 1 is to be provided kept aboard the liftboat with gasket, bolts and eight washers. Facilities are to be available enabling such a connection to be used on either side of the liftboat.



9 Machinery Spaces

Category A machinery spaces are to be protected by a fixed fire extinguishing system complying with 4-6-2/11.

9.1 Fixed Local Application Fire-fighting Systems

For liftboats of 2000 gross tonnage and above, the machinery spaces of category A above 500 m³ (17,657 ft³) in volume, in addition to the fixed fire-extinguishing system required in 4-6-2/11, are to be protected by an approved type of fixed water-based or equivalent local application fire-fighting system complying with the provisions of the IMO Guidelines for the Approval of Fixed Water-based Local Application Fire-fighting System for Use in Category A Machinery Spaces, MSC/Circ. 913. In the case of periodically unattended machinery spaces, the fire fighting system is to have both automatic and manual release capabilities. In case of continuously manned machinery spaces, the fire-fighting system is only required to have a manual release capability. The fixed local fire-fighting systems are to protect areas such as the following without the necessity of engine shutdown, personnel evacuation, or sealing the spaces:

- i) The fire hazard portion of internal combustion machinery used for the liftboat's main propulsion and power generation and, if provided;
- ii) The fire hazard portions of incinerators; and
- iii) Boiler front.

Activation of any local application system shall give a visual and distinct audible alarm in the protected space and at continuously manned stations. The alarm is to indicate the specific system activated. The system alarm requirements described within this Paragraph are in addition to, and not a substitute for, the detection and fire alarm system required in elsewhere in Sections 4-6-2 and 4-6-3.

9.3 Segregation of Purifiers for Heated Fuel Oil

Fuel oil purifiers for heated oil are to be placed in separate room or rooms, enclosed by steel bulkheads extending from deck to deck and provided with self-closing doors. In addition, the room is to be provided with the following:

- i) Independent mechanical ventilation or ventilation arrangement that can be isolated from the machinery space ventilation, of the suction type.
- ii) Fire detection system.
- iii) Fixed fire-extinguishing system capable of activation from outside the room. The extinguishing system is to be dedicated to the room but may be a part of the fixed fire extinguishing system for the machinery space.

However, for the protection of purifiers on liftboats of 2000 gross tonnage and above located within a machinery space of category A above 500 m³ (17,657 ft³) in volume, the above referenced fixed dedicated system is to be a fixed water-based or equivalent, local application fire-extinguishing system complying with the provisions of 4-6-2/9.1. The system is to be capable of activation from outside the purifier room. In addition, protection is to be provided by the fixed fire-extinguishing system covering the Category A machinery space in which the purifier room is located, see 4-6-2/11.

- iv) Means of closing ventilation openings and stopping the ventilation fans, purifiers, purifier-feed pumps, etc. 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 with regard to location, containment of possible leakage, shielding and ventilation. In such cases, a local fixed water-based fire-extinguishing system complying with the provisions of 4-6-2/9.1 is to be provided. Where, due to the limited size of the category A machinery space, a local fixed water-based fire-extinguishing system is not provided, than an alternative type of local dedicated fixed fire-extinguishing system is to be provided for the protection of the purifiers. In either case, the local fire extinguishing system is to activate automatically or manually from the centralized control station or other suitable location. If automatic release is provided, additional manual release is also to be arranged.

11 Fixed Fire Extinguishing Systems

11.1 Gas Smothering

11.1.1 Storage (2013)

Where the gas smothering medium is stored outside the protected space, the storeroom is to be situated in a safe and readily accessible position and is to be effectively ventilated by a ventilation system independent of all other spaces.

Spaces for storage of cylinders or tanks for extinguishing gas are not to be used for other purposes. These spaces are not to be located forward of the forward collision bulkhead, when fitted. Access to these spaces is to be possible from the open deck. Spaces situated below the deck are to be located no more than one deck below the open deck.

Spaces where entrance from the open deck is not provided or which are located below deck are to be fitted with mechanical ventilation. The exhaust duct (suction) is to be lead to the bottom of the space. Such spaces are to be ventilated with at least 6 air changes per hour.

Fire-extinguishing media protecting the cargo holds (see 4-6-2/27) 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.

11.1.2 Design (2013)

Containers and associated pressure components are to be designed based upon an ambient temperature of 55°C (131°F).

For CO₂ fire extinguishing systems, the wall thickness of steel piping is to be suitable for the pressure and not less than the thickness identified in 4-6-2/Table 1. Column A is for piping from storage containers to distribution station, and column B is for piping from distribution station to nozzles. For other fixed gas fire extinguishing systems, calculations showing compliance with 4-5-2/5.9 are to be submitted for approval.

Where the fire-extinguishing medium is used as the power source for the pre-discharge alarm, the piping to the alarm is to comply with Column B of 4-6-2/Table 1.

The relief valve of a CO₂ fire extinguishing system is to discharge outside of the CO₂ container storage compartment.

Gray cast iron piping components are not to be used for fixed gas fire extinguishing systems.

TABLE 1
Minimum Steel Pipe Wall Thickness for CO₂ Medium Distribution Piping (2013)

<i>Nominal size, mm</i>	<i>OD mm</i>	<i>A mm</i>	<i>B mm</i>	<i>Nominal size, in.</i>	<i>OD in.</i>	<i>A in.</i>	<i>B in.</i>
15	21.3	2.8	2.6	1/2	0.840	0.110	0.102
20	26.9	2.8	2.6	3/4	1.050	0.110	0.102
25	33.7	4.0	3.2	1	1.315	0.157	0.126
32	42.4	4.0	3.2	1 1/4	1.660	0.157	0.126
40	48.3	4.0	3.2	1 1/2	1.9	0.157	0.126
50	60.3	4.5	3.6	2	2.375	0.177	0.142
65	76.1	5.0	3.6	2 1/2	2.875	0.197	0.142
80	88.9	5.5	4.0	3	3.5	0.220	0.157
90	101.6	6.3	4.0	3 1/2	4.0	0.248	0.157
100	114.3	7.1	4.5	4	4.5	0.28	0.177
125	139.7	8.0	5.0	5	5.563	0.315	0.197
150	168.3	8.8	5.6	6	6.625	0.346	0.22

Notes:

- 1 The above minimum thicknesses are derived from those thicknesses available in ISO 4200 Series 1 (OD), JIS (N.P.S.), or ASTM (N.P.S.). Diameter and thickness according to other recognized standards will be accepted.
- 2 For threaded pipes, where approved, the thickness is to be measured to the bottom of the thread.
- 3 The internal surface of pipes outside of the engine room is to be galvanized.
- 4 For larger diameters the minimum wall thickness will be subject to special consideration by ABS.
- 5 In general, the minimum thickness is the nominal wall thickness and no allowance need be made for negative tolerance or reduction in thickness due to bending.

11.1.3 Alarm

(2013) Means are to be provided for automatically giving audible and visual warning of the release of fire extinguishing gas into any space to which personnel normally have access. The alarm is to operate for at least a 20-second period before the gas is released. Alarms may be pneumatically (by the extinguishing medium or by air) or electrically operated.

11.1.3(a) Electric. If electrically operated, the alarms are to be supplied with power from the main and an emergency source of electrical power.

11.1.3(b) Pneumatic. If pneumatically operated by air, the air supply is to be dry and clean and the supply reservoir is to be automatically kept charged at all times and is to be fitted with a low pressure alarm. The air supply may be taken from the starting air receivers. Any stop valve fitted in the air supply line is to be locked or sealed in the open position. Any electrical components associated with the pneumatic system are to be powered from the main and an emergency source of electrical power.

11.1.3(c) Uninterruptible Power Supply (2013). For fire extinguishing systems that protect the machinery space containing the main source of power, instead of the power supply arrangements required above for electrically operated alarms and electrical components associated with pneumatic alarms, an uninterruptible power supply which is supplied with power from the emergency switchboard is to be provided.

11.1.4 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 the protected space.

11.3 Carbon Dioxide Systems (2013)

In addition to the applicable requirements of 4-7-3/3.3 of the *Steel Vessel Rules*, fixed carbon dioxide fire extinguishing systems are to be in accordance with Chapter 5.2.1 and 5.2.2 of the International Code for Fire Safety Systems. Fixed low-pressure carbon-dioxide systems are to be in accordance with 4-7-3/3.5 of the *Steel Vessel Rules*.

11.5 Foam

11.5.1 Fixed High Expansion Foam Systems (1 July 2009)

In addition to the applicable requirements of the Rules, fixed high expansion foam systems are to be in accordance with Chapter 6 of the International Code for Fire Safety Systems.

Fixed foam fire-extinguishing systems using inside air are to be designed, constructed and tested in accordance with the requirements identified in MSC.1/Circ. 1271, *Guidelines for the Approval of High-Expansion Foam Systems Using Inside Air for the Protection of Machinery Spaces and Cargo Pump-Rooms*.

Foam concentrates are to be of an approved type.*

* *Note:* Reference is made to the International Maritime Organization MSC/Circular 670 Guidelines for the Performance and Testing Criteria, and Surveys of High-Expansion Foam Concentrates for Fixed Fire-Extinguishing Systems.

11.5.2 Fixed Low Expansion Foam Systems

Low expansion foam systems may be fitted in addition to the required fixed fire extinguishing system. In addition to the applicable requirements of the Rules, fixed low expansion foam systems are to be in accordance with Chapter 6 of the International Code for Fire Safety Systems. Foam concentrates are to be of an approved type.**

** *Note:* Reference is made to the International Maritime Organization MSC/Circular 582 Guidelines for the Performance and Testing Criteria, and Surveys of Low-Expansion Foam Concentrates for Fixed Fire-Extinguishing Systems.

11.7 Fixed Water Spraying Systems

In addition to the requirements of the Rules, fixed water spraying systems, are to be in accordance with Chapter 7 of the International Code for Fire Safety Systems.

11.9 Clean Agent Fire Extinguishing Systems (2013)

Fixed gas fire-extinguishing systems equivalent to those specified in 4-6-2/11.1 through 4-6-2/11.7 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.

11.9.1 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 4-6-2/11.9.2).

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.

11.9.2 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).

11.9.3 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 4-6-2/Table 1 (Columns A or B, as applicable).

11.9.4 System Installation

11.9.4(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 4-6-2/11.1.1, 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.

11.9.4(b) Alarm. An audible and visual predischage alarm in accordance with 4-6-2/11.1.3 and paragraph 6 of IMO MSC/Circ. 848 as amended by MSC/Circ. 1267 is to be provided.

11.9.4(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 accessed by personnel. If the protected space is permanently unmanned, except for repairs or maintenance, 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.
- 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.

11.9.4(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 4-6-2/11.9.2).

13 Additional Requirements for Liftboats of 500 Gross Tons and Over Engaged in International Voyages

Liftboats of 500 gross tons and over, engaged in international voyages, are to comply with the additional requirements in 4-6-2/15 through 4-6-2/25. These requirements need not be applied for liftboats in domestic service which do not engage in international voyages.

15 Fireman's Outfit (2012)

At least two complete fireman's outfits are to be carried on board the liftboat.

Each outfit is to consist of an approved breathing apparatus, a lifeline, a safety lamp, an axe, non-conducting boots and gloves, a rigid helmet and protective clothing.

Two (2) spare charges are to be provided for each required breathing apparatus. All air cylinders for breathing apparatus are to be interchangeable. Liftboats that are equipped with suitably located means for fully recharging the air cylinders free from any contamination need carry only one spare charge for each required apparatus.

The fireman's outfits and equipment are to be stored so as to be easily accessible and ready for use and are to be stored in widely separate positions.

16 Emergency Escape Breathing Devices (EEBDs) (2005)

16.1 Accommodation Spaces

All liftboats are to carry at least two emergency escape breathing devices and one spare device within accommodation spaces.

16.3 Machinery Spaces

On all liftboats, within the machinery spaces, emergency escape breathing devices are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of fire. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces. (See the Guidelines for the performance, location, use and care of emergency escape breathing devices, MSC/Circ. 849 and 1081). The number and locations of EEBDs are to be indicated in the fire control plan required in 4-6-1/1.9.

A summary of the MSC/Circ. 1081 requirements are shown in 4-6-2/Table 2. This applies to machinery spaces where crew are normally employed or may be present on a routine basis.

TABLE 2
Minimum Number of Required EEBDs (2005)

A. In machinery spaces for category A containing internal combustion machinery used for main propulsion⁽¹⁾:
a) One (1) EEBD in the engine control room, if located within the machinery space b) One (1) EEBD in workshop areas. If there is, however, a direct access to an escape way from the workshop, an EEBD is not required; and c) One (1) EEBD on each deck or platform level near the escape ladder constituting the second means of escape from the machinery space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
B. In machinery spaces of category A other than those containing internal combustion machinery used for main propulsion,
One (1) EEBD should, as a minimum, be provided on each deck or platform level near the escape ladder constituting the second means of escape from the space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
C. In other machinery spaces
The number and location of EEBDs are to be determined by the Flag Administration.

Note:

- 1 Alternatively, a different number or location may be determined by the Flag Administration taking into consideration the layout and dimensions or the normal manning of the space.

17 Portable Fire Extinguishers

A spare charge is to be provided for each required portable fire extinguisher, which can be readily recharged onboard. If recharging is not possible onboard, duplicate extinguishers are to be provided.

19 Portable Foam Applicator Units (1 July 2009)

Each Category A machinery space is to be provided with at least one portable foam applicator unit.

19.1 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.

19.3 System Performance

- 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.
- 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).
- 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 $\pm 10\%$ of that determined in 4-6-2/19.3ii).
- 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.

21 Fire Detection and Fire Alarm Systems (2012)

Any required fixed fire detection and fire alarm system is to meet the requirements in Chapter 9 of the International Code for Fire Safety Systems.

In addition to the above, the requirement of SOLAS II-2/7.7 “*manually operated call points complying with the Fire Safety Systems Code shall be installed throughout the accommodation spaces, service spaces and control stations*”, does not require the fitting of a manually operated call point in an individual space within the accommodation spaces, service spaces and control stations. However, a manually operated call point are to be located at each exit (inside or outside) to the open deck from the corridor such that no part of the corridor is more than 20 m (66 ft) from a manually operated call point. Service spaces and control stations which have only one access, leading directly to the open deck, are to have a manually operated call point not more than 20 m (66 ft) (measured along the access route using the deck, stairs and/or corridors) from the exit. A manually operated call point is not required to be installed for spaces having little or no fire risk, such as voids and carbon dioxide rooms, nor at each exit from the navigation bridge, in cases where the control panel is located in the navigation bridge.

23 Sample Extraction Smoke Detection Systems

Any required fixed sample extraction smoke detection system is to meet the requirements in Chapter 10 of the International Code for Fire Safety Systems.

25 Accommodation and Service Spaces

25.1 Fixed Systems

A fire detection and alarm system (methods IC or IIIC) or an automatic sprinkler, fire detection and fire alarm system (method IIC) is to be installed in accommodation and service spaces in accordance with Regulation II-2/7 of the International Convention for the Safety of Life at Sea (SOLAS) 1974 and Amendments in force.

25.3 Portable Fire Extinguishers

Portable fire extinguishers are to be provided as required by 4-6-1/9. However, for liftboats of 1000 gross tons and above, the total number of extinguishers for accommodation spaces, service spaces, spaces in which the liftboat's radio or main navigating equipment or emergency source of power is located, and locations where the fire recording or fire control equipment is located is not to be less than five.

27 Release of Smoke from Machinery Space (2011)

Suitable arrangements are to be made to permit the release of smoke, in the event of fire, from the machinery space of Category A. The normal ventilation may be acceptable for this purpose. The means of control is to be provided for permitting the release of smoke and such control is to be located outside the space concerned so that they will not be rendered inaccessible in the event of fire in the space they serve. See also 4-7-3/5.17.1

PART

4

CHAPTER 6 Fire Extinguishing Systems

SECTION 3 Requirements for Liftboats Under 500 Gross Tons

1 Fire Pumps

1.1 Number of Pumps

All liftboats are to have at least two fire pumps. Only one of the pumps need be independently power-driven and one of the pumps may be attached to the propulsion unit. For liftboats less than 20 m (65 ft) in length, one power driven pump which may be an attached unit, and one hand operated fire pump may be provided.

1.3 Capacity

The capacity of each power driven fire pump is to be in accordance with 4-6-3/Table 1. Hand pumps, where permitted, are to have a minimum capacity of 1.1 m³/hr (5 gpm).

3 Fire Extinguishing Systems

Unless the Flag Administration has specific requirements for installation for fire extinguishing systems, the following requirements are to be met:

3.1 Fixed Systems

For all liftboats, fixed fire extinguishing systems are to be fitted in the machinery spaces when propulsion and auxiliary engines, with a total aggregate power of 750 kW (1000 bhp) or greater, are installed (see 4-1-1/13.1) and in any machinery space in which an oil fuel unit for heated fuel oil is installed, regardless of the total aggregate power.

3.3 Portable Extinguishers

Machinery spaces are to be provided with portable fire extinguishers in accordance with the applicable requirements in 4-6-1/Table 2.

5 Carbon Dioxide Systems

Where a fixed carbon dioxide fire extinguishing system is installed, the system is to comply with the requirements of 4-6-2/11.1 and 4-6-2/11.3, except that storage arrangements may be in accordance with the following:

5.1 Storage

Generally, the cylinders are to be located outside the protected space in a room, which is situated in a safe and readily accessible location. The access doors to the storage space are to open outwards. 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 is to be independent of the protected space, except that where this is impracticable due to space limitations, the following requirements may be considered:

- i) The door between the storage location and the protected space is to be self-closing with no holdback 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.
- v) An additional entrance to the storage location, independent of the protected space, is provided.

7 Axe

One fire axe is to be provided on each liftboat 20 m (65 ft) in length and over.

TABLE 1
Fire Pump Minimum Capacity for Liftboats Less Than 500 Gross Tons

<i>Liftboat Length</i>	<i>Minimum Capacity</i>
Less than 20 m (65 ft)	5.50 m ³ /hr (25 gpm)
20 m (65 ft) or greater but less than 30.5 m (100 ft)	11.0 m ³ /hr (50 gpm)
30.5 m (100 ft) or greater but less than 61 m (200 ft)	14.3 m ³ /hr (66.6 gpm)
61 m (200 ft) or greater	Capacity is to be in accordance with 4-6-2/5.1

CHAPTER 7 Electrical Installations

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CHAPTER 7 **Electrical Installations**SECTION 1 **General****1 Applications**

Electrical apparatus and wiring systems are to be constructed and installed to the satisfaction of the Surveyor in accordance with the following requirements, which are applicable to all ocean-going liftboats but which may be modified for liftboats classed for limited service. The following detailed Rules are minimum requirements for classification purposes. Consideration will be given, however, to arrangements or details which can be shown to comply with other recognized standards, provided they are not less effective.

For liftboats having an aggregate generator capacity not exceeding 75 kW, the requirements contained in 4-7-5/7 are to be complied with. Electrical installations in machinery spaces with gasoline engines will be specially considered.

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 liftboat's navigation and systems including safety for dangerous cargoes to be carried (secondary essential services); and
- Emergency services as described in 4-7-2/5.3 (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 4-7-1/Table 4 and 4-7-1/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

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 or other recognized standard may be accepted.

3.11 Hazardous Area (Hazardous Location)

An area where flammable or explosive vapor, gas, or dust, or explosives may normally 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 liftboat 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”

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 10.4.1 of IEC Publication 60079-11.

3.23 Low Voltage (2014)

Low Voltage in these Rules refers to voltages up to and including 1000 V AC and 1200 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 the load and speed within the permissible operating range. The load and speed variations include the overloads applied frequently, which may be 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 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

Equipment having an enclosure in which positive pressure is maintained to prevent against the ingress of external atmosphere and complying with the requirements in 4-7-3/9.3.3.

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 4-7-2/1, 4-7-3/1, 4-7-4/1 and 4-7-5/3.3.

7 Standard Distribution System (2014)

The following are recognized as standard systems of distribution. The 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

* 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 4-7-1/Table 1. Any special system, such as electronic circuits, which cannot operate satisfactorily within the limit shown in 4-7-1/Table 1, is not to be supplied directly from the system but by alternative means, such as through a stabilized supply.

11 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 the equipment may be expected to encounter.

13 Insulation Material

For the purpose of these requirements insulating material is designated as follows.

13.1 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).

13.3 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).

13.5 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).

13.7 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).

13.9 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).

13.11 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.

15 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 4-7-1/Tables 2 and 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. Type of enclosure required for protection of equipment is to be suitable for the intended location. See 4-7-3/3.1.1 for selection of 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 4-7-5/Table 1.

17 Temperature Ratings

17.1 General (2014)

For equipment associated with control and monitoring systems described in Part 4, Chapter 7 of the *Under 90m Rules*, refer to 4-7-2/15.9.2 therein.

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.

17.3 Reduced Ambient Temperature (2005)

17.3.1 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 45°C and maintained at a value not less than 35°C, provided:

- i) The equipment is not to be used for emergency services and is located outside of the machinery space(s).
- 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 45°C ambient temperature.
- iii) The equipment is to be able to initially start to work safely at a 45°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.

17.3.2 Rating of Cables

In accepting a lesser ambient temperature than 45°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.

17.3.3 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 4-7-1/3.7, and the capability of cooling is to be witnessed by the Surveyor at sea trial.

19 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 4-7-4/7.11.6 and 4-7-5/1.1.3 for additional requirements for switchboard and high voltage systems.

21 Service Trial

21.1 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 liftboat 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 demonstrated satisfactorily. 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 4-7-3/5.1.3.

21.3 Communication Facilities

Satisfactory operation of the interior communications system required by 4-7-2/15 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 4-7-2/15 provide the capability of carrying on a conversation while the liftboat is being navigated.

