U.S. Department
of Transportation

**United States
Coast Guard**

Load Line Technical Manual

American Bureau of Shipping

CHAPTER II

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CHAPTER II

LOAD LINE CALCULATION

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Preface to the electronic version

In 1990, the U.S. Coast Guard commissioned the American Bureau of Shipping (ABS) to prepare a report that integrated U.S. load line regulations & policies, ABS and IACS interpretations, IMO circulars, and the International Convention on Load Lines (ICLL) into a single reference document.

This *"Load Line Technical Manual"* is the result of that effort. It sets forth the technical procedures for evaluating, calculating and assigning ICLL load lines, using USCG and ABS policies where the Convention leaves certain requirements "to the satisfaction of the Administration" or is open to interpretation. This manual applies to U.S. vessels seeking an international ICLL assignment or a domestic U.S. load line assignment for unrestricted voyages by sea; it does not cover U.S. load line regulations for other types of domestic voyages (such as coastwise or Great Lakes).

This electronic version of the manual has been divided into five *Adobe .pdf* files:

LL Tech Manual-ToC.pdf	Table of Contents
LL Tech Manual-Ch1.pdf	Chapter I, General Items
LL Tech Manual-Ch2.pdf	Chapter II, Load Line Calculation
LL Tech Manual-Ch3.pdf	Chapter III, Cond of Assignment-Minimum Freebrd
LL Tech Manual-Ch4.pdf	Chapter IV, Cond of Assignment-Increased Freebrd

This Technical Manual was originally prepared in 1990; therefore, it only incorporates material up to that time. Since then, there has been further evolution of load line policies, additional IACS interpretations, new IMO Circulars, etc. The ICLL itself has been amended by the 1988 Protocol (which entered into force on February 3, 2000) as well as subsequent amendments that were adopted in 2003 (and will enter into force on 1 January 2005). There are no immediate plans to incorporate these into this manual.

Date of this Preface: 6 Nov 2003

ABBREVIATIONS and VARIABLES

A	Minimum req'd freeing port area; or
	Angle in freeing port calculation for deck sheathing
Aa	Actual area of freeing port
Ae	Effective area of freeing port
AB	American Bureau of Shipping
A_h	Actual height of freeing port opening
ABP	Bow planform area used in the bow height trim resistivity calculation
ABS	American Bureau of Shipping
AP	After Perpendicular
b	Breadth of superstructure at the middle of its length; *or*
b	Average breadth of deck obstruction; or
	Breadth of a local well in the freeboard deck
b_1	Breadth of extension at superstructure end bulkhead; *or*
	Breadth of recess at midpoint of its length
b_1	Average breadth of deck obstruction No. 1
b_2	Average breadth of deck obstruction No. 2
b_b	Average breadth of deck bin
b_4	Half breadth of second recess at the midpoint of its length
B	Breadth as defined in the ICLL
B	Angle used in freeing port calc for non-flush openings
B_1	Half breadth of superstructure at start of extension; *or*
	Breadth of superstructure at the midpoint of the recess
B_4	Half breadth of superstructure at midpoint of the length of the second recess
B-60	A Type 'B' freeboard that is reduced by 60% of the difference between a Type 'A' and a Type 'B' tabular freeboard
B-100	A Type 'B' freeboard that is reduced by 100% of the difference between a Type 'A' and a Type 'B' tabular freeboard
B_b	Average breadth of the vessel in way of the well formed by a deck bin.
Bhd	Bulkhead
Bs	Breadth of the vessel at the mid-length of the superstructure
C	Camber
C1	Subdivision load line mark
Cb	Block coefficient
Circ	Circular
CL	Center line
cm	Centimeter(s)

Cor	Correction
D	Molded displacement;
	Molded depth
Dr	Depth of a local well in the freeboard deck
d_1	85% of the least molded depth
Df	Depth for freeboard
dk	Deck
E	Effective length of superstructure
f	Tabular freeboard
f	Freeing port area adjustment factor
f_b	Freeing port area factor for bins
F	Minimum required freeing port area
F_1	Freeing port area non-continuous deck obstruction
F_2	Freeing port area - continuous deck obstruction
fbd	Freeboard
FFA	Free Flow Area
FP	Forward perpendicular
ft	Feet
FW	Fresh Water load line mark
GM	Metacentric Height
gt	Gross tons
h	Actual height of trunk
h_1	Least height of superstructure
h_b	Bulwark height in way of freeing port opening
h_c	Actual trunk hatch coaming height
h_i	Height of inboard end
h_L	Least height of superstructure
h_o	Height of lower edge of freeing port opening above the deck
h_{rc}	Required trunk hatch coaming height
h_s	Standard height of superstructure
IACS	International Association of Classification Societies
ICLL	International Convention on Load Lines
IMO	International Maritime Organization
in	Inch
ISO	International Standards Organization
ITB	Integrated Tug Barge
l	Length of deck sheathed area which extends from side to side; *or*
	Length of a local well in the fbd dk
l	Length of a well

l'	Length of well for freeing port area determination
l_1	Length of superstructure set-in from the side of the vessel; *or* Length of recess
l_1	Average length of deck obstruction No. 1
l_2	Equivalent length of superstructure in way of recess
l_2	Average length of deck obstruction No. 2
l_4	Equivalent length of second recess
l_c	Length of camber in the molded half breadth of the vessel
L	Length as defined in the ICLL
L'	The mean enclosed length of the poop or forecastle up to a maximum of 0.5L
LCF	Longitudinal center of floatation
LL	Load line
LLAC	Load Line Advisory Circular
LLC	Load Line Convention
m	Meter(s)
mm	Millimeter(s)
MSC	Marine Safety Center
NVIC	Navigation Vessel Inspection Circular
OCMI	Officer in Charge Marine Inspection
oz	Ounce
R	Coefficient used in the depth correction
Reg	Regulation
Rev	Revision
s	Sheer credit for excess height of a poop or forecastle
S	Mean length of superstructure; *or* Summer load line mark
SLF	IMO Subcommittee on Stability and Load Lines and on Fishing Vessels safety
sp.gr	Specific gravity
Ss	Sheer strake thickness
Stab	Stability
Stbd	Starboard
Std	Standard
sw	Saltwater
T	Mean thickness of the exposed deck sheathing clear of deck openings; *or* Tons per centimeter (inch) immersion in salt water at the molded summer load waterline; *or* Tropical load line mark
TF	Tropical Fresh load line mark

US	United States
USA	United States of America
USCG	United States Coast Guard
V	Volume of the molded displacement of the vessel
W	Winter load line mark
WNA	Winter North Atlantic load line mark
WP	Waterplane
x	Distance lower edge of freeing port opening is above top of the deck sheathing
y	Difference between the actual and standard height of superstructure at the end of sheer
Z	Least difference between the actual and standard height of superstructure for sheer credit on a full superstructure vessel

REFERENCE SYSTEM

Footnotes are used throughout this manual to designate sources of information, and for notes to clarify or elaborate on the text given. The footnotes are placed on the bottom of the same page where the footnote reference mark appears.

Reference Sources

The eleven (11) common reference sources are indicated on the "Reference Material" page. For simplification, the bracketed number [ ] that precedes each reference source listed is used in the footnotes throughout this manual in lieu of the complete title of the reference. The titles of other source material not listed on the "Reference Material" page are given in their entirety.

In certain instances the reference source given in the footnote may be followed by the word "{basis}", which means that the reference source was used as the basis of the text, however the wording has been changed or expanded for clarification.

Footnote Reference Mark Location

The footnote reference mark is placed in the subject heading if the entire subject is taken from the reference source, and in the paragraph heading if the entire paragraph is taken from the source referenced. Reference marks placed at the end of a sentence generally mean that only that particular sentence is from the source referenced.

Regulation Reference

The term "Regulation" or simply "Reg." used throughout this manual refers to the *International Convention on Load Lines,1966* unless otherwise specified.

REFERENCE MATERIAL

[1] International Convention on Load Lines, 1966

[2] Code of Federal Regulations, Title 46, 1984

[3] Marine Safety Manual

[4] IMO Correspondence

[5] IACS Unified Interpretations of the International Convention on Load Lines, 1966

[6] U.S.C.G. Navigation and Vessel Inspection Circulars

[7] A.B.S. Circular Letters of Instruction

[8] U.S.C.G. Correspondence

[9] A.B.S. Correspondence

[10] Ship Design and Construction

[11] U.S.C.G. Load Line Advisory Circulars

HULL FORM CORRECTIONS

FREEBOARD CALCULATION FLOW CHART

A flow chart detailing the freeboard calculation process is given in APPENDIX I at the end of this chapter. The interdependency of various corrections can be readily seen, thereby assisting the user to determine in which order the corrections need to be calculated.

TABULAR FREEBOARD

Concept

The tabular freeboard is the base or starting point to determine the minimum geometric freeboard. It is predicated on the fact that a vessel with a certain length and standard configuration should have a particular freeboard for safety purposes.

Freeboard Tables

Tables of freeboard values are given in Regulation 28 for Type 'A' and Type 'B' vessels. The freeboard values are given as a function of length for vessel lengths between 24 m and 365 m (80-1200 ft).

The difference between the applicable tabular freeboards, graphically shown in Figure 17, will give a good approximation of the difference between the actual assigned freeboards for a given ship.

Extended Freeboard Table Values[1]

(a) Type 'A' Vessels

(i) Tabular freeboards for Type 'A' vessels with lengths between 365 m and 400 m (1200-1600 ft) are to be determined by the following formula:

$$f = 221 + 16.1\ L - 0.02\ L^2$$

[1] [4] LL. 18, LL.3/Circ.20, 26 May 1976

where f is the freeboard in mm
L is the length defined in Reg. 3(1)

(ii) Tabular freeboards for Type 'A' vessels with lengths of 400 m and above are to be the constant value, 3460 mm.

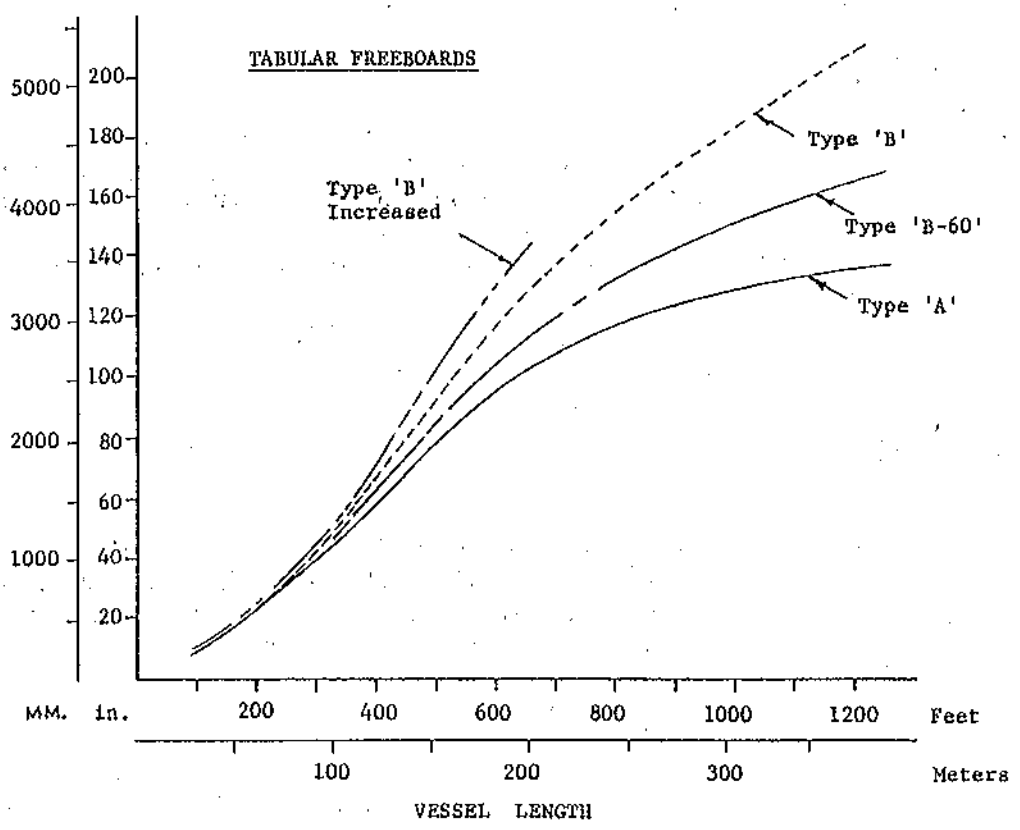

Figure 17. Graph of Tabular Freeboards

(b) Type 'B' Vessels

(i) Tabular freeboards for type 'B' vessels with lengths between 365 m and 400 m are to be determined by the following formula:

$$f = 587 + 23\ L - 0.0188\ L^2$$

where f is the freeboard in mm
L is the length defined in Reg. 3(1)

(ii) Tabular freeboards for Type 'B' vessels with lengths of 400 m and above are to be the constant value, 5605 mm.

Corrections[2]

Corrections are made to the tabular freeboard to compensate for differences between the actual vessel and the standard vessel with the same length. The standard vessel has inherent features as follows:

1) Block coefficient of 0.68;

2) L/D ratio of 15;

3) A standard deck sheer profile, with the forward deck sheer ordinates being twice the aft sheer ordinates;

4) Flush deck, no superstructure, except for a Type 'B' vessel under 100 m (328 ft) in length;

5) For manned vessels, a specific bow height at the forward perpendicular above the summer load waterline, based on the vessels length and block coefficient.

Tabular Freeboard Increase

Type 'B' vessels with hatch covers in position 1 which are:

1) Made of wood; or

2) Steel not complying with the indicated strength criteria; or

3) Other material that does not comply with the steel criteria;

are to have their tabular freeboard increased in accordance with the table given in Reg. 27(10).

CORRECTION FOR TYPE 'B' VESSELS WITH LIMITED SUPERSTRUCTURE

General- correction is a freeboard penalty

The first possible correction made to the tabular freeboard is the correction for Type 'B' vessels, with a length less than 100 m (328 ft), which have superstructure with an effective length[3] of less than 0.35 L. No correction is made for Type 'A' vessels, Type 'B' vessels with a length of 100 m or more, or Type 'B' vessels with an effective length of superstructure of 0.35 L or greater.

Metric Units

$$7.5(100 - L)(0.35 - E/L) \text{ millimeters}$$

[2] [4] Stab XX/5/3, USA, 2 Dec 1976

[3] The term "effective length" is defined and exemplified later in this chapter in the section on superstructure.

where:

L = length of vessel in meters.
E = effective length of superstructure(s) in meters.

English Units

0.09 (328 - L) (0.35 - E/L) inches

The effective length of superstructure(s) (E), in the above formulae, is determined excluding the length of trunks[4]

BLOCK COEFFICIENT CORRECTION

General

The second correction that is made to the tabular freeboard is the block coefficient (Cb) correction. This correction is applied only when the Cb is greater than 0.68.

Concept[5]

The block coefficient by definition ensures that at least 15% of the volume of the vessel should be above the maximum waterline to provide intact vessel buoyancy for storm conditions and general sea-keeping ability.

Correction[6]- possible freeboard penalty

Where the block coefficient (Cb) exceeds 0.68, the tabular freeboard specified in Regulation 28 as modified, if applicable by Regulations 27(8)[7], 27(9)[8], 27(10)[9] and 29[10] is to be multiplied by the factor:

$$\frac{Cb + 0.68}{1.36}$$

The Cb should be rounded off at three decimal places.[11]

[4] [4] LL. 41, LL.3/Circ.42, 13 April 1982. The term "trunks" is defined later in this chapter in the superstructure section.

[5] [4] Stab XX/5/3, USA, 2 Dec 1976

[6] [1] Reg. 30

[7] Type 'B-60' freeboard

[8] [8] Electronic Message 16 October 1986. For a Type 'B-100' freeboard, it has always been a US policy to include the Cb correction when performing a 'B-100' calculation even though Reg. 30 does not specifically reference Reg. 27(9).

[9] Type 'B-increased' freeboard due to deficient hatch covers.

[10] Correction for Type 'B' vessels under 100 m in length which have an effective length of superstructure less than 0.35L.

[11] Practice since at least 1976.

DEPTH CORRECTION

Concept

The standard depth of a vessel in accordance with the Convention is $1/15^{th}$ of the vessel's length. A vessel with a depth in excess of this standard will tend to have more draft and therefore less reserve buoyancy in relation to displacement. Consequently, a penalty increasing the freeboard is imposed.

Correction[12]- may be a penalty or a credit

Where D_f exceeds L/15 the freeboard is to be increased by:

$$(D_f - L/15)R \quad \text{millimeters}$$

where R is L/0.48 at lengths < 120 meters;
and 250 at 120 meters length and above,

or:

$$(D_f - L/15)R \quad \text{inches}$$

where R is L/131.2 at lengths < 393.6 feet,
and 3 at 393.6 feet length and above.

Negative Depth Correction[13]

Where D_f is <u>less</u> than L/15 a reduction to the freeboard can be made, at the same rate as described above, *provided* the vessel contains:

1) An enclosed superstructure covering 0.6L amidships; or

2) A complete trunk[14]; or

3) A combination of detached enclosed superstructure(s) and trunk(s) which extend over the entire length of the vessel.

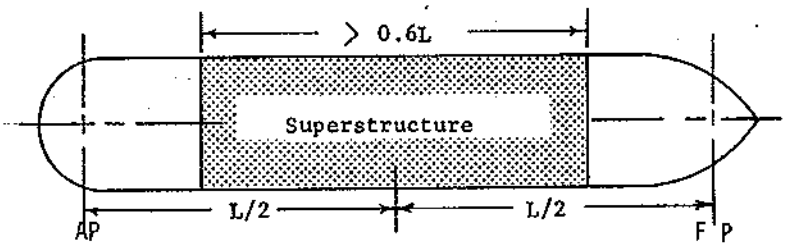

Figure 18. Enclosed Superstructure for Negative Depth Correction Credit

[12] [1] Reg. 31(1).
[13] [1] Reg. 31(2)&(3)
[14] Trunk is defined later in this chapter in the superstructure section.

Height Reduction[15]

When the height of a superstructure, or raised quarter deck or trunk is less than the corresponding standard height[16], it is recommended that the calculated reduction in freeboard be corrected in the ratio of the height of the actual superstructure, raised quarter deck or trunk to the applicable standard height.

DECK LINE CORRECTION

General

The deck line is a horizontal line marked amidships on each side of the vessel which is used as a reference line from which the assigned freeboards are measured. Its upper edge is to normally pass through the point where the continuation outwards of the upper surface of the freeboard deck intersects the outer surface of the shell. The deck line may be placed with reference to another fixed point on the ship *provided* that the freeboard is correspondingly corrected.[17]

Concept-adjustment to prevent a possible penalty

The depth for freeboard (D_f) is the molded depth amidships plus the thickness of the freeboard deck stringer plate.

If the freeboard deck has camber and the sheer strake has a substantial thickness, the difference between the depth for freeboard used in the freeboard calculation, and the location of the deck line could be substantial; in some cases as much as 5 mm. This difference is called the deck line correction and it is deducted from the calculated freeboard. The deck line correction compensates for the difference between the "theoretical" freeboard calculation, and the "physical" marking of the assigned freeboards on the vessel.

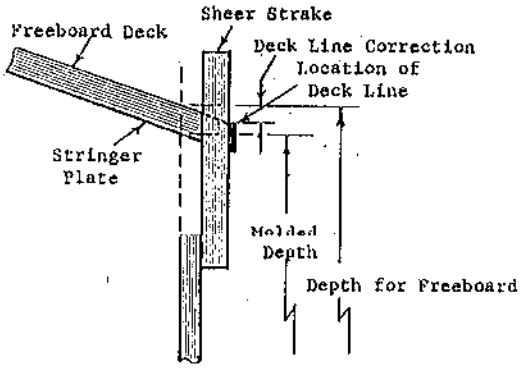

Figure 19. Deck Line Correction

[15] [4] LL. 24, LL.3/Circ.20, 26 May 1976

[16] Standard height of superstructure is defined in Reg. 33, as well as later in this chapter in the superstructure section.

[17] [1] Reg. 4.

Correction

Where the actual depth to the upper edge of the deck line is greater or less than D_p the difference between the depths is to be added to or deducted from the freeboard.[18]

Straight Line Camber

$$\text{Deck Line Correction} = \frac{C\,(Sc + t)}{(lc + t)}$$

Parabolic Camber

$$\text{Deck Line Correction} = C\,\frac{(lc + Ss + t)^2}{lc} - C$$

where:

C = Camber (mm or in);
lc = Length of camber in the molded half breadth of the vessel (m or ft);
Ss = Sheer strake thickness (m or ft);
t = shell thickness (m or ft).

