



GUIDE FOR BUILDING AND CLASSING

LIFTBOATS 2018

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

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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 2018 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. The primary changes from the 2017 edition of the Guide are identified and listed in Table 3. The effective date of the indicated Rule Changes is 1 January 2018, unless specifically indicated otherwise.
4. The effective date of each technical change since 1993 is shown in parenthesis at the end of the subsection/paragraph titles within the text of each Part. Unless a particular date and month are shown, the years in parentheses refer to the following effective dates:

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

For certain changes that have a major impact on shipyards, designers and vendors, ABS has instituted a two-year Rule cycle to give the industry more time to prepare for these changes. The text of these changes will appear in a box along with the effective date just under the existing requirement.

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 2018 Liftboat Guide

Guide for Building and Classing Liftboats		
Notices and General Information		2018
Part 1:	Conditions of Classification (Supplement to the ABS <i>Rules for Conditions of Classification – Offshore Units and Structures</i>) ⁽¹⁾	2018
Part 3:	Hull Construction and Equipment	2018
Part 4:	Machinery and Systems	2018
Part 5:	Surveys After Construction	2018
Rules for Conditions of Classification – Offshore Units and Structures – not included ^(1,2)		
Part 1:	Rules for Conditions of Classification – Offshore Units and Structures	2018
Rules for Materials and Welding – not included ⁽²⁾		
Part 2:	Rules for Materials and Welding	2018

Notes:

- 1 The requirements for conditions of classification are contained in the separate, generic ABS *Rules for Conditions of Classification (Part 1)*. Additional specific requirements are contained in Part 1 of these Rules.
- 2 The latest edition of these Rules is to be referred to. These Rules may be downloaded from the ABS website at www.eagle.org, Rules and Guides, Downloads or may be ordered separately from the ABS Publications online catalog at www.eagle.org, Rules and Guides, Catalog.

TABLE 2
Division and Numbering of 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 (2018)

TABLE 3
Summary of Changes from the 2017 Guide

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

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

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 3	Hull Construction and Equipment	
3-2-13/17.1	Strength	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-13/Figure 5 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-13/Figure 6 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-13/Figure 7 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-13/17.1.2	In way of Cutouts	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
PART 4	Vessel Systems and Machinery	
4-3-3/11.3.5 (New)	System Response Under Failure	To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)
4-3-3/11.9.7	Low Oil Level Alarm	To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)
4-3-3/11.9.12 (New)	Earth Fault	To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)
4-3-3/11.9.13 (New)	Deviation	To require a deviation alarm in addition to basic failure detection, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)
4-5-1/9.19.3(c)	Fire Resistance	To clarify the cases in which flexible hoses need not be of fire-resistant type. (Incorporates Notice No. 1)
4-7-2/7.9	Harmonics	To specify that the harmonic distortion calculation report is to be kept on board for exceptions to the 8% limit in cases where all installed equipment and systems have been designed for higher THD levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1)
4-7-2/9.18 (New)	Harmonic Distortion for Liftboat Electrical Distribution System including Harmonic Filters	To introduce requirements for survey of harmonic filters and harmonic distortion levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1)
4-7-2/9.19	Protection of Harmonic Filter Circuits Associated with Electric Propulsion	To introduce requirements for survey of harmonic filters and harmonic distortion levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1)
4-7-4/13.1.1	General	To identify the standards that have been withdrawn or replaced by new ones and to consider approaches for cables not manufactured to IEC standards identified, in line with IACS UR E7 Rev.4 Apr. 2016. (Incorporates Notice No. 1)