TABLE 1
Voltage and Frequency Variations [See 4-7-1/9] (2008)

<i>Voltage and Frequency Variations for AC Distribution Systems</i>		
<i>Quantity in Operation</i>	<i>Permanent Variation</i>	<i>Transient Variation (Recovery Time)</i>
Frequency	±5%	±10% (5 s)
Voltage	+6%, -10%	±20% (1.5 s)

<i>Voltage Variations for DC Distribution Systems (such as systems supplied by DC generators or rectifiers)</i>	
<i>Parameters</i>	<i>Variations</i>
Voltage tolerance (continuous)	±10%
Voltage cyclic variation deviation	5%
Voltage ripple (AC rms over steady DC voltage)	10%

<i>Voltage Variations for Battery Systems</i>	
<i>Type of System</i>	<i>Variations</i>
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)

<i>First IP Numeral</i>	<i>Short Description</i>	<i>Definition</i>
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)

<i>Second IP Numeral</i>	<i>Short Description</i>	<i>Definition</i>
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. <i>Note:</i> 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.

See Designation and examples in 4-7-1/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 liftboats, and also for auxiliary boilers where steam is used for equipment supplying primary essential services
(f)	Oil burning installations for steam plants on steam turbine liftboats and for auxiliary boilers where steam is used for equipment supplying primary essential services
(g)	Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps, etc.
(h)	Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
(i)	Electric generators and associated power sources supplying primary essential equipment
(j)	Hydraulic pumps supplying primary essential equipment
(k)	Viscosity control equipment for heavy fuel oil
(l)	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)	Navigation lights, aids and signals
(k)	Internal communication equipment required by 4-7-2/15
(l)	Fire and gas detection and alarm system
(m)	Lighting system
(n)	Electrical equipment for watertight and fire-tight closing appliances
(o)	Electric generators and associated power sources supplying secondary essential equipment
(p)	Hydraulic pumps supplying secondary essential equipment
(q)	Control, monitoring and safety devices/systems of equipment for secondary essential services
(r)	Elevating (jacking) systems
(s)	(2005) Ambient temperature control equipment required by 4-7-1/17.3
(t)	(2010) Watertight Doors (see 3-2-9 and 3-2-11/7)

CHAPTER 7 **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
- Internal Communication
- General Emergency Alarm
- Fire Detection and Alarm
- Steering Gear Control
- Intrinsically-safe Equipment
- Emergency Generator Starting

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 liftboats 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**

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 protective devices.

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 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 overcurrent 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 4-7-2/9.1.5.

1.7 Load Analysis (2012)

An electric-plant load analysis is to be submitted for review. The electric-plant load analysis is to cover all operating conditions of the liftboat, such as normal sea going, cargo handling (loading/unloading), harbor in/out and emergency operations.

The analyses are to include:

- The simultaneous operation of loads on the emergency switchboard as per 4-7-2/5.3. Where the emergency generator capacity is less than the sum of all of the nameplate rated loads, which can be simultaneously connected to the emergency switchboard, then the analysis are to be supported by a justification for each reduced or non-simultaneous load used.
- High voltage ship service transformers or converters, where applicable per 4-7-2/7.1.6
- Identifying the loads to be tripped to ensure continuity of supply per 4-7-2/3.3.2iv), 4-7-2/3.1.6(a), 4-7-2/9.3.3.

3 Ship Service Main Source of Power

3.1 Power Supply by Generators

3.1.1 Number of Generators

All liftboats using electricity for ship's service power or light are to be provided with at least two electric generators for the ship service electrical demand.

3.1.2 Capacity of Generators (2004)

The capacity of the generating sets is to be such that in the event of any one generating set being stopped it will still be possible without recourse to the emergency source of power to supply those services necessary to provide normal operational conditions of propulsion and safety, preservation of the cargo and minimum comfortable conditions of habitability which are to include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water. See also 4-7-2/3.1.6. In addition, the generating sets are to be such that with any one generator or its primary source of power out of operation, the remaining generating sets are capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition as defined in 4-1-1/13.21, within thirty minutes of the blackout. See also 4-7-2/3.1.3.

3.1.3 Starting from Dead Ship Condition (2009)

In restoring the propulsion, from a dead ship condition (see 4-1-1/13.17), no stored energy is to be assumed available for starting the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available to start the emergency generator at all times.

The emergency source of electrical power may be used to restore the propulsion, provided its capability either alone or combined with that of any other available sources of electrical power is sufficient to provide at the same time those services required to be supplied by 4-7-2/5.3.2 to 4-7-2/5.3.3.

The emergency source of electrical power and other means needed to restore the propulsion are to have a capacity such that the necessary propulsion starting energy is available within 30 minutes of blackout as defined in 4-1-1/13.19. Emergency generator stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded).

See also 4-7-2/3.1.6 and 4-7-4/7.15.2 below.

3.1.4 Power Supplied by Propulsion Generator

For liftboats propelled by electric power and having two or more constant voltage propulsion generators, the ship's service electric power may be derived from this source and additional ship's service generators need not be fitted provided that with one propulsion generator out of service, a speed of one-half of the design speed can be maintained. See 4-7-5/3.17.4 and 4-7-5/3.17.5 for details of propulsion generator.

3.1.5 Fuel Capacity for Generator Prime Mover

Where the fuel for any ship's service generator prime mover differs from the fuel for the main propulsion plant, adequate fuel capacity for that ship's service generator prime mover with adequate margins is to be provided for the longest anticipated run of the liftboat between fueling ports.

3.1.6 System Arrangement (2004)

3.1.6(a) General. For liftboats of 500 GT and above, where the main source of electrical power is necessary for propulsion and steering and the safety of the liftboat, the system is to be so arranged that the electrical supply to equipment necessary for these services is maintained or is capable of being restored in no more than 45 seconds in the case of loss of any one of the generators in service in accordance with the provision in 4-7-2/3.1.6(b) or 4-7-2/3.1.6(c).

Load shedding of non-essential services, and where necessary, secondary essential services (see 4-7-1/3.7) or other arrangements, as may be necessary, are to be provided to protect the generators against the sustained overload. For main bus bar subdivision, see 4-7-4/7.15.2.

3.1.6(b) Single Generator Operation. Where the electrical power is normally supplied by a single generator, provision is to be made, upon loss of power, for automatic starting and connecting to the main switchboard of a stand-by generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries in sequential operation, if necessary to permit propulsion and steering and to ensure the safety of the liftboat. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds after loss of the electrical power supply but in no case in more than 45 seconds.

3.1.6(c) Multiple Generator Operation. Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, the system is to be so arranged that in the event of the loss of any one of the generators in service, the electrical liftboat will be maintained by the remaining generator(s) in service.

3.3 Generator Driven by Propulsion Unit (2004)

3.3.1 Constant Speed Drive

A generator driven by a main propulsion unit (shaft generator) capable of operating continuously at a constant speed, e.g., a system where the liftboat speed and direction are controlled only by varying propeller pitch, may be considered to be one of the generators required by 4-7-2/3.1.1, provided that the arrangements stated in *i)* to *iii)* below are complied with:

- i)* The generator and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in 4-7-4/3.19.2 and 4-7-1/Table 1 under all weather conditions during sailing or maneuvering and also while the drilling unit is stopped.
- ii)* The rated capacity of the generator and the generating systems is safeguarded during all operations given under *i)* and is such that the services required by 4-7-2/3.1.2 can be maintained upon loss of any generator in service.
- iii)* An arrangement is made for starting a standby generator and connecting it to the switchboard, in accordance with 4-7-2/3.1.6.

3.3.2 Variable Speed Drive

Shaft generator installations not capable of operating continuously at a constant speed may be used for normal operational and habitable conditions of the liftboat provided that the arrangements stated in i) to v) below are complied with. This type of generator will not be counted as one of the generators required by 4-7-2/3.1.2.

- i) In addition to this type of generator, generators of sufficient and adequate rating are provided, which constitute the main source of electrical power required by 4-7-2/3.1.2.
- ii) When the frequency variations at the main bus bar exceed the following limits due to the speed variation of the propulsion machinery which drives the generator, arrangements are made to comply with 4-7-2/3.1.6.

Permanent frequency variation: $\pm 5.5\%$

Transient frequency variation: $\pm 11\%$ (5 sec)

- iii) The generators and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in 4-7-4/3.19.2 and 4-7-1/Table 1.
- iv) Where load-shedding arrangements are provided, they are fitted in accordance with 4-7-2/9.3.3.
- v) Where the propulsion machinery is capable of being operated from the navigation bridge, means are provided or procedures are in place to ensure that power supply to essential services are maintained during maneuvering conditions in order to avoid a blackout situation.

3.5 Sizing of AC Generator

In selecting the capacity of an alternating-current generating plant, particular attention is to be given to the starting current of motors forming part of the system. Under normal sea going condition of the liftboat with one generator held in reserve as a standby, the remaining generator sets operating in parallel and initially carrying minimum load necessary for operating the liftboat are to have sufficient capacity with respect to the largest idle motor on the liftboat so that the motor can be started and the voltage drop occasioned by its starting current will not cause any already running motor to stall or control equipment to drop out.

5 Emergency Source of Power

5.1 General

A self-contained emergency source of electrical power is to be provided.

5.1.1 Location

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.

5.1.2 Separation

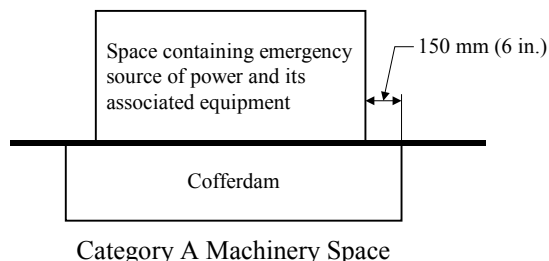
5.1.2(a) Machinery Space of Category A. The location of the emergency source of electrical power, associated power transformer, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated 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.

5.1.2(b) *Machinery Space Other Than Category A.* Spaces containing emergency sources of power are to be separated from machinery spaces (as defined in 4-1-1/13.3) 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 sources 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.

5.1.2(c) *Alternative Arrangement (2008).* The following alternative arrangements may be considered in lieu of 4-7-2/5.1.2(a).

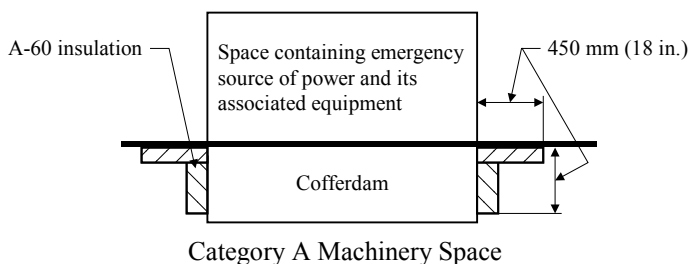
- i) Separation by a cofferdam having dimensions as required for ready access and extending at least 150 mm (6 in.) beyond the boundaries of the space containing the self-contained emergency source of power and its associated equipment as stated in 4-7-2/5.1.2(a). See 4-7-2/Figure 1 below. Except for cables feeding services located in the machinery space, emergency electric cables are not to be installed in such cofferdams unless the cofferdam is insulated to A-60.

FIGURE 1
Cofferdam with Extension Beyond the Boundaries of the Space Containing the Emergency Source (2008)



- ii) Separation by a cofferdam having dimensions as required for ready access between category A machinery space and the space containing the self-contained emergency source of power and its associated equipment as stated in 4-7-2/5.1.2(a) without extension beyond the boundaries. Any contiguous lines between these spaces at the corner of the cofferdam are to be insulated to A-60 for a length of 450 mm (18 in.) at the category A machinery space side. See 4-7-2/Figure 2 below.

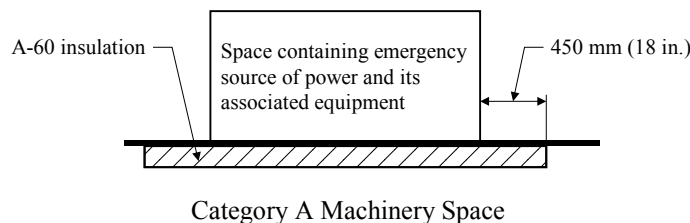
FIGURE 2
Cofferdam without Extension Beyond the Boundaries of the Space Containing the Emergency Source (2008)



- iii) The contiguous boundaries insulated to A-60 with the insulation extending at least 450 mm (18 in.) beyond the boundary of the space containing the self-contained emergency source of power and its associated equipment as stated in 4-7-2/5.1.2(a). See 4-7-2/Figure 3 below.

The arrangements indicated in 4-7-2/Figure 3 below can be considered only when it can be shown that the arrangements are in compliance with the requirements of the flag administration.

FIGURE 3
Boundary Insulated to A-60 with the Insulation Extending Beyond the
Boundaries of the Space Containing the Emergency Source (2008)



5.3 Emergency Services

5.3.1 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 4-7-2/5.3.2 to 4-7-2/5.3.7, if they depend upon an electrical source for their operation.

5.3.1 General (2012)

- i) The electrical power available from the emergency source 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. Where the sum of the loads on the emergency generator switchboard exceeds the power available, an analysis demonstrating that the power required to operate the services simultaneously is to be produced. The analysis is to be submitted for review in support of the sizing of the emergency generator.
- ii) 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 services listed in 4-6-2/5.3.2 through 4-6-2/5.3.8 for the period specified.

5.3.2 Lighting Systems and Navigation Light

5.3.2(a) Emergency Lighting for 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.

5.3.2(b) Emergency Lighting for 18 hours:

- i) In all service and accommodation alleyways, stairways and exits;
- ii) In the machinery spaces and main generating stations including their control positions;

- iii) In all control stations, machinery control rooms, and at each main and emergency switchboard;
- iv) At all stowage positions for firemen's outfits;
- v) At the steering gear; and
- vi) At the fire pump referred to in 4-7-2/5.3.4 at the sprinkler pump, if any, at the emergency bilge pump, if any, and at the starting positions of their motors.

5.3.2(c) *For period of 18 hours:*

- i) Navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force.

5.3.3 Communication System, Navigation Aid, and Alarm Systems.

For a period of 18 hours:

5.3.3(a) VHF radio installation required by Regulation IV/7.1.1 and IV/7.1.2 of SOLAS 1974, as amended; and if applicable:

- i) The MF radio installation required by Regulation IV/9.1.1, IV/9.1.2, IV/10.1.2 and IV/10.1.3 of SOLAS 1974 as amended
- ii) The liftboat earth station required by Regulation IV/10.1.1 of SOLAS 1974 as amended
- iii) The MF/HF radio station required by Regulation IV/10.2.1, IV/10.2.2 and IV/11.1 of SOLAS 1974 as amended.

5.3.3(b) All internal communication equipment as required in an emergency

5.3.3(c) Shipborne navigational equipment (i.e., radar, gyro compass, etc.) as required by Regulation V/19 of SOLAS 1974 as amended except that where such provision is unreasonable or impracticable for liftboats less than 5,000 GT, this may be waived if evidence of approval by the Administration is submitted.

5.3.3(d) Required fire detection and fire alarm systems

5.3.3(e) Intermittent operation of the daylight signaling lamp, the liftboat'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 18 hours from an accumulator battery suitably located for use in an emergency.

5.3.4 Emergency Fire Pump

For period of 18 hours, one of the fire pumps required by 4-6-2/5.3 if dependent upon the emergency generator for its source of power.

5.3.5 Steering Gear

Steering gear to comply with 4-7-2/11.5 if powered from emergency source, for a period of 10 minutes continuous operation on liftboats of less than 10,000 GT.

5.3.6 Emergency Control and Monitoring Systems

Emergency control monitoring systems as required by 4-7-4/11 of the *Under 90m Rules*.

5.3.7 Liftboats on Short Duration Voyages

In a liftboat engaged regularly in voyages of short duration, where an adequate standard of safety is attained, a lesser period than the 18-hour period specified in 4-7-2/5.3.2(b), 4-7-2/5.3.2(c), 4-7-2/5.3.3, and 4-7-2/5.3.4 but not less than 12 hours may be accepted.

5.3.8 Other Emergency Services (2005)

For a period of 30 minutes, free-fall lifeboat secondary launching appliance, if the secondary launching appliance is not dependent on gravity, stored mechanical power or other manual means.

5.5 Power Supply

5.5.1 General

The emergency source of electrical power may be either a generator or an accumulator battery in accordance with 4-7-2/5.5.2 or 4-7-2/5.5.3 below:

5.5.2 Generator (2014)

Where the emergency source of electrical power is a generator, it is to be:

5.5.2(a) 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

5.5.2(b)

i) 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 4-7-2/5.7 are to be connected automatically to the emergency generator as quickly as is safe and practicable subject to a maximum of 45 seconds, or

ii) Provided with a transitional source of emergency electrical power as specified in 4-7-2/5.7 unless an emergency generator is provided capable both of supplying the services referred to in 4-7-2/5.7 of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 seconds, and

5.5.2(c) 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 4-5-4/7).

5.5.3 Accumulator Battery

Where the emergency source of electrical power is an accumulator battery it is to be capable of:

5.5.3(a) 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;

5.5.3(b) Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

5.5.3(c) Immediately supplying at least those services specified in 4-7-2/5.7.

5.5.4 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 the blackout situation (see 4-1-1/13.19) dead ship condition (see 4-1-1/13.17), and routine use for testing (see 4-7-2/5.11). 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 4-7-2/5.9.5.

For use of the emergency generator in port, see 4-7-2/5.15.

5.7 Transitional Source of Power

The transitional source of emergency electrical power where required by 4-7-2/5.5.2(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 is to be so arranged as to supply automatically 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 4-7-2/5.3.2. 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 4-7-2/5.3.3(b), 4-7-2/5.3.3(d) and 4-7-2/5.3.3(e) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

5.9 Emergency Switchboard

5.9.1 General

The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

5.9.2 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.

5.9.3 Accumulator Battery

No accumulator battery fitted in accordance with 4-7-2/5.5.3 or 4-7-2/5.7 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.

5.9.4 Interconnector Feeder Between Emergency and Main Switchboards (2014)

The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnection feeder, which is to be protected at the main switchboard against overload and short circuit. The interconnection 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 interconnection 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 interconnection 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 Guide, the main ship service switchboard is a switchboard which is connected to the secondary of the step-down transformer producing the required voltage.

5.9.5 Disconnection of Non-emergency Circuits

For ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard so that electrical power is to be available automatically to the emergency circuits.

5.11 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.

5.13 Starting Arrangements for Emergency Generator Sets

5.13.1 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.

5.13.2 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.

5.13.3 Charging of Stored Energy

The stored energy is to be maintained at all times, as follows:

5.13.3(a) Electrical and hydraulic starting systems are to be maintained from the emergency switchboard;

5.13.3(b) 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;

5.13.3(c) 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.

5.13.4 Manual Starting

Where automatic starting is not required as per 4-7-2/5.5.2(b), 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 4-7-2/5.13.2 and 4-7-2/5.13.3 are to be complied with except that starting may be manually initiated.

5.15 Use of Emergency Generator in Port (for Liftboat 500 GT and Over)

Unless instructed otherwise by the Flag Administration, the emergency generator may be used during lay time in port for supplying power to the liftboat, provided the following requirements are complied with.

5.15.1 Arrangements for the Prime Mover

5.15.1(a) Fuel oil tank. The fuel oil tank for the prime mover is to be appropriately sized and provided with a level alarm, which is to be set to alarm at a level where there is still sufficient fuel oil capacity for the emergency services for the period of time required by 4-7-2/5.3.

5.15.1(b) Rating. The prime mover is to be rated for continuous service.

5.15.1(c) Filters. The prime mover is to be fitted with fuel oil and lubricating oil filters in accordance with 4-2-1/7.1 and 4-2-1/9.9, respectively.

5.15.1(d) Monitoring. The prime mover is to be fitted with alarms, displays and automatic shutdown arrangements as required in 4-7-4/Table 7 of the *Under 90m Rules*, except that for fuel oil tank low-level alarm, 4-7-2/5.15.1(a) above is to apply instead. The displays and alarms are to be provided in the centralized control station. Monitoring at the engineers' quarters is to be provided as required in 4-7-4/31 of the *Under 90m Rules*.

5.15.1(e) Fire detection. The emergency generator room is to be fitted with fire detectors. Where the emergency generator is located in a space separated from the emergency switchboard, fire detectors are to be located in each space. The fire detection and alarm system is to be in compliance with 4-6-2/21 and may be a part of another system.

5.15.2 System Arrangements

5.15.2(a) Independence. The power supply circuits, including control and monitoring circuits, for the use of emergency generator in port are to be so arranged and protected that any electrical fault, except for the emergency generator and the emergency switchboard, will not affect the operation of the main and emergency services.

5.15.2(b) Changeover arrangement. Means are to be provided to readily change over to emergency operation.

5.15.2(c) Overload prevention. The generator is to be safeguarded against overload by automatically shedding such other loads that the supply to the required emergency loads is always available.

5.15.3 Operational Instruction

Operational instructions, such as that on fuel oil tank level, harbor/seagoing mode changeover arrangements, etc. are to be provided on board. Before the liftboat is underway all valves, switches, etc. are to be in the positions for their intended mode of operation of the emergency generator and the emergency switchboard. Such instructions are to be distinctly posted at the emergency generator room. Planned maintenance is to be carried out only while in port.

5.17 Alarms and Safeguards for Emergency Diesel Engines (2006)

5.17.1 Information to be Submitted

Information demonstrating compliance with these requirements is to be submitted for review. The information is to include instructions to test the alarm and safety systems.

5.17.2 Alarms and Safeguards

5.17.2(a) Alarms and safeguards are to be fitted in accordance with 4-7-2/Table 1.

5.17.2(b) The safety and alarm systems are to be designed to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the liftboat.

5.17.2(c) Regardless of the engine output, if shutdowns additional to those specified in 4-7-2/Table 1 are provided, except for the overspeed shutdown, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

5.17.2(d) The alarm system is to function in accordance with 4-7-2/5.1 through 4-7-2/5.13 of the *Under 90m Rules*, with additional requirements that grouped alarms are to be arranged on the bridge.

5.17.2(e) In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

5.17.2(f) Local indications of at least those parameters listed in 4-7-2/Table 1 are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

TABLE 1
Alarms and Safeguards for Emergency Diesel Engines
[See 4-7-2/5.17] (2009)

<i>Systems</i>	<i>Monitored Parameters</i>		<i>A</i>	<i>Auto Shut Down</i>	<i>Notes</i> [A = Alarm; x = apply]
Fuel oil	A1	Leakage from pressure pipes	x		
Lubricating oil	B1	Temperature – high	x		For engines having a power of 220 kW or more.
	B2	Lubricating oil pressure – low	x		
	B3	(2009) Oil mist in crankcase, mist concentration – high; Bearing temperature – high; or Alternative arrangements	x		(2009) For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 in.). See 4-2-1/7.2 of the <i>Steel Vessel Rules</i> .
Cooling medium	C1	Pressure or flow – low	x		For engines having a power of 220 kW or more.
	C2	Temperature – high	x		
Engine	D1	Overspeed activated	x	x	For engines having a power of 220 kW or more.