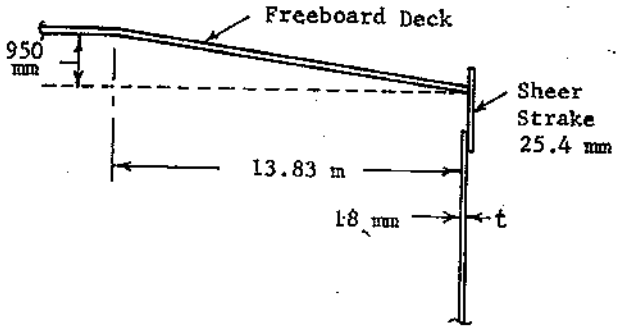

Figure 20. Deck Line Correction- Straight Line Camber

$$\text{Dk. Line Cor.} = 950\,\frac{(13.83 + 0.018 + 0.0254)}{13.83} - 950$$

$$= 2.98 \text{ mm}$$

This value is then deducted from the calculated freeboard.

[18] [1] Reg. 32.

SUPERSTRUCTURE

CORRECTION CONCEPT[1]

Concept-correction is always a freeboard credit

The superstructure correction is a required freeboard addition for Type 'B' vessels with a length between 24-100 m (79-328 ft),[2] and an allowed reduction for vessels with a length over 100 m. The theory of both corrections presumes the superstructure will provide righting energy to resist large rolling angles. It is for this reason that a deck structure does not qualify as a superstructure when it is set in from the side of the vessel more than 0.04B. When adequate superstructure exists, it is presumed to augment the normal above water volume of the vessel.

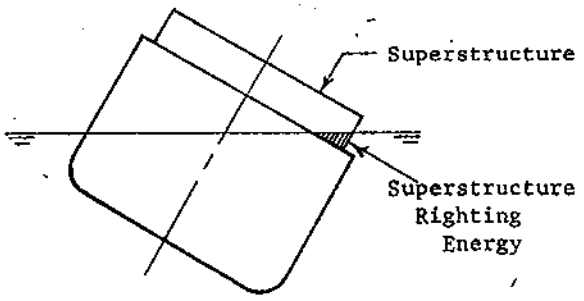

Figure 21. Superstructure Righting Energy

Superstructure Correction Procedure

The deduction for superstructure is determined in the following sequence:

1) Which deck structures qualify as a superstructure;

2) Determine the mean length (S) of each detached superstructure by correcting its actual length for a curved end bulkhead, or for a possible recess or extension;

3) Determine the effective length (E) for each detached superstructure by modifying the mean length (S) for a breadth correction, if the superstructure does not extend to the sides of the vessel, and for a height correction where the actual height is less than the standard height;

[1] [4] Stab XX/5/3,USA, 2 Dec 76

[2] There is no addition for Type 'B' vessels with superstructure $\geq$0.35L.

4) Sum the effective lengths of all superstructures to determine the total effective length;

5) The percentage of allowable superstructure deduction is determined from the applicable table based on the actual percentage of total effective length of all superstructures to the length of the vessel;

6) The maximum superstructure correction deduction is determined by assuming that the total effective length of all superstructures is equal to the total length of the vessel;

7) Multiply the maximum superstructure correction deduction by the percentage of allowable deduction to determine the superstructure credit deduction.

DEFINITIONS

Superstructure[3]

A superstructure is a decked structure on the freeboard deck, extending from side to side of the vessel, or with the side plating not being inboard of the shell plating more than 4% of the breadth of the vessel. A raised quarter deck[4] is regarded as a superstructure.

Enclosed Superstructure is a superstructure with:[5]

1) Enclosing bulkheads of sufficient construction;

2) Access openings, if any, in these bulkheads are fitted with doors complying with the requirements of Regulation 12;

3) All other openings in the sides or ends of the superstructure are fitted with weathertight means of closing.

A bridge or poop is not regarded as enclosed *unless* access is provided for the crew to reach machinery and other working spaces inside these superstructures by alternative means which are available at all times when bulkhead openings are closed.[6] Superstructures which are not enclosed do not have an effective length.

Types of Structures

Bridge is a superstructure which does not extend to either the forward or after perpendicular.

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3 [1] Reg. 3(10) {basis}

4 See Figure 28.

5 [1] Reg. 3(10)

6 [4] LL. 3, LL.3/Circ.20, 26 May 1976

Detached Bridge is a bridge that is not attached to other superstructures. A bridge whose after bulkhead is located within 0.05L from the after perpendicular does not qualify as a detached bridge.[7]

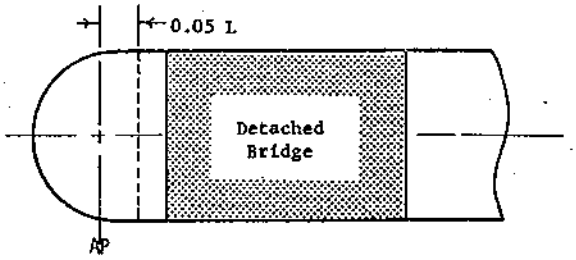


Figure 22. Detached Bridge

Forecastle is a superstructure which extends from the forward perpendicular[8] aft to a point which is forward of the after perpendicular.

Full Superstructure is a superstructure which, as a minimum, extends from the forward to the after perpendicular.

Poop is a superstructure which extends from the after perpendicular[9] forward to a point which is aft of the forward perpendicular.

Raised Quarter Deck is a superstructure which extends forward from the after perpendicular, has an intact front bulkhead,[10] and generally has a height less than a normal superstructure. Where the forward bulkhead is not intact due to doors or other access openings, the superstructure is then to be considered as a poop.[11] A raised quarter deck is formed when the after portion of the weather deck or upper deck is raised a few feet above the forward portion.

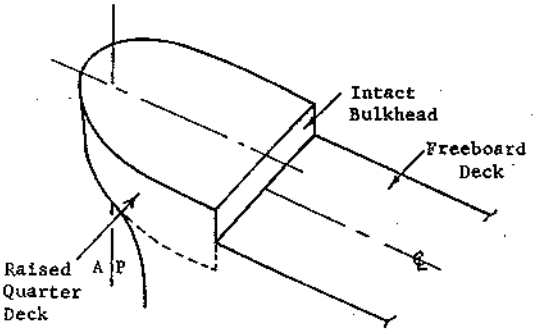


Figure 23. Raised Quarter Deck

[7] [4] LL. 28; LL.3/Circ.77, 13 October 1986

[8] The forecastle may originate from a point forward of the FP.

[9] The poop may originate from a point aft of the AP.

[10] Side scuttles (portholes) of the non-opening type fitted with efficient deadlights and bolted manhole covers may be allowed. {basis [5] LL.41}

[11] [1] Reg. 35(4)

Trunk is by definition not a superstructure. A trunk is a weathertight structure on the freeboard deck which has a breadth less than 92% of the breadth of the vessel, *and* complies with *all* of the following[12]

1) The trunk is at least as strong as a superstructure;

2) The hatchways are in the trunk deck, and the hatchway coamings and covers comply with the requirements of Regulations 13 - 16 inclusive, and the width of the trunk deck stringer provides a satisfactory gangway and sufficient lateral stiffness. Small access openings with watertight covers may be permitted in the freeboard deck;

3) The trunk deck provides a permanent working platform, fore and aft, fitted with guard rails. Detached trunks are to be connected to superstructures by permanent gangways.

4) Ventilators are protected by the trunk, by watertight covers or by other equivalent means;

5) Open guard rails are fitted on the weather parts of the freeboard deck at the sides of the vessel in way of the trunk for at least half its length;

6) The machinery casings above the freeboard deck level are protected by the trunk, or by a superstructure of at least standard height, or by a deck house of the same height and of equivalent strength;

7) The breadth of the trunk is at least 60% of the breadth of the vessel; and

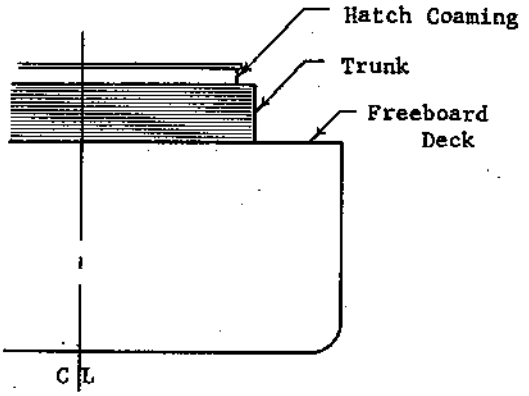
8) Where there is no superstructure, the length of the trunk is at least 0.6L.

The sides of a trunk included in the freeboard calculation are to be intact, i.e. no openings. Side scuttles of the non-opening type and bolted manhole covers are allowed.

The inclusion of a trunk in the freeboard calculation does not prohibit the fitting of openings in the bulkheads of adjacent superstructures such as poops, bridges or forecastles *provided* there is no direct communication between the superstructure and the trunk.[13]

[12] [1] Reg. 36(1)
[13] [4] LL. 41, LL.3/Circ.42, 13 April 1982

Figure 24. Trunk



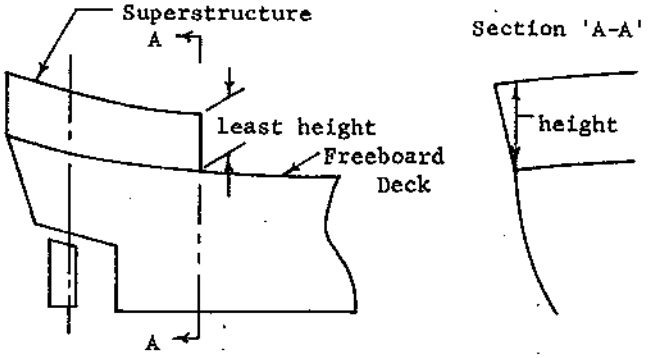
HEIGHT

Definition

The height of a superstructure is the least vertical height measured at the side, from the top of the freeboard deck beams to the top of the superstructure deck beams.[14]

For each individual superstructure, the height to be credited is the least vertical height throughout the length of the entire structure.

Figure 25. Superstructure Height



STANDARD HEIGHT

Concept[15]

The maximum height of a deck structure, which qualifies as a superstructure, that can be credited as superstructure in the freeboard calculation is referred to as the **standard height** of superstructure. No superstructure credit is given for that portion of a superstructure that extends above the standard height. Since the purpose of

[14] [1] Reg. 3(10)
[15] [1] Regs. 33 & 35

superstructure is to provide righting energy to resist large rolling angles, that portion above the standard height would provide little assistance except at extremely large rolling angles.

STANDARD HEIGHT VALUES[16]

Metric Units

L (meters)	Raised Quarter Deck	All other Superstructure
30 or less	0.90	1.80
75	1.20	1.80
125 or more	1.80	2.30

English Units

L (feet)	Raised Quarter Deck	All other Superstructure
98.5 or less	3.0	5.9
246	3.9	5.9
410 or more	5.9	7.5

The standard height at intermediate lengths of the vessel is to be obtained by linear interpolation.

The standard height of a trunk is the standard height of a super structure other than a raised quarter deck.[17]

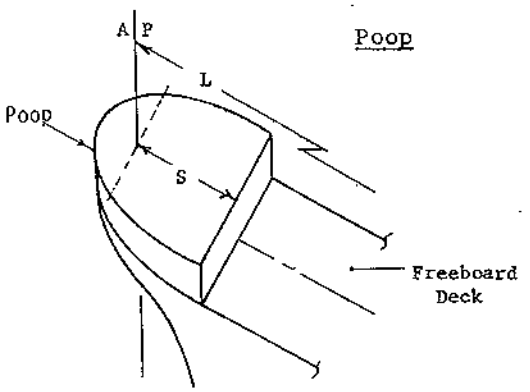
LENGTH

Definition[18]

The length of a superstructure is the mean length (S) of the part of superstructure which lies within the length (L).

[16] [1] Reg. 33
[17] [1] Reg. 36(3)
[18] [1] Reg. 34(1)

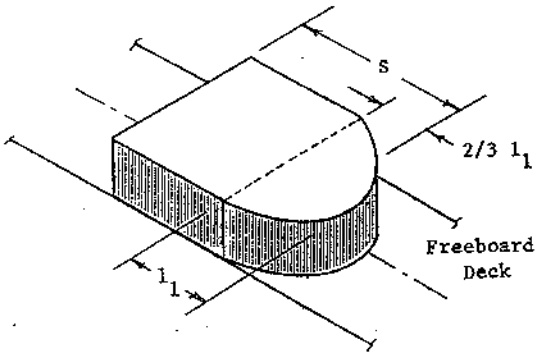
Figure 26. Superstructure Length



Curved End Bulkheads[19]

Where the end bulkhead of an enclosed superstructure extends in a fair convex curve beyond its intersection with the superstructure sides, the length of the superstructure may be increased on the basis of an equivalent plane bulkhead. The increase is to be two-thirds of the fore and aft extent of the curvature. The maximum curvature which may be taken into account in determining the increase is one-half of the breadth of the superstructure at the point of the intersection of the curved end of the superstructure with its side.

Figure 27. Superstructure Length with a Curved End Bulkhead

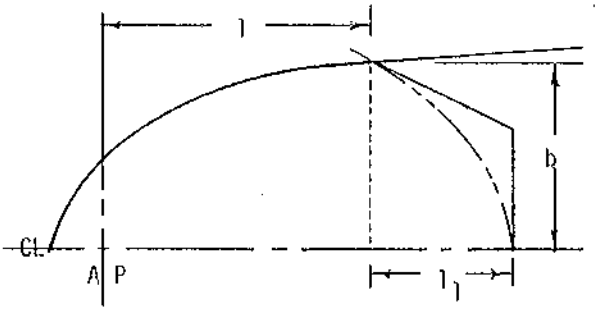


Canted Side Bulkheads

Where the sides of enclosed superstructures are canted inboard, the mean length is determined by inscribing a parabola and determining an equivalent plane bulkhead following the procedure given for curved end bulkheads, as shown in the following figure.

[19] [1] Reg. 34(2)

Figure 28. Superstructure with Canted Side Bulkheads



$S = l + 2/3\ l_1$
where: $l_{1max} = b$
$E = l + 2/3\ l_1 (h_1/h_s)$
where: $h_1/h_s \leq 1.0$

EFFECTIVE LENGTH

Definition[20]

The effective length (E) of an enclosed superstructure is equal to the mean length of superstructure (S) that is:

1) Equal to or greater than the standard height of superstructure; *and*

2) Extends the full breadth of the vessel for the entire mean length of the superstructure.

Superstructures which are not enclosed do not have an effective length.

Breadth Correction[21]

Where a superstructure is set in from the side of the vessel, as permitted in Regulation 3(10)[22], the effective length is its mean length modified by the ratio of b/B_s, where:

b is the breadth of the superstructure at the middle of its length; *and*

B_s is the breadth of the vessel at the middle of the superstructure.

Where a superstructure is set in for a part of its length, this modification is to be applied only to the set in part.

Height Correction[23]

Where the height of a superstructure is less than the standard height, the effective length will be its mean length reduced in the ratio of the actual height to the standard height. Where the actual height

[20] [1] Reg. 35(1)
[21] [1] Reg. 35(2)&(5) {basis}
[22] See "Superstructure - Definition."
[23] [1] Reg. 35(3) {basis}

exceeds the standard, no increase is to be made to the effective length of the superstructure.

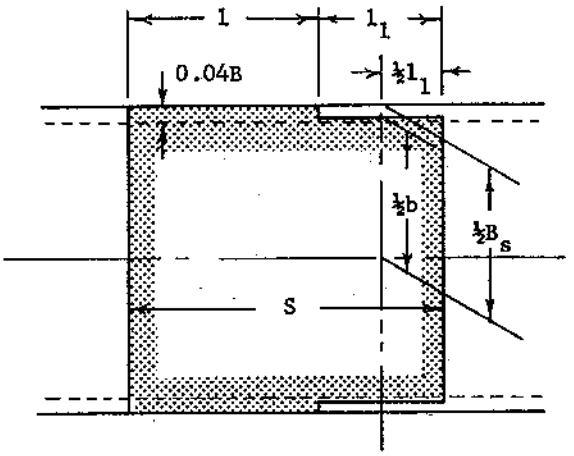


Figure 29.
Effective Length of Superstructure

$$S = l + l_1$$

$$E = [\ 1 + l_1\ (b/B_s)\ ]\ h_l/h_s$$

where:

h_l = least height of superstructure
h_s = standard height of superstructure

Raised Quarter Deck[24]

The effective length of a raised quarter deck[25] is its length up to a maximum of 0.6L.

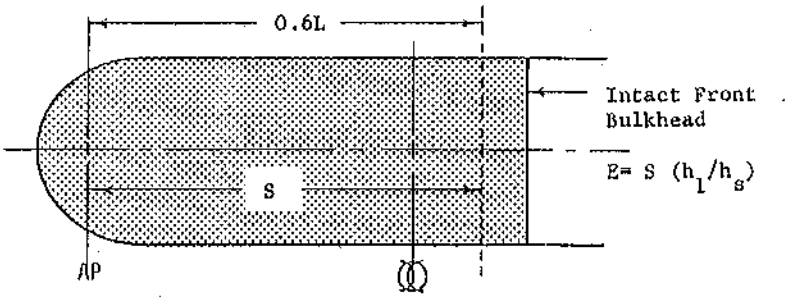
The maximum effective length of 0.6L for a raised quarter deck stipulated above is measured from the after perpendicular.[26]

[24] [1] Reg. 35(4)

[25] Provided it is fitted with an intact front bulkhead. See definition of raised quarter deck. Where the bulkhead is not intact, the raised quarter deck is to be treated as a poop of less than standard height.

[26] [4] LL. 25, LL.3/Circ.20, 26 May 1976. Even where a poop is fitted in conjunction with the raised quarter deck.

Figure 30. Effective Length of a Raised Quarter Deck



If a raised quarter deck is set in from the side of the vessel for part of its length[27], the effective length is determined in the same manner as any other superstructure type *except*:

1) The least height is compared to the standard height of a raised quarter deck;[28] *and*

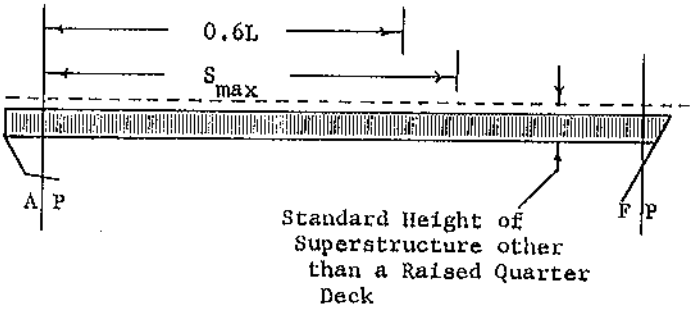
2) The maximum effective length is equal to 0.6L.

Full Superstructure - Raised Quarter Deck[29]

In a vessel with a superstructure which extends over the whole length of the freeboard deck, *and* has a least height less than the standard height of a superstructure, the part of the superstructure from the after perpendicular up to a maximum of 0.6L may be treated as a raised quarter deck. In this respect if no interior watertight front bulkhead is fitted to separate the raised quarter deck portion from the remainder of the structure, the bow may be considered to act as the intact front bulkhead.

The length limit of 0.6L for a raised quarter deck applies to the effective length for a raised quarter deck of less than standard height.

Figure 31. Effective Length of a Full Superstructure, a Portion considered as a Raised Quarter Deck



[27] As permitted for a superstructure, maximum 0.04B.

[28] See table on page 48.

[29] [4] LL.3/Circ.22, 19 May 1977

$$S_{max} = 0.6L \ (B_s/b) \ h_s/h_l$$

where: $h_l/h_s \leq 1.0$, and $b/B_s \leq 1.0$

$$E_{max} = 0.6L = S \ (b/B_s) \ h_l/h_s$$

SLOPING END BULKHEADS[30]

Definition

A "sloping end bulkhead" is defined as the end bulkhead of an enclosed superstructure which is less than vertical.[31]

If the enclosed superstructure extends from side to side of the vessel, and the slope of the end bulkhead(s) is less than 15°, the configuration should be treated as sheer.[32]

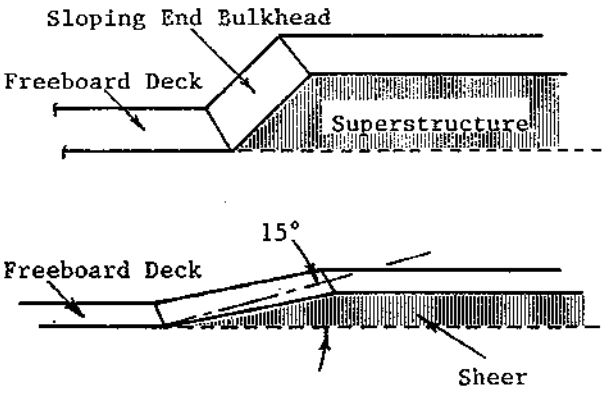


Figure 32. Superstructure with Sloping End Bulkhead

Mean Length

When the height of the superstructure, clear of the slope, is equal to or smaller than the standard height, the mean length (S) is to be obtained as shown in Figure 33(a).

When the height is greater than standard, the mean length (S) is to be obtained as shown in Figure 33(b).

Effective Length

When the height of the superstructure, clear of the slope, is less than the standard height, its effective length (E) should be its mean length

[30] [4] SLF 29/15, Annex 6, 8 Feb 1984 (LL.37/Rev.1)

[31] Vertical being defined as 90° to the waterline or baseline.