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

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 3	Hull Construction and Equipment	
3-2-7/7.3	Proportions	To specify a limitation of the maximum required thickness for girders and webs, in line with other ABS Rules.
3-2-8/3.3	Permissible Load	To modify the permissible load to consider material yield strength.
3-2-10/5.7	Girders and Web	To specify a limitation of the maximum required thickness for girders and webs, in line with other ABS Rules.
3-2-13/7.3	Lower Rudder Stocks	To make the stress units consistent with the allowable stress.
3-2-13/Figure 4	Tapered Couplings	To be consistent with the requirements of 3-2-13/11.7.
3-2-13/17.5	Diaphragm Plates	To allow larger openings on diaphragm plates when the effects of openings are considered in the strength assessment.
3-3-A1 (Title)	Computer Software for Onboard Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/5	Types of Stability Software	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/7.1	Calculation Program	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/7.5	Warning	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/7.15 (New)	Computer Model	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/7.17 (New)	Further Requirements for Type 4 Stability Software	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/Table 1	Acceptable Tolerances	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/11.1	Conditions of Approval of the Onboard Software for Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/11.5	Specific Approval	To align the Rules with IACS UR L5, Revision 3.
3-3-A1/15	Installation Testing	To align the Rules with IACS UR L5, Revision 3.
3-4-A1/1.1	<No Title>	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-4-A1/5	Fire Test Requirements	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-4-A1/7	Structural Fire Integrity Test Procedures	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-4-A1/Table 1	Structural Fire Integrity Matrix	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-6-1	Tank, Bulkhead and Rudder Tightness Testing	To reflect the comments from Administrations, Industry Organizations and IMO considered during review of the proposed Testing Guidelines associated with SOLAS Chapter II-1, Regulation 11, reflected in IACS UR S14 (Rev.6, Sept 2016).
PART 4	Machinery and Systems	
4-5-3/5.15.4(c)	Sludge Piping	To align the requirement with Regulation 12 of MARPOL Annex 1, as amended by Resolution MEPC. 266(68).
4-5-7/3.3.2	Ventilation of Storage Room	To clarify that the requirements are applied to acetylene gas (as flammable gas) only.
4-5-7/3.3.3	Electrical Installation in Storage Room	To clarify that the requirements are applied to acetylene gas (as flammable gas) only.
4-5-7/3.5.4	Gas Cylinders	To clarify that the requirements are applied to acetylene gas (as flammable gas) only.

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-6-2/11.1.1	Storage	To align the requirements for the location of the control panel with Chapter 10, paragraph 2.4.1.2 of the FSS Code (as amended by resolution MSC.292(87) as interpreted by IMO MSC.1/Circ. 1487 and IACS UI SC 260 (Rev. 1).
4-6-2/11.1.2	Design	To clarify the requirements for the pressure rating of the distribution pipe.
4-6-2/11.1.3	Alarm	To align the requirements with IACS UI SC132 (Rev.4).
4-7-2/5.1.1	Location	To explicitly prohibit the installation of other unrelated equipment in the emergency generator room.
4-7-3/Table 1	Minimum Degree of Protection	To permit plugs and socket outlets installed in hazardous areas, in line with IEC 61892-7 Para. 8.11.1 and IEC 60079-14 Para. 5.13.
4-7-4/Table 6	Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers, Motor Control Centers and Controllers	To align the requirement with IEC 60092-302 and IEC 61892-3.
4-7-4/Table 7	Equipment and Instrumentation for Switchboard	To provide a reference to the requirements for high voltage systems.
4-7-5/1.3.5	Earth Fault Detection and Indication	To clarify the requirements for audible and visual indication of earth faults for high voltage systems.

PART

1

Conditions of Classification

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

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PART

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CHAPTER 1 Scope and Conditions of Classification

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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 (1 October 2015)

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 – Elevated Condition** or **Restricted Service – Afloat Condition**. 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 1)*, 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

(1 October 2015) 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. The primary language of the Operating Manual is to be English. Liftboats not meeting the criteria for unrestricted service are to have the notation **Restricted Service – Elevated Condition** or **Restricted Service – Afloat Condition** and details of the service restrictions are to be placed in the Operating Manual. 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) (1 October 2015) Identification of “Restricted 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

Section/Paragraph	Requirement
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

Section/Paragraph	Requirement
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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PART 3

CHAPTER 1 General

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PART

3

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.

PART

3

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.

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

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

- F_w = hydrodynamic force vector per unit length along the member, acting normal to the axis of the member
- F_D = drag force vector per unit length
- F_I = inertia force vector per unit length

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

- C = 1.025 (0.1045, 1.99)
- D = 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 denotes the diameter)
- C_D = drag coefficient (dimensionless)

- 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.

$$F_w = F_D + F_I$$

$$= (C/2) D C_D (u_n - u'_n) |u_n - u'_n| + C (\pi D^2/4) a_n + C (\pi D^2/4) C_m (a_n - a'_n)$$

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)