5.19 Liftboats Less Than 500 GT Having Electrical Plants of 75 kW and Above

5.19.1 General

This requirement is intended for liftboats less than 500 GT having electrical plants of an aggregate capacity of 75 kW and above. The emergency source of electrical power is to be self-contained and readily available. 4-7-2/5.1.1, 4-7-2/5.1.2, 4-7-2/5.5 through 4-7-2/5.11 and 4-7-2/5.19 are also applicable. Where the source of electrical power is a battery, see 4-7-3/3.7 for the installation. For emergency lighting, a relay-controlled, battery-operated lanterns are acceptable.

5.19.2 Capacity

The emergency source of electrical power is to be capable of supplying simultaneously at least the following services for the period as specified herein:

5.19.2(a) Emergency lighting for 2 hours for:

- i) At muster and embarkation stations for survival craft
- ii) At survival craft, launching appliances and the area of water into which they are launched

5.19.2(b) Emergency lighting for 6 hours for:

- i) In all service and accommodation alleyways, stairways and exits, personnel elevators and shafts;
- ii) In the machinery spaces and main generating stations including their control positions;
- iii) In all control stations, machinery control rooms, and at each main and emergency switchboard;
- iv) At all stowage positions for firemen's outfits;
- v) At the steering gear; and

5.19.2(c) Navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force.

5.19.2(d) Radio Installations for calling distress signals and rescue for 6 hours

5.19.2(e) Internal communication equipment as required in an emergency for 6 hours.

5.21 Requirements by the Governmental Authority

Attention is directed to the requirements of the governmental authority of the country, whose flag the liftboat flies, for the emergency services and the accumulator batteries.

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 4-7-1/7. 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 boards 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 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 mm² wire. Circuit-disconnecting devices are to be provided for each motor branch circuit and to be in accordance with 4-7-3/3.13.2 and 4-7-4/7.17.2.

7.1.6 Power Supply Through Transformers and Converters

7.1.6(a) Continuity of Supply (2014). Where transformers and/or converters form a part of the liftboat's main service electrical system supplying essential services and services necessary for minimum comfortable conditions of habitability, the number and capacity of the transformers and/or converters are to be such that, with any one transformer or converter, or any one single phase of a transformer out of service, the remaining transformers and/or converters or remaining phases of the transformer are capable of supplying power to these loads under normal seagoing conditions.

See 4-7-5/1.3.6 for the additional requirements applicable for high voltage transformers.

7.1.6(b) Arrangements. 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. This multipole isolating switch is not to be installed on the transformer casing or its vicinity (in so far as practicable) to preclude its damage by fire or other incident at the transformer. A circuit breaker provided in the secondary circuit in accordance with 4-7-2/9.15.1 will be acceptable in lieu of a multipole isolating switch.

7.1.6(c) *Transformers and Converters for Battery Charger (2004)*. Where batteries connected to a single battery charger are the sole means of supplying DC power to equipment for essential services, as defined in 4-7-1/3.7, failure of the single battery charger under normal operating conditions should not result in total loss of these services once the batteries are depleted. In order to ensure continuity of the power supply to such equipment, one of the following arrangements is to be provided:

- i) Duplicate battery chargers; or
- ii) A single battery charger and a transformer/rectifier (or switching converter) which is independent of the battery charger, provided with a change-over switch; or
- iii) Duplicate transformer/rectifier (or switching converter) units within a single battery charger, provided with a change-over switch.

The above requirements are not applicable for the following:

- The equipment for the essential services, which contains a single transformer/ rectifier with a single AC power supply feeder to such equipment.
- The services which are not used continuously, such as battery chargers for engine starting batteries, etc.

7.1.7 Heating Appliances

Each heater is to be connected to a separate final subcircuit. However, a group of up to 10 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 the space for disconnecting such circuits.

7.3 Hull Return System

7.3.1 General

The hull return system is not to be used for power, heating, or lighting except the following:

- 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.

7.3.2 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 4-7-3/7.5.2.

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 liftboat 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 4-7-2/9.11 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 liftboat'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 liftboat'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 (2014)

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. **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.**

9 Circuit Protection System

9.1 System Design

9.1.1 General

Electrical installations are to be protected against accidental overload and short circuit, except

- i) As permitted by 4-7-2/11.3
- 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:

- Continued supply to remaining essential circuits in the event of a fault, and
- 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 characteristics (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. The 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 4-7-4/Table 10 except as otherwise permitted for generator, motor, and transformer circuit protection in 4-7-2/9.3, 4-7-2/9.13 and 4-7-2/9.15. 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 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 4-6-2/9.1.2(b)]. All circuit protective devices are to comply with the requirements for making capacity [see 4-6-2/9.1.2(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 4-7-2/9.3.2 and 4-7-2/9.7.1. Except for cascade system (backup protection) in 4-7-2/9.1.4, 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 cascade system (back-up protection) as specified in 4-7-2/9.1.4(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 overcurrent 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 4-7-2/9.1.5, 4-7-2/9.5.1, and 4-7-2/9.5.2(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 liftboat, 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 liftboat, 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 4-7-1/3.7 for the definition of essential services.

- i) Primary essential services that, when disconnected, will cause immediate disruption to propulsion and maneuvering of the liftboat,
- ii) Emergency services as listed in 4-7-2/5.3, and
- iii) Secondary essential services that, when disconnected, will:
 - cause immediate disruption of systems required for safety and navigation of the liftboat, such as:
 - Lighting systems,
 - Navigation lights, aids and signals,
 - Internal communication systems required by 4-7-2/15, 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 4-7-2/9.1, 4-7-2/9.3, 4-7-2/9.5 and 4-7-2/9.7 where applicable. See also 4-7-2/5.9.

9.5 Protection for Alternating-current (AC) Generators

9.5.1 Short-time Delay Trip (2008)

Short-time delay trip are to be provided with circuit breakers for AC generators. See also 4-7-2/9.3.2. 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 4-7-2/9.3.1) 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 (2008). 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. See also 4-7-2/9.3.2.

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 2% to 6% of the rated power for turbines and in the range 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 4-7-2/9.5.2(b). When the 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 4-7-2/9.5.2(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 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 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 4-7-2/9.13.2 or 4-7-2/9.13.3 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 4-7-3/3.13.2 and 4-7-4/7.17.2.

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.

<i>Type of Motor</i>	<i>Rating or Setting in % Motor Full-load Current</i>
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, it is 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 4-7-2/11.3). 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 4-7-1/Table 4).
- ii) Only those secondary essential services (see 4-7-1/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 unprotected part of installation. Fuses are to be placed as near as possible to the tapping from the supply.

9.19 Protection of Harmonic Filter Circuits (2014)

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 Systems for Steering Gear

11.1 Power Supply Feeder

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. 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 systems 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.

11.3.2 Undervoltage Release

Power unit motor controllers and other automatic motor controllers are to be fitted with undervoltage release.

11.5 Emergency Power Supply

Where the rudder stock is required by 3-2-13/7.1 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 liftboat at the summer draft while running at one half the maximum speed. The alternative power supply is to have a capacity for at least 10 minutes of continuous operation. See 4-7-2/5.3.5.

11.7 Controls, Instrumentation, and Alarms

See 4-3-3/11.

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 liftboat normally accessible to and used by 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 4-7-2/5.3.2 of this Section 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 4-7-2/13.1.1 inoperative.

13.1.3 Lighting Circuits in 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 are 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.

13.1.4 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.

13.3 Navigation Light System

13.3.1 Feeders

The masthead, side and stern lights are to be separately connected to a distribution board reserved for navigation light, placed in an accessible position on bridge, and is connected directly or through transformers to the main or emergency switchboard. These lights are to be fitted with duplicate lamps or other dual light sources and are to be controlled by an indicator panel. Provision is to be made on the bridge for the navigation lights to be transferred to an alternative supply. See 4-7-2/5.3.2(c) for power supply.

13.3.2 Navigation Light Indicator

Each navigation light as listed in 4-7-2/13.3.1 is to be provided with an indicator panel which gives audible and/or visual warning automatically in the event of extinction of the light. If an audible device is used, it is to be connected to a separate source of supply, for example a primary or accumulator (storage) battery. If a visual signal is used which is connected in series with the navigation light, means are to be provided to prevent the extinction of the navigation light due to failure of the visual signal. A means for disconnection of each navigation light circuit is to be provided at the indicator panel.

13.3.3 Protection

Each navigation light as listed in 4-7-2/13.3.1 is to be protected by a fuse or circuit breaker in each insulated pole. Similarly, the navigation light indicator panel is to be provided with a fused-feeder disconnect double-pole switch or double-pole circuit breaker which may be fitted on the distribution board or the indicator panel. The rating of the fuses or circuit breaker setting is to be at least twice that of the largest branch fuse or the circuit breaker setting and greater than the maximum panel load.

15 Interior Communication Systems

15.1 Navigation Bridge

15.1.1 General

At least two independent means are to be provided for communicating orders from the navigation bridge to the position in the machinery space or in the control room from which the speed and direction of thrust of the propellers are normally controlled. Appropriate means of communication are to be provided to any other positions from which the main propulsion machinery may be controlled. See 4-7-2/5.3.3(b) for power supply.

15.1.2 Engine Order Telegraph

One of the communicating means between navigation bridge and the main propulsion control position is to be an engine room telegraph which provides visual indication of the orders and responses both in the machinery space and on the navigation bridge. Final subcircuit for power supply to this system is to be independent of other electrical systems and control, monitoring, and alarm systems. See 4-7-2/5.3.3(b) for power supply. Communication network and power supply circuit for this may be combined with the engine order telegraph system specified in 4-7-2/15.3. For liftboats less than 500 GT, an engine order telegraph need not be provided if the propulsion plant is controlled entirely from the navigation bridge with no means of normal engine control from the engine room.

15.3 Main Propulsion Control Stations

A common talking means of voice communication and calling or engine order telegraph repeater is to be provided between the main 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 liftboat is being navigated. Final subcircuit 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 4-7-2/15.5.

15.5 Voice Communications

15.5.1 Propulsion and Steering Control Stations

A common talking means of voice communication and calling or engine order telegraph is to be provided between the navigation bridge, main 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.

15.5.2 Communication in Case of an Emergency (2007)

Means of voice communication is to be available for transfer of information between all locations where action may be necessary in case of an emergency. Such locations include machinery spaces, SCR rooms and all locations vital to the safety of the unit. Simultaneous talking among these locations is to be possible at all times and the calling to these locations is always to be possible even if the line is busy.

15.5.3 Jacking System (2011)

A voice communication system is to be provided between the central jacking control station and a location at each leg in self-elevating units.

15.5.4 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 4-7-2/5.3.3(b) for power supply.

15.7 Emergency and Interior-communication Switchboard

Emergency and interior-communication switchboards, when fitted, are to comply with the applicable parts of 4-7-4/7 and attention is directed to the requirements of the governmental authority whose flag the liftboat flies.

15.9 Public Address System (2007)

Where a public address system is provided to supplement the general emergency alarm required by 4-7-2/17.1.1, the public address system is to comply with Subparagraphs 4-7-2/15.9.1 through 4-7-2/15.9.3 as follows:

15.9.1 System Requirements

The system is to be a loud speaker installation enabling the broadcast of messages to all spaces where crew members are normally present and to muster stations. The system is to provide for the broadcast of messages from the navigation bridge and other places on board as may be required by ABS, with an override function so that all emergency messages may be broadcast if any loudspeaker in the spaces concerned has been turned off, its volume has been turned down or the public address system is in use for other purposes.

The system is to be installed with acoustic marginal conditions and is not to require any action from the addressee. The system is to be protected against unauthorized use.

15.9.2 Minimum Sound Levels

With the liftboat underway in normal conditions, the minimum sound pressure levels for broadcasting emergency announcements in interior spaces are to be 75 dB (A) and at least 20 dB (A) above the corresponding speech interference level.

15.9.3 Emergency Source of Power

The system is to be connected to the emergency source of power.

15.9.4 Public Address System Combined with General Alarm System (2013)

Where a single system serves for both public address and general emergency alarm functions, the system is to be arranged so that a single failure is not to cause the loss of both systems and is to minimize the effect of a single failure. The major system components, such as power supply unit, amplifier, alarm tone generator, etc., are to be duplicated. Power supply is to comply with 4-7-2/17.1.2(b) and 4-7-2/17.1.2(c).

The coverage provided by the arrangement of the system loops and speakers is to be such that after a single failure, the announcements and alarms are still audible in all spaces. Duplication of system loops and speakers in each room or space is not required provided the announcements and alarms are still audible in all spaces.

17 Manually Operated Alarms

17.1 General Emergency Alarm System

17.1.1 General

Each liftboat over 100 GT is to be fitted with a general emergency alarm system, complying with the requirement of 4-7-2/17.1.2, to summon crew to muster stations and initiate the actions included in the muster list. The system is to be supplemented by either a public address system in accordance with 4-7-2/15.9 or other suitable means of communication. Any entertainment sound system is to be automatically turned off when the general emergency alarm is activated.

17.1.2 System Requirements (2009)

17.1.2(a) The general emergency alarm system is to be capable of sounding the general emergency alarm signal consisting of seven or more short blast followed by one long blast on the liftboat'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 liftboat's main supply and the emergency source of electrical power required by 4-7-2/5.

17.1.2(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.

17.1.2(c) An alarm is to be provided to indicate when there is a loss of power in any one of the feeders required by 4-7-2/17.1.2(b).

17.1.2(d) As an alternative to two feeders as described in 4-7-2/17.1.2(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.

17.1.2(e) The system is to be capable of operation from the navigation bridge and, except for liftboat's whistle, also from other strategic points. The system is to be audible throughout all the accommodation and normal crew working spaces. 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.

17.1.2(f) (2014) The minimum sound pressure levels for the emergency alarm tone in interior spaces are to be 80 dB and at least 10 dB (A) above ambient noise levels existing during normal equipment operation with the liftboat underway in moderate weather.

17.1.2(g) The sound pressure levels at the sleeping position in cabins and in cabin bathrooms are to be at least 75 dB (A) and at least 10 dB (A) above ambient noise levels.*

* Note: Refer to Code on Alarms and Indicators adopted by IMO Resolution A.830 (19).

17.3 Engineers' Alarm (2007)

An engineers' alarm operable from the centralized propulsion machinery control station in the engine room or at the propulsion machinery local control position, as appropriate, is to be provided. It is to be audible in each engineer's cabin, and its sound pressure level is to comply with 4-7-2/17.1.2. See 4-7-2/5.3.3(e) for power supply.

17.5 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. See 4-7-2/5.3.3(e) for power supply.

19 Fire Protection and Fire Detection Systems

19.1 Emergency Stop

19.1.1 Ventilation System (2013)

19.1.1(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 4-6-6/1.13.1(b) and 4-6-6/5.3.6 of the *Under 90m Rules*, and 4-6-1/5.1 of this Guide.

19.1.1(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 4-7-2/19.1.1(c) and 4-7-2/19.1.1(d).

In the case of liftboats for which SOLAS may be applicable, the means of stopping the ventilation fans is to be grouped so as to be operable from two positions, one of which is to be located outside the space.

19.1.1(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 4-7-2/19.1.1(b) and 4-7-2/19.1.1(d). See 4-6-1/5.1.

19.1.1(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.

19.1.2 Other Auxiliaries (2009)

See 4-6-1/5.3 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).

19.3 Fire Detection and Alarm System

See 4-6-2/21 and 4-6-2/25.

CHAPTER 7 **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. Where cable penetration methods for A- or B-class decks or bulkheads are shown, an evidence of approval by an Administration signatory to 1974 SOLAS as amended is also to be submitted.

For high voltage systems see installation requirements given in 4-7-5/1.9.3.

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
- Detector, Manual Call Point and Alarm Panel for Fire Detection and Alarm System
- 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 4-7-3/9.3.
- 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 4-7-3/9.1.4.

1.7 Maintenance Schedule of Batteries (2008)

Maintenance Schedule of batteries for essential and emergency services. See 4-7-3/3.7.5.

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 4-7-3/Table 1 for 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 4-7-3/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.

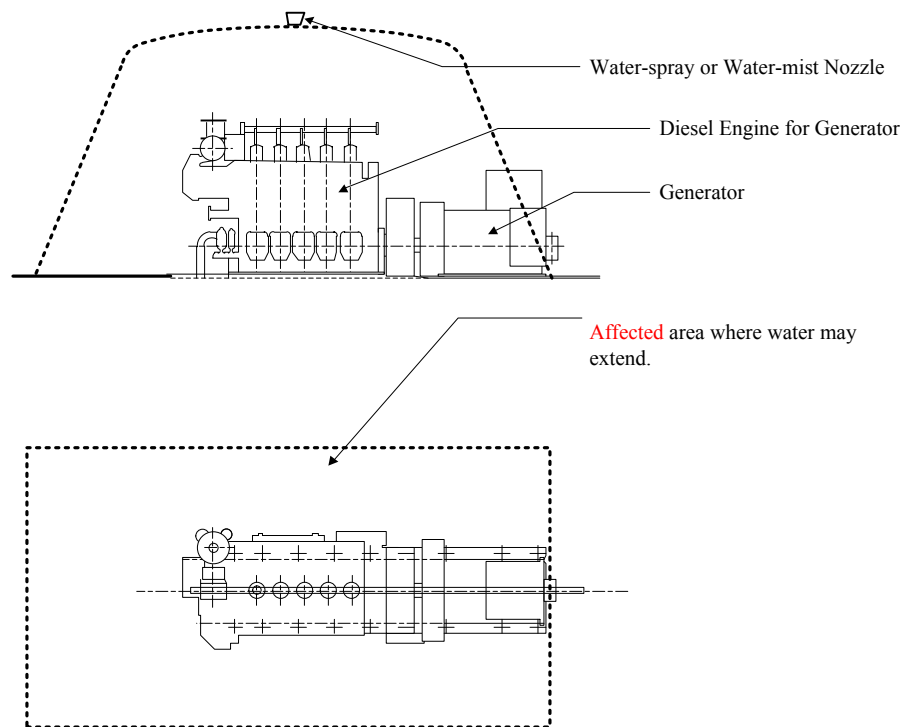
3.1.3 Accessibility

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.

3.3 Generators

All generators are to be located with their shafts in a fore-and-aft direction on the liftboat and are to operate satisfactorily in accordance with the inclination requirements of 4-1-1/17. 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.

FIGURE 1
Example of Area Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces (2014)



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 4-7-3/Table 1. However where they are protected by drip covers, they may have an enclosure of the 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 (2008). 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 4-7-3/9.1.1 and is to be IEC Publication 60079 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) 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(e) 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 4-7-3/9.7 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. 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 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 liftboat's safety management system and integrated into the liftboat'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 4-7-3/3.7.2 and 4-7-3/3.7.3 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 spaces as bunkers, storerooms, cargo holds or compartments allotted to 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 non-combustible non-hygroscopic enclosures. Metal enclosures and all exposed metal parts in non-metallic enclosures are to be earthed to the liftboat'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

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.

3.11.4 Lighting Distribution Boards (2013)

To prevent the simultaneous loss of main and emergency lighting distribution boards due to localized fire or other casualty, these distribution boards are to be installed as widely apart as practicable in the machinery spaces.

For spaces other than the machinery space (e.g., accommodation space, ro-ro cargo spaces, etc.), these lighting distribution boards are to be installed at locations which are separated by a boundary wall. For the navigation bridge, the main and emergency lighting distribution boards are not to be installed in the same compartment of the navigation console or panel.

Cables emanating from the main or emergency lighting switchboard to the main or emergency lighting distribution board respectively are also to be installed as widely apart as practicable. See also 4-7-2/13.1.2.

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 4-7-4/7.17.2).

3.13.2(b) Location. 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. 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 liftboat'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 hazardous areas nor are portable lights to be used for berth lights in crew's quarters.

3.25 Receptacles and Plugs of Different Ratings (2013)

Receptacles and plugs of different electrical ratings are not to be interchangeable. In cases where it is necessary to use 230 volts portable equipment, the receptacles for their attachment are to be of a type which will not permit attaching 115 volts equipment. Receptacles and plugs for a rated current in excess of 16 A are to be interlocked with a switch such that the plug cannot be inserted or withdrawn when the switch is in the "on" position.

3.27 Installation Requirements for Recovery from Dead Ship Condition (2005)

Means are to be provided to ensure that machinery can be brought into operation from the dead ship condition without external aid. See 4-1-1/19.

Where the emergency source of power is an emergency generator which complies with 4-7-2/5.15 and 4-7-2/3.1.3, this emergency generator may be used for restoring operation of the main propulsion plant, boilers and auxiliary machinery.

Where there is no emergency generator installed, the arrangements for bringing main and auxiliary machinery into operation are to be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed onboard the liftboat without external aid. If for this purpose an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

The arrangements for bringing the main and auxiliary machinery into operation are to have a capacity such that the starting energy and any power supplies for propulsion engine operation are available within 30 minutes of a blackout condition.

3.29 Services Required to be Operable Under a Fire Condition (2008)

For the purpose of 4-7-3/5.17.2, 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

3.31 High Fire Risk Areas (2008)

For the purpose of 4-7-3/5.17, the examples of the high fire risk areas are the following:

- i) Machinery spaces as defined by 4-1-1/13.1 and 13.3
- ii) Spaces containing fuel treatment equipment and other highly flammable substances
- iii) Galley and pantries containing cooking appliances
- iv) Laundry containing drying 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 4-7-3/5.33. However, approved splices will be permitted at interfaces of new construction modules, when necessary to extend existing circuits for a liftboat undergoing repair or alteration, and in certain cases to provide for cables of exceptional length (See 4-7-3/5.29).

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

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 area unless protected from bilge water. See also 4-6-6/1.9.3 of the *Under 90m Rules* for cables used for echo sounder, speed log, and impressed current cathodic protection system in hazardous areas.

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 4-7-4/13.1.2.
- 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.