[32] No superstructure credit is given. For a definition and further details on "sheer", see the section on sheer later in this chapter.

(S) as obtained in one of the above paragraphs, reduced in the ratio of its actual height to the standard height.

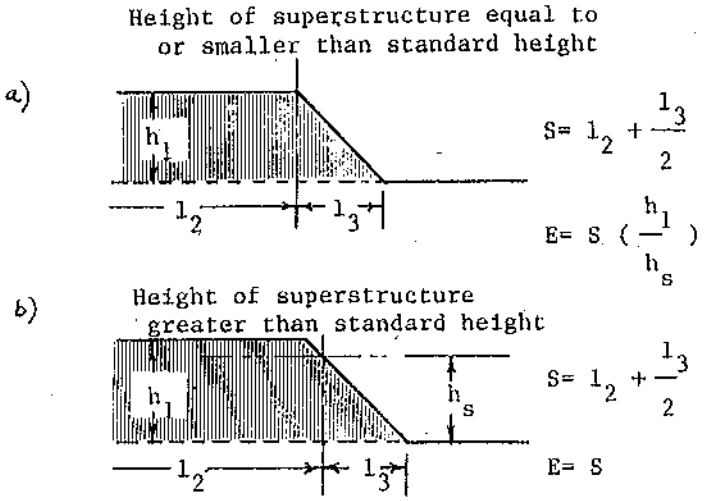


Figure 33. Credit for Superstructure with a Sloping End Bulkhead

SUPERSTRUCTURE EXTENSION

Definition[33]

To be considered as a "superstructure extension", a deck structure must:

1) Be enclosed and weathertight; *and*

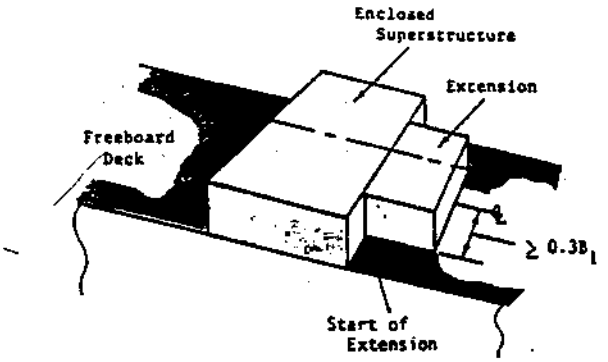
2) Be attached to an enclosed superstructure; *and*

3) Have a breadth, on each side of the centerline of the vessel, of at least 30% of the breadth of the vessel.[34]

[33] [4] LL.15, LL.8/Circ.20, 26 May 1976 (basis)

[34] When evaluating a superstructure extension the breadth of the vessel is measured at the superstructure end bulkhead, i.e. at the start of the extension.

Figure 34. Superstructure Extension

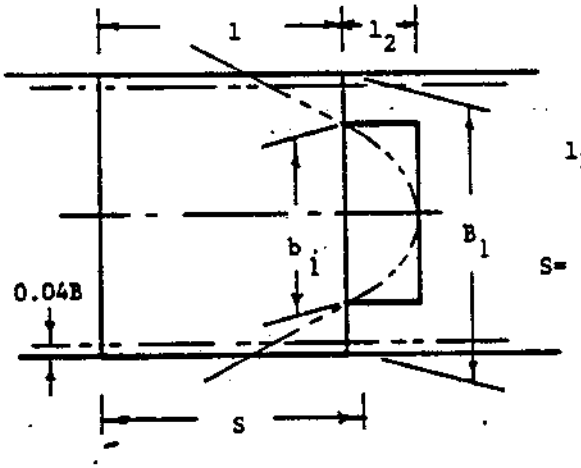


B_1 = breadth of vessel at start of extension.

Superstructure Credit[35]

The mean length of a superstructure may be increased by considering an equivalent superstructure bulkhead in the form of a parabola. This parabola should extend from the extension at the center line and pass through the junction of the actual superstructure bulkhead with the sides of the extension and extend to the sides of the vessel. This parabola should be completely contained within the boundary of the superstructure and its extensions.

Figure 35. Superstructure Extension Credit



$$l_{2\ max} = \frac{b_1^2}{2B_1}$$

$$S = 1 + l_2 \left[1 - \frac{1}{3}\left(\frac{B_1}{b_1}\right)^2\right]$$

[35] [4] LL.15, LL.3/Circ.20, 26 May 1976 (basis)

SUPERSTRUCTURE RECESS

Definitions[36]

A superstructure recess refers to the area where part of an end bulkhead(s) of an enclosed superstructure is recessed. To be considered as a "recess," the area in question:

1) Is not to extend to the sides of the superstructure, i.e. there is always to be some buoyant superstructure outboard of the recessed area; *and*

2) Need not be decked over.

One or more recess(es) may be located in one or both superstructure end bulkhead(s). There is no minimum or maximum breadth for a recess.

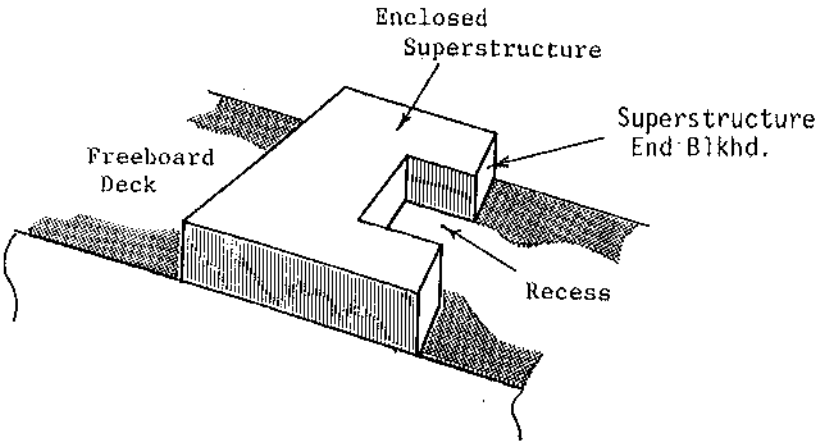


Figure 36. Superstructure Recess

Superstructure Deduction[37]

Where a superstructure end bulkhead is recessed, the mean length of the superstructure is to be reduced by an amount equivalent to the area of the recess. The area of the recess is divided by the breadth of the superstructure at the mid-length of the recess.

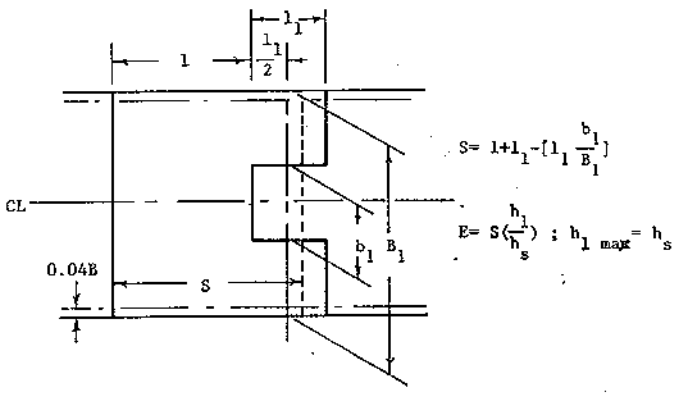
If a recess is unsymmetrical about the centerline of the vessel, the largest portion of the recess should be considered as applying to both sides of the vessel.[38]

[36] [4] LL.15, LL.3/Circ.20, 26 May 1976 (basis)

[37] [4] LL.15, LL.3/Circ.20, 26 May 1976 (basis)

[38] For further details see the section concerning unsymmetrical superstructures later in this chapter.

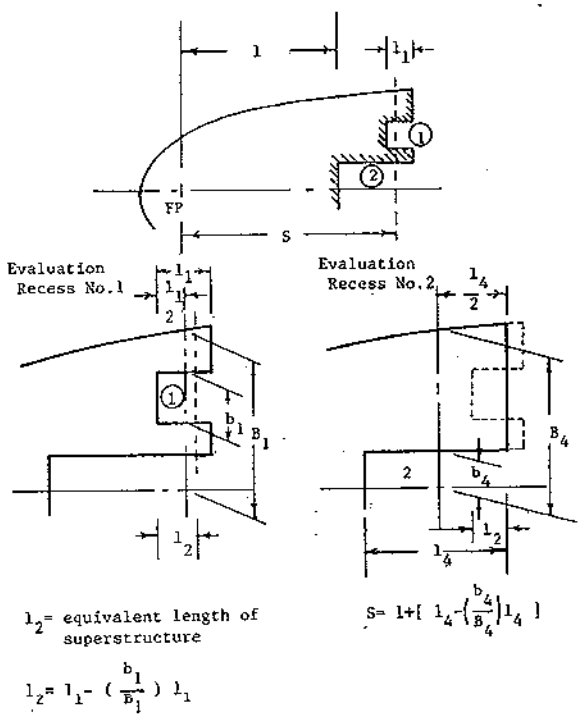
Figure 37.
Superstructure
Recess Deduction



Multiple Recesses[39]

If two or more recesses are contained in one superstructure end bulkhead, each recess is evaluated separately. The recess with the shorter length is considered first. The mean length of the superstructure is reduced by an amount equivalent to the area of the shorter recess related to the breadth of the superstructure at the mid-length of the shorter recess. This procedure reduces the superstructure with two recesses into a superstructure of an equivalent length that contains one recess. The procedure is then repeated for the longer recess using the equivalent length of the superstructure determined by considering the shorter recess.

Figure 38.
Superstructure with
Multiple Recesses



[39] Practice for more than fifteen years.

TRUNKS

Definition[40]

A **trunk** is a weathertight structure on the freeboard deck which has a breadth less than 92% of the breadth of the vessel, *and* complies with *all* of the following:

1) The trunk is as strong as a superstructure;

2) The breadth of the trunk is at least 60% of the breadth of the vessel;

3) Where there is no superstructure, the length of the trunk is at least 0.6L;

4) Regulation 36(1)b,c,d,e, and f which address specific requirements for hatchways, crew protection, ventilators, and machinery casings;

5) The width of the trunk deck stringer provides a satisfactory gangway and sufficient lateral stiffness;

6) The sides of a trunk are to be intact. Side scuttles[41] of the non-opening type and bolted manhole covers may be allowed. The inclusion of a trunk in the calculation of freeboard does not prohibit the fitting of openings in the bulkhead of adjacent superstructures such as poops, bridges or forecastles *provided* there is no direct communication between the superstructure and the trunk.

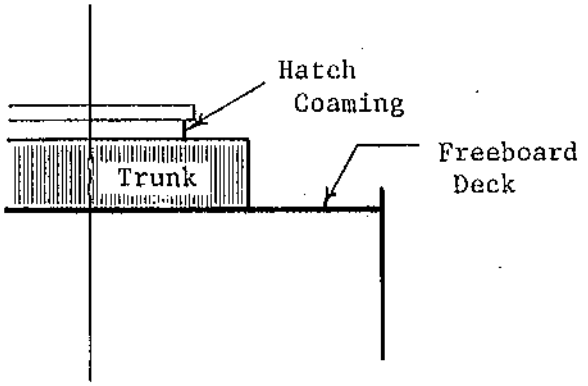


Figure 39. Trunk

[40] [1] Reg. 36(1)

[41] [4] LL.41, LL./Circ.42, 13 April 1982. A side scuttle is commonly referred to as a porthole or airport.

General Particulars

Trunks by definition are not a superstructure, and while superstructure credit is allowed for such structures, they are not to be taken into account as part of the total mean length (S) in the sheer correction, nor are they to be considered in the effective length (E) which is used in the tabular freeboard correction for Type 'B' vessels with limited superstructure.[42]

The standard height of a trunk is the standard height of a superstructure other than a raised quarter deck.[43]

The breadth of the trunk is to be measured between the trunk side bulkheads.

Continuous Hatchways[44]

It is recommended that continuous hatchways may be treated as a trunk in the freeboard computation *provided* Regulation 36 is complied with in all respects.

The trunk deck stringer referred to in Regulation 36(1)(b),[45] *may* be fitted outboard of the trunk side bulkhead in association with all of the following:

1) The stringer is to provide a clear walkway of at least 450 mm (17 1/2")in width on each side of the vessel;

2) The stringer is to be a solid plate efficiently supported and stiffened.

3) The stringer is to be as high above the freeboard deck as practicable.

4) Hatch cover securing appliances are to be accessible from the stringer or walkway.

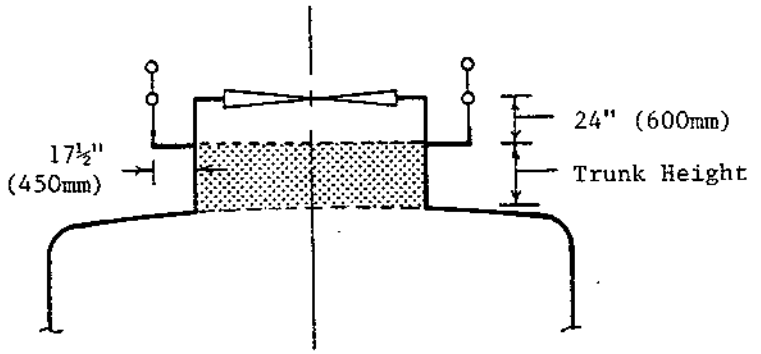


Figure 40. Continuous Hatchway as a Trunk

[42] [4] LL.41, LL.3/Circ.42, 13 April 1982
[43] [1] Reg. 36(3)
[44] [4] LL.26/Rev.1, SLF 29/15, 8 February 1984
[45] Item 5) above

Effective Length

The mean length of an efficient trunk reduced in the ratio of its mean breadth to breadth of the vessel at the mid-length of the trunk is its effective length.[46]

$$E = l\,(b/B)$$

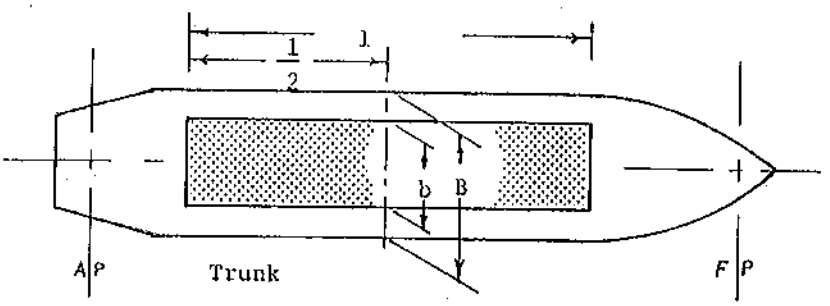


Figure 41. Trunk-Effective Length

Trunk Height

Where the height of a trunk is less than the standard height, its effective length is to be reduced in the ratio of the actual to the standard height. Where the height of the hatch coamings on the trunk deck are less than that required under Regulation 15(1),[47] a reduction from the actual height of the trunk is to be made which corresponds to the difference between the actual and the required height of coaming.[48]

In the case where the trunk height is less than standard and the trunk hatch coamings are also of less than the standard coaming height, or omitted entirely, doubt may arise whether the trunk hatchways are located in position 1 or position 2 and, consequently, about the reduction to be made in the actual trunk height. It is considered that in these cases the reduction from the actual height of trunk on account of insufficient hatch coaming height is to be taken as the difference between 600 mm and the actual height of coaming, or 600 mm if no hatch coamings are fitted.[49] A reduction in the actual height of trunk is not required in cases where only small hatches with less than standard coaming heights are fitted in the trunk deck for which dispensation from the requirement of standard coaming height may be given.[50]

---

[46] [1] Reg. 36(2)

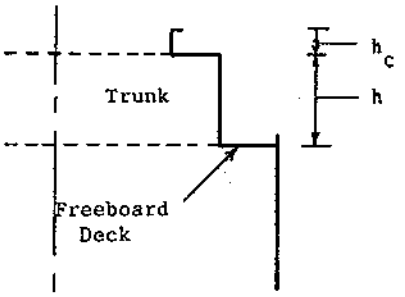
[47] For details on hatch coaming height requirements see hatchways in Chapter III of this manual.

[48] [1] Reg. 36(4)

[49] [4] LL.27, LL.3/Circ.20, 26 May 1976. It is assumed that the hatch opening is flush with the top of the trunk. If a 600 mm hatch coaming were fitted no reduction in the trunk height is necessary. For a coaming of any lesser height, the reduction is proportionate.

[50] [4] LL.27, LL.3/Circ.20, 26 May 1976 (basis)

Figure 42. Trunk Hatch Coamings



Height of trunk = $h + h_c - h_{rc}$

where:

h = actual height of the trunk;
h_c = actual hatch coaming height;
h_{rc} = required " " " ;
$h_{c\,max} = h_{rc}$

UNSYMMETRICAL SUPERSTRUCTURE

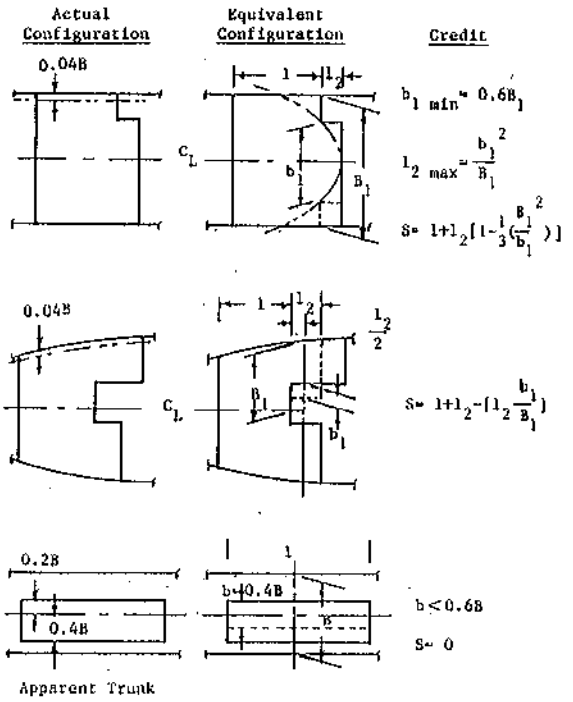
Definition

The term "unsymmetrical" superstructure refers to one which is not completely symmetrical about the longitudinal center line of the vessel.

Superstructure Credit

When a superstructure is unsymmetrical about the longitudinal center line, the side which offers the least mean and effective length is to be considered to exist on both sides of the center line, and the superstructure correction is then calculated using the same techniques used for symmetrical superstructures.

Figure 43. Unsymmetrical Superstructure Configurations



SUPERIMPOSED SUPERSTRUCTURE

Definition

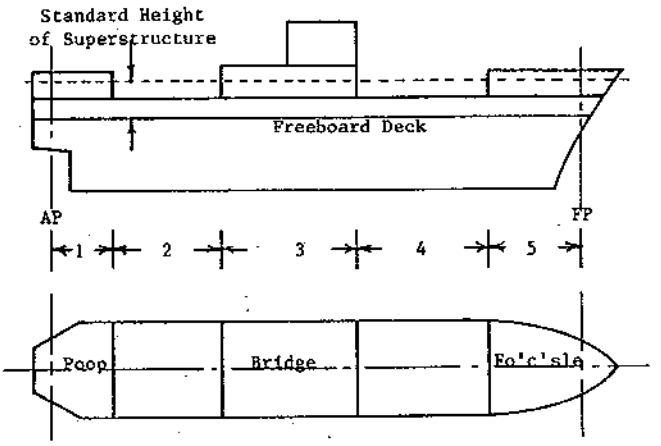
The term "superimposed" superstructure refers to a deck structure that would qualify as an enclosed superstructure that is located on top of a full superstructure.[51] The full superstructure *may* be less than, equal to, or greater than standard height.

Full Superstructure-Less Than Standard Height

On a vessel with a full superstructure of less than standard height which has superimposed superstructures, which extend the full breadth of the full superstructure on the freeboard deck, credit may be given for the superimposed structures in the superstructure correction.

[51] A full superstructure is one which extends from the AP to the FP.

Figure 44. Superimposed Superstructure



The vessel is divided up into segments that are less than, and greater than standard height. Credit is given for segments 1, 3 and 5 without a height correction. The effective lengths of segments 2 and 4 are adjusted for the height deficiency. The respective effective length of each segment is added to determine the total effective length of the superstructure.

Full Superstructure ≥ Standard Height

For a vessel with a full superstructure that is equal to or greater than the standard height of the superstructure, no additional superstructure credit is given for a superimposed superstructure.

Sheer credit *may* be given for an enclosed poop or forecastle superimposed on a complete superstructure which is equal to or greater than the standard height.[52]

Mean and Effective Length

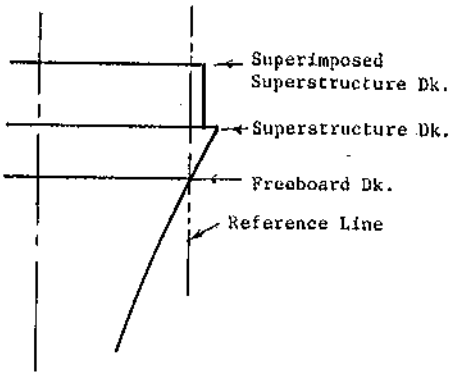
The mean and effective lengths of superimposed superstructures are determined in the same manner as if these superstructures were on the freeboard deck.

