Uniform Shipping Laws Code 2008

Section 5G: Construction – Design Loading

(CTH, NSW, NT, QLD, SA, TAS, VIC & WA)

SUB-SECTION G

CONTENTS

Part I—General

G.1 General

Sub-section B of this Section requires that the structural strength of every vessel to which this Section applies shall be sufficient for the service for which the vessel is intended. Where a vessel is not designed and constructed in accordance with the Rules of a classification society, then the structure shall be designed in accordance with whichever of Parts II and III of this Sub-section is appropriate.

Part II—Displacement Hulls

G.2 Introduction

Where scantlings for displacement vessels are to be derived from first principles, then for displacement vessels less than 35 metres in length, minimum loadings as determined below shall be used in their determination.

Vessels 35 metres in length and over will be specially considered by the Authority.

G.3 Shell

A head of salt water varying from 1.25 metres above the exposed deck at the bow to 0.625 metres at the forward quarter point and constant at 0.625 metres above the exposed deck aft to the transom shall be used.

G.4 Decks

The following design loads (kg/m^2) shall be used:

Vessels of Classes A, B or C

Exposed freeboard deck—(0.02L + 0.76) 1025

Forecastle deck or superstructure deck forward of amidships 0.5L—(0.02L + 0.46) 1025 (725 kg/m^2 minimum)

Freeboard deck within superstructure or deckhouse, any deck below freeboard deck or superstructure deck between 0.25L forward of and 0.2L aft of amidships—(0.01L + 0.61) 1025

All other locations—(0.01L + 0.3) 1025

Vessels of Classes D & E

Exposed freeboard deck—(0.02L + 0.46) 1025

First deck above freeboard deck—(0.01L + 0.46) 1025

All other locations—(0.01L + 0.3) 1025

Tank Tops & Cargo Decks—All Vessels

For a deck or a portion of a deck forming a tank top the greater of the following:

(a) two thirds of the distance in metres from the tank top to the top of the overflow; or

(b) two thirds of the distance in metres from the tank top to the bulkhead deck or freeboard deck.

For a deck on which cargo or stores are carried is the 'tween deck height at side; where the cargo masses exceed 720 kg/m^3 the design head in metres is to be adjusted accordingly.

For an exposed deck on which cargo is carried the design loading is 3750 kg/m^2 where it is intended to carry deck cargoes in excess of 2636 kg/m^2 this head is to be increased in proportion to the added loads.

G.5 Longitudinal Bending Stress

In addition to the above loadings but excluding the 1785 kilograms per metre load on deck panels, assume a longitudinal bending stress acting at the extreme hull fibres tapering to zero at the neutral axis.

The longitudinal extent of this stress distribution is to be tapered uniformly to zero stresses at the ends of the hull.

G.6 Bulkheads

In general, main sub-division bulkheads below the main deck shall be designed to resist a head to the main deck combined with the live and dead loads from the deck(s) at the top of the bulkhead.

Structural non-tight bulkheads at the first level below the main deck shall be designed to resist a uniform load of 350 kilograms per square metre combined with the water and dead loads.

G.7 Superstructures and Deckhouses

The following design loads (kg/m^2) shall be used.

Front Ends

Vessels of Classes A, B & C—(0.0199L + 0.51) 1025

Vessels of Classes D & E—(0.0199L + 0.30) 1025

Sides and After Ends

Vessels of Classes A, B & C—(0.0159L + 0.27) 1025

Vessels of Classes D & E—(0.0093L + 0.19) 1025

Part III—Planing Hulls

G.8 Introduction

G.8.1 The design principles elaborated in this Part are based on those developed by Heller and Jasper (Transactions of the Royal Institution of Naval Architects 1961, Volume 103, page 49).

Where alternative design principles are used these should be submitted to the Authority together with the plans and calculations for the proposed vessel.

G.9 Basic Assumptions

G.9.1 It is assumed that

(1) the structure can be idealised as a system with a single degree of freedom.

(2) equivalent static loads may be determined for application to the structure.

(3) rigid body accelerations varying linearly from 4.0 g at the bow to 0.0 g at the stern with acceleration at the centre of gravity (assumed at Midships) of 2.0 g, are applicable to commercial planing craft.