5.3 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

Single conductor cables may be used for power transmission provided the following arrangements are 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) 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 mm² (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 4-7-4/13.1.5 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 liftboat 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 4-7-3/5.17.1 and 4-7-3/5.29.

5.9 Support, Fixing and Bending

5.9.1 Support and Fixing

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 in Item 4-7-3/5.9.1(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 4-7-3/5.9.1(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 4-7-3/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 4-7-3/5.9.1(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 of the flame retardant type 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 4-7-4/Table 10.

<i>Number of Cables in One Bunch</i>	<i>Reduction Factor</i>
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 4-7-3/5.13.4.

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 stuffing tubes, transit devices or pourable materials are being installed in accordance with manufacturer's installation procedures.

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 liftboat are to be provided with braided metallic armor and otherwise suitably protected from mechanical injury as appropriate for the location. See also 4-7-3/9.1.3 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, 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, including those listed in 4-7-3/3.29, are not to pass through high fire risk areas (see 4-7-3/3.31). For Emergency Fire Pumps, see requirements in 4-7-3/5.17.3.

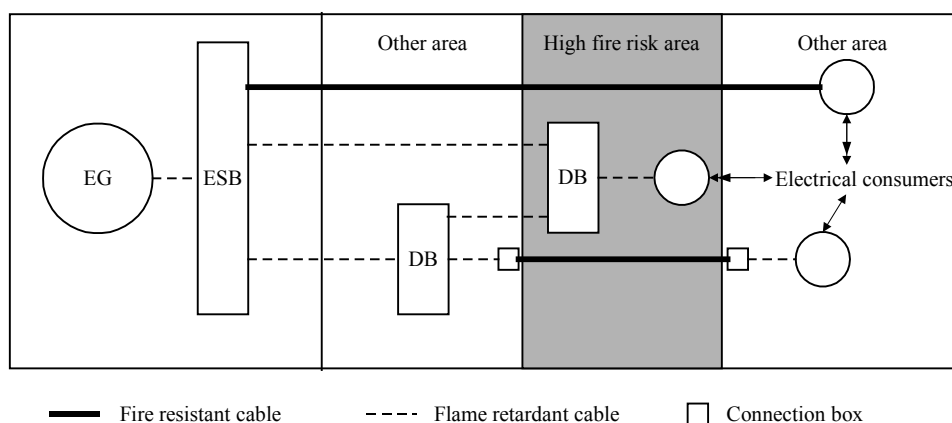
These cables and wiring are also to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

5.17.2 Services Necessary Under a Fire Condition (2013)

Where cables for services required to be operable under a fire condition (see 4-7-3/3.29) including their power supplies pass through high fire risk areas (see 4-7-3/3.31) other than those which they serve, they are to be so arranged that a fire in any of these areas does not affect the operation of the service in any other area. For Emergency Fire Pumps, see requirements in 4-7-3/5.17.3. This may be achieved by any of the following measures:

5.17.2(a) Fire resistant cables in accordance with 4-7-4/13.1.3 are installed and run continuous to keep the fire integrity within the high fire risk area. See 4-7-3/Figure 2.

FIGURE 2
Cables within High Fire Risk Areas (2008)



5.17.2(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 4-7-3/5.17.2(a) and 4-7-3/5.17.2(b).

5.17.3 Electrical Cables for the Emergency Fire Pump (2013)

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 4-7-4/13.1.3, where they pass through other high fire risk areas.

5.17.4 Requirements by the Governmental Authority

Attention is directed to the requirements of the governmental authority of the country, whose flag the liftboat flies, for the installation of emergency circuits required in liftboats.

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 4-7-3/5.13. 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 4-7-4/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 4-7-3/9.1.3 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 4-7-3/7.9 or provided 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 liftboat provided the plans required by 4-7-3/1.3 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 4-7-4/11.7 as well as 4-7-3/5.33.2 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

Separate junction boxes are to be used for feeders and circuits of each of the following rated voltage levels:

5.33.3(a) Rated voltage levels not exceeding those specified in 4-7-3/7.1.

5.33.3(b) Rated voltage levels exceeding those in 4-7-3/5.33.3(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 it contains. A physical barrier may be used in lieu of two separate junction boxes for circuits having rated voltage levels corresponding to those in either 4-7-3/5.33.3(a) or 4-7-3/5.33.3(b).

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 4-7-3/5 and 4-7-4/13 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) 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 V 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 liftboat's structure. Alternatively, they are to be connected to the hull by a separate conductor in accordance with 4-7-3/7.5. 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 4-7-3/Table 3.

7.5.2 Earthed Distribution System

Earthing conductors in earthed distribution system are to comply with 4-7-3/7.5.1, except that the earthing conductor in line C4 of 4-7-3/Table 3 is to be $A/2$.

7.5.3 Connection to Hull Structure

All connection of an earth-continuity conductor or earthing lead to the liftboat's structure is to be made in an accessible position and is secured by a screw of brass or other corrosion-resistant material having 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. See 4-4-1/9.21 of the *Under 90m Rules* for control of static electricity.

7.7 Portable Cords

Receptacle outlets operating at 50 volts DC or 50 volts AC rms or more are to have a 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 subcircuits may be earthed at the supply end only. All metallic coverings of power and lighting cables passing through hazardous area or connected to equipment in such an area are to be earthed at least at each end. See also 4-7-2/15.9.3 of the *Under 90m Rules*.

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 Equipment and Installation in Hazardous Area

9.1 General Consideration

9.1.1 General (2008)

Electrical equipment and wiring are not to be installed in hazardous area unless essential for operational purposes.

9.1.1(a) Electrical Equipment Types. Only electrical equipment of the following types, complying with IEC Publication 60079 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.

9.1.1(b) *Fans.* Fans used for the ventilation of the hazardous areas are to be of non-sparking construction in accordance with 4-7-3/9.7.

9.1.2 Lighting Circuits

All switches and protective devices for lighting fixtures in hazardous area 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 to open the grounded conductor. The switches and protective devices for lighting fixtures are to be suitably labeled for identification purposes.

9.1.3 Cables Installation

Cables in hazardous areas are to be armored or mineral-insulated metal-sheathed. Where these cables pass through boundaries of such locations, they are to be run through gastight fittings. No splices are allowed in hazardous areas except in intrinsically-safe circuits.

9.1.4 Permanent Warning Plates

Permanent warning plates are to be installed in the vicinity of hazardous areas in which electrical equipment is installed to advise personnel carrying out maintenance, repair or surveys of availability of the booklet/list of equipment in hazardous areas referenced in 4-7-3/1.5, if required for their use.

9.3 Certified-safe Type Equipment and System

9.3.1 Installation Approval

Electrical equipment in hazardous areas is to be of a type suitable for such locations. Where permitted by the this Guide, electrical equipment of 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.

9.3.2 Intrinsically-safe System (2005)

9.3.2(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.

9.3.2(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.

9.3.2(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.

9.3.2(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.

9.3.2(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.

9.3.2(f) *Replacement.* Unless specifically approved, replacement equipment for intrinsically-safe circuits is to be identical to the original equipment.

9.3.3 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.

9.5 Paint Stores

9.5.1 General

Electrical equipment in paint stores and in ventilation ducts serving such spaces as permitted in 4-7-3/9.1.1 is to comply with the requirements for group IIB class T3 in IEC Publication 60079.

The following type of equipment will be acceptable for such spaces.

- i) Intrinsically-safe defined by 4-7-1/3.21
- ii) Explosion-proof defined by 4-7-1/3.9
- iii) Pressurized defined by 4-7-1/3.43
- iv) Increased safety defined by 4-7-1/3.17
- v) Other equipment with special protection recognized as safe for use in explosive gas atmospheres by a national or other appropriate authority

9.5.2 Open Area Near Ventilation Openings

In the areas on open deck within 1 m (3.3 ft) of ventilation inlet or within 1 m (3.3 ft) (if natural) or 3 m (10 ft) (if mechanical) of exhaust outlet, electrical equipment and cables where permitted by 4-7-3/9.1.1 are to be in accordance with 4-7-3/9.1.2, 4-7-3/9.1.3 and 4-7-3/9.3.1.

9.5.3 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.

9.7 Non-sparking Fans

9.7.1 Design Criteria

9.7.1(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.).

9.7.1(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 ducts to prevent the entrance of object into the fan casing.

9.7.2 Materials

9.7.2(a) Impeller and its Housing. Except as indicated in 4-7-3/9.7.2(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.

9.7.2(b) Electrostatic Charges. Electrostatic charges both in the rotating body and the casing are to be prevented by the use of anti-static 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 liftboats themselves.

9.7.2(c) Acceptable Combination of Materials. Tests referred to in 4-7-3/9.7.2(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.

9.7.2(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.

9.7.3 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 4-7-3/3.1.1] (2014)
(For high voltage equipment, see 4-6-5/Table 1)

Example of Location	Condition of Location	Switchboards, Distribution Boards, Motor Control Centers & Controllers (See 4-7-3/3.9 to 4-7-3/3.13)							
		Generators (See 4-7-3/3.3)							Accessories ⁽³⁾
		Motors (See 4-7-3/3.5)							
		Transformers, Converters							
		Lighting Fixtures (See 4-7-3/3.17)							
		Heating Appliances (See 4-7-3/3.19)							
Dry accommodation space	Danger of touching live parts only	IP20	-	IP20	IP20	IP20	IP20	IP20	
Dry control rooms ⁽⁴⁾		IP20	-	IP20	IP20	IP20	IP20	IP20	
Control rooms	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	
Refrigeration 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

- Empty spaces shown with “-“ indicate installation of electrical equipment is not recommended.
- Socket outlets are not to be installed in machinery spaces below the floor plates, enclosed fuel and lubricating oil separator rooms or spaces requiring certified safe equipment.
- “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 4-7-3/3.23.
- (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.
- (2006) See 4-7-3/3.1.1(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.
- (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 4-7-3/5.9.2]

Cable Construction		Overall Diameter, <i>D</i>	Minimum Internal Bending Radius
Insulation	Outer Covering		
Thermoplastic and elastomeric	Metal-sheathed armored or braided	Any	6 <i>D</i>
	Other finish	$D \leq 25 \text{ mm (1 in.)}$	4 <i>D</i>
		$D > 25 \text{ mm (1 in.)}$	6 <i>D</i>
Mineral	Hard metal-sheathed	Any	6 <i>D</i>

TABLE 3
Size of Earth-continuity Conductors and Earthing Connections
[See 4-7-3/7.5]

Type of Earthing Connection		Cross-sectional Area, <i>A</i> , of Associated Current Carrying Conductor	Minimum Cross-sectional Area of Copper Earthing Connection
Earth-continuity conductor in flexible cable or flexible cord	A1	$A \leq 16 \text{ mm}^2$	<i>A</i>
	A2	$16 \text{ mm}^2 < A \leq 32 \text{ mm}^2$	16 mm ²
	A3	$A > 32 \text{ mm}^2$	$A/2$
Earth-continuity conductor incorporated in fixed cable	For cables having an insulated earth-continuity conductor		
	B1a	$A \leq 1.5 \text{ mm}^2$	1.5 mm ²
	B1b	$1.5 \text{ mm}^2 < A \leq 16 \text{ mm}^2$	<i>A</i>
	B1c	$16 \text{ mm}^2 < A \leq 32 \text{ mm}^2$	16 mm ²
	B1d	$A > 32 \text{ mm}^2$	$A/2$
	For cables with bare earth wire in direct contact with the lead sheath		
	B2a	$A \leq 2.5 \text{ mm}^2$	1 mm ²
	B2b	$2.5 \text{ mm}^2 < A \leq 6 \text{ mm}^2$	1.5 mm ²
Separate fixed earthing conductor	C1a	$A \leq 3 \text{ mm}^2$	Stranded earthing connection: 1.5 mm ² for $A \leq 1.5 \text{ mm}^2$ <i>A</i> for $A > 1.5 \text{ mm}^2$
	C1b		Unstranded earthing connection: 3 mm ²
	C2	$3 \text{ mm}^2 < A \leq 6 \text{ mm}^2$	3 mm ²
	C3	$6 \text{ mm}^2 < A \leq 125 \text{ mm}^2$	$A/2$
	C4	$A > 125 \text{ mm}^2$	64 mm ² (see Note 1)

Notes:

- For earthed distribution systems, the size of earthing conductor need not exceed $A/2$.
- Conversion Table for mm² 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 7 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 4-7-4/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 4-7-4/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 4-7-1/3.7) or for services indicated in 4-7-4/Table 11 are to be designed, constructed and tested in accordance with the requirements of 4-7-4/3.

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 4-7-4/Table 11 are to include at least the tests described in 4-7-4/3.3.1(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 4-1-1/17.

3.1.3(b) *Insulation Material*. For the requirements covering insulation material, see 4-7-1/13.

3.1.3(c) *Capacity of Generators.* For requirements covering main generator capacity, see 4-7-2/3.1.2 and 4-7-2/3.5. For requirements covering emergency generator capacity, see 4-7-2/5.3.1.

3.1.3(d) *Power Supply by Generators.* For requirements covering power supply by main or emergency generator, see 4-7-2/3.1.2 and 4-7-2/5.5.2 respectively.

3.1.3(e) *Protection for Generator Circuits.* For requirements covering protection for generator, see 4-7-2/9.3, 4-7-2/9.5 and 4-7-2/9.7.

3.1.3(f) *Protection for Motor Circuits.* For requirements covering protection for motor branch circuit, see 4-7-2/9.13.

3.1.3(g) *Installation.* For requirements covering installation, see 4-7-3/3.3 for generators and 4-7-3/3.5 for motors.

3.1.3(h) *Protection Enclosures and its Selection.* For requirements covering degree of the protection and the selection of equipment, see 4-7-1/15 and 4-7-3/3.1, 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 4-7-1/3.7) or for services indicated in 4-7-4/Table 11 are to be tested in accordance with 4-7-4/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 4-7-4/Table 11 are to be tested in accordance with 4-7-4/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 4-7-4/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 of the order of one-half to one megohm.

3.7 Overload and Overcurrent Capability

3.7.1 AC Generators

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. Three phase motors, except for commutator motors, having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 2 minutes. For three-phase and single phase 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 are 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

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 4-7-4/Table 2. The requirements in 4-7-4/Table 2 apply to those machines other than high voltage systems covered by 4-7-5/1.11.1(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 4-7-4/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 de-energized period of sufficient duration to re-establish the machine temperatures within 2°C (3.6°F) of the coolant, the temperature rises are not to exceed those given in 4-7-4/Table 3. At the beginning of the temperature measurement, 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 4-7-4/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 4-7-4/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 4-7-1/13.11.

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 4-7-1/17. Where provision is made for ensuring the ambient temperature of the space is 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 (2006)

3.13.1(a) Rotors of non-integrated auxiliary machinery. The design of the following specified rotating shafts and components, when not integral with the propulsion shafting, are to comply with the following:

- Rotor shaft: 4-2-4/5.3.1* and 4-2-4/5.3.2*
- Hollow shaft: 4-3-1/7.3
- Key: 4-3-1/9 and 4-2-4/5.3.2*
- Coupling flanges and bolts: 4-2-1/17 and 4-3-1/19

* Note: Rules for Building and Classing Steel Vessels

3.13.2(b) Rotors of integrated auxiliary machinery (2012). Shaft motors and shaft generators, which are an integral part of the line shafting, shall be evaluated for maximum combined load (steady and dynamic torque and bending) acting within operating range of installation. Accordingly, the shaft diameter design criteria per 4-2-4/5.3.1 and 4-2-4/5.3.2 of the *Steel Vessel Rules* is to be evaluated for maximum torsional moment acting within the operating speeds, instead of torsional moment T at rated speed.

The shaft diameter of the motors and generators, that are an integral part of the line shafting, may also be designed per 4-3-1/7 and are to be evaluated based on engineering analyses.

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 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 the casings. See item 7 in 4-7-4/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 are 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 4-7-4/Table 4a.

3.15 Lubrication

Rotating machines are to have continuous lubrication at all running speeds and all normal working bearing temperatures, with the liftboat's inclinations specified in 4-1-1/17. 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 Diesel Engines for Generators

Diesel-engine prime movers are to meet the applicable requirements in Part 4, Chapter 2 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 (2007). The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within $\pm 10\%$ of the rated frequency with a recovery time within $\pm 1\%$ of the final steady state condition in not more than 5 seconds when:

- i) Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off,

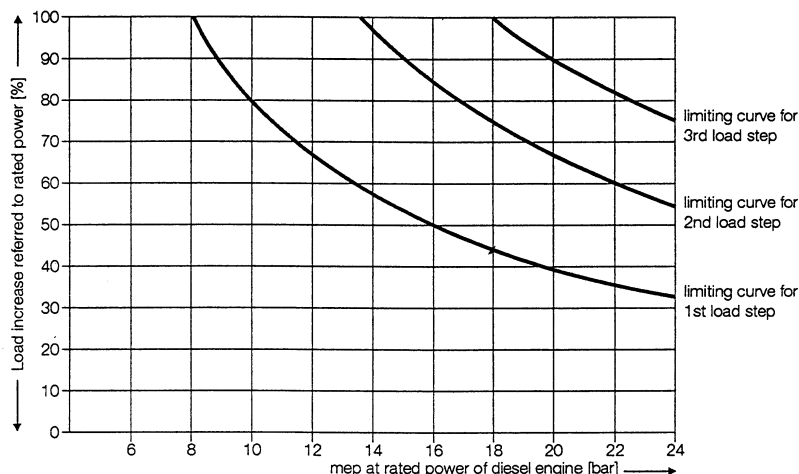
In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable provided the overspeed protective device, fitted in addition to the governor, as required by 4-7-4/3.17.2, is not activated.

- 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 $\pm 1\%$ of the final steady state condition in no more than 5 seconds.

3.17.1(b) Power Management System. 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 4-7-4/3.17.1(a)ii) above may be permitted provided it is in accordance with 4-7-4/Figure 1. 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.

FIGURE 1
Limiting Curves for Loading 4-stroke Diesel Engines
Step by Step from No-load to Rated Power as Function
of the Brake Mean Effective Pressure



3.17.1(c) Frequency Variations in Steady State. The permanent frequency variation is to be within $\pm 5\%$ of the rated frequency at all loads between no load and full load.

3.17.1(d) Emergency Generator Prime Movers (2007). For prime movers driving emergency generators the requirements of 4-7-4/3.17.1(a)i) and 4-7-4/3.17.1(c) above are to be met even when:

- i) Their total consumer load is applied suddenly, or
- ii) Their total consumer load is applied in steps, subject to:
 - The total load is supplied within 45 seconds since power failure on the main switchboard
 - The maximum step load is declared and demonstrated
 - The power distribution system is designed such that the declared maximum step loading is not exceeded
 - The compliance of time delays and loading sequence with the above is to be demonstrated at the liftboat's trials.

3.17.2 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 4-7-4/3.15 for pressure-lubricated machines.

3.19 Alternating-current (AC) Generators

3.19.1 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.

3.19.2 Voltage Regulation (2007)

3.19.2(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.

3.19.2(b) Variation from Rated Voltage – Steady Conditions. Each AC generator for ship's service driven by its prime mover having governor characteristics complying with 4-7-4/3.17.1 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.

3.19.2(c) Variation from Rated Voltage – Transient Conditions. 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.

Consideration can be given to performing the test required by 4-7-4/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.

3.19.2(d) Short Circuit Conditions. 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 3 times its rated full load current for a period of 2 seconds or of such magnitude and duration as required to properly actuate the associated electrical protective devices.

3.19.3 Parallel Operation

For AC generating sets operating in parallel, the following requirements are to be complied with. See also 4-7-2/9.5.1 for protection of AC generators in parallel operation.

3.19.3(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.

3.19.3(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 kilowatt of the largest generator or 25% of the rated output in kilowatt 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.

3.19.3(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.

3.21 Direct-current (DC) Generators

3.21.1 Control and Excitation of Generators

3.21.1(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.

3.21.1(b) *Polarity of Series Windings.* The series windings of each generator for two wire DC system are to be connected to negative terminal of each machine.

3.21.1(c) *Equalizer Connections.* See 4-7-4/7.15.3.

3.21.2 Voltage Regulation

3.21.2(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.

3.21.2(b) *Compound-wound Generator.* Compound-wound generators are to be so designed in relation to the governing characteristics of 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.

3.21.2(c) *Automatic Voltage Regulators.* Ship's service generators which are of 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 regulators will not be required for the ship's service generators of 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.

3.21.3 Parallel Operation

For DC generating sets operating in parallel, the following requirements are to be complied with. See also 4-7-2/9.7.2 for protection of DC generators in parallel operation.

3.21.3(a) *Stability.* The generating sets are to be stable in operation at all loads from no-load to full-load.

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 12% of the rated output in kilowatt of the largest generator or 25% of the rated output in kilowatt 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) *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 to the satisfaction of the Surveyor after installation.

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 4-7-3/3.7.3 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 4-7-2/5.5.3 and 4-7-2/5.7, respectively.

5.1.3(b) Protection of Batteries. For requirements covering protection of batteries, see 4-7-2/9.9.

5.1.3(c) Battery Installation. For requirements covering battery installation, ventilation of the battery location and protection from corrosion, see 4-7-3/3.7.

5.1.3(d) Cable Installation. For requirements covering cable installation in battery room, see 4-7-3/5.23.

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 degrees from normal. The filling plugs are to be so constructed as to prevent spilling of electrolyte due to ship motions 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 4-7-3/3.7.4. 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 4-7-4/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 4-2-1/13.9 and 4-7-2/5.13 for main engine starting and starting arrangement of emergency generator, respectively.

7 Switchboards, Distribution Boards, Chargers, 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 is 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 4-7-4/Table 11.

7.1.1(b) Motor Controllers. Motor controllers of 100 kW and over intended for essential services or for services indicated in 4-7-4/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 4-7-4/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 4-7-4/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 4-7-4/7.1.1(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 4-1-1/17.

7.1.2(b) *Emergency Switchboard*. For requirements covering emergency switchboard, see 4-7-2/5.9.

7.1.2(c) *Circuit Breakers*. For requirements covering generator circuit breakers, see 4-7-4/11.1.

7.1.2(d) *Feeder Protection*. For requirements covering feeder protection, see 4-7-2/9.3 to 4-7-2/9.17, 4-7-2/11.3, 4-7-2/13.1.4, and 4-7-2/13.3.3.