When a superimposed superstructure is set in from the side of the superstructure deck, an imaginary vertical reference line is drawn, perpendicular to the baseline, which intersects the freeboard deck and the side shell of the vessel, at the mid-length of the superimposed superstructure. The relation between the side of the superimposed superstructure and the reference line is used to assess the mean and effective length of the superimposed superstructure.[53]

[52] [4] LL.29, LL.3/Circ.20, 26 May 1976 {basis}. For details on sheer, see the section on sheer later in this chapter.

[53] See Figure 45. If the side of the superimposed superstructure is outboard of the reference line, there is no breadth correction imposed.

Figure 45. Superimposed Superstructure Set in From Side of the Superstructure Deck



Cross Section at Midlength of Superimposed Superstructure.

DEDUCTION FOR SUPERSTRUCTURE AND TRUNKS

Process For Determining Superstructure Credit

1) Sum the total effective lengths (E) of all superstructures and trunks, as a function of the load line length (L).

2) Determine the corrected allowable "percentage of deduction" from the tables, with possible additional corrections.

3) Determine the maximum superstructure freeboard deduction, (total E/L= 1.0), based on the load line length (L) of the vessel.

4) Multiply the maximum superstructure deduction by the corrected allowable percentage of deduction to determine the superstructure freeboard deduction to be credited.

Percentage of Deduction[54]

The percentage of deduction is obtained from one of the tables on the following page:

[54] [1] Reg. 37 (2)&(3)

PERCENTAGE OF DEDUCTION

TYPE 'A' VESSELS		TYPE 'B' VESSELS	
Total effective length of superstructures and trunks	Percentage of deduction for all types of superstructures	Vessels with forecastle and without detached bridge	Vessels with forecastle and detached bridge
		Column I	Column II
0	0	0	0
0.1L	7	5	6.3
0.2L	14	10	12.7
0.3L	21	15	19
0.4L	31	23.5	27.5
0.5L	41	32	36
0.6L	52	46	46
0.7L	63	63	63
0.8L	75.3	75.3	75.3
0.9L	87.7	87.7	87.7
1.0L	100	100	100

Percentages at intermediate lengths of superstructures are to be obtained by linear interpolation.

Additional Corrections for Type 'B' Vessels[55]

1) **Bridge**

Where the effective length of a bridge is less than 0.2L, the percentages are to be obtained by linear interpolation between columns I and II. See item 3), forecastle correction, which may also apply.

2) **Detached Bridge**[56]

a) When applying the above table, it is considered that any detached superstructure whose after bulkhead is located 0.05L or more forward of the after perpendicular may be treated as a detached bridge.

b) A superstructure whose after bulkhead is located within 0.05L from the after perpendicular does not qualify as a detached bridge.

c) See item 3), forecastle correction, which may also apply.

[55] [1] Reg. 37 (3) {basis}
[56] [4] LL.28; LL.3/Circ.77, 13 Oct 1986

3) **Forecastle**

a) Where no forecastle is fitted, *or* where the effective length of a forecastle is less than 0.07L, the percentages given in Column I and II above are to be reduced by:

$$5 \times \frac{(0.07L - f)}{0.07L}$$

where f is the effective length of the forecastle.

b) Where the effective length of a forecastle is more than 0.4L, the percentages are be to obtained from Column II.

c) The forecastle correction is still applied even if the effective lenght of the bridge is less than 0.2L.

Maximum Freeboard Deduction[57]

Where the sum of the effective lengths of all superstructures and trunks is 100% of the load line length (L), the deduction from the freeboard is:

Vessel Length	Freeboard Deduction
24 m (79 ft)	350 mm (14 in)
85 m (279 ft)	860 mm (34 in)
122 m (400 ft) & over	1070 mm (42 in)

Deductions at intermediate lengths are to be obtained by linear interpolation.

[57] [1] Reg. 37(1)

SHEER

GENERAL CONCEPTS

Definition

The relation of the longitudinal fore and aft height of the deck to a horizontal[1] reference line that intersects the deck at amidships.[2]

Concept- may be a penalty or a credit

The sheer profile provides additional buoyancy at the fore and aft ends of the vessel to help right the vessel when pitching and reduces deck wetness.

Sheer Correction

The sheer correction is determined by comparing the actual sheer profile of the vessel on the freeboard deck to that of a standard ship of the same length as defined in the Convention. The comparison is made between the area under the actual sheer profile curve to that under the standard sheer profile curve.

Sheer Correction Procedure

The correction for excess or deficiency of sheer is determined in the following sequence:

Actual Sheer Profile

1) Location of the 6 sheer ordinates;

2) Height of the actual sheer profile curve above the sheer reference line at the location of the six ordinates;

3) Excess superstructure height sheer credit, at the after or forward perpendicular for a poop or forecastle respectively, or at all six ordinates for a full superstructure;

4) Area under the forward and after halves of the equivalent sheer profile curve;

[1] Horizontal is defined as parallel to the waterline.

[2] [1] Reg. 38(1) & (2) {basis}

Standard Sheer Profile

5) Height of the standard sheer profile curve at the location of the six ordinates;

6) Area under the forward and after halves of the standard sheer profile curve;

Variation Measurement

7) Compare the area under the forward and after halves of the equivalent actual sheer profile curve to the area under the forward and after halves of the standard sheer profile curve to determine the effective or rule sheer profile areas;

8) Subtract the sum of the effective or rule areas from the sum of the standard sheer areas to determine the allowable sheer credit areas;

9) Average the forward and after sheer credit areas;

10) Multiply by the sheer correction variation, which includes the total mean length of superstructure, to determine the deficiency or excess of sheer;

11) If there is excess sheer, check to ensure that sheer credit given does not exceed the maximum deduction allowed.

Sheer Ordinates

The sheer profile, both actual and standard, is defined by seven evenly spaced sheer ordinates. The sheer ordinates are located at:

1) After perpendicular;

2) 1/6 L forward of the after perpendicular;

3) 1/3 L forward of the after perpendicular;

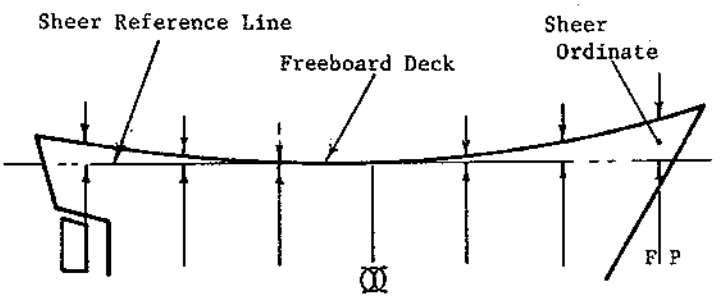
4) Amidships

5) 1/3 L aft of the forward perpendicular;

6) 1/6 L aft of the forward perpendicular;

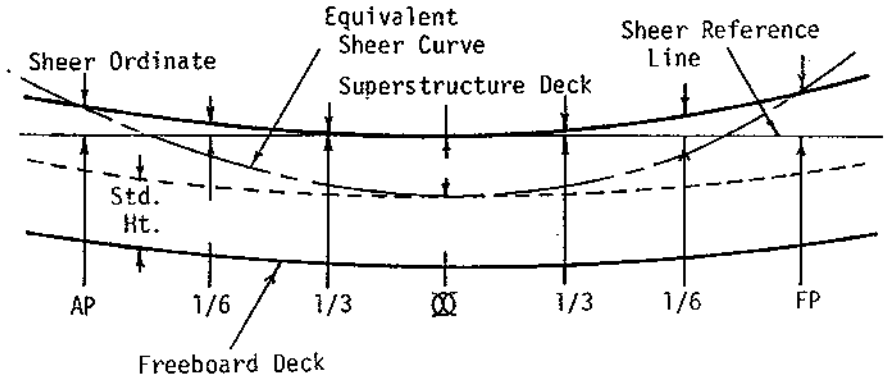
7) Forward perpendicular.

Figure 46. Sheer Concepts



Sheer ordinates are usually measured at the freeboard deck. In ships with a superstructure of *at least* standard height which extends over the whole length of the freeboard deck, the sheer ordinates are measured at the superstructure deck.[3] Where the height *exceeds* the standard, the least difference **Z** between the actual and standard heights is to be added to each end ordinate, i.e. the forward and after perpendicular ordinate. Similarly, the intermediate ordinates at distances of 1/6 L and 1/3 L from each perpendicular are to be increased by **0.444Z** and **0.111Z** respectively.

Figure 47. Sheer Ordinates Full Superstructure



In vessels with a superstructure that extends over the entire freeboard deck that is *less* than standard height, the sheer ordinates are measured at the freeboard deck.

If the deck where the sheer ordinates are measured is below the sheer reference line, at the location of one or more of the ordinates, the sheer measurement at the ordinate is taken as a negative value.

[3] [1] Reg. 38(5)

In vessels with topsides of unusual form in which there is a step or break in the topsides, the sheer is considered in relation to the equivalent depth amidships.[4] The sheer reference line is then located at this point.

STANDARD SHEER PROFILE

Concept

For a given length, a standard vessel has a sheer profile that is determined by values at evenly spaced ordinates, the height of the forward ordinates being exactly double the height of the respective after ordinates.

The area under the actual sheer profile, for the forward half of the vessel, is compared to the area under the standard sheer profile for the forward half of the standard vessel with the same length. Likewise, the areas under the actual and standard sheer profiles for the after half of the vessel are compared.

Ordinates

The value of the sheer ordinates of the standard sheer are listed in the table given in Regulation 38(8). The area under the forward and after half of the standard sheer profile curve, derived by summing the standard sheer ordinates multiplied by the appropriate Simpsons multiplier[5], is determined from the following equations:

AFTER HALF

Metric: 66.7/8 (L/3 + 10) English: (0.2665 x L + 26.65)/8

FORWARD HALF

Metric: 133.4/8 (L/3 + 10) English: (0.533 x L + 53.3)/8

VARIATION MEASUREMENT AND CALCULATION[6]

Concept- Deficiency/Excess of Forward/Aft Half

Where the actual sheer profile differs from the standard sheer profile, a comparison is made between the area under each half of the vessel.[7]

[4] [1] Reg. 38(4)

[5] In Reg. 38(8), the Simpsons multiplier is referred to as a "factor". Simpsons multipliers are part of Simpsons Rule which is a numerical integration method for finding the area under a curve.

[6] [1] Reg. 38(9),(10), &(11) {basis}

[7] The area referred to is that between the sheer curve and the sheer reference line for the full length of the vessel.

This is accomplished by multiplying the four ordinates of each profile in the forward and after half by the appropriate factors given in the table of ordinates in Regulation 38(8). The difference between the sums of the respective products and those of the standard divided by 8 measures the deficiency or excess of sheer in the forward or after half of the vessel.

Deficiency/Excess of Total Vessel

The arithmetical mean of the excess or deficiency in the forward and after halves of the vessel measures the total excess or deficiency of sheer.

CREDIT FOR EXCESS HEIGHT OF SUPERSTRUCTURE

Concept

Where an enclosed poop or forecastle is of standard height with greater sheer than that of the freeboard deck, or is of more than standard height, an addition to the sheer of the freeboard deck is to be made as provided below.[8] Sheer credit may also be given for a poop or forecastle when the height at the FP or AP exceeds the least height of the structure.

Correction[9]

Sheer credit may be given for a poop or forecastle by using the following formula:

$$s = y/3 \, [\, L'/L \,]$$

where:

s = Sheer credit, to be deducted from the deficiency or added to the excess of sheer.

y = Difference between the actual and standard height of superstructure at the end of sheer[10] (in. or mm.). For a raised quarter deck, the standard height of "other superstructures" not a raised quarter deck is to be used,[11] as listed in Regulation 33.

Where the height of a superstructure is less than standard, "y" is to be taken as the difference between the actual and minimum height of the superstructure at the end of sheer.[12] In such cases

[8] [1] Reg. 38(7)
[9] [1] Reg. 38(12)
[10] End of sheer is interpreted as at the forward and after perpendicular.
[11] [4] LL.30; LL.3/Circ.20, 26 May 1976
[12] [4] LL.16; LL.3/Circ.20, 26 May 1976

the superstructure deck is not to be less than the minimum height above the virtual sheer curve[13] at any point.

L' = The mean enclosed length of the poop or forecastle up to a maximum of 0.5L.

L = Length of the vessel.

The above formula provides a curve in the form of a parabola tangent to the actual sheer curve at the freeboard deck and intersecting the end ordinate at a point below the superstructure deck a distance equal to the standard height of a superstructure. The superstructure deck is to be not less than standard height above this virtual curve at any point. This curve represents the actual sheer that is considered within the forecastle or poop area.

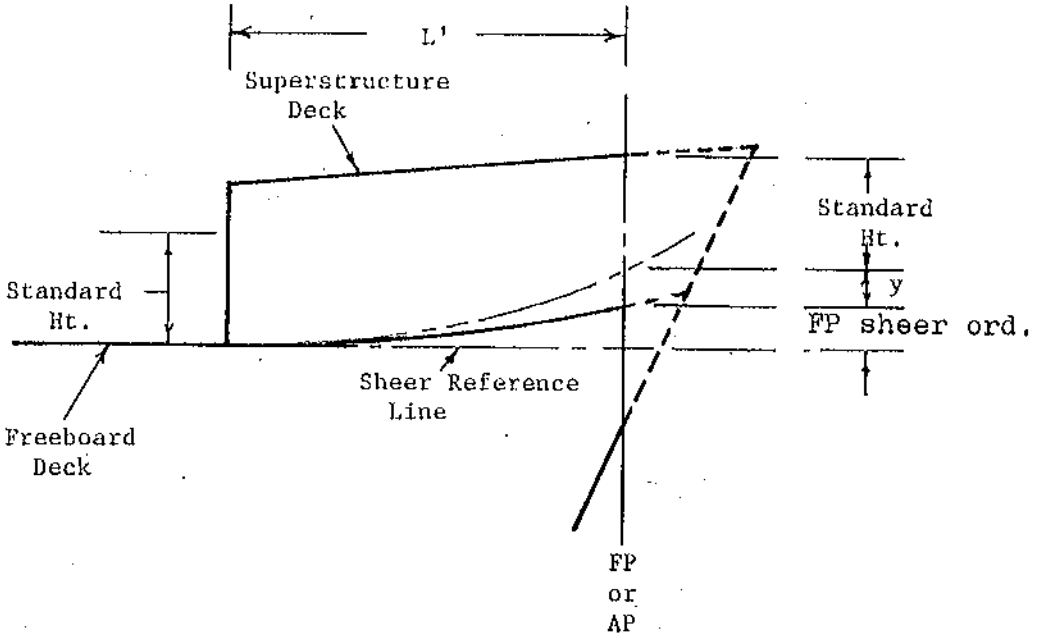


Figure 48. Sheer Credit Excess Superstructure Height

"y" for Forecastle or Poop of less than Standard Height[14]

Where a forecastle or poop height is less than standard height, and the sheer on the forecastle deck is greater than sheer on the freeboard deck, credit for the excess height of the superstructure may be given.

[13] The "virtual sheer curve" is defined as the hypothetical parabolic curve which is tangent to the freeboard deck at the end of the enclosed superstructure and intersects the AP or FP at a point below the superstructure deck equal to either the standard or minimum height of the superstructure, whichever is less.

[14] [4] LL.16; LL.3/Circ.20, 26 May 1976

In such cases "y" is to be taken as the difference between the actual and minimum height of the superstructure at the end of sheer. The superstructure deck is not to be less than the minimum height above the virtual sheer curve at any point.

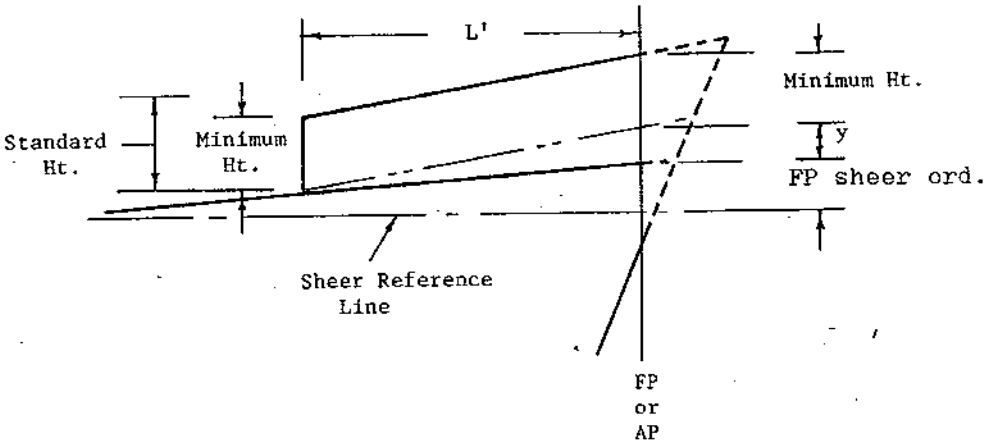


Figure 49. Sheer Credit Superstructure Height is Less Than Standard

"y" for Raised Quarter Decks[15]

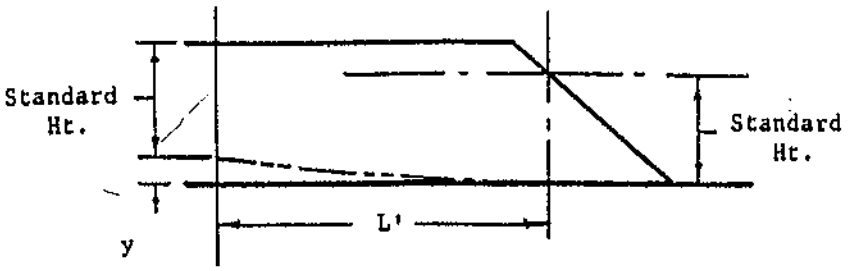
Sheer credit for excess height of the superstructure may be applied to a raised quarter deck *only* when the height of the raised quarter deck is greater than the standard height of "other superstructures" as defined in Regulation 33, and only for the amount by which the actual height of the raised quarter deck exceeds that standard height.

Sloping End Bulkheads[16]

When a poop or forecastle has sloping end bulkheads, the sheer credit *may* be allowed for the excess height and the formula given previously in the section labeled "Correction" is to be used. The values for y and L' are indicated in the following figure.

[15] [4] LL.30; LL.3/Circ.20, 26 May 1976
[16] [4] LL.37; LL.3/Circ.22, 19 May 1977

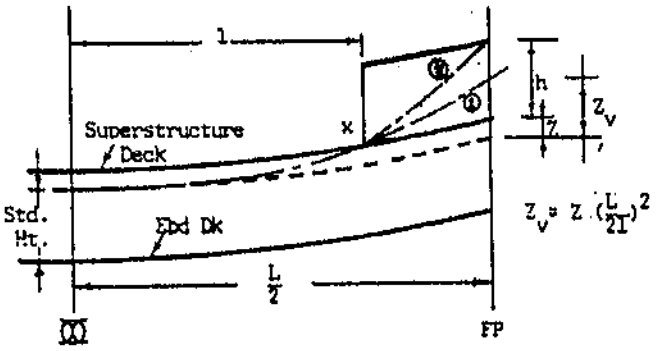
Figure 50. Sheer Credit For Excess Height Of Superstructure With Sloping End Bulkhead



Sheer Credit for Superimposed Superstructures[17]

In applying Regulation 38(5) (sheer on a complete superstructure ship) where there is an enclosed poop or forecastle superimposed on a complete superstructure, sheer credit should be allowed for such poop or forecastle, according to the method of Regulation 38(12) as shown in the following figure.

Figure 51. Sheer Credit - Superimposed Superstructures



Where:

Z = As defined in Reg. 38(5).

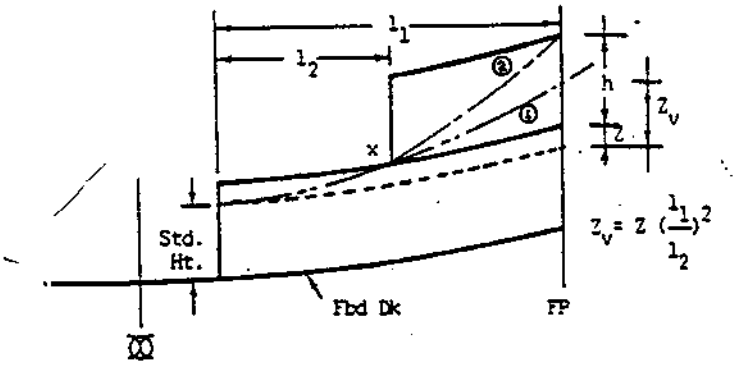
Zv = The end ordinate of a virtual standard parabolic curve taken through the point "X". If Zv is greater than (Z + h), the end ordinate should be (Z + h).

Sheer Credit - Stepped Forecastle or Poop[18]

In applying Regulation 38(7) and 38(12) where a poop or forecastle consists of two layers, the method shown in the following figure should be used.