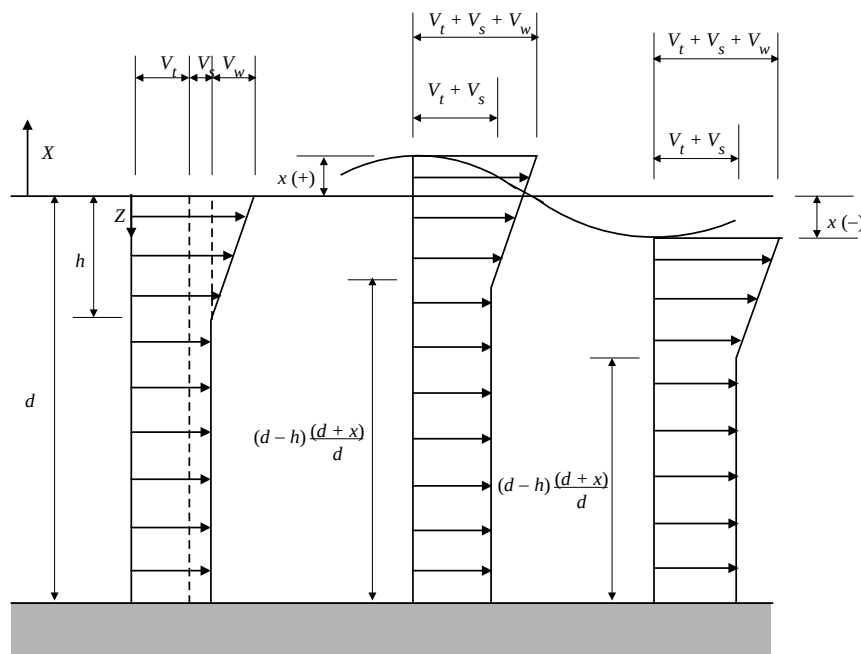
u_c = component of the current velocity vector, V_c , normal to the axis of the member in m/s (ft/s)

$|u_c|$ = 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
0.0–15.3	0–50	1.00
15.3–30.5	50–100	1.10
30.5–46.0	100–150	1.20
46.0–61.0	150–200	1.30
61.0–76.0	200–250	1.37
76.0–91.5	250–300	1.43
91.5–106.5	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
244.0–259.0	800–850	1.79
259.0 and above	850.0 and above	1.80

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 ($5.12T^2$ 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:

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

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

FIGURE 1
Ratio of Crest Elevation to Wave Height

SI and Metric Units

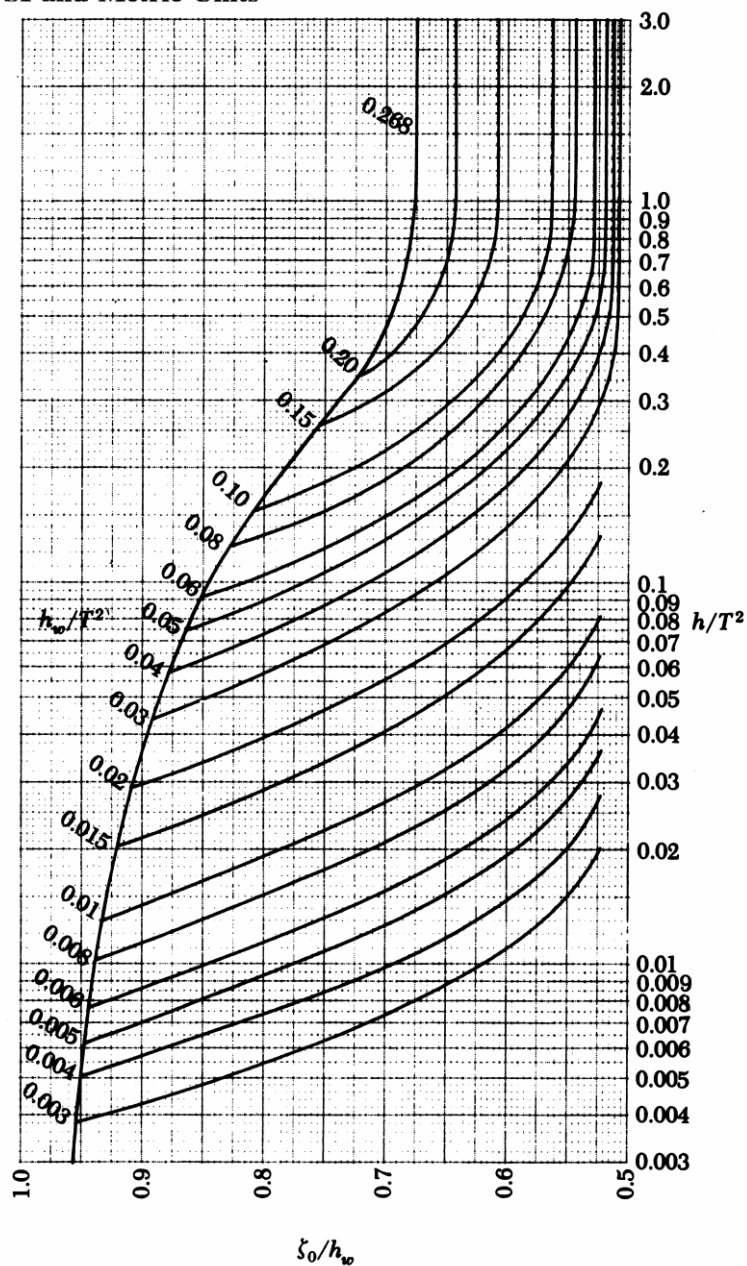


FIGURE 1
Ratio of Crest Elevation to Wave Height

U.S. Units

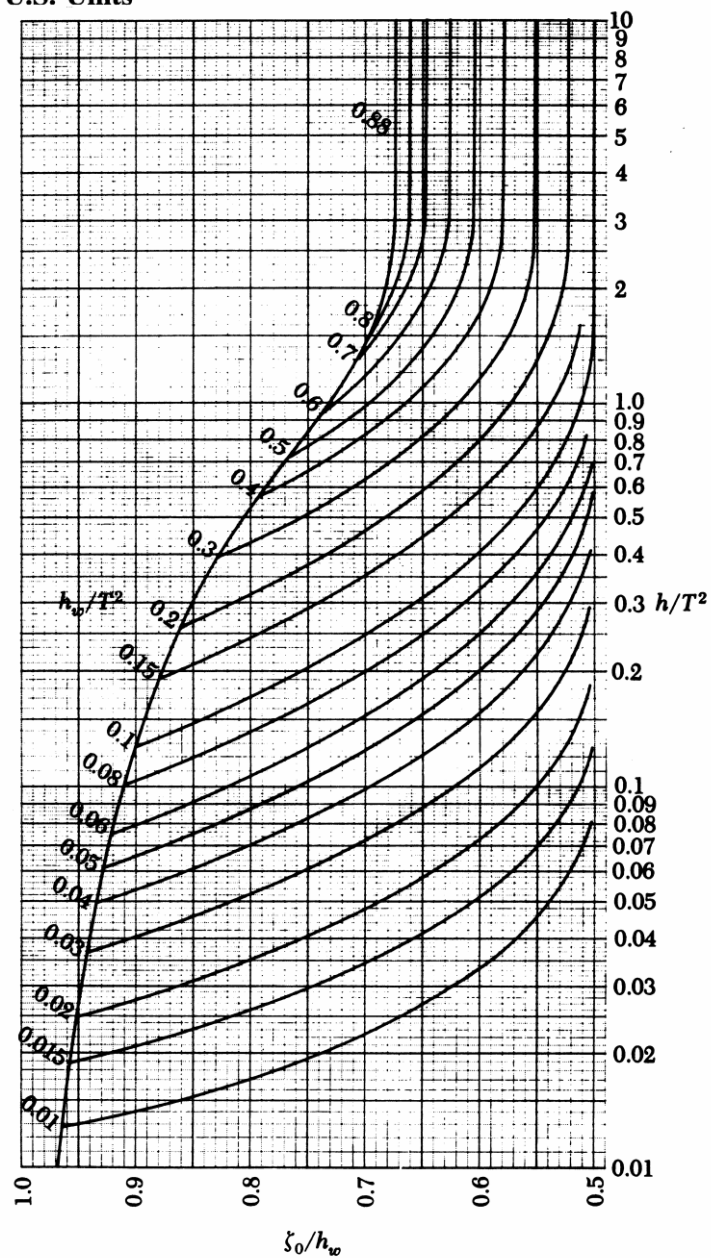


FIGURE 2
Relative Wave Height