7.1.2(e) *Hull Return and Earthed Distribution Systems*. For requirements covering hull return system and earthed distribution system, see 4-7-2/7.3 and 4-7-2/7.5, respectively

7.1.2(f) *Earthing*. For requirements covering earthing connections, see 4-7-3/7.

7.1.2(g) *Installation*. For requirements covering installation, see 4-7-3/3.9 for switchboard, 4-7-3/3.11 for distribution boards, and 4-7-3/3.13 for motor controllers and control centers.

7.1.2(h) *Protection Enclosures and its Selection*. For requirements covering degree of the protection and the selection of equipment, see 4-7-1/15 and 4-7-3/3.1, 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 4-7-4/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 4-7-4/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 4-7-4/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 4-7-1/3.7), services indicated in 4-7-4/Table 11, emergency source of power (see 4-7-2/5), and transitional source of power (see 4-7-2/5.7) 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 4-7-4/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 this 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

The dielectric strength of the insulation is to be tested for 60 seconds by an alternating voltage applied in accordance with 4-7-4/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 liftboat.

The test voltage at the moment of application is not to exceed 50% of the values given in 4-7-4/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 a 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 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 mm² (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 4-7-4/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 2.
- 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.

<i>Rated Operational Voltage V</i>	<i>Rated Impulse Withstand Test Voltage kV</i>
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 55 Volts. 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) Systems of 55 Volts and Less. For distribution boards, chargers or controllers where voltage to earth or between poles does not exceed 55 volts DC or 55 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 liftboat'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 4-7-2/9.17.

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 4-7-4/7.1 to 4-7-4/7.13, 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 (2014)

Where the main source of electrical power is necessary for propulsion of the liftboat, 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 4-7-4/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 4-7-4/7.1 to 4-7-4/7.13, 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 ($\frac{1}{8}$ in.) thick at every point.
- Nonmetallic materials which have ample strength, are noncombustible and nonabsorptive (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, be self-supported, or be braced to the bulkhead.

7.17.2 Disconnect Switches and Circuit Breakers

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 4-7-4/7.1 to 4-7-4/7.13, 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 (2008)

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 within a period of at least 10 hours. See also 4-7-4/7.19.6(c).

7.19.3 Discharge Protection (2008)

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). For battery charger units and DC UPS units, see 4-7-2/7.1.6(c).

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. When changeover occurs, for battery charger units and DC UPS units required to comply with 4-7-2/7.1.6(c).

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 4-7-3/3.7, 4-7-3/3.9, 4-7-3/3.11, and 4-7-3/3.13 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 4-7-3/3.7. Since valve regulated sealed batteries are considered low-hydrogen-emission batteries, calculations are to be submitted in accordance with 4-7-3/3.7.2(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 4-7-3/3.7.

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 4-7-2/5.3 for emergency services and 4-7-2/5.7 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 4-7-4/7.19.6(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 4-7-4/7.19.2.

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 4-7-4/7.3.1.

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 to the satisfaction of the Surveyor after installation.

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, see 4-7-2/7.1.6.

9.1.2(b) Protection. For requirements covering protection of transformers, see 4-7-2/9.15.

9.1.2(c) Protection Enclosures and its Selection. For requirements covering selection of the protection enclosures for location conditions, see 4-7-3/3.1.1.

9.1.3 Forced Cooling Arrangement (Air or Liquid)

Where forced cooling medium is used to preclude the transformer from exceeding temperatures outside 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 4-7-4/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 4-7-4/Table 4c.

9.5.4 Prevention of the Accumulation of Moisture

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

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 4-7-4/9.3.

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 4-7-1/3.7) or for services indicated in 4-7-4/Table 11 are to be designed, constructed and tested in accordance with the requirements of 4-7-4/10.

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 4-7-1/3.7) or for services indicated in 4-7-4/Table 11 are to include at least the tests described in 4-7-4/10.7. 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 4-7-2/7.9 and 4-7-1/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 and 4-1-1/Table 2.

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 4-6-3/Table 1. For HV converters, the enclosure is to satisfy the requirements in 4-6-5/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

Design of cooling systems is to be based on an ambient air temperature of 45°C (113°F) indicated in 4-1-1/39 and 4-1-1/Table 2.

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. The resistivity of the cooling liquid is to be monitored and an alarm given both locally and remotely in a continuously manned location if the resistivity 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 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

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. Visual and audible alarms are to be provided at control station in the event of tripping of the protective fuses for these devices.

10.5.10(b) Overcurrent Protection. Arrangements are to be made so that the permissible current of semiconductor elements cannot be exceeded during normal operation.

10.5.10(c) Short Circuit Protection. Fuses are to be provided for protection of short circuit of semiconductor converters. Visual and audible alarms are to be provided at the control station for tripping of these semiconductor protective fuses. In case of a blown fuse, the respective part of the plant is to be taken out of operation.

10.5.10(d) Fuses. Each semiconductor device shall have an individual semiconductor fuse. Each of these semiconductor fuses shall be monitored and alarmed in the event of activation. Circuits that are operated with a load-independent current may be excluded from having fuses for each semiconductor device.

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.

<i>System Voltage (V)</i>	<i>Minimum Clearance Distance (mm)</i>
≤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.

<i>Working Voltage (rms) (V)</i>	<i>Minimum Creepage Distance (mm)</i>
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 4-7-2/9.19 for additional protection requirements.

For liftboats with electric propulsion, refer to 4-7-2/Table 6B of the *Under 90m Rules*.

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 4-7-2/9.19.

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

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 on one prototype of a converter or the first of a batch of identical converters. Routine tests shall be carried out on each assembly. A summary of the required type tests and routine tests are given in the Table below:

No.	Tests (see 4-7-4/10.7)	Type Test	Routine Test	ABS Reference	IEC Test Reference
1	Visual inspection	x	x	4-7-4/10.7.1	61800-5-1/5.2.1
2	Insulation test (AC or DC voltage test)	x	x	4-7-4/10.7.2	61800-5-1/5.2.3.2
3	Insulation resistance test	x	x	4-7-4/10.7.4	60146-1-1/7.2.3.1
4	Impulse voltage test	x		4-7-4/10.7.3	61800-5-1/5.2.3.1
5	Cooling system test	x	x	4-7-4/10.7.5	61800-5-1/5.2.4.5
6	Breakdown of components test	x		4-7-4/10.7.6	61800-5-1/5.2.3.6.4
7	Light load and functional test	x	x	4-7-4/10.7.7	60416-1-1/7.3.1
8	Rated current test	x		4-7-4/10.7.8	60416-1-1/7.3.2
9	Temperature rise test	x		4-7-4/10.7.9	61800-5-1/5.2.3.8
10	Capacitor discharge test	x		4-7-4/10.7.10	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 4-7-4/10.5.3.

- 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)

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 and is to be applied continuously for at least 60 seconds. 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 4-6-4/10.5.11.

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.

<i>Materials and Components</i>	<i>Thermometer Method (°C)</i>	<i>Resistance Method (°C)</i>
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 4-7-4/10.7.7 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 4-7-4/9.3.

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 ($\pm 20\%$).

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 4-7-1/17.

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 liftboat, 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 to the satisfaction of the Surveyor after installation.

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 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 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 4-7-4/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 4-7-4/11.7.2 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, junction boxes are to be clearly identified defining their function and voltage.

13 Cables and Wires

13.1 Cable Construction

13.1.1 General (2010)

Electric cables are to have conductors, insulation and moisture-resistant jackets, in accordance with IEC Publication 60092-350, 60092-351, 60092-352, 60092-353, 60092-354, 60092-359, 60092-373, 60092-374, 60092-375, 60092-376, or IEEE Std. 45. Other recognized marine standards 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. 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 mm² (1,973.5 circ. mils) for power and lighting,
- 0.5 mm² (986.8 circ. mils) for control cables,
- 0.5 mm² (986.8 circ. mils) for essential or emergency signaling and communications cables except for those assembled by the equipment manufacturer, and
- 0.35 mm² (690.8 circ. mils) for telephone cables for non-essential communication services except for those assembled by the equipment manufacturer.

See 4-7-4/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:

- Depending on the intended installation, cables constructed to IEC Publication 60092 standards are to comply with the flammability criteria of IEC Publication 60332-3, category A/F or A/F/R, or
- Cables constructed to IEEE Std. 45 are to comply with the flammability criteria of that standard.
- Cables constructed to another recognized marine standard, where specially approved, are to comply with the flammability criteria of IEEE Std. 45 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 (2008)

When electric cables are required to be fire resistant, they are to comply with the requirements of IEC Standard 60331-31 for cables greater than 20 mm overall in diameter, otherwise they are to comply with the IEC Standard 60331-21 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 4-7-3/3.29 and 4-7-3/5.17

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 4-7-4/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 Testing Schedule for Rotating Machines of 100 kW and Over
[See 4-7-4/3.3.1(a)]

<i>Tests</i>		<i>AC generators</i>		<i>AC motors</i>		<i>DC machines</i>	
		<i>Type test ⁽¹⁾</i>	<i>Routine test ⁽²⁾</i>	<i>Type test ⁽¹⁾</i>	<i>Routine test ⁽²⁾</i>	<i>Type test ⁽¹⁾</i>	<i>Routine test ⁽²⁾</i>
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	Verification of voltage regulation system.	x	x ⁽³⁾				
5	Rated load test and temperature rise measurement.	x		x		x	
6	Overload/over-current test.	x	x ⁽⁴⁾	x	x ⁽⁴⁾	x	x ⁽⁴⁾
7	Verification of steady short circuit condition. ⁽⁵⁾	x					
8	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 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 Only functional test of voltage regulator system.
- 4 Applicable only to generators and motors ≥ 100 kW (135 hp) for essential services.
- 5 Verification at steady short circuit condition applies to synchronous generators only.
- 6 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 4-7-4/3.9]

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	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: – the field winding connected across resistance or more than ten times the field winding resistance, or – 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 – between the terminals of the field winding, or – between the terminals of any section for a sectionalized field winding, 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) <i>Exception 1</i> —Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field winding during starting <i>Exception 2</i> —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:

- 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.
- High-voltage tests on machines having graded insulation is to be subject to special consideration.
- 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.
- 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 4-7-4/3.11.1] (2007)

Ambient Temperature = 50°C ⁽¹⁾

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	50	—	70	90	115
			Embedded temp. detector	55	—	75	95	120
	b)	AC windings of machines having rated output above 200 kW (or kVA) but less than 5,000 kW (or kVA)	Resistance	50	65	70	95	115
			Embedded temp. detector.	55	—	80	100	120
	c)	AC windings of machines having rated outputs of 200 kW (or kVA) or less ⁽²⁾	Resistance	50	65	70	95	115
2	Windings of armatures having commutators	Thermometer	40	55	60	75	95	
		Resistance	50	65	70	95	115	
3	Field windings of AC and DC machines having DC excitation, other than those in item 4	Thermometer	40	55	60	75	95	
		Resistance	50	65	70	95	115	
4	a)	Field winding of synchronous machines with cylindrical rotors having DC excitation winding embedded in slots, except synchronous induction motors	Resistance	—	—	80	100	125
	b)	Stationary field windings of AC machines having more than one layer	Thermometer	40	55	60	75	95
			Resistance	50	65	70	95	115
			Embedded temp. detector.	—	—	80	100	125
	c)	Low resistance field winding of AC and DC machines and compensating windings of DC machines having more than one layer	Thermometer	50	65	70	90	115
			Resistance	50	65	70	90	115
	d)	Single-layer windings of AC and DC machines with exposed bare or varnished metal surfaces and single layer compensating windings of DC machines ⁽³⁾	Thermometer	55	70	80	100	125
			Resistance	55	70	80	100	125
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. 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 The limit of temperature rise in the above Table is based on an ambient temperature of 50°C in accordance with IEC Publication 60092-101. For rotating machines based on a 45°C ambient, the temperature rises may be increased by 5°C. (See 4-7-4/3.11.2).
- 2 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.
- 3 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 4-7-4/3.13.9]

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 4-7-4/5.3.3]

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 4-7-4/9.5.3]

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 4-7-4/11.5.4]

The manufacturer's name
The identification number of the equipment

TABLE 5
Factory Testing Schedule for Switchboards, Chargers, Motor Control Centers, and
Controllers [See 4-7-4/7.3.1] (2014)

- 1 Insulation resistance measurements in accordance with 4-7-4/7.5
- 2 Dielectric strength test in accordance with 4-7-4/7.7 and the Table below
- 3 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

<i>Rated Insulation Voltage</i>	<i>Dielectric Test Voltage AC rms</i>
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 1200 V inclusive*	3500 V
<i>Note: *For Direct-current (DC) only</i>	

TABLE 6
Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers,
Motor Control Centers and Controllers ⁽¹⁾
[See 4-7-4/7.11.6]

<i>Rated Insulation Voltage (V)</i>	<i>Minimum Clearances, mm (in.)</i>	<i>Minimum Creepage Distances, mm (in.)</i>
Up to 250	15 (¹⁹ / ₃₂)	20 (²⁵ / ₃₂)
From 251 to 660	20 (²⁵ / ₃₂)	30 (¹³ / ₁₆)
Above 660 ⁽²⁾	25 (1)	35 (¹³ / 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 4-7-5/1.1.3.

TABLE 7
Equipment and Instrumentation for Switchboard
[See 4-7-4/7.15.4]

<i>Instrumentation and Equipment</i>		<i>Alternating-current (AC) Switchboard</i>	<i>Direct-current (DC) Switchboard</i>
1.	Pilot Lamp	A pilot lamp for each generator connected between generator and circuit breaker. See Note 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. See Note 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. See Note 1.
3.	Field Rheostat	A field rheostat for each generator and each exciter. See Note 2.	A field rheostat for each generator. See Note 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. See Note 3.	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 4-7-5/5.3. See Note 3.
5.	Ammeter	An ammeter for each generator with a selector switch to read the current of each phase. See Note 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. See Note 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. See Note 3.	Not applicable.
9.	Prime mover Speed Control	Control for prime mover speed for paralleling. See Note 3.	Not applicable.
10.	Wattmeter	Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator. See Note 3.	Not applicable.
11.	Frequency Meter	A frequency meter with selector switch to connect to any generator. See Note 3.	Not applicable.
12.	Field Switch	A double-pole field switch with discharge clips and resistor for each generator. See Note 2.	Not applicable.
13.	Voltage Regulator	A voltage regulator. See Note 3.	Not applicable.
14.	Stator Winding Temperature Indicator	For alternating current propulsion generator above 500 kW, a stator winding temperature indicator is to be fitted for each generator control panel. See Notes 3 and 4.	For direct current propulsion generator above 500 kW, an interpole winding temperature indicator is to be fitted for each generator control panel. See Notes 3 and 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 liftboats have centralized control systems in accordance with Part 4, Chapter 7 of the *Under 90m 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 4-7-4/7.15.4 of this Guide.
- 4 For high voltage systems, see also 4-7-5/1.11.1(c).

TABLE 8
Temperature Rise for Transformers ^(1, 2) (2014)
[See 4-7-4/9.3]

<i>Insulation Class</i>	<i>Average Winding-Temperature Rise Limits at Rated Current, °C (°F)</i>
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 4-7-4/9.3.

TABLE 9
Types of Cable Insulation [See 4-7-4/13.1.4] (2013)

<i>Insulation Type Designation</i>	<i>Insulation Materials</i>	<i>Maximum Conductor Temperature</i>
V75, PVC	Polyvinyl Chloride – Heat resisting	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 4-7-4/13.1.1) 45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes											
mm ²	10 ³ circ mils	1-core				2-core				3- or 4-core			
		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 4-7-4/13.1.1) 45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes											
mm ²	10 ³ circ mils	1-core				2-core				3- or 4-core			
		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:

- 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.
- The current rating values given in 4-7-4/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.
- For bunched cables, 4-7-3/5.11.1.
- These current ratings are applicable for both armored and unarmored cables.
- If ambient temperature differs from 45°C (113°F), the values in 4-7-4/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

- Where the number of conductors in a cable exceeds 4, 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 4-7-4/Table 10
5-6	80
7-24	70
25-42	60
43 and above	50

- 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).
- 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 4-7-4
[See 4-7-4/1, 4-7-4/3.1.1, 4-7-4/3.3.1, 4-7-4/7.1.1 and 4-7-4/7.3.1] (2010)

(a)	Equipment necessary for specific class notations (Such as refrigerated cargo notations, dynamic positioning systems, etc.). See Note.

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 7 Electrical Installations

SECTION 5 Specialized Installations

1 High Voltage Systems

1.1 General

1.1.1 Application

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 7 for low voltage equipment and systems as well.

1.1.2 Standard Voltages

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 (2014)

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.

<i>Nominal Voltage in kV</i>	<i>Minimum Air Clearance in mm (in.)</i>
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.

<i>Rated Voltage kV</i>	<i>Rated Impulse Withstand Voltage kV (peak value)</i>
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 Distance. The minimum creepage distances for main switchboards and generators are given in the Table below:

Nominal Voltage <i>V</i>	Minimum Creepage Distance for Proof Tracking Index <i>mm (in.)</i>			
	<i>300 V</i>	<i>375 V</i>	<i>500 V</i>	<i>>600 V</i>
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.

1.1.3(e) Creepage Distances. The minimum creepage distances for equipment other than main switchboards and generators are given in the Table below:

Nominal Voltage <i>V</i>	Minimum Creepage Distance for Proof Tracking Index <i>mm (in.)</i>			
	<i>300 V</i>	<i>375 V</i>	<i>500 V</i>	<i>>600 V</i>
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.

1.1.3(f) Non-standardized Parts. For non-standardized parts within the busbar section of a switchgear assembly, the minimum creepage distance is to be at least 25 mm/kV. Behind the current limiting devices, the minimum creepage is to be at least 16 mm/kV.

1.3 System Design

1.3.1 Selective Coordination

Selective coordination is to be in accordance with 4-7-2/9.1.5, regardless of the system neutral earthing arrangement.

1.3.2 Earthed Neutral Systems

1.3.2(a) Neutral earthing. 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. 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

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

An earth fault is to be indicated by visual and audible means. In low impedance or direct earthed systems, provision is to be made to disconnect automatically the faulty circuits. 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)

Requirements for the number and capacity of transformers are given in 4-7-2/7.1.6(a).

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 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

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 4-7-2/9.15. 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. Discriminative tripping is to be provided for the following. See 4-7-2/9.1.5.

- 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. 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 4-7-2/1.7 and 4-7-2/9.3.3.

1.7.2(c) Protection from Electrical Disturbance. 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 4-7-5/1.11.3(b).

1.7.2(d) Protection from Earth-Faults. 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 4-7-2/9.15.2 for requirements.

1.7.3 Voltage Transformers for Control and Instrumentation

Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

1.7.4 Fuses

Fuses are not to be used for overload protection.

1.7.5 Over Voltage Protection

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 4-7-3/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.* 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.

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.* In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

1.9.3(b) *Segregation.* 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 4-7-5/1.1.3(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.* 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 (2014). 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.

When a DC voltage withstand test is carried out, the voltage is to be not less than:

$$1.6(2.5U_o + 2 \text{ kV}) \quad \text{for cables of rated voltage } (U_o) \text{ up to and including 3.6 kV, or}$$

$$4.2U_o \quad \text{for higher rated voltages}$$

where U_o is the highest phase to earth voltage to which the cable is required to be rated.

The test voltage is to be maintained for a minimum of 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.

Alternatively, an AC voltage withstand test may be carried out upon advice from the high voltage cable manufacturer at a voltage not less than the normal operating voltage of the cable, and it is to be maintained for a minimum of 24 hours.

Note: Tests in accordance with IEC Publication 60502 will also be considered adequate.

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 (2014)

1.11.1(a) *Protection (2014)*. Refer to 4-7-5/Table 1 for ingress protection (IP) requirements.

1.11.1(b) *Windings*. 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 4-7-4/Table 1. Each subsequent production unit of and accepted design is to be tested in accordance with the “routine tests” schedule also indicated in 4-7-4/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 (M Ω)
$1000 < U_n \leq 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \leq 15000$	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 (2014)*.

- 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 60466.
- ii) Refer to 4-6-4/7.15.2 for requirements for the division of main bus bars.

1.11.2(b) *Clearance and Creepage Distances*. For clearance and creepage distances, see 4-7-5/1.1.3.

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*. 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.

1.11.2(e) *Earthing and Short-circuiting Facilities*. For maintenance purposes, an adequate number of earthing and short circuiting facilities is 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 (2014)*

- i) Switchgear is to be type tested in accordance with IEC 62271-200 for Accessibility Type A if the arrangement of the liftboat is such that access to spaces containing HV switchgear are to authorized personnel only. In situations where this cannot reasonably be expected, then the switchgear is to be designed and tested to IEC 62271-200 for Accessibility Type B (General Public).
- 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 cm² 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.

<i>Rated Voltage (kV)</i>	<i>Rated Power Frequency Withstand Voltage (kV)</i>
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

1.11.3(a) *Application (2008)*. Provisions of 4-7-5/1.11.3 are applicable to power transformers for essential services. See also 4-7-4/9. Items 4-7-5/1.11.3(c) and 4-7-5/1.11.3(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 60076 Series. 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. In addition to the details required in 4-7-4/9, 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. Transformers are to have a degree of protection in accordance with 4-7-1/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 4-7-5/1.9.1.

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. 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 4-7-5/1.7.2(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. In addition to the requirements in 4-7-4/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

1.11.4(a) Standards. Cables are to be constructed to IEC Publication 60092-353, 60092-354, or other equivalent recognized standard. See also 4-7-4/13.1.

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, liftboat 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 liftboat 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 liftboat'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

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.

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 4-7-5/1.13.2 and still meet the requirements of 4-7-2/3.1.2 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 liftboat's HV equipment. The description 'preliminary' is used to capture the fact that it may not be the final document used by the liftboat'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 Electric Propulsion System

3.1 General (2007)

3.1.1 Application (2014)

The following requirements in this subsection are applicable to electric propulsion systems. 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 7, as well.

3.1.2 Plans and Data to be Submitted

In addition to the plans and data to be submitted in accordance with 4-7-2/1, 4-7-3/1, and 4-7-4/1, the following plans and data are to be submitted for review:

- One line diagrams of 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 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 propulsion system including data for semiconductor converter, cooling system with its interlocking arrangement.