[17] [4] LL.29/Rev.1; LL.3/Circ.77, 13 October 1986 (basis). See USCG ltr to CCG 1 May 1986
[18] [4] LL.29/Rev.1; LL.3/Circ.77, 13 October 1986

Figure 52. Sheer Credit- Stepped Forecastle or Poop



Where:

Z = As defined in Reg. 38(5).

Zv = The end ordinate of a virtual standard parabolic curve taken through the point "X". If Zv is greater than (Z + h), the end ordinate should be (Z + h).

When the length of the first tier superstructure is greater than 0.5L, the virtual standard parabolic curve should commence at amidships as indicated in Figure 51.

Rule or Effective Sheer Profile[19]

The excess or deficiency of the forward and after half of the actual sheer profile is compared with the respective forward and after half of the standard sheer profile in the following table to determine the rule or effective sheer profile that can be used. The term "Actual" and "Standard" refer to the respective sheer profile areas.

[19] [1] Reg. 38(9),(10) & (11) (basis)

ACTUAL SHEER PROFILE COMPARED WITH STD		EFFECTIVE SHEER PROFILE TO USE	
FORWARD HALF	AFT HALF	FORWARD HALF	AFT HALF
Excess	Excess	Actual	Actual
Deficient	Deficient	Actual	Actual
Deficient	Excess	Actual	Standard
Excess	Deficient and > 75% of Std.	Actual	Actual
Excess	Deficient and < 50% of Std.	Standard	Actual
Excess	Deficient and 50 - 75% of Standard	Standard plus a percentage of Excess	Actual

Excess or Deficiency of Sheer (Total Sheer)

The summation of the forward and after effective or rule sheer profile areas subtracted from the summation of the forward and after standard sheer profile areas, divided by two, determines the arithmetical mean of the excess or deficiency in sheer. This is considered the excess or deficiency of sheer.

SHEER CORRECTION CALCULATION

Correction Formula

The excess or deficiency of sheer is multiplied by the following formula:

$$0.75 - S/2L$$

S is the total mean length of enclosed superstructures, *excluding* the length of trunks.[20]

[20] [4] LL.41; LL.3/Circ.42, 13 April 1982

Where the rule or effective sheer is *less* than the standard sheer, the correction for deficiency in sheer is to be *added* to the freeboard.[21]

Where the rule or effective sheer is *greater* than the standard sheer, the correction is to be *deducted* from the freeboard *provided* the vessel complies with the stipulations addressed in the following section.

ALLOWABLE DEDUCTION FOR EXCESS SHEER[22]

Requirement

The correction for excess of sheer is to be deducted from the freeboard *provided* the vessel has an enclosed superstructure which covers 0.1L before and 0.1L abaft amidships. For vessels with no enclosed superstructure in this region, no deduction is to be made to the freeboard.

Where an enclosed superstructure covers less than 0.1L before and 0.1L abaft amidships, the deduction is to be made by linear interpolation, as a percentage of length within this zone.

Height Correction[23]

It is recommended that the height of the superstructure is to be related to the standard height. When the height of the superstructure or raised quarter deck is less than standard, the reduction is to be in the ratio of the actual to the standard height.

Maximum Deduction[24]

The maximum deduction for excess sheer is:

125 mm. per 100 m. of vessel length

1 1/2 in. per 100 ft. of vessel length

[21] [1] Reg. 38(14)
[22] [1] Reg. 38(15)
[23] [4] LL.31: LL.3/Circ.20, 26 May 1976
[24] [1] Reg. 38(15)

MINIMUM BOW HEIGHT

GENERAL REQUIREMENTS AND CONCEPTS

Definition[1]

The **bow height** is defined as the vertical distance at the forward perpendicular between the assigned summer load waterline, including any designed trim, and the top of the exposed deck at side.[2]

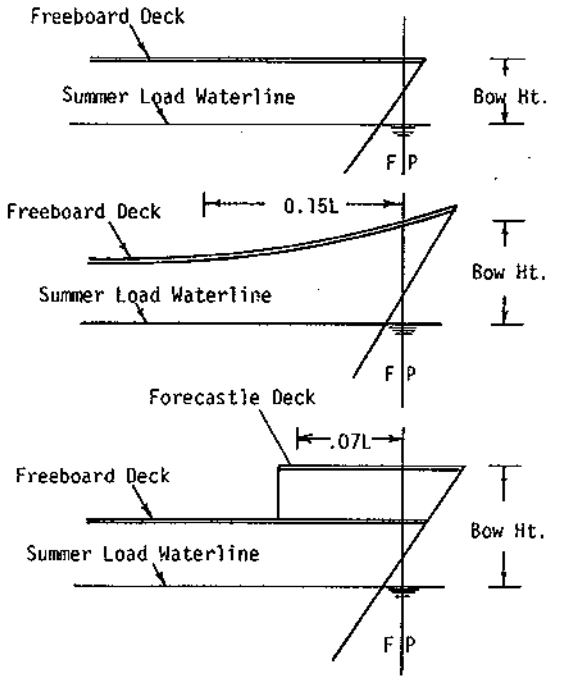


Figure 53. Bow Height

Concept- correction is a freeboard penalty

All **manned** vessels receiving a load line are required to comply with the minimum bow height requirement stipulated in Regulation 39. The bow height requirement ensures that there is reserve buoyancy at the bow to resist pitching and minimize bow immersion when underway in rough weather.

[1] [1] Reg. 39(1)

[2] The "exposed" deck refers to either the freeboard deck or the forecastle deck if it qualifies.

REQUIRED BOW HEIGHT

The bow height as defined above is not to be less than:

Metric Units

Length < 250 m,

$$56\ L\ (1 - \frac{L}{500})\ \frac{1.36}{C_b + 0.68}\ \text{mm}$$

Length ≥ 250 m,

$$7000\ \frac{1.36}{C_b + 0.68}\ \text{mm}$$

where:

L is the length of the vessel in meters;

C_b is the block coefficient which is to be taken as not less than 0.68.

English Units

Length < 820 ft,

$$0.672\ L\ (1 - \frac{L}{1640})\ \frac{1.36}{C_b + 0.68}\ \text{in}$$

Length ≥ 820 ft,

$$275.6\ \frac{1.36}{C_b + 0.68}\ \text{in}$$

where:

L is the length of the vessel in feet;

C_b is the block coefficient which is to be taken as not less than 0.68.

ACTUAL BOW HEIGHT[3]

Determination

To determine the actual bow height, credit may be given for:

1) The **summer freeboard**, which includes the stringer plate thickness. On vessels to which timber freeboards are assigned the

[3] [1] Reg. 39(2)

summer freeboard should relate to the normal summer load waterline and not the timber summer load waterline;[4]

2) **Sheer** on the freeboard deck *provided* the sheer extends for 15% of the length of the vessel abaft the forward perpendicular;

3) **Superstructure**, including the superstructure deck thickness at the forward perpendicular[5], provided the mean length (S) of the superstructure extends from the stem to a point at least 0.07L abaft the forward perpendicular, and complies with the following requirements:

   a. For vessels 100 m (328 ft) in length or less, the superstructure is to be enclosed (as defined previously in this chapter);

   b. For vessels over 100 m (328 ft) in length the structure does not have to comply with the requirements of an enclosed superstructure, however it is to be fitted with closing appliances to the satisfaction of the assigning authority.[6]

4) **Design trim** of the vessel (at the FP) can be credited, however a restriction for the maximum draft at the forward perpendicular will be placed on the Load Line Certificate.

5) **Forecastle deck sheer** may be taken into account, even if the length of the forecastle is less than 0.15L, but greater than 0.07L, *provided* that the forecastle height is not less than one half of the standard height of the superstructure between 0.07L and the forward perpendicular.[7]

Where the forecastle height is less than one half the standard height of the superstructure the credited bow height may be determined as follows:

[4] [4] LL.43; LL.3/Circ.42, 13 April 1982

[5] Where the thickness of the superstructure deck plate at the forward perpendicular at side differs from the thickness of the freeboard deck stringer plate thickness amidships, te difference is to be added or subtracted from the summer freeboard before crediting the summer freeboard in the actual bow height. [1] Reg. 39(1) {basis}

[6] [1] Reg. 39(2)

[7] [5] LL.38, 1976, Rev.1, 1983

a. When the freeboard deck has sheer extending from abaft 0.15L: *by* a parabolic curve having its origin at 0.15L abaft the forward perpendicular at a height equal to the midship depth of the vessel, extended through the point of intersection of forecastle bulkhead and deck, and up to a point at the forward perpendicular not higher than the level of the forecastle deck. However, if the value of the height denoted h_t in the following figure is smaller than the value of the height denoted h_b, then h_t may be replaced by h_b in the available bow height.

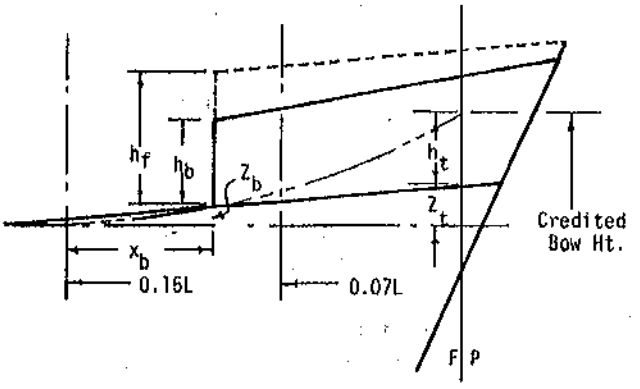


Figure 54. Bow Height Forecastle Deck Sheer Example 1

$h_t = Z_b\,(0.15L / x_b)^2 - Z_t$

h_f = Half the std. ht. of the superstructure

b. When the freeboard deck has sheer extending for less than 0.15L or has no sheer: *by* a line from the forecastle deck at side and at 0.07L extended parallel to the base line to the forward perpendicular.

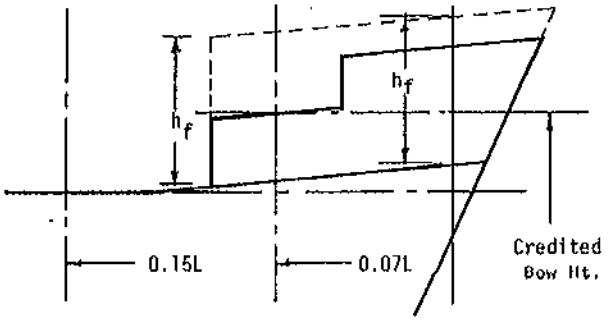


Figure 55. Bow Height Forecastle Deck Sheer Example 2

BOW HEIGHT CORRECTION

Once the geometric freeboard, excluding the bow height correction, has been determined, the actual bow height at the forward perpendicular is compared to the required bow height. If the actual bow height

is deficient, the freeboard is increased until the required bow height is achieved. The difference between the freeboard necessary to meet the bow height requirement and the geometric freeboard, excluding the bow height correction, is referred to as the **bow height penalty**. The minimum geometric freeboard includes the addition of the bow height penalty.

SPECIAL CONSIDERATION TRIM RESISTIVITY[8]

General

Vessels which cannot meet the required bow height, because of exceptional operational requirements, may be given *special consideration*[9] by the assigning authority.[10] NVIC 10-86 addresses a procedure to be used to evaluate an equivalency to the required bow height to reduce the freeboard penalty imposed.

Concept

The intent of the bow height requirement is to ensure that a vessel's bow configuration develops sufficient longitudinal righting energy to recover from a bow immersion in a seaway. A comparsion is made betwen the vessel's actual forward longitudinal trimming moment (volume x moment arm) to that formed by a hypothetical parabolic sheer curve, in the same region, extending to a sufficient level at the FP ordinate to meet the minimum required bow height. The effect of this procedure is a reduction in the penalty layer. It has been the policy of the U.S. Coast Guard to assign a lesser penalty layer consistent with providing such an equivalent longitudinal righting moment.

Calculation

The hypothetical parabolic curve addressed above has an upper boundary which begins at the sheer reference line level at a point 15% of the vessel's length (L) aft of the forward perpendicular (FP), and extends in a parabolic curve to the minimum bow height level at the FP.

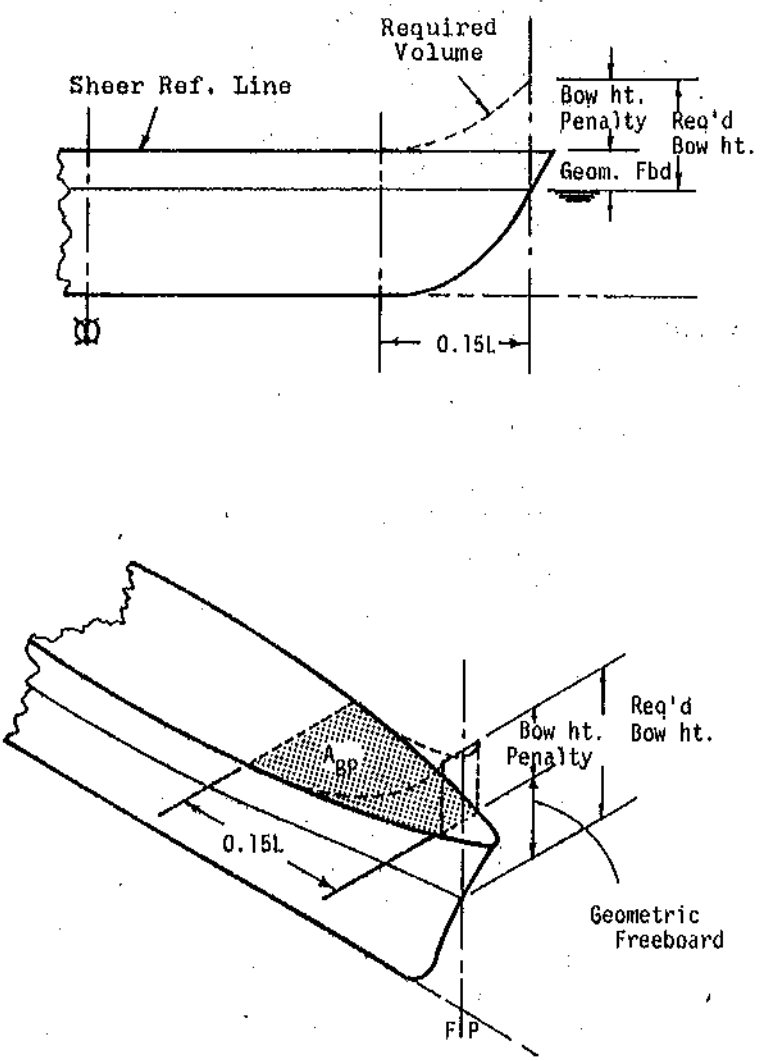
---

[8] [6] 10-86

[9] Special consideration does not necessarily mean a waiver; it refers to an equivalency. The provision of vessel design or operational features which compensate for deficiencies creating an equivalent level of safety.

[10] [2] 42.20-70 (c)

Figure 56. Bow Height Trim Resistivity Concept



The "bow planform area" consists of the area of the sheer reference line waterplane bounded:

- Port and starboard by the side shell;
- Aft at a point 15% of the vessel's length abaft the FP; *and*
- Forward by the FP.

This area is shown by the shaded area labeled A_{BP} in the preceding figure.

The required volume extends from the sheer reference line waterplane to the parabolic curve in a wall-sided fashion within the vertical bounds of the "bow planform area." The moment of this volume about amidships is the "required volumetric moment."

The **freeboard penalty layer** assigned in lieu of the bow height penalty is derived by dividing the required volumetric moment, *less* any credit volumetric moment, by the moment of the bow planform area about amidships.

The reduced bow height penalty is expressed as follows:

$$E_r = \frac{(V_R \times r_R) - (V_A \times r_A)}{(A_{BP} \times r_{BP})}$$

where:

E_r = reduced bow height penalty

V_R = the required volume

V_A = the actual volume

A_{BP} = bow planform area

r_R, r_A, r_{BP} = appropriate moment arms referenced to some longitudinal reference of the centroid of V_R, V_A, or A_{BP} as appropriate.

The **credit moment** is obtained by multiplying the actual volume, above the zero sheer reference plane, by the distance from the centroid of the actual volume to amidships. Cutouts and recesses in the bow region, above and below the zero sheer reference plane, should be treated as negative volumes and areas. Superstructures and trunks, up to one standard height of superstructure[11], may be considered effective in contributing to the actual volume *provided*:

1) enclosed bulkheads are of sufficient construction;

2) any access openings within 15% L of the FP must be fitted with doors complying with the requirements of Reg. 12; *and*

3) all other openings in the sides or ends of the superstructure must be fitted with efficient weathertight closures.

The credit moment calculation should be conducted assuming the vessel has zero trim, *unless* the vessel has "design trim" which may be considered.

[11] [8] Electronic Message 25 June 1986

LOAD LINE MARKS AND MINIMUM FBDS

GENERAL ITEMS

Details of Marking[1]

The ring, lines and letters are to be painted in white or yellow on a dark background, or black on a light background. They are to permanently marked on the sides of the vessel by welding or scribing to the satisfaction of the assigning authority. The marks are to be plainly visible and, if necessary, special arrangements are to be made for this purpose.

Verification of Marks[2]

The Load Line Certificate is not to be delivered to the vessel by the assigning authority until after its surveyor has ascertained that the vessel meets all conditions of assignment, the applicable survey requirements have been completed, and the correct placement of the marks on the sides of the vessel have been confirmed.

DECK LINE AND CENTER OF RING

Deck Line[3]

The deck line is a horizontal line 300 mm (12 in.) in length, 25 mm (1 in.) in breadth, that serves as a reference point from which the load line marks are measured. It is marked amidships[4] on each side of the vessel, so that its upper edge is normally at the point where the upper surface of the freeboard deck continued outwards intersects the side shell. It may be placed at another location, in the same vertical plane, due to an obstruction, rounded gunwale etc. *provided* that the distance to the center of the ring and corresponding freeboards are corrected. The location of the reference point and the identification of the freeboard deck is indicated on the Load Line Certificate.

Load Line Mark[5]

The load line mark, also referred to as the "center of the ring" or "Plimsoll Mark", consists of a ring 300 mm (12 in.) in outside diameter, 25 mm (1 in.) in breadth, which is intersected by a horizontal line 450 mm (18 in.) in length, 25 mm (1 in.) in breadth, the upper edge of which passes through the center of the ring.

---

1 [1] Reg. 8 {basis}
2 [1] Reg. 9 {basis}
3 [1] Reg. 4 {basis}
4 Amidships is defined as the midpoint of the load line length.
5 [1] Reg. 5

The center of the ring is placed amidships, and at a distance equal to the assigned summer freeboard measured vertically below the upper edge of the deck line.

Lines To Be Used With The Load Line Mark[6]

The seasonal freeboard lines assigned in conjunction with the load line mark each consist of a horizontal line 230 mm (9 in.) in length, 25 mm (1 in.) in breadth, and extend forward of and at a right angle to a vertical line 25 mm (1 in.) in breadth marked at a distance 540 mm (21 in.) forward[7] of the center of the ring.

The density allowances are marked in similar fashion extending aft of the vertical line indicated in the preceding paragraph.

Mark of Assigning Authority[8]

The mark of the assigning authority by whom the load lines are assigned may be indicated alongside the load line ring above the horizontal line which passes through the center of the ring, or above and below it. This mark is to consist of not more than four initials to identify the assigning authority's name, each measuring approximately 115 mm (4 1/2 in.) in height and 75 mm (3 in.) in width.

SEASONAL ALLOWANCES[9]

Summer Freeboard

The Summer Load Line is indicated by the upper edge of the horizontal line which passes through the center of the ring, and also by a seasonal line marked with a S.

The minimum summer freeboard corresponds to the tabular freeboard as modified by all applicable corrections, including required bow height. The minimum summer freeboard, in salt water, *excluding* the possible deck line correction, *is not* to be less than 50 mm (2 in.). For vessels which are fitted with hatchways in position 1 with covers which are:

1) Made of wood; *or*

2) Steel *not* complying with the indicated strength criteria; *or*

3) Other material that *does not* comply with the steel criteria;

the minimum freeboard is not to be less than 150 mm (6 in.).

---

6 [1] Reg. 6

7 The density and seasonal allowance grid lines are marked forward of the center of the ring on both sides of the vessel, with the exception of the timber allowance lines which are marked aft of the ring. In the illustrations shown in the manual, the starboard side of the vessel is indicated.

8 [1] Reg. 7

9 [1] Reg. 6 and 40

Winter Freeboard

The Winter Load Line is indicated by the upper edge of a line marked W.

The minimum freeboard in the winter zone is the summer freeboard plus one forty-eighth of the summer molded draft.

Tropical Freeboard

The Tropical Freeboard Line is indicated by the upper edge of a line marked T.

The minimum freeboard in the tropical zone is the summer freeboard minus one forty-eighth of the summer molded draft.

The minimum tropical freeboard, in salt water, *excluding* the possible deck line correction, *is not* to be less than 50 mm (2 in.). For vessels which are fitted with hatchways in position 1 with covers which are:

1) Made of wood; or

2) Steel *not* complying with the indicated strength criteria; or

3) Other material that *does not* comply with the steel criteria;

the minimum tropical freeboard is not to be less than 150 mm (6 in.).