SI and Metric Units

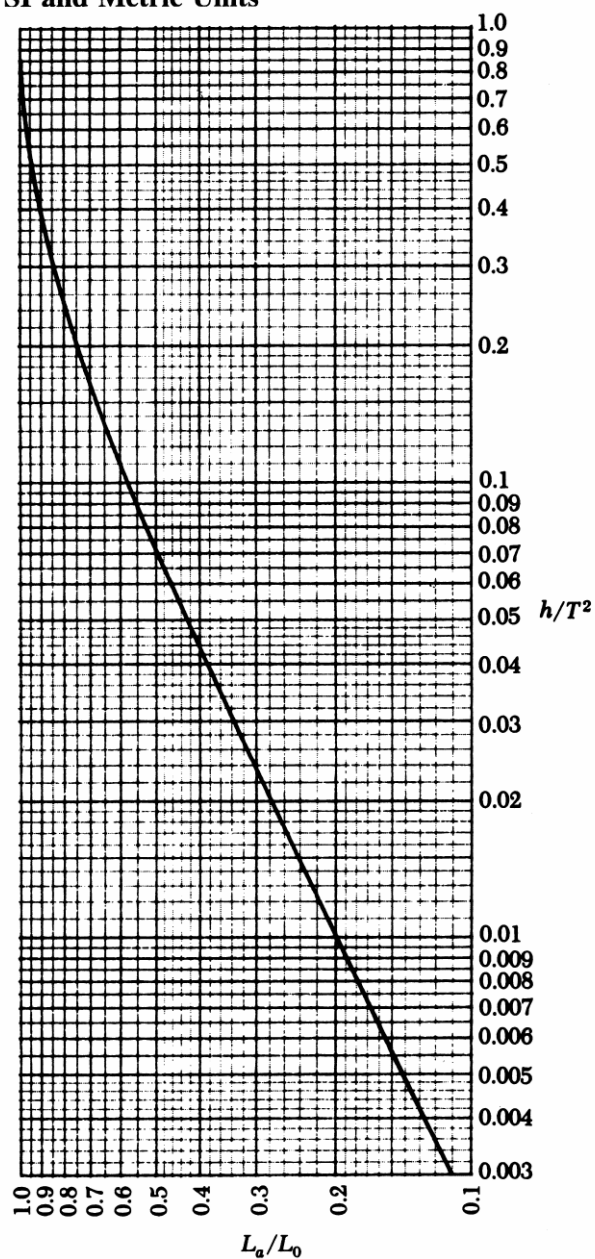


FIGURE 2
Relative Wave Height

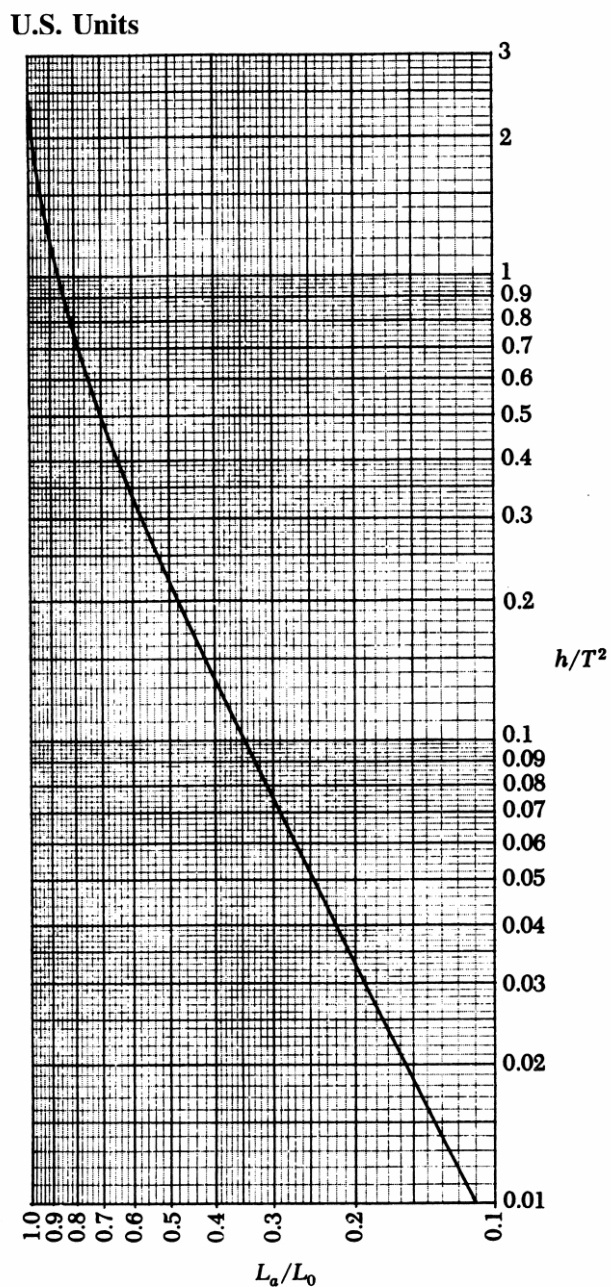


FIGURE 3
Wave Length Correction Factor