3.3 System Design (2007)

3.3.1 General (2014)

For the purposes of the electric propulsion system requirements, **an electric propulsion system is one in which the main propulsion of the liftboat is provided by at least one electric motor.** An integrated electric propulsion system is a system where a common set of generators supply power to the liftboat service loads as well as the propulsion loads.

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 liftboat. This requirement is not intended to require complete duplication of a single propulsion motor where that motor includes redundant windings and components.

3.3.2 Generating Capacity

For liftboats 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 liftboat services (essential services, normal services and for minimum comfortable conditions of habitability) and an effective level of propulsion.

3.3.3 Power Management System (2014)

For liftboats 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 liftboat'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.

3.3.4 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 4-7-1/9. See also 4-7-5/3.17.4(a) and 4-7-5/3.17.4(e).

3.3.5 Harmonics (2014)

A harmonic distortion calculation is to be submitted for review for all liftboats 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 4-7-2/7.9. The harmonic distortion levels at dedicated propulsion buses are also to be within the limits of 4-7-2/7.9, 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 4-7-2/9.19.

3.5 Propulsion Power Supply Systems (2014)

3.5.1 Propulsion Generators

3.5.1(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. See also 4-7-2/3.1.4.

3.5.1(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 liftboats where any additional exciter set may be common for the liftboat.

3.5.1(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.

3.5.1(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 one half of design speed.

3.5.1(e) Features for Other Services. If the propulsion generator is used for other purposes than for propulsion, 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.

3.5.2 Propulsion Excitation

3.5.2(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.

3.5.2(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.

3.5.2(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.

3.7 Circuit Protection

3.7.1 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.

3.7.2 Direct-current (DC) Propulsion Circuits

3.7.2(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.

3.7.2(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.

3.7.3 Excitation Circuits

An overload protection is not to be provided for opening of the excitation circuit.

3.7.4 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.

3.7.5 Semiconductor Converters

3.7.5(a) Overvoltage Protection. Means are to be provided to prevent excessive overvoltages in a supply system to which converters are connected. Visual and audible alarms are to be provided at the control station for tripping of the protective fuses for these devices.

3.7.5(b) Overcurrent Protection. Arrangements are to be made so that the permissible current of semiconductor elements cannot be exceeded during normal operation.

3.7.5(c) Short-circuit Protection. Fuses are to be provided for protection of short-circuit of semiconductor converters. Visual and audible alarms are to be provided at the control station for tripping of these semiconductor protective fuses. In case of blown fuse, the respective part of the plants is to be taken out of operation.

3.7.5(d) Filter Circuits. Fuses are to be provided for filter circuits. Visual and audible alarms are to be provided at the control station for tripping of the fuse.

3.7.6 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.

3.9 Protection for Earth Leakage

3.9.1 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.

3.9.2 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.

3.9.3 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.

3.9.4 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.

3.11 Electric Propulsion Control

3.11.1 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.

3.11.2 Automatic and Remote Control Systems

Where two or more control stations are provided outside the engine room, or where automatic control of the propulsion machinery is provided, Section 4-7-1 through Section 4-7-5 of the *Under 90m Rules*, as applicable, are to be complied with. See 4-7-1/3 of the *Under 90m Rules* for propulsion class symbols.

3.11.3 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.

3.11.4 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.

3.11.5 Emergency Stop

Each control station shall have an emergency stop device which is independent of the control lever.

3.11.6 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.

3.11.7 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.

3.11.8 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 oil gauges are mounted on the main-control assembly, provision is to be made so that the oil will not come in contact with the energized parts in case of leakage.

3.11.9 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 circuits 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.

3.13 Instrumentation at the Control Station

3.13.1 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.

3.13.1(a) For AC Systems. Ammeter, voltmeter, indicating wattmeter and field ammeter(*) for each propulsion generator and for each synchronous motor. See also 4-7-4/Table 6 of the *Under 90m Rules*.

3.13.1(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. See also 4-7-4/Table 6 of the *Under 90m Rules*.

3.13.1(c) For Electric Slip Couplings. An ammeter for the coupling excitation circuit.

* Field ammeter is not required for brushless generators.

3.13.2 Indication of Propulsion System Status

The control stations of the propulsion systems are to have at least the following indications for each propeller.

3.13.2(a) "Ready for Operation". Power circuits and necessary auxiliaries are in operation.

3.13.2(b) "Faulty". Propeller is not controllable.

3.13.2(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.

3.15 Equipment Installation and Arrangement (2014)

3.15.1 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 4-7-1/19, 4-7-4/7.11.6, and 4-7-5/1.11.2(b).

3.15.2 Accessibility and Facilities for Repairs

3.15.2(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.

3.15.2(b) Facility for Supporting. Facilities shall be provided for supporting the shaft to permit inspection and withdrawal of bearings.

3.15.2(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.

3.15.3 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 4-7-3/5.9.1.

3.17 Machinery and Equipment (2014)

3.17.1 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 above referenced *Part 2*.

3.17.2 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 4-7-4/Table 3 are not to be exceeded.

3.17.3 Protection Against Moisture Condensation

4-7-4/3.13.7 is applicable for rotating machines and converters regardless of the weight of the machines.

3.17.4 Prime Movers

3.17.4(a) Capability. The prime mover rated output are 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 liftboat making full way ahead, the prime mover is to be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

3.17.4(b) Speed Control. Prime movers of any type are to be provided with a governor capable of maintaining the pre-set steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

3.17.4(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.

3.17.4(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.

3.17.4(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.

3.17.5 Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors

3.17.5(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 recirculating systems are used.

3.17.5(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 insulation is self-extinguishing.

3.17.5(c) Air Coolers. (2004) Air cooling systems for propulsion generators are to be in accordance with 4-2-1/11.3 and 4-2-1/11.7. Water-air heat exchangers of rotating propulsion machines for single systems (single generator and single motor), as specified in 4-7-5/3.5.1(b), 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 of such water leakage.

3.17.5(d) Temperature Sensors. Stator windings of AC machines and interpole windings of DC machines, rated above 500 kW, are to be provided with temperature sensors. See 4-7-4/Table 6 of the *Under 90m Rules*.

3.17.5(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.

3.17.5(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.

3.17.6 Direct-current (DC) Propulsion Motors

3.17.6(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.

3.17.6(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.

3.17.7 Electric Couplings

3.17.7(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.

3.17.7(b) Accessibility for Repairs. The coupling is to be designed to permit removal as a unit without moving the engine. See also 4-7-5/3.15.2(a).

3.17.7(c) Temperature Rating. The limits of temperature rise are to be the same as for alternating-current generators given in 4-7-4/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 4-7-4/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 4-7-1/13.11.

3.17.7(d) Excitation. Excitation is to be provided as required for propulsion generators. See 4-7-4/3.19.1, 4-7-4/3.21.1, and 4-7-5/3.17.6.

3.17.7(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.

3.17.7(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

3.17.8 Semiconductor Converters for Propulsion (2014)

Semiconductor converters are to comply with the requirements in 4-7-4/10.

3.17.9 Reactors and Transformers for Semiconductor Converters

3.17.9(a) General. Interphase reactors and transformers used with semiconductor converters are to conform with the requirements of 4-7-4/9.1.1, 4-7-4/9.1.2(c), 4-7-4/9.3, 4-7-4/9.5.1 and 4-7-4/9.5.2, and the following.

3.17.9(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.

3.17.9(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 4-7-4/Table 8.

3.17.10 Switches

3.17.10(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.

3.17.10(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, nonspilling tanks.

3.17.10(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.

3.17.11 Propulsion Cables

3.17.11(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 mm² (2,960 circ. mils).

3.17.11(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).

3.17.11(c) Braided Metallic Armor and Impervious Metallic Sheaths. 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.

3.17.11(d) Inner Wiring. The insulation of internal wiring in main control gear, including switchboard wiring, shall be of flame-retardant quality.

3.17.11(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.

3.19 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 liftboat 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.

5 Three-wire Dual-voltage DC System

5.1 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.

5.3 Neutral Earthing

5.3.1 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.

5.3.2 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.

5.5 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.

7 Electrical Plants of Less Than 75 kW

7.1 General

Electrical plants having an aggregate capacity of less than 75 kW are to comply with the following requirements and the requirements in this Chapter 4, Section 7, as applicable – except 4-7-1/17, 4-7-2/1.3, 4-7-2/1.5, 4-7-2/3, 4-7-2/5, 4-7-2/7.1.6(b), 4-7-2/9.1.5, 4-7-2/11.5, 4-7-2/11.7, 4-7-2/13.3, 4-7-2/15, 4-7-2/17.1, 4-7-2/17.3, 4-7-2/19.3, 4-7-3/1.1, 4-7-3/3.9, 4-7-4/7.15.2, 4-7-4/13 and 4-7-5/1.

7.3 Standard Details

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, are to be indicated on the submitted plans or may be submitted in a booklet format.

7.5 Calculations of Short-circuit Currents

In the absence of precise data, the following short circuit currents at the machine terminals are to be assumed:

7.5.1 Direct Current Systems

Ten times the full load current for generators normally connected (including spare) for each generator capable of being simultaneously connected.

Six times full load current for motors simultaneously in service

7.5.2 Alternating Current Systems

Ten times the full load current for generators normally connected (including spare) for each generator capable of being simultaneously connected – symmetrical rms

Three times full load current of motors simultaneously in service.

7.7 Lightning Protection

A lightning-protection system consisting of a copper spike, and a copper conductor of at least 8 mm² (No. 8 AWG) is to be installed on each non-metallic mast. The spike is to project at least 150 mm (6 in.) above the uppermost part of the liftboat, the conductor is to run clear of metal objects and as straight as practicable to the metallic steel structure of the liftboat.

7.9 Temperature Ratings

In the requirements contained in 4-7-5/7, an ambient temperature of 40°C (140°F) has been assumed for all locations. Where the ambient temperature is in excess of this value, the total temperature specified is not to be exceeded. Where equipment has been rated on ambient temperature less than that contemplated, consideration will be given to the use of such equipment provided the total temperature for which the equipment is rated will not be exceeded.

7.11 Generators

Liftboats using electricity for propulsion auxiliaries or preservation of cargo are to be provided with at least two generators. These generators are not to be driven by the same engine. The capacity of the generating sets is to be sufficient to carry the necessary load essential for the propulsion and safety of the liftboat and preservation of the cargo with any one generator set in reserve. Liftboats having only one generator are to be provided with a battery source to supply sufficient lighting for safety.

7.13 Emergency Source of Power

7.13.1 Capacity

The emergency source of electrical power is to have adequate capacity to provide emergency lighting for a period of at least 6 hours.

7.13.2 Sources

The emergency power source may be any of the following:

- i) An automatically connected or manually controlled storage battery; or
- ii) An automatically or manually started generator; or
- iii) Relay-controlled, battery-operated lanterns.

7.13.3 Battery Sources

Where the source of electrical power is a battery connected to a charging device with an output of more than 2 kW, the battery is to be located as near as practicable to but not in the same space as the emergency switchboard, distribution board or panel.

7.15 Cable Construction

Cables are to have copper conductors constructed in accordance with a recognized standard and are to be of the stranded type, except sizes not exceeding 1.5 mm² (16 AWG) may have solid conductors.

7.17 Switchboards, Distribution Boards and Panels

7.17.1 Installation

Switchboards, distribution boxes panels and panels are to be installed in dry accessible, and well-ventilated areas. Not less than 610 mm (24 in.) clearance is to be provided in front of switchboards, distribution boxes panels and panels. When located at the helm or other area adjacent to or part of an open cockpit or weather deck, they are to be protected by a watertight enclosure.

7.17.2 Instrumentation

A voltmeter, ammeter, frequency meter, and voltage regulator are to be provided for each generator installed. Control equipment and measuring instruments are to be provided as necessary to insure satisfactory operation of the generator or generators.

7.19 Navigation Running Lights

Mast head, port, starboard, and stern lights when required are to be controlled by a running light indicator panel. A fused-feeder disconnect switch is to be provided; the rating of the fuses is to be at least twice that of the largest branch fuse and greater than the maximum panel load.

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 ¹⁾		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 4-7-3/3.1.1 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.

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PART

4

CHAPTER 8 Hazardous Area Installations

SECTION 1 General

1 Hazardous Areas

Liftboats may temporarily install equipment on deck which creates hazardous areas. If any of the liftboat's intended modes of operation include hazardous equipment, arrangements are to be made to accommodate and operate such equipment safely. To this end, the area where such equipment will be installed is to be considered hazardous and electrical equipment, ventilation and access to adjacent spaces in this area are to be in accordance with this Guide. Alternatively, if the area where temporary hazardous equipment will be installed is not in compliance with this Guide, a procedure for making this area suitable for such equipment is to be developed.

1.1 Definitions

1.1.1 Hazardous Areas

Hazardous areas are all those areas where a flammable atmosphere may be expected to exist continuously or intermittently. Such flammable atmospheres may arise from well test operations or other operations such as the use and storage of flammable liquids, paint and acetylene, or any such operations pertinent to the particular service of the unit. Hazardous areas are subdivided into Zones 0, 1 and 2 defined as follows:

- *Zone 0* A zone in which an explosive gas-air mixture is continuously present or present for long periods.
- *Zone 1* A zone in which an explosive gas-air mixture is likely to occur in normal operating conditions.
- *Zone 2* A zone in which an explosive gas-air mixture is not likely to occur, and if occurs, it will exist only for a short time.

1.1.2 Enclosed Space

An enclosed space is considered to be a space bounded by decks and bulkheads which may or may not have doors, windows, or other similar openings.

1.1.3 Semi-Enclosed Location

A semi-enclosed location is considered to be a location where natural conditions of ventilation are notably different from those on open decks due to the presence of structure such as roofs, windbreaks, and bulkheads and which are arranged so that the dispersion of gas may not occur.

1.3 Classification of Areas

The delineation of hazardous areas for equipment and systems is to be in accordance with API RP 505 "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities as Class I, Zone 0, Zone 1, and Zone 2". Alternative standards for hazardous area delineation will also be considered.

1.5 Openings, Access and Ventilation Conditions Affecting the Extent of Hazardous Areas

Except for operational reasons, access doors or other openings are not to be provided between a non-hazardous space and a hazardous zone or between a Zone 2 space and a Zone 1 space.

Where such access doors or other openings are provided, any enclosed space having a direct access to any Zone 1 location or Zone 2 location becomes the same zone as the location except that:

1.5.1

An enclosed space with direct access to any Zone 1 location is considered as Zone 2 provided:

- i) The access is fitted with a gas-tight door opening into the Zone 2 space, and
- ii) Ventilation is such that the air flow with the door open is from the Zone 2 space into the Zone 1 location, and
- iii) Loss of ventilation is alarmed at a normally manned station;

1.5.2

An enclosed space with direct access to any Zone 2 location is not considered hazardous provided:

- i) The access is fitted with a self-closing gas-tight door that opens into the non-hazardous space, and
- ii) Ventilation is such that the air flow with the door open is from the non-hazardous space into the Zone 2 locations, and
- iii) Loss of ventilation is alarmed at a normally manned station;

1.5.3

An enclosed space with access to any Zone 1 location is not considered hazardous provided:

- i) The access is fitted with gas-tight self-closing doors forming an air lock, or a single self-closing gas-tight door which opens toward the non-hazardous space and has no hold-back device,
- ii) Ventilation is such that the air flow with the door or air lock doors open is from the non-hazardous space into the Zone 1 location (i.e., non-hazardous space has ventilation overpressure in relation to the Zone 1 location), and
- iii) Loss of ventilation overpressure is alarmed at a normally manned station.

3 Ventilation (Relative to Hazardous Areas)

3.1 General

Attention is to be given to ventilation inlet and outlet locations and airflow in order to minimize the possibility of cross contamination. Ventilation inlets are to be located in non-hazardous areas. Ventilation for hazardous areas is to be completely separate from that for non-hazardous areas.

3.3 Ventilation of Hazardous Areas

Enclosed hazardous spaces are to be provided with ventilation so as to maintain them at a lower pressure than less hazardous zones. The arrangement of ventilation inlet and outlet openings in the space is to be such that the entire space is efficiently ventilated, giving special consideration to location of equipment, which may release gas, and to spaces where gas may accumulate. The outlet air from Zone 1 and Zone 2 spaces is to be led in separate ducts to outdoor locations which in the absence of the considered outlet are of the same or lesser hazard than the ventilated space. The internal spaces of such ducts are the same Zone as the inlet space. Ventilation ducts for hazardous areas are to be at underpressure in relation to less hazardous areas and at overpressure in relation to more hazardous areas, when passing through such areas, and are to be rigidly constructed to avoid air leaks. Fans are to be of non-sparking construction in accordance with 4-8-1/7.3.4.

3.5 Ventilation of Non-Hazardous Areas

Ventilation inlets and outlets for non-hazardous spaces are to be located in non-hazardous areas. Where passing through hazardous areas, ducts are to have overpressure in relation to the hazardous area

5 Machinery Installations (Relative to Hazardous Areas)

5.1 General

Exhaust outlets of internal-combustion engines and boilers are to discharge outside of all hazardous areas. Air intakes are to be not less than 3 m (10 ft) from hazardous areas. Exhaust outlets of internal combustion engines are to be fitted with suitable spark-arresting devices, and exhaust piping insulation is to be protected against possible oil absorption in areas or spaces where the exhaust piping is exposed to oil or oil vapors.

5.3 Hazardous Areas

Internal-combustion engines are not to be installed in Zone 0 hazardous areas. When essential for operational purposes, internal-combustion engines may be installed in Zone 1 and 2 hazardous areas. Such installations will be subject to special consideration. Fired boilers are not to be installed in hazardous areas.

7 Electrical Installations in Hazardous Areas

7.1 Plans and Data to be Submitted

A plan showing hazardous areas is to be submitted for review together with the following:

- i) A list of intended permanently installed electrical equipment in the indicated hazardous areas, including a description of the equipment, applicable degree of protection and ratings. See 4-8-1/7.3.2.
- ii) For permanently installed intrinsically-safe systems, also wiring plans, installation instructions with any restrictions imposed by the certification agency
- iii) Procedure for making a specific area suitable for temporary hazardous equipment.

When the selection of the equipment has been finalized, a list identifying all permanently installed equipment in hazardous areas, their degree of protection, rating, manufacturer's name, model number and evidence of certification is to be submitted. If evidence of certification is unavailable, this list is to be submitted for review and then will be forwarded to the local surveyor for verification of the certification markings on the listed equipment. An approved copy of this list/booklet is to be maintained on board for future reference. See 4-8-1/7.3.1.

7.3 Equipment and Installations in Hazardous Areas

7.3.1 General Considerations

7.3.1(a) General (2008). Electrical equipment and wiring are not to be installed in hazardous areas unless essential for operational purposes. Hazardous areas are defined in 4-8-1/1.1. For certified safe-type equipment, see 4-8-1/7.3.2.

- i) *Electrical Equipment Types.* Only electrical equipment of the following types, complying with IEC Publication 60079 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.

- ii) *Fans.* Fans used for the ventilation of the hazardous areas are to be of non-sparking construction in accordance with 4-8-1/7.3.4.

7.3.1(b) Electrical Equipment. The following equipment and cables are acceptable for installation in hazardous locations:

- i) **Zone 0 Areas.** Only certified intrinsically safe circuits or equipment and associated wiring are permitted in Zone 0 areas.
- ii) **Zone 1 Areas.** Equipment and cables permitted in Zone 1 areas are to be:
 - Certified intrinsically-safe circuits or equipment and associated wiring certified flameproof (explosion proof) equipment
 - Certified increased safety equipment; for increased safety motors, consideration is to be given to the protection against overcurrent
 - Pressurized enclosure type equipment [see 4-8-1/7.3.2(c)]
 - Permanently installed cables with:
 - Metallic armor, or
 - Of mineral insulated metallic sheathed type, or
 - Installed in metallic conduit with explosion proof gas-tight fittings, or
 - Flexible cables, where necessary, provided they are of heavy-duty type.
- iii) **Zone 2 Areas.** Equipment and cables permitted in Zone 2 areas are to be:
 - All equipment approved for Zone 1 areas
 - The following equipment provided the operating temperature does not exceed 315°C (600°F) and provided any brushes, switching mechanisms, or similar arc-producing devices are approved for Zone 1 areas:
 - Enclosed squirrel cage induction motors
 - Fixed lighting fixtures protected from mechanical damage
 - Transformers, solenoids, or impedance coils in general purpose enclosures
 - Cables with moisture-resistant jacket (impervious-sheathed) and protected from mechanical damage.

7.3.1(c) Cables Installation (2006). Cables in hazardous areas are to be armored or mineral-insulated metal-sheathed where required by 4-8-1/7.3.1(b), except for cables of intrinsically safe circuits subject to the requirements of 4-7-3/5.13. Where cables pass through hazardous area boundaries, they are to be run through gas-tight fittings. No splices are allowed in hazardous areas except in intrinsically-safe circuits. Where it is necessary to join cables in hazardous areas (e.g., flexible cable connections to non-flexible cables), the joints are to be made in approved junction boxes.

7.3.1(d) Lighting Circuits. 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.

7.3.1(e) Permanent Warning Plates. Permanent warning plates are to be installed in the vicinity of hazardous areas in which electrical equipment is installed to advise personnel carrying out maintenance, repair or surveys of availability of the booklet/list of equipment in hazardous areas referenced in 4-8-1/7.1, if required for their use.

7.3.2 Certified-Safe Type and Pressurized Equipment and Systems

7.3.2(a) 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 certified safe type will be approved for installation provided such equipment has been type-tested and certified by a competent, independent testing laboratory as suitable for hazardous areas and provided that there is no departure in the production equipment from the design so tested and approved.

7.3.2(b) Intrinsically-safe System (2005).

- i) 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.
- ii) Separation and Mechanical protection.* The installation of the cables is to be arranged as follows:
 - 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.
 - Conductors of intrinsically safe circuits and non-intrinsically safe circuits are not to be carried in the same cable.
 - Cables of intrinsically safe circuits and non-intrinsically safe circuits are not to be in the same bundle, duct or conduit pipe.
 - 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.
- iii) 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.
- iv) 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.
 - When separation is accomplished by distance, then the clearance between terminals is to be at least 50 mm, or
 - 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.
- iv) 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.
- v) Replacement.* Unless specifically approved, replacement equipment for intrinsically safe circuits is to be identical to the original equipment.