Winter North Atlantic Freeboard

The Winter North Atlantic Freeboard Line is indicated by the upper edge of a line marked WNA.

The Winter North Atlantic Mark is assigned *only* to vessels 100 m *and* less. The minimum freeboard for these vessels which enter part of the North Atlantic defined in Reg. 52 during the winter seasonal period, is the winter freeboard *plus* 50 mm (2 in.). For all other vessels, the winter freeboard is to to used in the Winter North Atlantic Zone, and the Winter North Atlantic Freeboard Line is not marked.

DENSITY ALLOWANCES[10]

Fresh Water Freeboards

The Fresh Water Load Line in the summer seasonal zone is indicated by the upper edge of a line marked F.

The difference between the Fresh Water Load Line mark and the Summer Freeboard Mark is the allowance to be made for loading in fresh water in other seasonal zones.

[10] [1] Reg. 6 and 40(7) and (8)

The minimum freeboard in fresh water of unit density (sp.gr. 1.000) is to be obtained by deducting from the minimum freeboard in salt water:

$$\frac{D}{40\ T} \text{ centimeters (in.)}^{11}$$

where:

D = molded displacement[12] in salt water in metric (long) tons at the molded summer load waterline;

T = tons per centimeter (inch) immersion in salt water at the molded summer load waterline.

Where the displacement at the summer load waterline cannot be certified, the deduction is to be one forty-eighth of the molded summer draft.

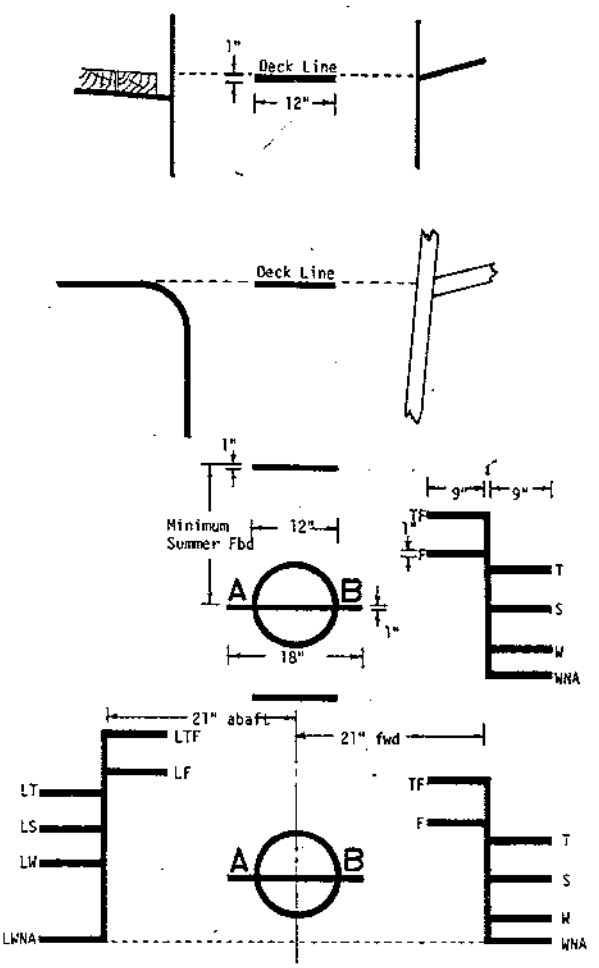
Tropical Fresh Water Freeboard

The tropical Fresh Water Load Line is indicated by the upper edge of a line marked **TF**. The Tropical Fresh Water allowance is obtained by addition of the tropical seasonal allowance and the fresh water allowance.

[11] Derivation of the coefficient 40 = 1/sp.gr(sw) - sp.gr.(fw) = 1/1.025-1.000

[12] [8] Electronic Message 11 July 1986

Figure 57.
Freeboard Markings



INCREASED FREEBOARDS

Concept

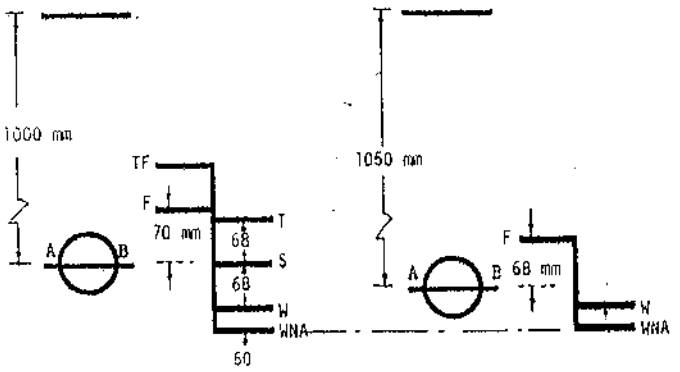
A freeboard is considered increased when it is greater than the minimum freeboard determined by the vessel's geometric particulars. The increase may be attributable to a limitation of the vessel's strength or stability characteristics, or simply a voluntary increase for operational reasons. Relaxations from the Conditions of Assignment may be granted to a vessel assigned an increased freeboard *provided* the safety conditions are determined to be satisfactory.[13]

Small Increase

The increase in freeboard is considered small when the location of the center of the ring is above the level of the lowest applicable seasonal load line mark corresponding to the minimum geometric freeboard. In such cases, the minimum geometric freeboard seasonal allowances that are below the level of the assigned center of ring are also to be marked.

[13] [2] 42.13-10(e)

Figure 58. Load Line Marks-Small Increase in Freeboard



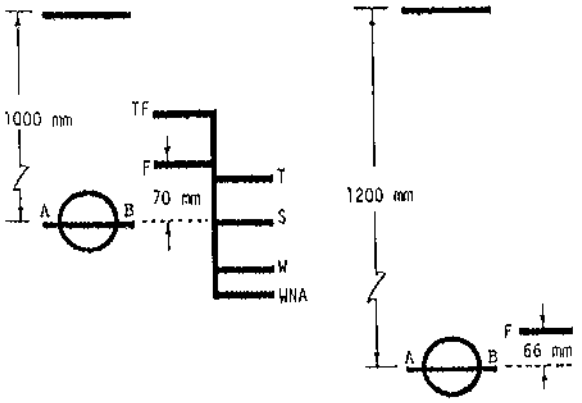
(measurements are made from the top of the applicable line)

In the preceding example, the Winter and Winter North Atlantic Marks from the minimum geometric freeboard grid are included in the assigned increased freeboard grid. A new summer mark is marked at the new location of the center of ring and the Summer, Tropical and Tropical Fresh marks are omitted.

Large Increase - All Seasons Freeboard

The increase in freeboard is considered large when the location of the center of the ring is below the level of the lowest applicable seasonal load line mark corresponding to the minimum geometric freeboard. In such cases, only the Fresh Water Load Line need be marked.[14]

Figure 59. Large Increased Freeboard



Large Increase - Optional Full Grid

When a large increase in freeboard exists, at the option of the owner, a full grid of density and seasonal allowances may be assigned. These

[14] [1] Reg. 6(6)

allowances are determined based on the summer molded draft corresponding to the increased summer freeboard. If the vessel operates predominately in the summer and tropical seasonal zones, the owner may benefit from this option as compared to the "all seasons" freeboard assignment.

MISCELLANEOUS CONCEPTS

Restricted Service[15]

Where the characteristics of a vessel, the nature of the vessel's service, or navigational limits make any of the seasonal load lines inapplicable, these lines may be omitted.

Subdivision Freeboard[16]

Subdivision load line(s) are assigned to a passenger vessel that complies with all the applicable load line requirements. The subdivision load line corresponds to the maximum draft at which a vessel may operate determined by the subdivision and stability analysis. The subdivision load line draft cannot be exceeded even if the geometric summer or seasonal load lines draft would be greater. When the subdivision load line is located on a vessel in a position *between* the highest and lowest seasonal load line marks, the seasonal load line marks above the subdivision load line will be omitted and those below will be marked.

When the subdivision freeboard is *greater* than the largest seasonal freeboard, (lowest seasonal freeboard mark), all seasonal freeboard marks are omitted and *only* the subdivision load line and fresh water allowance marks are assigned.

The subdivision load lines are marked aft of the vertical line,[17] which is to be extended as necessary to connect the lowest and the highest load lines marked on the vessel, to assist the master and port authorities to locate the proper mark.

The Subdivision Load Line for the principal passenger condition is designated by a C1 mark. The principal passenger condition for a vessel having spaces used for passengers and cargo alternatively is the condition where only those spaces appropriated *exclusively* to passengers are taken into consideration for determination of the subdivision load line. Alternate conditions are designated by a C2 and C3 mark etc. The position of each load line and the conditions under which a particular load line is applicable is to be noted on the Load Line Certificate.

[15] [1] Reg. 6(5)
[16] [2] Part 46
[17] Same side as the density allowances.

Generally only the **C1** mark and the **FW** mark are assigned

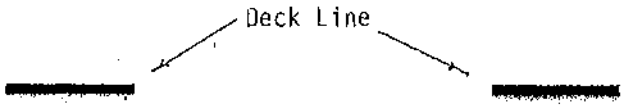
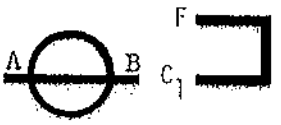
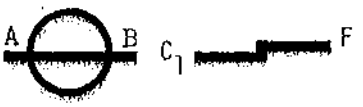


Figure 60. Subdivision Load Line



Subdivision Freeboard - Normal Marking



Subdivision Freeboard - Marking when Fresh Water Allowance is less than 29 mm (1 1/8")

Minimum Allowance[18]

The seasonal freeboard and density allowance lines are 25 mm (1 in.) in breadth or thickness. Therefore for clarity and proper marking on the vessel's sides, the minimum allowance that may be assigned is 29 mm (1 1/8 in.).

[18] Practice since 1976.

MISC. FREEBOARD ITEMS AND CORRECTIONS

CORRECTION FOR LOCAL WELLS AND RECESSES

Local Wells and Recesses in the Freeboard Deck[1]

Where a recess is arranged in the freeboard deck, and it does not extend to the side of the vessel, the freeboard calculated without regard to the recess is to be corrected for the consequent loss of buoyancy. The correction to be made is equal to the value obtained by dividing the volume of the recess by the waterplane area of the ship at 85% of the least molded depth.

1) The correction is a straight addition to the freeboard obtained after *all* other corrections have been applied, except bow height.

2) Where the freeboard, corrected for lost buoyancy as specified above, is greater than the minimum geometric freeboard determined on the basis of a molded depth measured from the baseline to the bottom of the recess, the latter value may be used.[2]

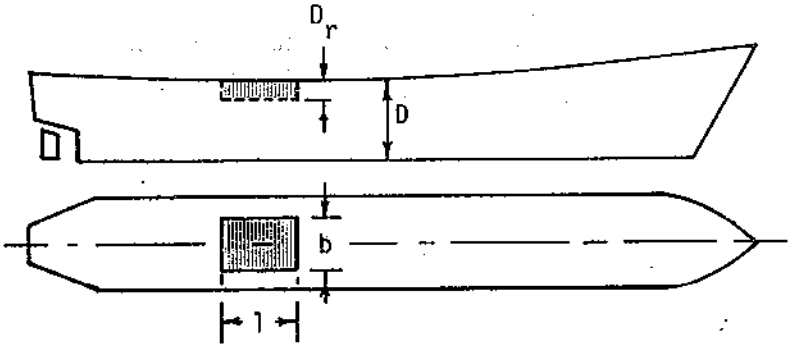


Figure 61. Recess in Freeboard Deck Correction

The addition to the freeboard is equal to:

(l x b x Dr) / WP Area @ 0.85D.

where:

Dr = Depth of recess
l = Length " "
b = Breadth " "
WP = Waterplane

[1] [5] LL.48/Rev.1, SLF 30/15/5, SLF 31/WP.9

[2] To check this stipulation requires two separate freeboard calculations.

Recesses in a second deck, designated as the freeboard deck, may be disregarded *provided* all openings in the weather deck are fitted with weathertight closing appliances.

Due regard is to be given to the drainage of exposed recesses and to the free surface effects on stability.

Dredgers, hopper barges or other similar types of vessels with large open holds require individual consideration.

MOONPOOLS

Definition[3]

A moonpool is a watertight well in the main/upper deck, extending down through the vessel and through the shell bottom, thus having direct communication with the sea resulting in a permanent loss of buoyancy for the portion of the moonpool below the waterline.

Correction[4]

Where moonpools are arranged within the hull in open communication with the sea, the volume of the moonpool should not be included in the calculation of any hydrostatic properties.

An addition should be made to the geometric freeboard if the moonpool has a larger cross-sectional area above the waterline at 0.85D than below the waterline. This addition for the excess portion above the 0.85D waterline should be made, as previously prescribed for wells or recesses in the freeboard deck, to reflect the lost buoyancy.

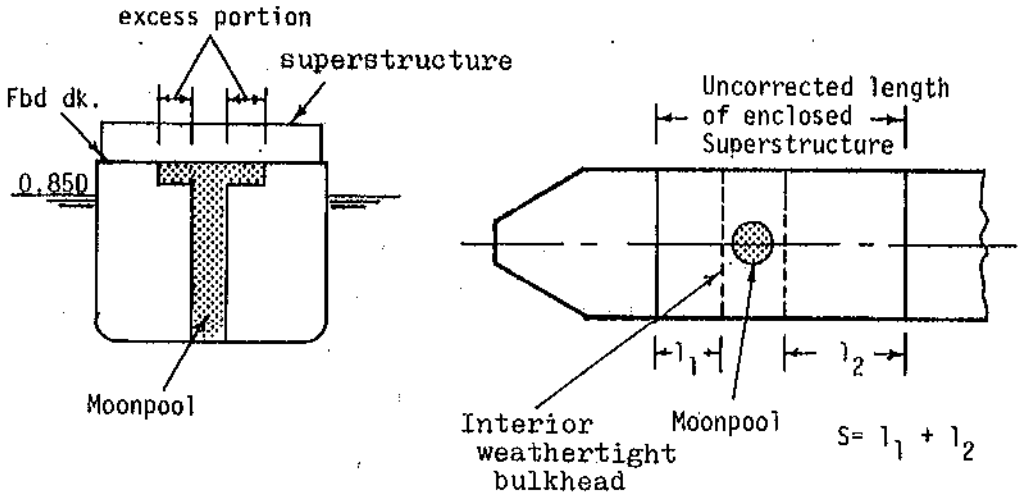


Figure 62.
Moonpool Correction

[3] [4] SLF 30/17/5, USA,8 January 1985
[4] [4] SLF 31/WP.9, 5 June 1986

If only part of an enclosed superstructure contains the moonpool, a deduction is to be made from the effective length of the superstructure to compensate for the lost buoyancy.

STERN NOTCHES AND CUTOUTS

Definition

Stern notches or cutouts are depressions in the outer shell boundary of the vessel at the level of the 0.85D waterline. They may or may not extend to the freeboard deck or bottom of the vessel.

Consideration

When determining the load line length, the extreme buoyant profile length at the 0.85D waterline is to be used as the basis. A large notch or cutout which creates very small "appendage like" structures may require special consideration.

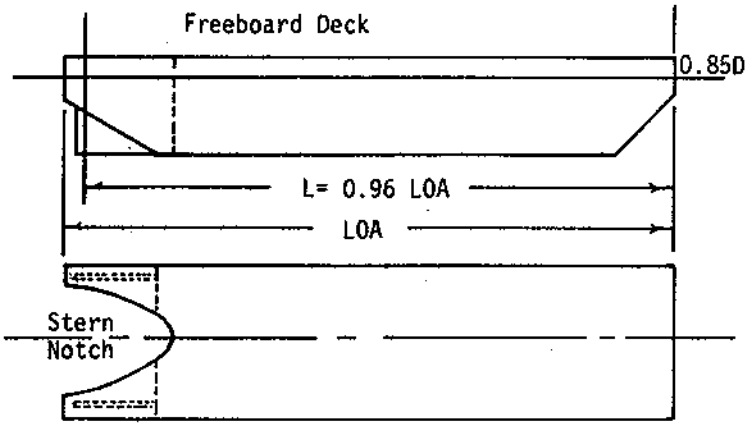


Figure 63. Stern Notch-Load Line Length

Since stern notches or cutouts should be reflected in the hydrostatic properties of the vessel, no special correction is necessary to the block coefficient.

TONNAGE OPENINGS IN SUPERSTRUCTURE BULKHEADS

Definition

A "tonnage opening" is an opening in a bulkhead of a minimum designated size for the purpose of exempting the space from inclusion in

the gross tonnage of the vessel. Tonnage openings are secured by non-gasketed hook-bolted plates, which need not be used at sea, and must be hose tested to prove weathertightness before credit may be given in the freeboard calculation. For details on tonnage opening closures see Section III of this manual.

Consideration[5]

For load line purposes a tonnage opening closure properly fitted, tested, and with the proper sill height may be considered as a weathertight closure, thereby allowing possible superstructure credit for the space in question.

[5] [8] 28 APR 1966 USCG

FREEBOARD CALCS. FOR UNIQUE VESSELS

MOBILE OFFSHORE DRILL UNITS[1]

General

The minimum freeboard of units which cannot be computed by the normal methods laid down by the Convention are determined on the basis of meeting the applicable intact stability, damage stability and structural requirements for transit conditions and drilling operations while afloat. The freeboard is not to be less than that computed from the Convention where aaplicable.

The requirements of the Convention with respect to weathertightness and watertightness is taken as a basis for all units in the afloat conditions.

Self-Elevating Units

A self-elevating unit is a unit with movable legs capable of raising its hull above the surface of the sea.

A load line is assigned to self-elevating units based on its geometric particulars as calculated under the terms of the 1966 ICLL. When *floating* or in a *transit* condition from one operational area to another units are subject to all conditions of assignment of that Convention unless specifically approved. When these units are supported by the sea-bed or are in the process of lowering or raising their legs, they are not subject to the terms of the Convention.

Some Calculation Specifics:

length -96% of the profile length of the unit at the 0.85D waterline.[2]

breadth -Measured at the mid-point of the load line length.

depth -Measured at the mid-point of the load line length.

bow height-Units which are manned under tow are subject to the bow height requirement. Special consideration, such as the trim resistivity procedure, may be applied where necessary.

moonpools -See the section on "moonpools" of this manual for guidance.

[1] [4] MODU CODE sec 3.7

[2] Provided a rudder stock is not fitted.

mats -A mat or similar supporting structure is to be ignored in the freeboard calculation.

appendages-Narrow wing extensions at the stern of the unit should be considered as appendages and excluded for the determination of length and for the calculation of freeboards.

Load Line Marks:

Only the center of the ring is assigned. Since many units have configurations that cause the LCF, corresponding to the assigned summer load waterline, to be an appreciable distance from the midpoint of the load line length[3], the ring is longitudinally located at LCF location.[4]

Surface Units

A surface unit is a unit with a ship or barge-type displacement hull of single or multiple hull construction intended for operation in the floating condition.

Load lines are assigned to surface units as calculated under the terms of the Convention.

Load Line Marks:

When assigning load line marks to surface units, the same guidelines are followed that are applied to all conventional vessels. For details see the section on load line marks in this manual.

Column Stabilized Units

A column stabilized unit is a unit with a main deck connected to the underwater hull or footings by columns or caissons.

The hull form of this type of unit makes the calculation of a geometric freeboard impracticable. Therefore the minimum freeboard is to be determined by meeting the applicable requirements for:

strength -the strength of the unit's structure;

stability -intact and damage stability requirements; *and*

clearance -the minimum clearance between passing wave crests and deck structure.

The Load Line Length used on the Load Line Certficate is the length overall.

[3] Usually with a triangular shaped planform.

[4] Since many units have sheer due to camber, if the depth of the unit at the LCF differs from the depth used in the geometric freeboard calculation, an appropriate addition or subtraction is to be made to the assigned freeboard.

Load Line Marks:

Only the center of the ring is assigned. The ring is to be located in a position where it is visible to the operators of the unit, preferably near its longitudinal center.[5]

MULTI-HULL VESSELS

General

A multi-hull vessel is a vessel where the freeboard deck is supported by two or more buoyant hulls, i.e. a catamaran or trimaran.

Calculation Consideration

The vessel is considered as one entire structure when determining the minimum geometric freeboard. The breadth used in the block coefficient and for determining superstructure credit is the breadth of the entire vessel, not just the breadth of one of the waterborne hulls. If by using normal procedures and interpretations the minimum geometric freeboard determined is unreasonable for the operation of the vessel, special consideration may be given by the assigning authority, on a case by case basis, predicated on the attributes of the configuration in question.[6]

INTEGRATED TUG-BARGE COMBINATIONS[7]

Definitions

Pushing Mode ITB

A Pushing Mode ITB has the characteristics of a ship of comparable size in that it has a similar seakeeping capability and it remains in the pushing mode throughout the voyage under all anticipated conditions. A Pushing Mode ITB may be connected to the barge with either a rigid or an articulated connection system; *and*

a) cannot meet the towline pull stability criteria[8]; *or*

b) does not have the necessary equipment for towing by hawser; *or*

c) cannot demonstrate safe separation from the barge under all operating conditions for which the tug and barge are designed to operate as a combined unit.