SI and Metric Units

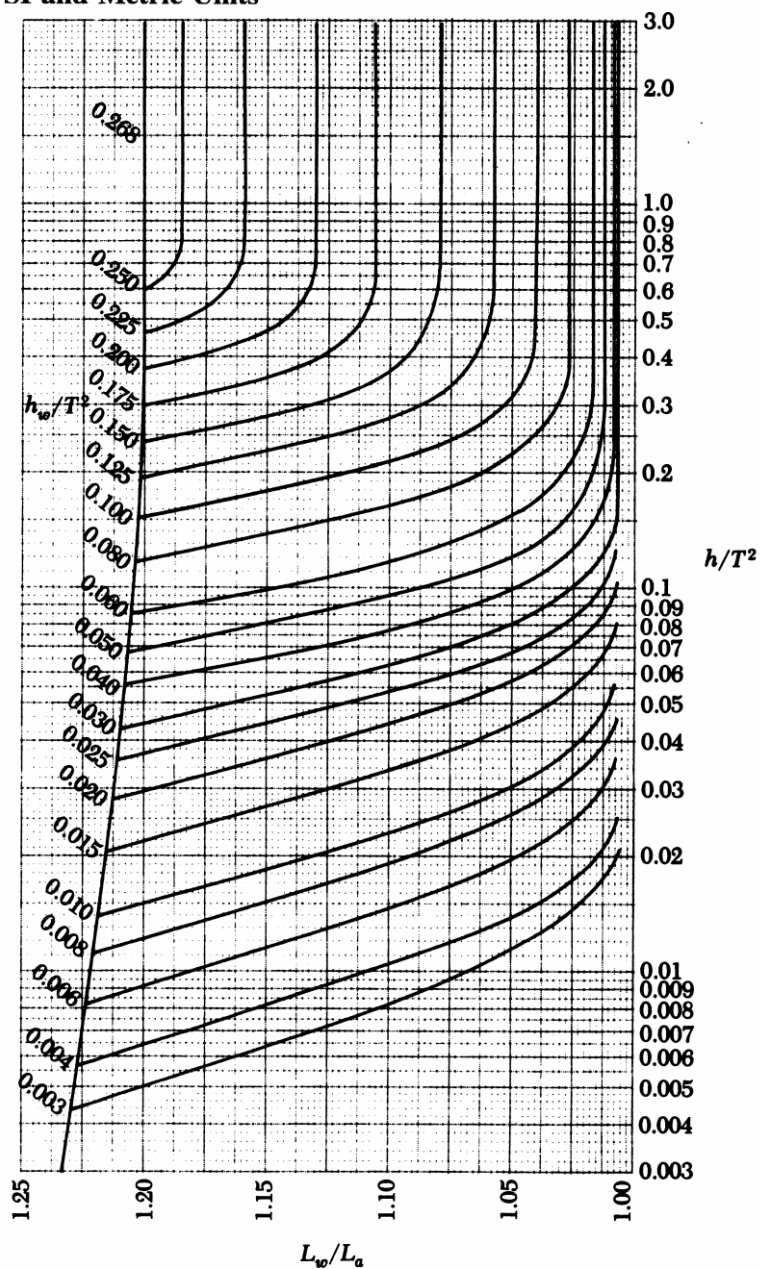


FIGURE 3
Wave Length Correction Factor

U.S. Units

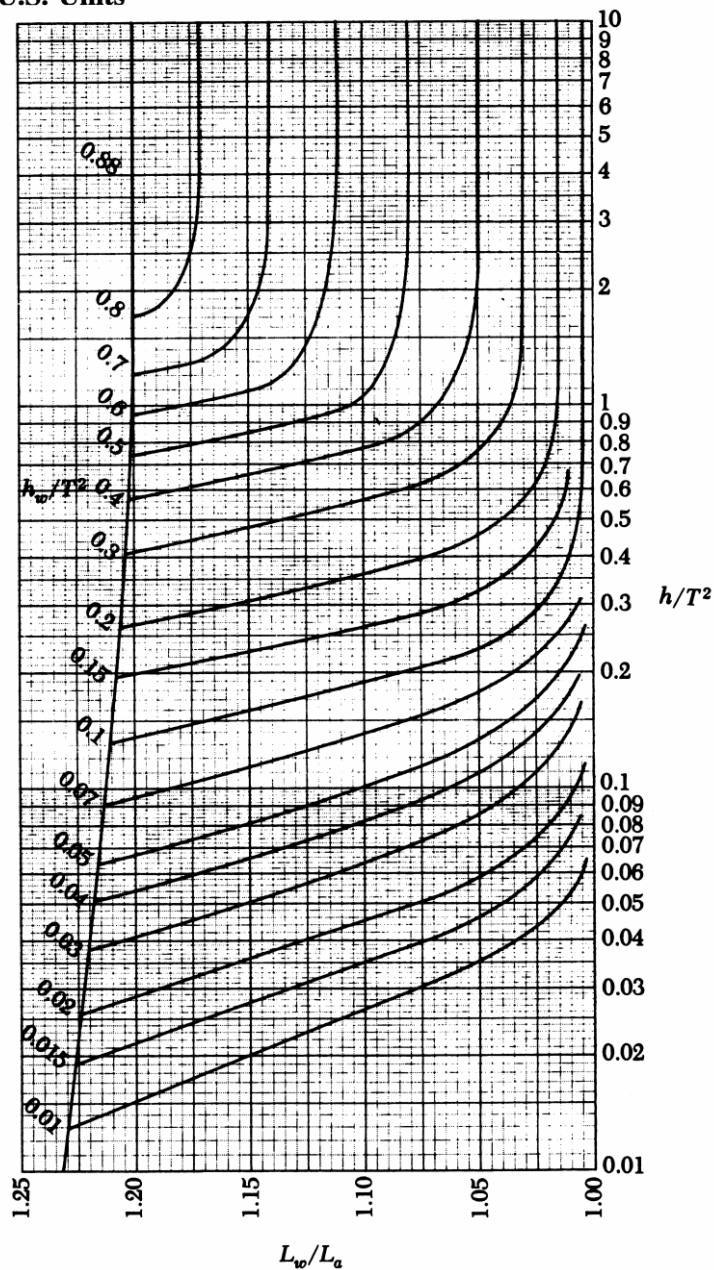


FIGURE 4
Drag Force Factor