7.3.2(c) 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.

7.3.3 Paint Stores

7.3.3(a) General. Electrical equipment in paint stores and in ventilation ducts serving such spaces as permitted in 4-8-1/7.3.1 is to comply with the requirements for group IIB class T3 in IEC Publication 60079.

The following type of equipment will be acceptable for such spaces.

- i) Intrinsically-safe systems
- ii) Explosion-proof equipment
- iii) Pressurized equipment
- iv) Increased safety equipment
- v) Other equipment with special protection recognized as safe for use in explosive gas atmospheres by a national or other appropriate authority.

7.3.3(b) Open Area Near Ventilation Openings. In the areas on open deck within 1 m (3.3 ft) of ventilation inlet or within 1 m (3.3 ft) (if natural) or 3 m (10 ft) (if mechanical) of exhaust outlet, the installation of electrical equipment and cables is to be in accordance with 4-8-1/7.3.1.

7.3.3(c) 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.

7.3.4 Non-sparking Fans

7.3.4(a) Design Criteria

- i) **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.).
- ii) **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 ducts to prevent the entrance of object into the fan casing.

7.3.4(b) Materials

- i) **Impeller and its Housing.** Except as indicated in 4-8-1/7.3.4(b)iii) 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.

- ii) *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.
- iii) *Acceptable Combination of Materials.* Tests referred to in 4-8-1/7.3.4(b)i) above are not required for fans having the following combinations:
 - Impellers and/or housings of nonmetallic material, due regard being paid to the elimination of static electricity;
 - Impellers and housings of non-ferrous materials;
 - 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;
 - Any combination of ferrous (including austenitic stain-less steel) impellers and housings with not less than 13 mm (0.5 in.) tip design clearance.
- iv) *Unacceptable Combination of Materials.* The following impellers and housings are considered as sparking-producing and are not permitted:
 - Impellers of an aluminum alloy or magnesium alloy and a ferrous housing, regardless of tip clearance;
 - Housing made of an aluminum alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance;
 - Any combination of ferrous impeller and housing with less than 13 mm (0.5 in.) design tip clearance.

7.3.4(c) *Type Test.* Type tests on the finished product are to be carried out using an acceptable national or international standard. The tests need not to be witnessed by the Surveyor for individual fans produced on a production line basis, provided the Surveyor is satisfied from periodic inspections and the manufacturer's quality assurance procedures that the fans are being satisfactorily tested to appropriate standards.

Surveys After Construction

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PART 5

CHAPTER 1 Surveys After Construction

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CHAPTER 1 **Surveys After Construction**SECTION 1 **Conditions for Surveys After Construction****1 Damage, Failure and Repair****1.1 Examination and Repair**

Damage, failure, deterioration or repair to hull, legs, footings or other structures, machinery or equipment, which affects or may affect classification, is to be submitted by the Owners or their representatives for examination by a Surveyor at first opportunity. All repairs found necessary by the Surveyor are to be carried out to the Surveyor's satisfaction.

1.3 Repairs

Where repairs to hull, legs, footings or other structures, machinery or equipment, which affect or may affect classification, are planned in advance to be carried out, a complete repair procedure including the extent of proposed repair and the need for Surveyor's attendance is to be submitted to and agreed upon by ABS reasonably in advance. Failure to notify ABS, in advance of the repairs, may result in suspension of the liftboat's classification until such time as the repair is redone or evidence submitted to satisfy the Surveyor that the repair was properly carried out.

Note: The above applies to repairs during voyage or on site.

The above is not intended to include maintenance and overhaul to hull, other structures, machinery and equipment in accordance with the recommended manufacturer's procedures and established marine practice and which does not require ABS approval; however, any repair as a result of such maintenance and overhauls which affects or may affect classification is to be noted in the ship's log and submitted to the Surveyor as required by 5-1-1/1.1.

1.5 Representation

Nothing contained in this Section or in a rule or regulation of any government or other administration, or the issuance of any report or certificate pursuant to this Section or such a rule or regulation, is to be deemed to enlarge upon the representations expressed in 1-1-1/1 through 1-1-1/7 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* and the issuance and use of any such reports or certificates are to be governed in all respects by 1-1-1/1 through 1-1-1/7 of the above referenced Part 1.

3 Notification and Availability for Survey

The Surveyors are to have access to classed liftboats at all reasonable times. The Owners or their representatives are to notify the Surveyors on all occasions when a liftboat can be examined in dry dock or on a slipway.

The Surveyors are to undertake all surveys on classed liftboats upon request, with adequate notification, of the Owners or their representatives and are to report thereon to the committee. Should the Surveyors find occasion during any survey to recommend repairs or further examination, notification is to be given immediately to the Owners or their representatives in order that appropriate action may be taken. The Surveyors are to avail themselves of every convenient opportunity for carrying out periodical surveys in conjunction with surveys of damages and repairs in order to avoid duplication of work. See also Section 1-1-8 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

5 Attendance at Port State Request

It is recognized that Port State authorities legally may have access to a liftboat. In cooperation with Port States, ABS Surveyors will attend on board a classed liftboat when so requested by a Port State and upon concurrence by the liftboat's master will carry out a survey in order to facilitate the rectification of reported deficiencies or other discrepancies that affect or may affect classification. ABS Surveyors will also cooperate with Port States by providing inspectors with background information, if requested. Such information includes text of conditions of class, survey due dates, and certificate expiration dates.

Where appropriate, the liftboat's flag state will be notified of such attendance and survey.

7 Annual Classification Surveys

Annual Class Surveys of hull, machinery, and automation are to be made within three months before or after each annual anniversary date of the crediting of the previous Special Periodical Survey or original construction date. For liftboats on Continuous Survey, all continuous Survey requirements for those parts (items) due are generally to be completed each year. Continuous items that are three months or more overdue at time of Annual Survey attendance will be basis for the Annual Survey not to be credited and for non-endorsement of class certificate. Consideration may be given to an extension to complete major items.

9 Intermediate Surveys

Intermediate Surveys are to be carried out either at the second or third Annual Survey or between these surveys.

11 Special Periodical Surveys

11.1 Interval

A Special Periodical Survey is to be completed within five years after the date of build or after the crediting date of the previous Special Periodical Survey. The fifth annual survey must be credited as a requirement of the Special Periodical Survey. The interval between Special Periodical Surveys may be reduced by the Committee.

11.3 Commencement

Special Periodical Survey may be commenced at the fourth annual survey and be continued with completion by the fifth anniversary date. Where the Special Periodical Survey is commenced prematurely, the entire survey is normally to be completed within 15 months if such work is to be credited to the Special Periodical Survey.

11.5 Credited Date

A Special Periodical Survey will be credited as of the completion date of the survey but not later than five years from date of build or from the date recorded for the previous Special Periodical Survey. If the Special Periodical Survey is completed within three months prior to the due date, the Special Periodical Survey will be credited to agree with the effective due date.

11.7 Unusual Cases

Special consideration may be given to Special Periodical Survey requirements in the case of liftboats of unusual design, in lay-up or in unusual circumstances. Consideration may be given for extensions of Rule required Special Periodical Surveys under extreme circumstances

13 Continuous Surveys

13.1

At request of the owner, and upon approval of the proposed arrangements, a system of Continuous Surveys may be undertaken.

Each part (item) surveyed become due again for survey approximately five years from the date of the survey and the due parts (items) are generally to be completed each year. Continuous items that are three months or more overdue at time of Annual Survey attendance will be basis for the Annual Survey not to be credited and for non-endorsement of the class certificate. Consideration may be given to an extension to complete major items, for Continuous Surveys, a suitable notation will be entered in the *Record* and the date of the completion of the cycle published. If any defects are found during the survey, they are to be dealt with to the satisfaction of the Surveyor.

13.3

In addition to the foregoing, at a survey either at or between the second and third annual surveys, liftboats will require the equivalent of an Intermediate Survey as indicated in Section 5-1-4.

13.5

Out of water drydocking as required by 5-1-5/1.1 may be carried out at any time during the cycle provided that all requirements of Section 5-1-2 are met and thickness measurements as required by 5-1-5/1.21 are carried out when the liftboat is surveyed in drydock.

15 In-line Surveys

All items required to undergo Special Periodical surveys, including but not limited to hull, machinery, and automation, are to be carried out at the same time and interval in order that they are recorded with the same crediting date. In cases where damage has involved extensive repairs and examination, the survey thereon may, where approved by the Committee, be accepted as equivalent to Special Periodical Survey.

17 Lay-up and Reactivation

17.1

ABS is to be notified by the Owner that a liftboat has been laid-up. This status will be noted in the *Record*, and surveys falling due during lay-up will then be held in abeyance until the liftboat reactivates. Lay-up procedures and arrangements for maintenance of conditions during lay-up may be submitted to ABS for review and verification by survey.

17.3

In the case of liftboats which have been laid up for an extended period (i.e., six months or more) the requirements for surveys on reactivation are to be specially considered in each case, with due regard being given to the status of surveys at the time of the commencement of the lay-up period, the length of the period and the conditions under which the liftboat had been maintained during that period.

17.5

Were the lay-up preparations and procedures have been submitted to ABS for review and verified by Annual lay-up Surveys, consideration may be given to deducting part or all of the time in lay-up from the progression of survey intervals.

17.7

For liftboats returning to active service regardless of whether ABS has been informed previously that the liftboat has been in lay-up, a Reactivation Survey is required.

19 Incomplete Surveys

When a survey is not completed, the Surveyor is to report immediately upon the work done in order that Owners and the Committee may be advised of the parts still to be surveyed-

21 Alterations

No alterations which affect or may affect classification or the assignment of load lines are to be made to a classed liftboat unless plans of the proposed alterations are submitted and approved by an ABS Technical Office before the work of alteration is commenced. Such work, when approved, is to be carried out to the satisfaction of the Surveyor. Nothing contained in this Section or in a rule or regulation of any government or other administration, or the issuance of any report or certificate pursuant to this Section or such a rule or regulation, is to be deemed to enlarge upon the representations expressed in 1-1-1/1 through 1-1-1/7 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* and the issuance and use of any such reports or certificates are to in all respects be governed by 1-1-1/1 through 1-1-1/7 of the above referenced Part 1.

23 Welding and Replacement of Materials

23.1 Ordinary and Higher Strength Structural Steels

Welding or other fabrication performed on the structural steels listed in 2-1-2/Tables 1 through 4 and 2-1-3/Tables 1 through 4 is to be in accordance with the requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

23.3 Special Materials

Welding or other fabrication performed on other steels of special characteristics or repairs or renewals of such steel or adjacent to such steel is to be accomplished with procedures approved for the special materials involved. The procedures are to take into account the information provided under 3-1-2/1 and be in accordance with requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

23.5 Substitutions and Alteration

Substitutions of steel differing from that originally installed, alteration of original structural configuration, or change from riveted to welded joint is not to be made without approval by the ABS Technical Office.

CHAPTER 1 **Surveys After Construction**SECTION 2 **Drydocking Surveys or Equivalent****1 All Liftboats****1.1 Interval**

A Drydocking Survey is to be carried out two times in any 5-year period, with an interval not exceeding three (3) years between drydocking surveys. See also 5-1-5/1.1.

Consideration may be given for extensions of Rule required Drydock Survey under special circumstances.

1.3 Underwater Inspection in Lieu of Drydocking Survey

An approved underwater inspection by diver equivalent to a Drydocking Survey may be accepted at alternate Drydocking Surveys. This alternative will not be available for drydocking survey concurrent with the Special Survey-Hull referred to in 5-1-5/1.1.

Note: It is recognized that some lift boats are designed so as to enable the liftboat to be fully examined by a combination afloat examination and examination while elevated. In this case there is no need to place the liftboat on drydock or carry out an Underwater Inspection in Lieu of Drydocking Survey, provided the parts noted below are accessible to the attending Surveyor.

1.5 Parts to be Examined

The keel, stem, stern frame, rudder, propeller, outside of side and bottom plating, leg pad plating and underwater areas of legs, together with their connections as applicable, are to be cleaned as necessary and examined together with bilge keel, thruster, exposed parts of the stern bearing and seal assembly, sea chest, rudder pintles and gudgeons together with their respective securing arrangements. Leg connections to leg pads are to be non-destructively tested and examined at each drydocking survey. Non-destructive testing may be required of areas found to be suspect. All non-metallic expansion pieces in the seawater cooling and circulating systems are to be examined externally. Non-metallic expansion pieces in the main seawater circulating systems are to be examined both externally and internally when liftboat is examined on drydock. The stern bearing clearance or wear down and rudder bearing clearances are to be ascertained and reported on.

PART

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CHAPTER 1 Surveys After Construction

SECTION 3 Annual Surveys – Hull

1 Parts to be Examined

At each Annual Survey the hull is to be generally examined so far as can be seen and placed in satisfactory condition. The survey should include the following.

1.1

Confirmation that no unapproved changes have been made to the hatch covers, hatch coamings and their securing and sealing devices since the last survey. Exposed hatch covers are to be examined to confirm structural integrity and capability of maintaining weathertightness. Where significant wastage of steel hatch covers is noted, thickness gauging is to be carried out and renewals made as necessary.

1.3

Where mechanically operated steel covers are fitted, examination of:

- i) Hatch covers including plating and stiffeners
- ii) Tightness devices of longitudinal, transverse and intermediate cross junctions (gaskets, gasket lips, compression bars, drainage channels)
- iii) Clamping devices, retaining bars, cleating
- iv) Chain or rope pulleys
- v) Guides
- vi) Guide rails and track wheels
- vii) Stoppers, and similar devices
- viii) Wires, chains, gypsies, tensioning devices
- ix) Hydraulic system essential to closing and securing
- x) Safety locks and retaining devices
- xi) Loading pads/bars and the side plate edge
- xii) Guide plates and chocks
- xiii) Compression bars, drainage channels and drain pipes (if any)

Where wooden covers on portable beams or steel pontoon covers are fitted, examination of:

- i) Wooden covers and portable beams, carriers or sockets for the portable beams, and their securing devices
- ii) Steel pontoons
- iii) Tarpaulins
- iv) Cleats, battens and wedges
- v) Hatch securing bars and their securing devices

1.5

Examination of hatch coaming plating including deck connection, stiffeners, stays, pads, chocks and brackets.

1.7

Confirmation of the satisfactory operation of all mechanically operated hatch covers is to be made, including:

- i)* Stowing and securing in open condition
- ii)* Proper fit, and efficiency of sealing in closed condition
- iii)* Operational testing of hydraulic and power components, wires, chains, and link drives

1.9

Jackhouse/jackstand structures and attachment to upper hull or platform.

1.11

Jacking or other elevating systems and leg guide, externally.

1.13

Legs as accessible above the waterline.

1.15

Plating and supporting structure in way of leg wells.

PART

5

CHAPTER **1 Surveys After Construction**

SECTION **4 Intermediate Survey**

1 Salt Water Ballast Spaces

1.1

For liftboats over five (5) years of age an overall survey of a minimum of three (3) representative salt water ballast spaces selected by the Surveyor is to be carried out. Where poor coating condition is found, where soft coating has been applied, or where a protective coating has not been applied, the examination is to be extended to other ballast spaces of the same type.

For liftboats more than 10 years of age, all ballast tanks are to be examined.

1.3

If such examinations reveal no visible structural defects, the examination may be limited to a verification that the protective coating remains effective.

1.5

In salt water ballast spaces, other than double bottom tanks, where poor coating condition is found and owners or their representatives elect not to restore the coating, where a soft coating has been applied, or a protective coating has not been applied, the ballast tanks are to be internally examined at each subsequent Annual Survey

PART

5

CHAPTER 1 Surveys After Construction

SECTION 5 Special Periodical Survey – Hull

1 Parts to be Examined

Special Periodical Survey Hull is to include sufficient examination, tests and checks carried out by the Surveyors to satisfy themselves that the hull, equipment and related piping are in or placed in satisfactory condition and are fit for its intended purpose for the next five year period subject to proper maintenance and operation and to periodic surveys being carried out at the due dates. Special Periodical Survey is to include the following:

1.1

The liftboat is to be dry-docked and all items of 5-1-2/1.5 are to be examined.

1.3

The rudder is to be examined and when required, lifted and the gudgeons rebushed. The condition of carrier and steadiment bearing and the effectiveness of stuffing boxes are to be ascertained when the rudder is lifted.

1.5

The anchors and chain cables are to be ranged, examined and the required complement and condition verified. The chain locker, holdfasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

At SSH No.2 and subsequent surveys, chain cables are to be gauged and renewed in cases where their mean diameter is 12% or more below the original required nominal size.

Where structural alterations to be liftboat have resulted in a higher equipment numeral, the original chain cables may be used until their mean diameter has been reduced to 12% below the nominal diameter of the larger cable required by the higher equipment numeral.

1.7

All opening in the shell including overboard discharges are to be examined.

1.9

All decks, watertight bulkheads, and internal and external surfaces of shell plating are to be examined. Plating in way of side shell or superstructure portlights is to be especially examined.

1.11

1.11.1

All spaces including holds and their tween decks where fitted; double bottom, deep ballast, peak and cargo tanks; pump rooms, pipe tunnels, duct keels, machinery spaces, dry spaces, cofferdams and voids are to be internally examined including the plating and framing, bilges and drain wells, sounding venting, pumping and drainage arrangements. Where sounding pipes are fitted, the Surveyor is to verify that a thick steel plate is securely fixed below the sounding pipe for the rod to strike upon. Electrical bonding arrangements, including bonding straps where fitted, for the piping systems located within cargo tanks, pipe tunnels, cofferdams and void spaces bounding cargo tanks are also to be examined.

1.11.2

In salt water ballast spaces, other than double bottom tanks, where poor coating condition is found and owner or their representatives elect not to restore the coating, where soft coating has been applied, or where a protective coating has not been applied, the ballast tanks are to be internally at each subsequent Annual Survey.

1.13

1.13.1

All tank protective devices, where fitted, are to be examined externally for proper assembly and installation, damage, deterioration, or traces of carryover at the outlets. Where deemed suspect, the tank protective device is to be opened out for examination to confirm condition.

1.13.2

All pressure-vacuum valves and pressure relief valves are to be opened out, pressure and vacuum valve discs checked for good contact with their respective seats and/or proved by testing.

1.15

Internal examination requirements will be specially considered for lube oil tanks and for tanks used exclusively for permanent ballast which are fitted with an effective means of corrosion control.

1.17

Where double bottom and other tanks, except for the peak tanks, are used primarily for heavy oil fuel or exclusively for light oils, the internal examination may be waived, up to and including Special Periodical Survey – Hull No. 2, provided that upon a general external examination of the tanks, the Surveyor finds their condition to be satisfactory. Internal examination of all fuel tanks is required for Special Periodical Survey – Hull No. 3 and all subsequent Special Periodical Surveys.

1.19

Independent oil tanks in machinery spaces are to be externally examined and, if deemed necessary, tested under a head of liquid.

1.21

Thickness gaugings are to be carried out in accordance with 5-1-5/Table 1. Additionally, any part of the liftboat where wastage is evident or suspect, the Surveyor may require thickness gaugings in order to ascertain the actual thickness of the material.

TABLE 1
Thickness Gauging Requirements

<i>Special Periodical Survey Number 1</i>	<i>Special Periodical Survey Number 2</i>	<i>Special Periodical Survey Number 3</i>	<i>Subsequent Special Periodical Survey</i>
1) Suspect areas throughout the liftboat (particular attention to be paid to the legs in way of the Splash Zone).	1) Suspect areas throughout the liftboat. 2) Legs in way of Splash Zone. 3) Primary application structures where wastage is evident. 4) Representatives gaugings of upper hull deck and bottom plating and internals of one preload (ballast) tank.	1) Suspect areas throughout the liftboat. 2) Representative gaugings, throughout, of special and primary application structures. 3) Leg well structure. 4) Representative gaugings of deck, bottom, and side shell plating of hull and mat. 5) Representatives gaugings of upper hull deck and bottom plating and internals of at least two preload (ballast) tanks.	1) Suspect areas throughout the liftboat. 2) Comprehensive gaugings, throughout, of special and primary application structures. 3) Leg well structure. 4) Representative gaugings of deck, bottom, and side shell plating of hull and mat. 5) Substructure of derrick as deemed necessary. 6) Representative gaugings of internals of all preload (ballast) tanks.

Notes:

- 1 With reference to the operating history and arrangement and condition of coatings, specific thickness gauging locations should be selected which will provide the best representative sampling of areas likely to be most exposed to corrosion effect.
- 2 Gauging requirements noted may be modified as deemed necessary or appropriate by the Surveyor if the structure remains effectively protected against corrosion by a permanent type special coating.
- 3 In any case where excessive wastage is evident, additional gaugings may be required.
- 4 Structural application designation (special, primary, secondary) are defined as follows:
 - a. Secondary Application Structure (Least Critical)
 - Internal framing, including bulkheads and girders, in cylindrical legs
 - Internal bulkheads and framing members of upper hull structure
 - Internal bulkheads of bottom mat supporting structure, except where the structure is considered primary application
 - Deck, side and bottom plating of upper hull, except where the structure is considered primary application
 - Floating frames or yokes in jacking or other self-elevating systems
 - b. Primary Application Structure (Intermediate)
 - External plating of cylindrical legs
 - Main structural members of lattice type legs
 - Combinations of bulkhead, deck, side bottom plating within the upper hull, which form “box” or “I” type main supporting structure
 - Jack-house supporting structure and bottom footing structure which receives initial transfer of load from legs
 - Internal bulkheads, shell and deck of bottom mat supporting structure which distribute major loads, either uniform or concentrated.
 - Fixed frames in jacking or other self-elevating systems
 - c. Special Application Structure (Most Critical)
 - Legs in way of intersection with the footing.
 - Intersections of lattice type leg structures which incorporate novel construction, including the use of steel castings

1.23

Boundaries of double bottom, deep, ballast, peak, and other tanks are to be tested with a head of liquid. The testing of double bottoms and other spaces not designed for the carriage of liquid may be omitted provided a satisfactory internal examination together with an examination of the tank top is carried out.