[5] For units with six columns, the ring is usually placed on the inside of the center columns.

[6] If the hull depths differ, such as on some trimarans, the deeper hull is to be used for Load Line depth purposes.

[7] [6] 2-81 CH-1, 6 Jan 1982

[8] As defined in [2] 173.095

Dual Mode ITB

A dual Mode ITB is similar to a tug and barge where the tug is secured in the barge notch or on fenders by means such as wire rope, chains, lines or tackle now commonly used in offshore towing. In all respects the tug is considered equipped to tow by hawser. It does differ from a conventional tug in that it employs a method of connection which may permit greater speed, improved maneuverability and seakeeping, and which may be easier and safer to operate.

A Dual Mode ITB has *all* of the following characteristics:

a) The tug has a hull shape which permits safe hawser towing;

b) The tug meets the weather, dynamic and towline pull stability criteria;

c) The tug and barge are equipped and rigged with the necessary gear for hawser towing. This should include a towing winch or bitts, hawser, and bridle;

d) The tug has the capability to separate safely in a timely fashion at a predesigned sea state and shift to towing on a hawser. The capability to disconnect must be demonstrated;

e) The barge is subject to inspection (USCG C.O.I.) under applicable statutes. If the barge is not subject to inspection, the combined tug and barge will be considered a conventional tug barge combination.

Load Line Assessment

Pushing Mode Units

Both the tug and the barge are assigned load lines so that independent operation of *either* the tug or the barge is not precluded. The tug's load line is to be calculated and assigned independently. The required freeboard for the barge is to be calculated *both* independently and by taking into account the intact (and damage, if applicable) stability requirements of the combined unit. The load line which results in the greater freeboard from the above calculations is to be assigned to the barge. When operating in the pushing mode, the barge's load line may not be submerged, *but* consideration is to be given to approving loading conditions which submerge the tugs load line. In no case will loading conditions which submerge any portion of the tug's freeboard deck be approved. The barge of a Pushing Mode ITB will not be considered an unmanned barge for the purposes of the freeboard reduction provided for in the Load Line Regulations.[9]

[9] No 25% reduction in freeboard is allowed.

Dual Mode Units

Both the tug and the barge are assigned independently calculated load lines. An unmanned barge of a Dual Mode ITB *may* be considered for the freeboard reduction provided for in the Load Line Regulations.

DYNAMICALLY SUPPORTED CRAFT[10]

Definitions

Dynamically supported craft is a craft which operates on or above the water and which has characteristics different from the those of the conventional displacement ships. In general, these type of craft operate at higher speeds, *and* a significant portion of the weight is balanced in one mode of operation by other than hydrostatic forces. Dynamically Supported Craft generally include Air-Cushion Vehicles, Hydrofoils, Side Wall Craft, and Surface Effect Ships.

Calculation Process

The level of safety for these type of craft should be equivalent to that required by the Convention for conventional displacement ships.

The geometric freeboard is calculated for these craft in the waterborne displacement mode following the same procedures that are used for conventional displacement ships or multi-hulled vessels. Which procedure to be followed depends which configuration the craft in question

When determining the load line length, only the length of the rigid buoyant hull is to be considered.

[10] [4] Code For Dynamically Supported Craft, 1978 {basis}.

SAMPLE CALCULATIONS

DECK CARGO BARGE-SAMPLE CALCULATION

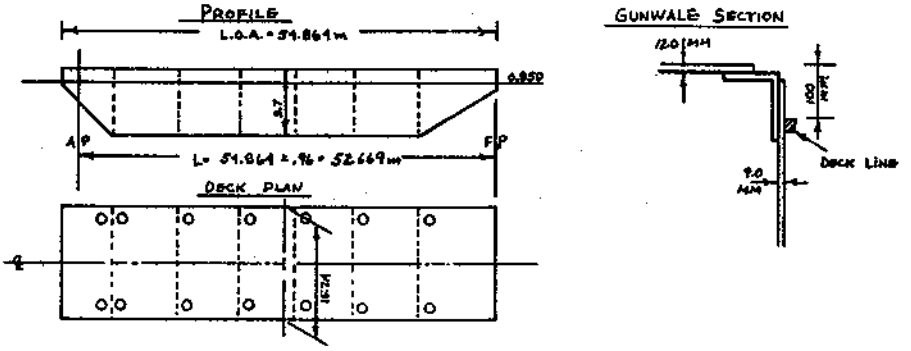


Figure 64. Deck Cargo Barge

FREEBOARD PARTICULARS

L.O.A.	= 54.864 m	Sheer Ordinates	
LL Length	= 52.669 m	AP =0	1/3F =0
Breadth	= 15.240 m	1/6A =0	1/6F =0
Depth (mld)	= 3.700 m	1/3A =0	FP =0
0.85D	= 3.145 m		
Disp.(mld) @0.85D	= 2356 mt		
Str. Plate Thick.	= 12.0 mm		
Keel Plate Thick.	= 9.0 mm		
Vessel is unmanned			

LOAD LINE LENGTH

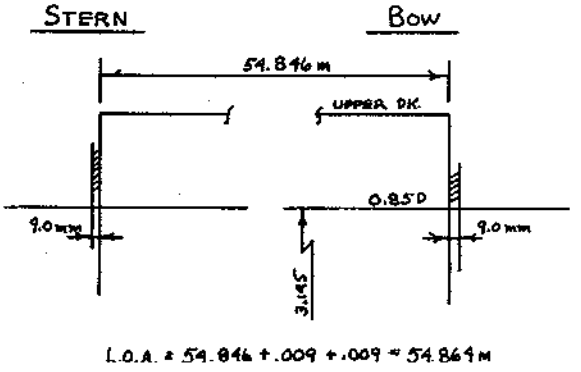


Figure 65. Deck Cargo Barge Length

********** AMERICAN BUREAU OF SHIPPING **********

1966 LOAD LINE CONVENTION - PROGRAM FREEBD
DUAL VERSION 2.0 - FEBRUARY 1985

D E C K C A R G O B A R G E - S A M P L E C A L C U L A T I O N

LOAD LINE TECHNICAL MANUAL

VESSEL TYPE "B", SEE ICLL REG. 27-(5) AND (6).

VESSEL UNMANNED, AND 25% REDUCTION IN SUMMER FREEBOARD REQUESTED.

LENGTH....= 52.669 M. DISPLACEMENT AT .85*DEPTH.....= 2356. M.TONS
BREADTH...= 15.240 M. THICKNESS OF STRINGER PLATE...= 12.000 MM.
DEPTH.....= 3.700 M. THICKNESS OF KEEL PLATE.....= 9.000 MM.

*** TABULAR FREEBOARD= 474.36 MM.

*** BLOCK COEF. CORRECTION FACTOR= 1.170
BLOCK COEFFICIENT= 0.9109

*** SUPERSTRUCTURE CORRECTION= 0.0 (FLUSH DECK VESSEL.)

*** DEPTH CORRECTION= 22.03 MM.
DEPTH FOR FREEBOARD= 3.712 M. LENGTH/15= 3.511 M.

*** "FLUSH DECK PENALTY":
CORRECTION FOR "B" VESSELS UNDER 100M= 124.24 MM.

*** SHEER CORRECTION:

STANDARD SHEER=	689.25	(AFT=	229.75	FORWARD=	459.50)
ACTUAL SHEER=	0.00	(AFT=	0.00	FORWARD=	0.00)

(STANDARD - ACTUAL)/2= 344.63 MM. (ACTUAL SHEER DEFICIENT FORE AND AFT.)
LENGTH FACTOR= 0.750

SHEER CORRECTION= 258.47 MM.

****** VESSEL TYPE "B" FREEBOARD RESULTS ******

TABULAR FREEBOARD	=	474.36 MM.
"FLUSH DECK PENALTY"	=	124.24 MM.
CORRECTED FOR BLOCK COEFFICIENT	=	700.23 MM.
DEPTH CORRECTION	=	22.03 MM.
SUPERSTRUCTURE CORRECTION	=	0.00 MM.
SHEER CORRECTION	=	258.47 MM.
CALCULATED SUMMER FREEBOARD	=	980.72 MM.

*** MOLDED DRAFT= 2.731 M. EXTREME DRAFT= 2.740 M.
(MOLDED DRAFT/48= 56.902 MM.)

****** 25% REDUCTION FOR UNMANNED BARGE ******

CALCULATED SUMMER FREEBOARD	=	980.72 MM.
25% REDUCTION	=	245.18 MM.
REDUCED SUMMER FREEBOARD	=	735.54 MM.

*** MOLDED DRAFT= 2.976 M. EXTREME DRAFT= 2.985 M.
(MOLDED DRAFT/48= 62.010 MM.)

*** FRESH WATER ALLOWANCE (AT SUMMER LOAD WATERLINE IN SALT WATER)
(DISPL. IN METRIC TONS, TPC IN TONS PER CM. IMMERSION)

$$\frac{2204.}{40 \times TPC} = \frac{2204.}{40 \times 4.83} = 11.408 \text{ CM.} = 114. \text{ MM.}$$

SUMMER DRAFT/48	=	62.	MM.
+ FRESH WATER ALLOWANCE	=	114.	MM.
*** TROPICAL FRESH WATER ALLOWANCE	=	176.	MM.

TROPICAL FRESH WATER LINE	176.	MM.	ABOVE	CENTER	OF DISC.
FRESH WATER LINE	114.	MM.	"	"	" "
TROPICAL LINE	62.	MM.	"	"	" "
WINTER LINE	62.	MM.	BELOW	"	" "
WINTER NORTH ATLANTIC LINE	112.	MM.	"	"	" "

RECOMMENDED FREEBOARD AMIDSHIPS FROM TOP OF STEEL UPPER DECK AT SIDE TO DECKLINE	=	100. MM.
DECK LINE TO SUMMER LINE	=	636. MM
" " TROPICAL FRESH WATER LINE	=	460. MM.
" " FRESH WATER LINE	=	522. MM.
" " TROPICAL LINE	=	574. MM.
" " WINTER LINE	=	698. MM.
" WINTER NORTH ATLANTIC LINE	=	748. MM.

TUG-SAMPLE CALCULATION

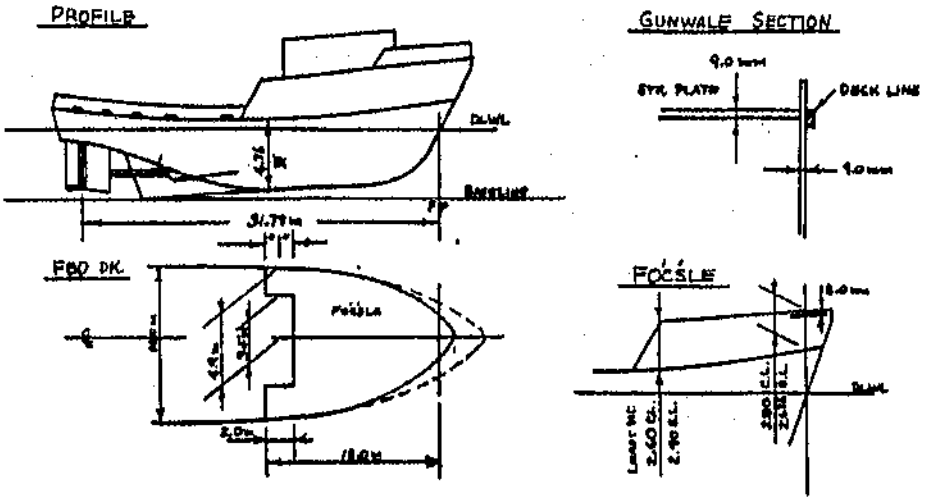


Figure 66. Tug Particulars

FREEBOARD PARTICULARS

LBP	= 31.790 m
LL Length	= 33.189 m
Breadth	= 10.000 m
Depth (mld @LBP/2)	= 4.760 m
LL Depth (mld)	= 4.750 m
Draft (designed)	= 4.500 m
Disp.(mld @DLWL)	= 675 mt
Disp.(mld @4.004)	= 540 mt
Str. Plate Thick.	= 9.0 mm
Keel Plate Thick.	= 12.0 mm

Sheer Ordinates

AP	=200	1/3F	=60
1/6A	=20	1/6F	=210
1/3A	=0	FP	=550

LOAD LINE LENGTH

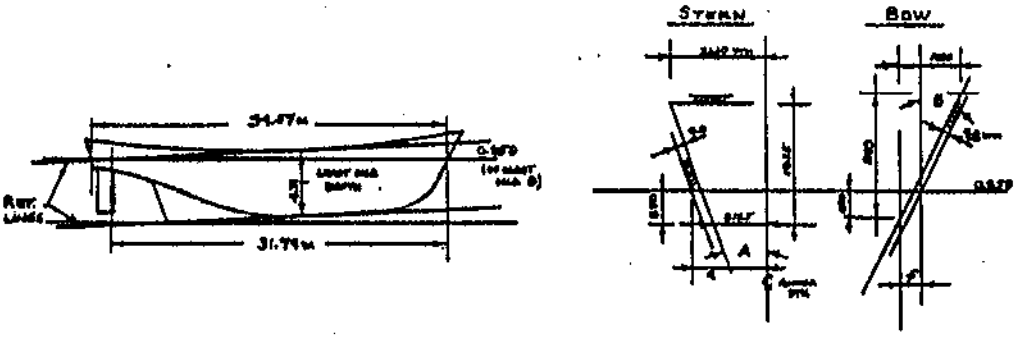


Figure 67. Tug Length

0.85D = 4.71(.85) = 4.004 m

tan A= (2610-2125)/1825= 0.2658; $\tan^{-1}A$ = 14.883°
tan B= 1000/1100 = 0.909; $\tan^{-1}B$ = 42.47°

a = 2125 + 850(0.2658) + 9.0/cos A
a = 2125 + 225.93 + 9.31 = 2360.20 mm

f = 450 (0.909) + 9.0/cos B
f = 409.09 + 9.0/0.74 = 421.25 mm

L to C_L Rdr. Stk.= 31.79 + 0.42125= 32.211 m
LWL = (32.221 + 2.3602) x 0.96 = 33.189 m
LL Length = 33.189 m

AP = 33.189 - 32.211 = 978 mm aft of C_L Rdr. Stk.

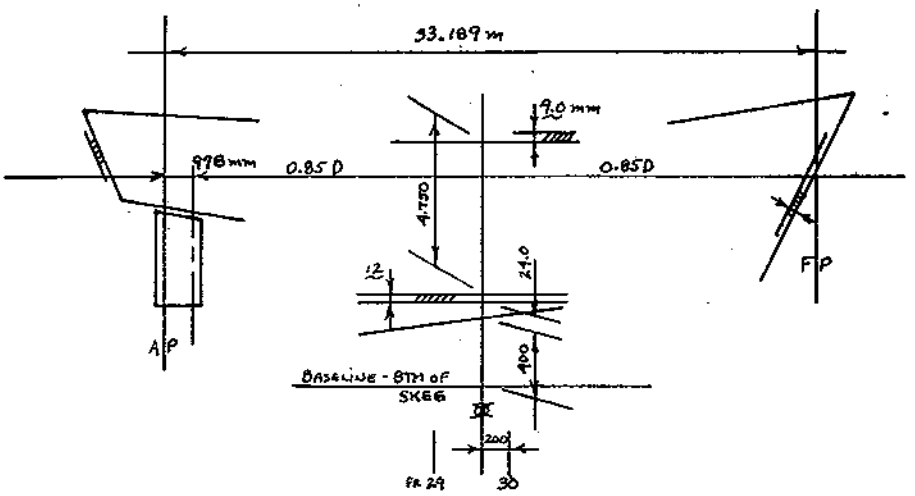


Figure 68. Tug Depth for Freeboard

D = Mld. Depth @ mid. pt. = 4.750 m
Df = 4.750 + Str. Pl. = 4.759 m
$D_{extreme}$ = 4.759 + 0.012 + 0.024 + 0.4 = 5.171m

LL mid. pt. = 200 mm aft of Fr. 30

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T U G S A M P L E C A L C U L A T I O N

LOAD LINE TECHNICAL MANUAL

VESSEL TYPE "B", SEE ICLL REG. 27-(5) AND (6).

VESSEL MANNED, MINIMUM BOW HEIGHT TO BE CHECKED.

LENGTH....= 33.189 M. DISPLACEMENT AT .85*DEPTH.....= 540. M.TONS
BREADTH...= 10.000 M. THICKNESS OF STRINGER PLATE...= 9.000 MM.
DEPTH.....= 4.750 M. THICKNESS OF KEEL PLATE.....= 36.000 MM.

*** TABULAR FREEBOARD= 276.51 MM.

*** BLOCK COEF. CORRECTION FACTOR= 1.000 (MINIMUM BLOCK COEF.=.68)
BLOCK COEFFICIENT= 0.3933

*** SUPERSTRUCTURE CORRECTION:

FORECASTLE
LEAST HEIGHT EQUALS OR EXCEEDS STANDARD OF 1.80 M.
SUPERSTRUCTURE IS FULL WIDTH.
EFFECTIVE LENGTH= 18.000 M. MEAN LENGTH= 18.000 M.

RECESS
HEIGHT CORRECTION FACTOR= 1.000
ADJUSTMENT TO . . .MEAN LENGTH= -1.429 M.
ADJUSTMENT TO EFFECTIVE LENGTH= -1.429 M.

E/L= 16.57/ 33.19= 0.4993 : PERCENTAGE ALLOWED= 35.94 %
100% ALLOWANCE= 426.83 MM.
SUPERSTRUCTURE CORRECTION= -153.41 MM.

*** DEPTH CORRECTION= 176.07 MM.
DEPTH FOR FREEBOARD= 4.759 M. LENGTH/15= 2.213 M.

*** SHEER CORRECTION:
STANDARD SHEER= 526.84 (AFT= 175.61 FORWARD= 351.23)
2*FOCSLE SHEER CREDIT ("Y"= 876.00 LENGTH= 16.57) = 291.59
ACTUAL SHEER= 494.09 (AFT= 32.50 FORWARD= 461.59)

DIFFERENCE OF AFT SHEERS/2= 71.56 MM.
(EXCESS FORWARD, BUT AFT LESS THAN 50% OF STANDARD PER ICLL REG. 38(11).)
LENGTH FACTOR= 0.500
SHEER CORRECTION= 35.80 MM.

```
      ****** VESSEL TYPE "B" FREEBOARD RESULTS ******

    TABULAR FREEBOARD                  =  276.51 MM.
    CORRECTED FOR BLOCK COEFFICIENT    =  276.51 MM.
    DEPTH CORRECTION                   =  176.07 MM.
    SUPERSTRUCTURE CORRECTION          = -153.41 MM.
    SHEER CORRECTION                   =   35.80 MM.
                                        ----------
    CALCULATED SUMMER FREEBOARD        =  334.98 MM.

*** BOW HEIGHT CORRECTION:                      SUMMER FREEBOARD=  334.98 MM.
                                                     SHEER AT FP=  550.00 MM.
                                               FOCSLE HEIGHT AT FP= 2676.00 MM.
      SUPERSTRUCTURE DECK THICKNESS - STRINGER PLATE THICKNESS=   -1.00 MM.
                                                                  ----------
                                     TOTAL OFFERED BOW HEIGHT= 3559.98 MM.
                                  MINIMUM REQUIRED BOW HEIGHT= 1735.21 MM.
    BOW HEIGHT CORRECTION              =    0.00 MM.
                                        ----------
    CALCULATED SUMMER FREEBOARD        =  334.98 MM.

*** MOLDED DRAFT=   4.424 M.        EXTREME DRAFT=   4.460 M.
    (MOLDED DRAFT/48=  92.167 MM.)

*** FRESH WATER ALLOWANCE (AT SUMMER LOAD WATERLINE IN SALT WATER)
    (DISPL. IN METRIC TONS, TPC IN TONS PER CM. IMMERSION)
      DISP.        655.
    ________  =  ___________  = 6.04 CM. = 60.4 MM.
    40 X TPC     40 X 2.71
                  SUMMER DRAFT/48  =     92.    MM.
          + FRESH WATER ALLOWANCE  =     60.    MM.
    ------------------------------   -----------
*** TROPICAL FRESH WATER ALLOWANCE  =    152.    MM.

 TROPICAL FRESH WATER LINE      152  MM. ABOVE CENTER OF DISC.
          FRESH WATER LINE       60. MM.   "      "    "    "
             TROPICAL LINE       92. MM.   "      "    "    "
               WINTER LINE       92. MM. BELOW   "    "    "
WINTER NORTH ATLANTIC LINE      142. MM.   "      "    "    "

RECOMMENDED FREEBOARD AMIDSHIPS FROM TOP OF STEEL UPPER DECK AT SIDE
TO DECKLINE                                 =       0. MM
DECKLINE TO SUMMER LINE                     =     335. MM
   "     "  TROPICAL FRESH WATER LINE       =     183. MM.
   "     "  FRESH WATER LINE                =     275. MM.
   "     "  TROPICAL LINE                   =     243. MM.
   "     "  WINTER LINE                     =     427. MM.
   "     "  WINTER NORTH ATLANTIC LINE      =     477. MM.
```