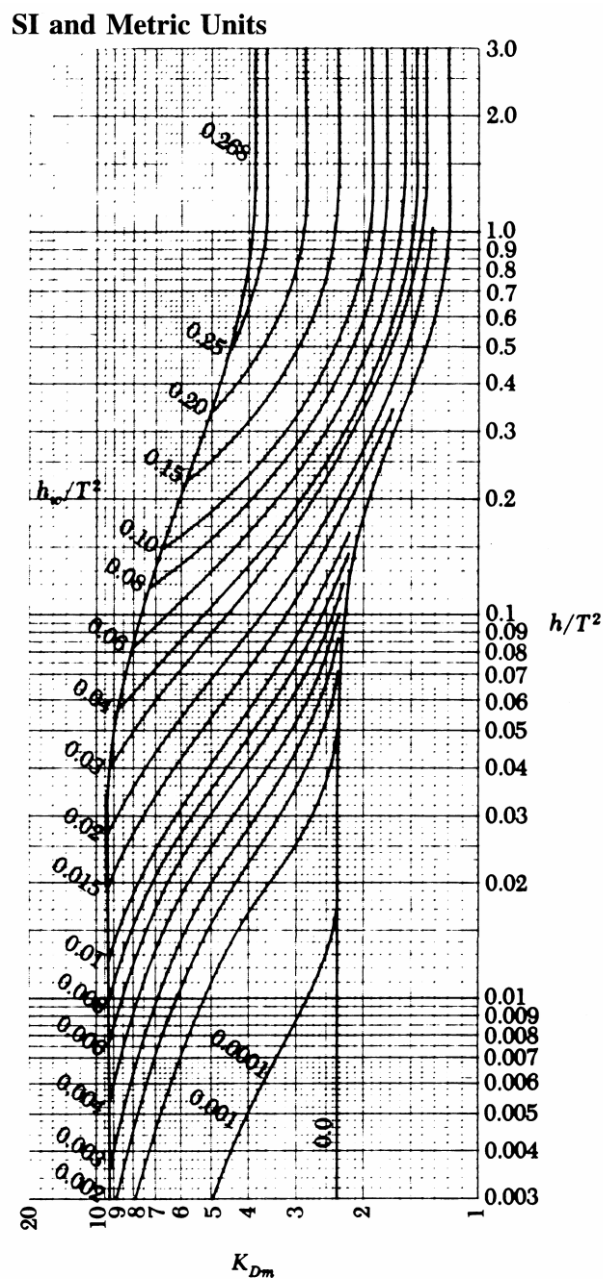


FIGURE 4
Drag Force Factor

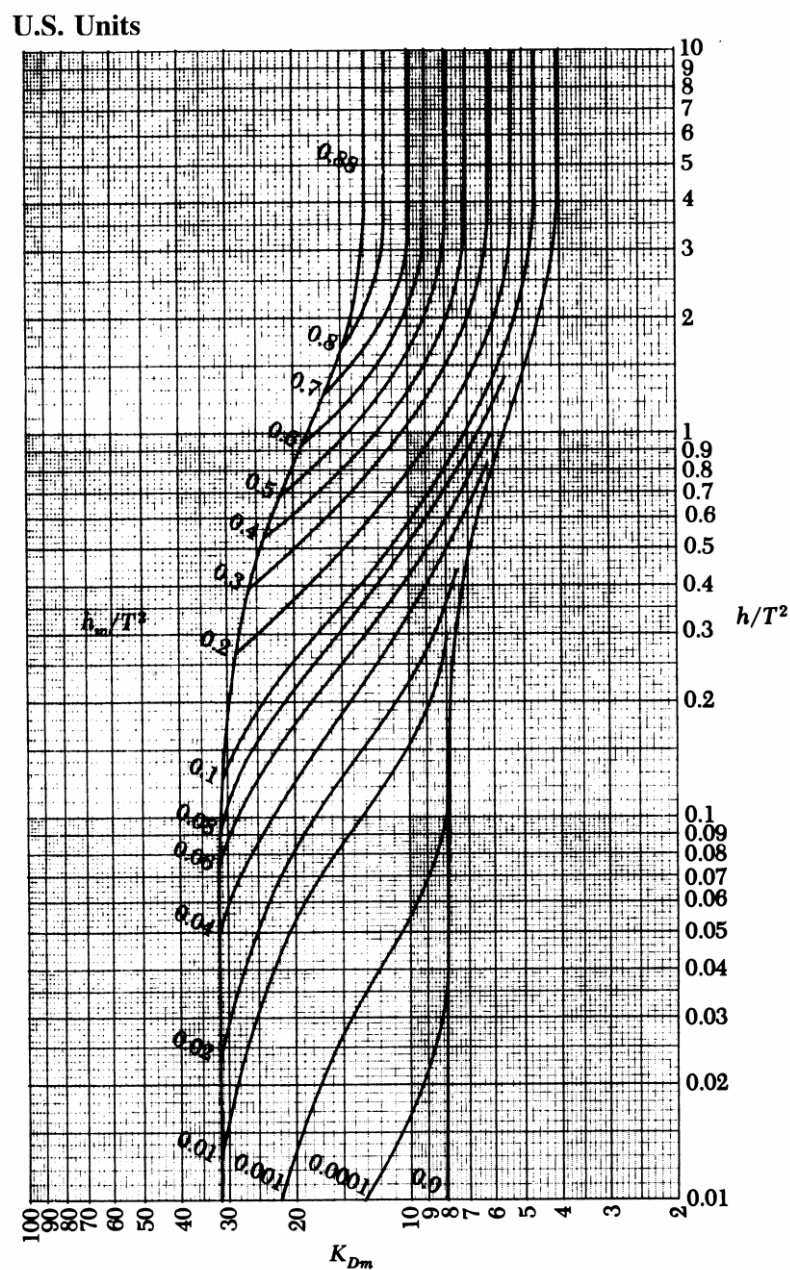


FIGURE 5
Ratio of Drag Force Lever to Still Water Depth