1.25

The hatch covers and coamings, where fitted, are to be surveyed as follows:

- i) A thorough inspection of the items listed in 5-1-3/1 is to be carried out.
- ii) Confirmation of the satisfactory operation of all mechanically operated hatch covers is to be made, including:
 - Stowage and securing in open condition;
 - Proper fit and efficiency of sealing in closed condition;
 - Operational testing of hydraulic and power components, wires, chains, and link drives;
- iii) Confirmation of the effectiveness of sealing arrangements of all hatch covers by hose testing or equivalent. Where the omission of gaskets has been approved, hose tests are not required provided the surveys required by 5-1-3/1.3 are satisfactorily carried out.
- iv) Thickness measurements of steel hatch covers, coamings and their stiffening members as found necessary by the Surveyor.

1.27

Load Line marks are to be checked and recut and/or painted as required.

PART 5

CHAPTER 1 Surveys After Construction

SECTION 6 Annual Surveys – Machinery

1 Parts to be Examined

At each Annual Survey the machinery and electrical installation are to be generally examined so far as can be seen and placed in satisfactory condition. The survey should include:

- i) Machinery and boiler spaces (where fitted) with particular attention to the propulsion system, auxiliary machinery, and confirmation that emergency escape routes are not blocked.
- ii) Main propulsion gear-tooth contact is to be examined at the end of the first Annual Survey after liftboat enters service, or after replacement gears have been placed in service. Examination of conventional gear units 1120 kW (1520 mhp, 1500 hp) and below for all epicyclic gear units will be subject to special consideration. See 4-3-1/9.9 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.
- iii) All accessible parts of the steering arrangements together with an operation test of the main and auxiliary steering gears, including their associated equipment and control systems, performed while the liftboat is not underway.
- iv) Testing of all means of communication between the navigating bridge, the machinery control positions, and the steering gear space, as well as the alternative steering position, if fitted.
- v) Bilge pumping system and bilge wells including operation of pumps, remote reach rods and level alarms, where fitted.
- vi) Boilers (where fitted), pressure vessels, and their appurtenances externally, including safety devices, foundations, control, relieving gear, high-pressure and steam escape piping, insulation and gauges.
- vii) Electrical machinery, the emergency sources of electrical power, the switchgear, and other electrical equipment including operation of same.
- viii) Confirmation, as far as practicable, of the operation of the emergency sources of electrical power and, where appropriate, their automatic operation.
- ix) Fire-extinguishing apparatus required for Classification as outlined in Part 4, Chapter 6 including examination and/or test of the following:
 - Fire main system including isolating valves and hydrants. Fire mains are to undergo satisfactory pressure testing at the working pressure.
 - Fire pumps including demonstration that each fire pump including the emergency fire pump can deliver two jets of water simultaneously from different hydrants.
 - Confirmation that fire hoses, nozzles, applicator and spanners are in good working condition and situated at their respective locations.
 - Confirmation that all semi-portable and portable fire extinguishers are in their stowed positions, checking for evidence of proper maintenance and servicing, conducting random check for evidence of discharged containers.
 - Examination of fixed fire-fighting system controls, piping, instructions and marking, checking for evidence of proper maintenance and servicing, including date of last systems tests.

- Examination as far as possible and testing as feasible of the fire and/or smoke detection system(s).
 - Confirmation, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery space are in working order.
 - Confirmation that the fireman's outfits are complete and in good condition.
- x) Where areas of the liftboat are designated for helicopter operations the following, where fitted, are to be examined and found or placed in satisfactory condition.
- Access arrangements, ventilation and electrical equipment.
 - Fuel storage and refueling system including tank, pumps, piping, valves, vent, sounding, overflow, spill containment, and remote shutdowns.

CHAPTER 1 **Surveys After Construction**SECTION 7 **Survey of Fire Extinguishing System Components**

The following requirements are intended as minimum classification requirements and do not prevent more extensive requirements by the flag Administration.

Where the examinations and tests required by 5-1-7/1 are carried out by flag Administration, their acceptance may be considered upon submission of evidence provided it is not less effective.

1 Carbon Dioxide and Halogenated Hydrocarbon Fixed System Containers

At Annual Survey – Machinery and Special Periodical Survey – Machinery as appropriate, containers for carbon dioxide or halogenated hydrocarbon are to be surveyed as follows:

1.1 External Examination

External examination of each container and its permanent fittings is to be carried out annually and is to include:

- i) Condition of fittings, manometers, outer surfaces, fastenings and insulation,
- ii) Serviceability of the automatic equipment, alarm and protection systems (if fitted), and
- iii) Condition of safety valves, safety membranes and other pressure safety devices.

Where damage or other indications such as corrosion or cold spots are found during the external examination, removal of the insulation and an internal examination or hydrostatic test may be required. Removal of the insulation is to be in accordance with the manufacturer's procedures.

1.3 Internal Examination

Where low pressure (carbon dioxide) or bulk (halogenated hydrocarbon) type containers more than five years old are discharged, ABS is to be notified before those containers are recharged so that an internal examination may be carried out.

Particular attention is to be given to the mounting seat of the valve heads of the pressure vessels, fittings, manhole covers and other areas subject to corrosion, pitting cracks, etc. Depending upon the findings of the internal examination, a hydrostatic test may also be required by the Surveyor.

1.5 Hydrostatic Testing

Periodic hydrostatic testing of high pressure carbon dioxide containers is to be carried out for not less than 10% of the containers during each 10 years period. Where Halon containers more than five years old are discharged, ABS is to be notified before these containers are recharged so that a hydrostatic test may be carried out. Hydrostatic testing is also required after repair or where found necessary after external or internal examination. A certificate of test by a recognized laboratory at the test pressure in accordance with 4-6-6/5.11.2 of the *Steel Vessel Rules* will be acceptable.

Alternate hydrostatic testing schedule in accordance with established national requirements may be specially considered.

1.7 Contents

The amount of the contents is to be verified on a two-yearly basis. Where the loss exceeds 10% for carbon dioxide and 5% for halogenated hydrocarbon, the container is to be recharged.

3 Foam Concentrates

At least twice during each five year Special Periodical Survey – Machinery period, the continued effectiveness of foam concentrate is to be verified by a test conducted by the manufacturer or an independent laboratory whose report is to be submitted to the Surveyor.

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5

CHAPTER 1 Surveys After Construction

SECTION 8 Special Periodical Surveys – Machinery

1 Parts to be Examined

At each Special Periodical Survey the following items are to be examined and placed in satisfactory condition.

1.1

All openings to the sea, including sanitary and other overboard discharges together with the valves connected therewith, are to be examined internally and externally while the liftboat is in dry dock and the fastenings to the shell plating are to be renewed when deemed necessary by the Surveyor.

1.3

Pumps and pumping arrangements, including valves, pipes, and strainers, are to be examined. The Surveyor is to be satisfied with the operation of the bilge system, including an internal examination of the emergency bilge suction valve. Other systems are to be tested as considered necessary.

1.5

Shafts (except the propeller shaft), thrust bearings, and lineshaft bearings are to be opened for examination.

1.7

The foundations of main and auxiliary machinery are to be examined.

1.9

Heat exchangers and other unfired pressure vessels with design pressures over 6.9 bar (7 kgf/cm², 100 psi) are to be examined, opened out and pressure tested as deemed necessary, and associated relief valves proven operable. Evaporators that operate with a vacuum on the shell need not be opened, but may be accepted on basis of satisfactory external examination and operational test or review of operating records.

1.11

Examination of the steering machinery is to be carried out, including an operational test and checking of relief valve settings. Further, a hydrostatic check of the steering system to the relief valve setting is to be conducted using the installed power units. The machinery may be required to be opened for further examination as deemed necessary by the Surveyor.

1.13

Reduction gearing is to be opened and examined as deemed necessary by the Surveyor in order to confirm the condition of the gears, pinions, shafts, bearings and lubrication system. Alternative means of ascertaining the condition of epicyclical gearing will be specially considered.

1.15

Examination of anchor windlass including operational check, check of the brake, and testing of safety devices.

1.17

Steam condensers are to be opened, examined, and leak tested as deemed necessary by the Surveyor.

1.19

Steam piping, where fitted, is to be examined and where deemed necessary by the Surveyor, sections may be required to be removed for examination. Where deemed necessary by the Surveyor, the thickness is to be ascertained by nondestructive means. Alternatively, for installation operating at temperatures not exceeding 427°C (800°F) hydrostatic tests to 1¼ times the working pressure may be accepted. Copper pipes are to be annealed before the test. Where deemed necessary by the Surveyor, the thickness is to be ascertained to determine the future working pressure.

1.21

Cycloidal propellers are to be examined, function tested, checked for leakage and opened as deemed necessary.

3 Electrical Equipment

The entire electrical installation including the following items are to be examined and placed in satisfactory condition.

3.1 Auxiliary Apparatus

- i) Fittings and connections on main switchboards and distribution panels are to be examined, and care is to be taken to see that no circuits are overfused.
- ii) Cables are to be examined as far as practicable without undue disturbance of fixtures.
- iii) All generators including emergency generator are to be run under load. Where the generators are arranged to operate in parallel, satisfactory load sharing and operation of the circuit breakers including the reverse power trip is to be demonstrated.
- iv) All equipment and circuits are to be inspected for possible development of physical changes or deterioration. The insulation resistance of the circuits is to be measured between conductors and between conductors and ground. These values are to be compared with those previously measured. Any large and abrupt decrease in insulation resistance is to be further investigated and corrected.
- v) Where electrical auxiliaries are used for vital purposes, the generator and motor are to be examined and their prime movers opened for inspection. The insulation resistance of each generator and motor is to be measured with all circuits of different voltages above ground being tested separately. This test is to be made with direct current potential to ground as follows:
 - 500 volts DC for units 550 volts AC (phase to phase) or lower and also for DC fields.
 - 1000 volts DC for units 551 volts AC (phase to phase) up to 4000 volts AC.
 - 2500 volts DC for units 4001 volts AC (phase to phase) and up.

The direct current potential is to be applied for at least 30 seconds and the minimum isolation resistance is to be of the order of one-half to one megohm.

3.3 Main Propulsion Apparatus

- i) The windings of generators and motors are to be thoroughly examined and found or made dry and clean. Particular attention is to be paid to the ends of all windings of stators and rotors.
- ii) All air ducts in stator coils and the ventilating holes in rotors and retaining rings of alternators are to be carefully examined and found or made clear and clean.
- iii) All cable runs are to be examined and found or placed in good condition as to supports, etc., and the ground connections of protective coverings or sheath found substantial and effective. Particular attention is also to be paid to high-potential bus insulators, which are to be free from dust or oil in order to prevent creepage to ground.

- iv) The insulation resistance of each propulsion unit is to be measured and found equal to the requirements noted above for auxiliary generators and motors. In order to further evaluate these insulation-resistance readings, it is recommended that a separate log be kept of insulation-resistance measurements taken frequently at regularly scheduled intervals. Humidity, ambient temperature, and condition of the machine are also to be noted. Any large and abrupt decrease in insulation resistance, when compared with those recorded in the log, is to be investigated and corrected.
- v) Alternatively, a log of insulation resistance values is to be made at the beginning of the survey and insulation resistance is to be measured again at the end of the survey; a comparison is to be made between the measured value and the log made at the beginning of the survey. Any large or abrupt decrease in insulation resistance is to be further investigated and corrected.

3.5 Major Repairs

On the occasion of major repairs, the coils repaired or renewed are to be subjected to a dielectric strain test as specified under the applicable parts of 4-7-4/3.9 and 4-7-4/7.7. In addition the circuits containing the repairs or renewals and coils which have been disturbed during repairs are to be subjected to dielectric strain tests for one minute by application of a potential of 125% of the maximum operating voltage of the circuits to which it is applied. The DC fields of generators and motors are to be subjected for one minute to a test potential equal to 50% of the value specified under the applicable parts of 4-7-4/3.9 and 4-7-4/7.7, and the whole apparatus operated under full-load conditions.

5 Internal-combustion Engines

5.1

Main and auxiliary internal combustion engines are to be opened and examined including cylinders, cylinder heads, valves and valve gear, fuel pumps, scavenging pumps, and superchargers, pistons, cross heads, connecting rods, crankshafts, clutches, reversing gear, air compressors, intercoolers, and other such parts of the main and auxiliary machinery as are considered necessary. Tie rods are to be re-tensioned as necessary, engine entablature bolting checked for tightness, and crankshaft deflections of low speed-type engines measured. Parts which have been examined within fifteen months need not be examined again except in special circumstances. Special consideration as to the requirements for Special Periodical Surveys may be given for main engines with bores 300 mm (11.5 in.) or under provided the engine is maintained under a manufacturer's scheduled maintenance program. The records of the program, including lubrication servicing, are to be made available to the Surveyor. Periodical over hauls, required by the manufacturer's scheduled maintenance program, are to be witnessed by the Surveyor and will be accepted for completion of the cycle.

5.3

Air reservoirs are to be examined and their relief valves proven operable. If air reservoirs cannot be examined internally they are to be hydrostatically tested.

5.5

Essential components of the engine fuel oil system including fuel oil service pumps, separator, and heaters are to be examined.

7 Jacking Systems (2011)

The jacking system for each leg typically includes the rack, rack guides, pinions, planetary gears, hydraulic or electrical drives and brake system. Component parts of the leg jacking systems are to be examined and reported upon. Racks and climbing pinions are to be visually examined for wear and proper tooth contact. Planetary gear boxes, at least one per leg, are to be opened and examined to the Surveyor's satisfaction. Lube oil samples from each remaining gearbox are to be taken and examined for the presence of contaminants and/or metal particles. If these conditions are noted the gearbox is to be opened for examination including nondestructive testing by an effective crack detection method to the Surveyor's satisfaction. Braking systems are to be opened and examined as considered necessary by the attending Surveyor. See also 5-1-8/3.

Jacking systems are to be operationally tested in accordance with 3-6-3/7.1. All control systems, including braking and fail-safe systems, are to be functionally tested and proven in good order.

At Special Periodical Survey No. 2 and subsequent Special Periodical Surveys, the leg jacking system is to be examined in the presence of the Surveyor by the original equipment manufacturer or other third party inspector mutually agreeable to the owner and the Surveyor.

9 Examination During Overhaul

On all occasions of overhaul or adjustment, access is to be provided for the Surveyor to examine the parts opened. In the event of defects being discovered, such other parts as may be considered necessary are to be opened and examined.

11 Examination at Shorter Intervals

If it is found desirable, upon inspection, that any part of the machinery should be examined at shorter intervals than specified above, it will be necessary for Owners to comply with the Committee's requirements in this respect.

CHAPTER 1 Surveys After Construction**SECTION 9 Tail Shaft Surveys****1 Interval**

The tail shaft survey interval is to be in accordance with 5-1-9/Table 1 and its associated notes. Consideration may be given for extensions of Rule required tail shaft surveys under special circumstances.

3 Survey Details**3.1 Tapered Shafts**

The survey details 5-1-9/3.1.1 and 5-1-9/3.1.2 below apply to a shafting arrangement where the propeller is taper fitted to the shaft.

3.1.1 Water-Lubricated Bearings

The survey is to consist of removing the propeller and drawing in and examining the entire shaft. During each survey, the shaft is to be examined by a surface crack-detection method (such as magnetic particle or dye penetrant) all around the shaft from the after edge of the liner for one-third of the length of the taper, including forward end of keyway (if fitted).

3.1.2 Oil-Lubricated Bearings

The survey may be carried out as described above. Alternatively, on the basis of satisfactory service record, lubricating oil analysis, bearing wear, and the condition of the inboard and outboard seal assemblies, the survey may consist of removing the propeller to expose the forward end of the taper and performing a nondestructive examination by a surface crack-detection method (such as magnetic particle or dye penetrant) all around the shaft in way of the forward portion of the taper section, including the end of keyway (if fitted).

3.3 Flanged Propeller Shafts

The Surveys detailed below are applicable where the propeller is fitted to the shaft by means of a coupling flange.

3.3.1 Water-Lubricated Bearings

The Survey is to consist of withdrawing the shaft in its entirety.

3.3.2 Oil-Lubricated Bearings

The Survey may be carried out as described above. Alternatively, the survey may consist of the verification of a satisfactory service record, lubricating oil analysis, stern bearing wear, shaft seal effectiveness, and for controllable pitch propellers a blade seal leak and function test.

3.3.3 Coupling Bolts and Flange Radius

Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul or repairs, the coupling bolts or flange radius are to be examined by means of a surface crack detection method.

3.3.4 Controllable-Pitch Propellers

Controllable-pitch propellers are to be surveyed along with the tailshaft. The propeller is to be function tested, examined for leaks, and opened out as deemed necessary by the attending Surveyor.

5 Allowable Bearing Wear-down

5.1 Water-Lubricated Bearing Other than Rubber

The after bearing is to be rebushed when clearance has reached the following limits:

Shaft Diameter, mm (in.)	Clearance, mm (in.)	
	<i>Machinery Amidships</i>	<i>Machinery Aft</i>
≤ 230 (9)	6.4 (0.25)	4.8 (0.19)
230 (9) ≤ 305 (12)	8.0 (0.31)	6.4 (0.25)
> 305 (12)	9.5 (0.38)	8.0 (0.31)

5.3 Water-lubricated Rubber Bearing

Water-lubricated rubber bearings are to be rebushed when any water groove is 50% of the original depth, or whenever the clearance exceeds the limits as given above for wood bearings, whichever occurs first.

5.5 Oil-lubricated Bearings

Oil-lubricated bearings are to be rebushed when the wear-down exceeds the manufacturer's recommendations.

7 Tube Shafts

Tube shafts, if fitted, are to be examined at the same interval as tails shafts.

TABLE 1
Tail Shaft Survey Interval (in years)

<i>Type of Service and Design</i>		<i>Single Screw</i>	<i>Multiple Screw</i>
1	Fresh Water Exclusively		
	a. Water-lubricated ⁽¹⁾	5	
	b. Oil-lubricated ⁽²⁾	5	
2	Fresh Water and Sea Water		
	a. Water-lubricated ⁽¹⁾		4 (5 ⁽³⁾)
	i) Cont. Liner or equivalent	3 (5 ⁽³⁾)	
	ii) All other shafts	3	4
	b. Oil-Lubricated ⁽²⁾		5

Notes:

- 1 For water lubricated bearings, an extension of up to one year may be considered, when requested by the Owner, on the basis of satisfactory service record and an external examination of the inboard and outboard tailshaft assemblies together with a bearing wear down check at the end of the normal survey period. A survey will be required for this extension.
- 2
 - a) For oil lubricated bearings, up to two (2) separate extensions of approximately one (1) year each may be considered when requested by the Owner, on the basis of satisfactory service and oil loss records, an external examination of the inboard and outboard seal assemblies, and an examination of oil sample at the time of granting each requested extension with a confirmation at the fifth year that bearing wear down is within allowable limits. A survey will be required for each extension.
 - b) In lieu of up to two (2) extensions of one (1) year each in 2a above, one (1) extension not exceeding five (5) years may be considered when requested by the owner provided survey consisting of the following is carried out at the fifth year
 - i) Verification of satisfactory service including records of oil loss
 - ii) Oil sample examination and test.
 - iii) Verification of no reported repairs by grinding or welding.
 - iv) Bearing wear down measurement (see 5-1-2/1.5)
 - v) Verification that propeller is free of damages which may cause the propeller to be out of balance.
 - vi) Bearing outboard seals are to be renewed and the seal liner found to be or placed in satisfactory condition.
 - vii) Bearing inboard seal assemblies are to be externally examined and found to be or placed in satisfactory condition.
- 3 Applicable to tailshafts protected by continuous metallic liner, or continuous cladding per 4-3-1/11 which effectively prevents seawater from contacting the steel shaft, or which have shafts of corrosion-resistant materials; the survey interval is five years, provided that in addition to the propeller hub details given in Part 4, Chapter 3, the design includes other features that would further reduce stress concentrations in the propeller assembly.

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CHAPTER 1 Surveys After Construction

SECTION 10 Boiler Surveys

1 Survey Interval

Waste-heat or fired auxiliary boilers intended for working pressures above 3.4 bar (3.5 kgf/cm² 50 psi), are to be surveyed at intervals not exceeding 2½ years; however, where requested by the Owner, an extension of the auxiliary or waste heat boiler survey interval of up to six months may be granted provided the boiler is surveyed twice in every 5-year period. The extension may be granted by the Surveyor after a satisfactory external examination of the boiler and review of boiler operating and feedwater records.

3 Parts to be Examined

3.1

At each survey the boilers, superheaters, and economizers are to be examined internally (water-steam side and externally fire side).

3.3

Boiler mountings and safety valves are to be examined at each survey and opened as considered necessary by the Surveyor.

3.5

The proper operation of the safety valves is to be confirmed at each survey.

3.7

When considered necessary by the Surveyor, the boilers and superheaters are to be subjected to hydrostatic pressure test.

CHAPTER 1 **Surveys After Construction**SECTION 11 **Shipboard Automatic and Remote Control Systems****1 Annual Survey**

In order to retain the **ACCU**, **ACC** or **ABCU** symbol, at each Annual Survey the automatic and remote-control system is to be generally examined so far as can be seen and placed in satisfactory condition. The examination is to be made with a ship's service generator in operation and the control system energized to permit random checking of function indicators, alarms and such control actuators as may be operational. The Surveyor is to examine the machinery records to check the performance of the control system throughout the period since the last survey and to establish if there has been any abnormal functioning or failures and what corrective measures had been taken to preclude their recurrence. The machinery fire-detecting and bilge water-level alarms are to be checked for performance.

3 Special Periodical Surveys

In order to retain the **ACCU**, **ACC** or **ABCU** symbol, at each Special Periodical Survey, the following items are to be examined and placed in satisfactory condition.

3.1 Control Actuators

All mechanical, hydraulic and pneumatic control actuators and their power systems are to be examined and tested as considered necessary.

3.3 Electrical

The insulation resistance of the windings of electrical control motors or actuators is to be measured, with all circuits of different voltages above ground being tested separately, and is to be on the order of one-half to one megohm.

3.5 Unattended Plants

Control systems for unattended machinery spaces are to be subjected to dock trials at reduced power on the propulsion engine to check the proper performance of all automatic functions, alarms and safety systems.