TANKER-SAMPLE CALCULATION

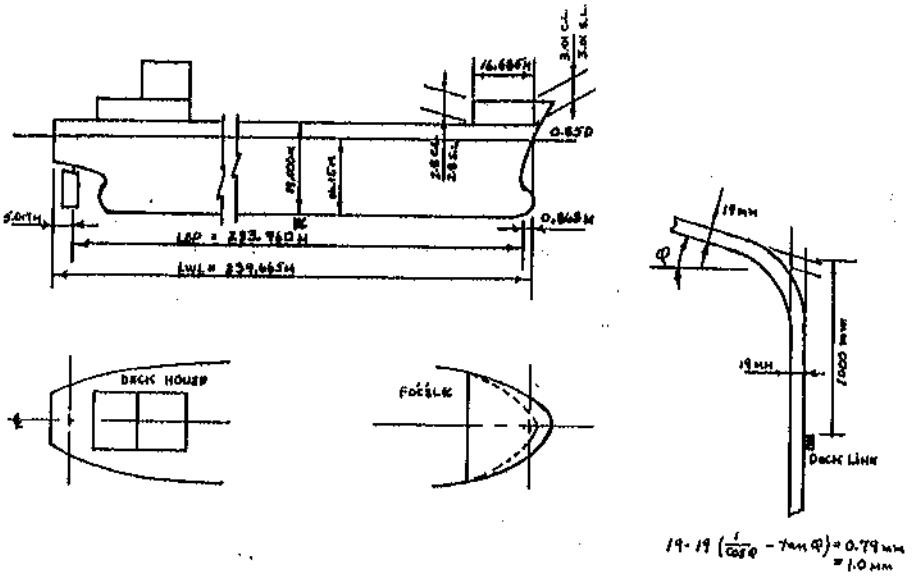

Figure 69. Tanker Particulars

FREEBOARD PARTICULARS

LBP	= 233.960 m
LL Length	= 234.823 m
Breadth	= 40.0 m
Depth (mld)	= 19.0 m
0.85D	= 16.15 m
Disp @ 0.85D	= 131905 mt
Disp (mld)@ 14.25m	= 116185 mt
Scantling Draft	= 14.35 m
Str. Plate Thick.	= 19.0 mm
Keel Plate Thick.	= 20.0 mm

Sheer Ordinates (mm)

AP	=350	1/3F	=0
1/6A	=0	1/6F	=7
1/3A	=0	FP	=615

LOAD LINE LENGTH

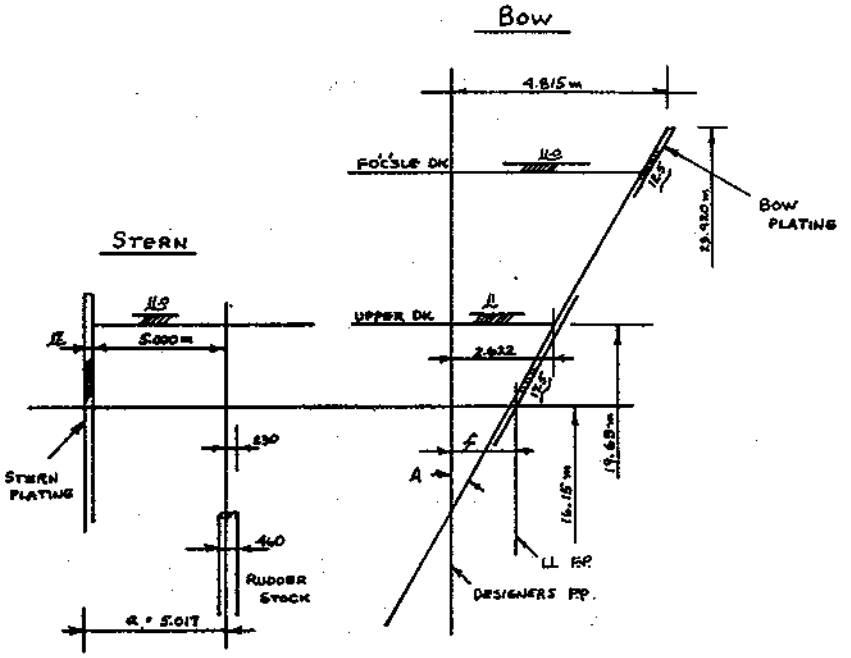

Figure 70. Tanker Load Line Length

0.85D = 19.0 x .85 = 16.15 m

tan A= (4.815 -2.622)/ 23.92-19.63 = 0.5112; $\tan^{-1}$ = 27.076°

a = 5.000 + 0.017 = 5.017 m

f = 2.622 - (19.63 - 16.15) 0.5112 + 0.0175/cos A
f = 2.622 - (1.779) + 0.01965 = 0.8627 m

L to C_L Rdr. Stk.= 233.960 + 0.863 = 234.823 m
LWL = 234.823 + 5.017 = 239.840 x 0.96 = 230.247 m
LL Length = 234.823

Fo'c'sle length = (Fr.97-78) x 0.8 + 0.622 + 0.863 = 16.685 m

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LOAD LINE TECHNICAL MANUAL

VESSEL TYPE "A", SEE ICLL REG. 27-(2),(3) AND (4).

VESSEL MANNED, MINIMUM BOW HEIGHT TO BE CHECKED.

```
LENGTH....=  234.823 M.      DISPLACEMENT AT .85*DEPTH.....= 131905. M.TONS
BREADTH...=   40.000 M.      THICKNESS OF STRINGER PLATE...= 19.000 MM.
DEPTH.....=   19.000 M.      THICKNESS OF KEEL PLATE.......= 20.000 MM.

*** TABULAR FREEBOARD= 2908.76 MM.

*** BLOCK COEF. CORRECTION FACTOR=   1.124
    BLOCK COEFFICIENT=  0.8487

*** SUPERSTRUCTURE CORRECTION:

    FORECASTLE
    LEAST HEIGHT EQUALS OR EXCEEDS STANDARD OF 2.30 M.
    SUPERSTRUCTURE IS FULL WIDTH.
    EFFECTIVE LENGTH=   16.685 M.            MEAN LENGTH=   16.685 M.

    E/L=   16.68/  234.82= 0.0711 : PERCENTAGE ALLOWED=    4.97 %
                                    100% ALLOWANCE= 1070.00 MM.
                          SUPERSTRUCTURE CORRECTION=  -53.22 MM.

*** DEPTH CORRECTION=  841.03 MM.
    DEPTH FOR FREEBOARD=  19.019 M.      LENGTH/15=  15.655 M.

*** SHEER CORRECTION:
          STANDARD SHEER=  2207.96  (AFT=   735.99   FORWARD=  1471.97)
    2*FOCSLE SHEER CREDIT ("Y"=  710.00    LENGTH=   16.68) =    33.63
            ACTUAL SHEER=   160.51  (AFT=    43.75   FORWARD=   116.76)
                          ---------

    (STANDARD - ACTUAL)/2=  1023.73 MM.  (ACTUAL SHEER DEFICIENT FORE AND AFT.)
          LENGTH FACTOR=     0.714
       SHEER CORRECTION=   731.43 MM.
```

```
      ****** VESSEL TYPE "A" FREEBOARD RESULTS ******

    TABULAR FREEBOARD                  = 2908.76 MM.
    CORRECTED FOR BLOCK COEFFICIENT    = 3269.50 MM.
    DEPTH CORRECTION                   =  841.03 MM.
    SUPERSTRUCTURE CORRECTION          =  -53.22 MM.
    SHEER CORRECTION                   =  731.43 MM.
                                        ----------
    CALCULATED SUMMER FREEBOARD        = 4788.74 MM.

*** BOW HEIGHT CORRECTION:                      SUMMER FREEBOARD= 4788.74 MM.
                                                     SHEER AT FP=  615.00 MM.
                                                FOCSLE HEIGHT AT FP= 3010.00 MM.
      SUPERSTRUCTURE DECK THICKNESS - STRINGER PLATE THICKNESS=   -8.00 MM.
                                                                  ----------
                                       TOTAL OFFERED BOW HEIGHT= 8405.74 MM.
                                    MINIMUM REQUIRED BOW HEIGHT= 6204.69 MM.
    BOW HEIGHT CORRECTION              =    0.00 MM.
                                        ----------
    CALCULATED SUMMER FREEBOARD        = 4789.   MM.

    CORRECTION TO REQUESTED MARKS      =    0.00 MM.
    (CALCULATED FREEBOARD GREATER THAN REQUESTED.)
                                        ----------
    CALCULATED SUMMER FREEBOARD        = 4789.   MM.
    DECK LINE CORRECTION                   1.0   MM.

                                       ----------
                                        4790.   MM.

*** MOLDED DRAFT=  14.230 M.       EXTREME DRAFT=  14.250 M.
    (MOLDED DRAFT/48= 296.464 MM.)

*** FRESH WATER ALLOWANCE (AT SUMMER LOAD WATERLINE IN SALT WATER)
    (DISPL. IN METRIC TONS, TPC IN TONS PER CM. IMMERSION)
    116,185       116,185
    -------  =  ---------  = 33.2  CM. = 332  MM.
    40 X TPC     40 X 87.4
                  SUMMER DRAFT/48  =     296.    MM.
          + FRESH WATER ALLOWANCE  =     332.    MM.
    ------------------------------    ----------
*** TROPICAL FRESH WATER ALLOWANCE  =     628.    MM.

 TROPICAL FRESH WATER LINE      628. MM. ABOVE CENTER OF DISC.
          FRESH WATER LINE      332. MM.   "     "    "    "
             TROPICAL LINE      296. MM.   "     "    "    "
               WINTER LINE      296. MM. BELOW   "    "    "

RECOMMENDED FREEBOARD AMIDSHIPS FROM TOP OF STEEL UPPER DECK
AT SIDE TO THE DECKLINE                    =     1000. MM.
DECK LINE TO SUMMER LINE                   =     3790. MM
 "    "    " TROPICAL FRESH WATER LINE     =     3162. MM.
 "    "    " FRESH WATER LINE              =     3458. MM.
 "    "    " TROPICAL LINE                 =     3494. MM.
 "    "    " WINTER LINE                   =     4086. MM.
```

ROLL ON/ ROLL OFF SAMPLE-CALCULATION

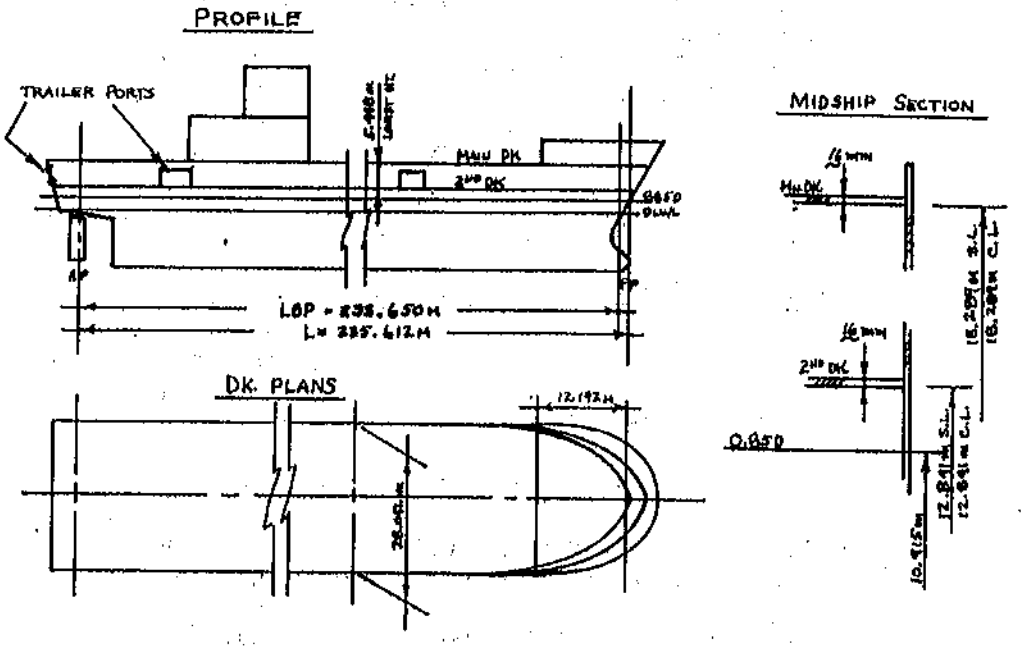

Figure 71. Ro/Ro Particulars

FREEBOARD PARTICULARS

Freeboard Deck	= Second Deck			
LBP	= 233.645 m	Sheer Ordinates (mm)		
LL Length	= 235.612 m	AP	=0	1/3F =0
Breadth	= 28.042 m	1/6A	=0	1/6F =0
Depth (mld)	= 12.841 m	1/3A	=0	FP =0
0.85D	= 10.915 m			
Disp. (mld)	= 44451.0 mt			
Scantling Draft (ext)	= 9.0 m			
" " Disp.(mld)	= 38863.3 mt			
" " TPC	= 28.5			
Str.Pl.Thick.(2nd dk)	= 19.0 mm			
Keel Plate Thick.	= 27.0 mm			

LOAD LINE LENGTH

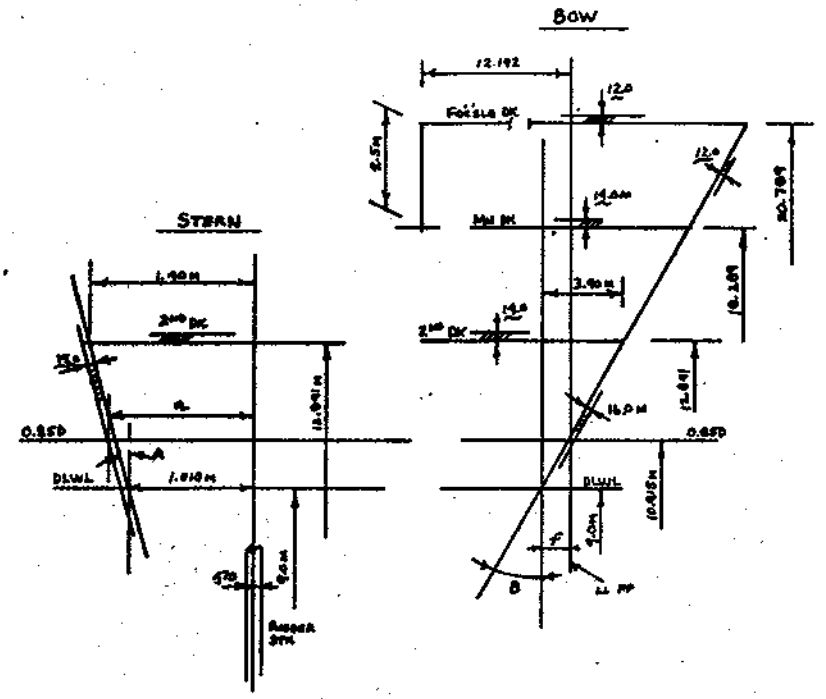

Figure 72. Ro/Ro Load Line Length

tan A= (1.4-1.010) / (12.841-9.0) = 0.1015 ; $\tan^{-1}A = 5.796°$
tan B= 3.9 / (12.841-9.0) = 1.0153 ; $\tan^{-1}B = 45.44°$

a = 1.010 + (10.915-9.0) + 0.017/cos A
a = 1.010 + 0.1944 + 0.01709 = 1.221 m

f = (10.915 - 9.0) 1.0153 + 0.016/cos B = 1.967 m

L to C_L Rdr. Stk.= 233.645 + 1.967 = 235.612 m
LWL = 235.612 + 1.221 = 236.833 x 0.96 = 227.360 m
LL Length = 235.612 m

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R O / R O S A M P L E C A L C U L A T I O N

LOAD LINE TECHNICAL MANUAL

VESSEL TYPE "B", SEE ICLL REG. 27-(5) AND (6).

VESSEL MANNED, MINIMUM BOW HEIGHT TO BE CHECKED.

LENGTH....= 235.612 M. DISPLACEMENT AT .85*DEPTH.....= 44451. M.TONS
BREADTH...= 28.042 M. THICKNESS OF STRINGER PLATE...= 16.000 MM.
DEPTH.....= 12.841 M. THICKNESS OF KEEL PLATE.....= 27.000 MM.

*** TABULAR FREEBOARD= 3815.96 MM.

*** BLOCK COEF. CORRECTION FACTOR= 1.000 (MINIMUM BLOCK COEF.=.68)
BLOCK COEFFICIENT= 0.6016

*** SUPERSTRUCTURE CORRECTION:

FULL SUPERSTRUCTURE
LEAST HEIGHT EQUALS OR EXCEEDS STANDARD OF 2.30 M.
SUPERSTRUCTURE IS FULL WIDTH.
EFFECTIVE LENGTH= 235.612 M. MEAN LENGTH= 235.612 M.

FORECASTLE
SUPERSTRUCTURE IS FULL WIDTH.
SUPERIMPOSED FOR SHEER CREDIT (IACS LL 29), LENGTH= 12.192 M.

E/L= 235.61/ 235.61= 1.0000 ; PERCENTAGE ALLOWED= 100.00 %
100% ALLOWANCE= 1070.00 MM.
SUPERSTRUCTURE CORRECTION=-1070.00 MM.

*** DEPTH CORRECTION= -712.62 MM.
DEPTH FOR FREEBOARD= 12.857 M. LENGTH/15= 15.707 M.
FULL SUPERSTRUCTURE COVERS .6*LENGTH AMIDSHIPS.

*** SHEER CORRECTION:
STANDARD SHEER= 2214.54 (AFT= 738.18 FORWARD= 1476.36)

* SHEER SHOULD BE MEASURED AT THE SUPERSTRUCTURE DECK PER ICLL REG. 38(5).
LEAST HEIGHT OF FULL SUPERSTRUCTURE EXCEEDS THE STANDARD :
SHEER ORDINATES ARE INCREASED FOR "Z" OF 3148.00 PER ICLL REG. 38(5).

```
    2*FOCSLE SHEER CREDIT ("Y"= 2500.00    LENGTH=   12.19) =    86.24
            ACTUAL SHEER=  2183.60  (AFT=  1048.68   FORWARD=  1134.92)
                           ---------

    DIFFERENCE OF FORWARD SHEERS/2=   170.72 MM.
    (EXCESS AFT, DEFICIENT FORWARD: ONLY DEFICIENCY MEASURED PER ICLL REG. 38(10).)
           LENGTH FACTOR=     0.250
        SHEER CORRECTION=    42.68 MM.

      ****** VESSEL TYPE "B" FREEBOARD RESULTS ******

    TABULAR FREEBOARD                 = 3815.96 MM.
    CORRECTED FOR BLOCK COEFFICIENT   = 3815.96 MM.
    DEPTH CORRECTION                  = -712.62 MM.
    SUPERSTRUCTURE CORRECTION         =-1070.00 MM.
    SHEER CORRECTION                  =   42.68 MM.
                                       ------------
    CALCULATED SUMMER FREEBOARD       = 2076.02 MM.

*** BOW HEIGHT CORRECTION:                      SUMMER FREEBOARD= 2076.02 MM.
              SHEER AT FP (INCLUDES "Z" PER ICLL REG. 38(5))= 3148.00 MM.
     FOCSLE HEIGHT AT FP (DOES NOT EXTEND 7% OF VESSEL LENGTH)=    0.00 MM.
            FULL SUPERSTRUCTURE HEIGHT AT FP (EXCLUDES "Z")= 2300.00 MM.
                                                             ------------
                                    TOTAL OFFERED BOW HEIGHT= 7524.01 MM.
                                MINIMUM REQUIRED BOW HEIGHT= 6976.81 MM.
    BOW HEIGHT CORRECTION             =    0.00 MM.
                                       ------------
    CALCULATED SUMMER FREEBOARD       = 2076.02 MM.

    CORRECTION TO REQUESTED MARKS     = 1807.98 MM.
                                       ------------
    CALCULATED SUMMER FREEBOARD       = 3884.00 MM.

*** MOLDED DRAFT=   8.973 M.       EXTREME DRAFT=   9.000 M.
    (MOLDED DRAFT/48= 186.937 MM.)

*** FRESH WATER ALLOWANCE AT EXISTING DRAFT = 340.91 MM.

 TROPICAL FRESH WATER LINE      528. MM. ABOVE CENTER OF DISC.
         FRESH WATER LINE       341. MM.   "     "    "    "
            TROPICAL LINE       187. MM.   "     "    "    "
              WINTER LINE       187. MM. BELOW   "    "    "

RECOMMENDED FREEBOARD AMIDSHIPS FROM TOP OF STEEL SECOND DECK AT SIDE
TO THE DECKLINE                          =       0. MM
DECKLINE TO SUMMER LINE                  =    3884. MM.
  "      "  TROPICAL FRESH WATER LINE     =    3356. MM.
  "      "  FRESH WATER LINE              =    3543. MM.
  "      "  TROPICAL LINE                 =    3697. MM.
  "      "  WINTER LINE                   =    4071. MM.
```

FREEBOARD CALCULATION FLOW CHART