(4) increased rigid body accelerations will be assumed for design of planing craft designed for more rigorous service than those of the conventional commercial planing craft (e.g. patrol craft, police launch, surveillance craft etc).

(5) the peak pressure resulting from any impact, when multiplied by the corresponding dynamic factor will give an equivalent static pressure (the effective pressure) which will result in approximately the same maximum deformation and same maximum stress as produced by the actual loading on the structure.

(6) the pressure distribution is assumed to be stationary but with pressure varying with time.

(7) the hull is a rigid body subject to external forces of gravity loads, buoyancy and impact pressures, the vertical components only, being considered.

G.10 Symbols

Po	maximum load per unit length along hull (kilograms/metre)
W	mass of hull (kilograms)
L	length of hull along waterline (metres)
a_{CG}	Acceleration of centre of gravity (metres/second^2)
g	acceleration due to gravity (metres/second^2)
G	half girth from keel to chine (metres)
p_o	peak pressure (Pascals)
p_1	maximum effective pressure (Pascals)
p	equivalent static pressure (Pascals)
P_h	hydrostatic pressure at rest (Pascals)
F_I	impact factor
F_T	transverse load distribution factor
σy	yield stress (Pascals)
wm	allowable permanent set (millimetres)
b	shorter side of a panel of plating (millimetres)
a	longer side of a panel of plating (millimetres)
E	modulus of elasticity (Pascals)
h	thickness of plate (millimetres)
w	uniformly distributed load on a frame (Newtons/metre^2)
F_L	longitudinal load distribution factor
a_B	acceleration at bow (metres/second^2)
a_S	acceleration at stern (metres/second^2)
σ_1	primary stress (Pascals)
σ_2	secondary stress (Pascals)
σ_3	tertiary stress (Pascals)
P_2	effective pressure corresponding to the maximum force condition (Pascals)
K	coefficient depending on boundary conditions, aspect ratio and point of measurement of stress.

G.11 Design Procedure

G.11.1 Maximum load per unit length along the hull

$$Po = \frac{3W}{2L}\left(1 + \frac{a_{CG}}{g}\right)$$

G.11.2 Peak pressure for application to local strength of a structural element

$$Po = \frac{3Po\, g}{G}$$

G.11.3 Maximum effective pressure

$P_I = P_o \times$ dynamic load factor.

The dynamic load factor may be taken as 1.1 where experimental or full-scale values are not available.

G.11.4 The equivalent static pressure for the design of plating (or shell panel)

$$p = (p_I \times F_I \times F_T) + P_h$$

F_I is the impact factor expressed as a function of distance from the bow and is determined from Figure 1

F_T is the transverse load distribution factor and is determined from Figure 2.

G.11.5 To select a plate thickness (in the case of a metal hull), the following factors need to be determined:

(a) the yield stress (σy)

Where welded construction is proposed, the yield stress appropriate to the heat affected material is adopted.

(b) the ratio of the allowable permanent set to the length of the shorter side of the panel. A ratio of 0.005 should normally be adopted ($w m_j/b$).

(c) permanent set coefficient $\frac{wm}{b}\sqrt{\frac{E}{\sigma y}}$

(d) width to thickness coefficient $\frac{b}{h}\sqrt{\frac{\sigma y}{E}}$

(e) non-dimensional pressure coefficient $\frac{pE}{\sigma y^2}$

Figure 3 may be used to determine the thickness of the plate. Allowance should be made for fatigue. Figure 4 may be used to adjust the thickness of aluminium plating.

G.11.6 To determine the scantlings of a bottom frame:

(a) if the frame is continuous from keel to chine and is slotted to pass over the longitudinal frames then the transverse load distribution factor for pin ended beams should be used and the frame treated as a beam with span equal to the half girth;

(b) if the transverse frame is continuous from keel to chine but passes through the longitudinals and is bracketed at the ends, then the transverse load distribution factor for fixed ends should be used and the frame treated as a fixed ended beam of length equal to the longitudinal spacing.

(c) a strip of plating of width $2h\sqrt{\frac{E}{\sigma y}}$ mm or the spacing of adjacent transverse which ever is less should be taken as the bottom flange of the frame.

(d) a uniformly distributed load equal to the product of the design pressure and the spacing of the transverses should be used, i.e. $w = p \times$ spacing. Then

$$\text{maximum bending moment} = \frac{w(zG)^2}{8}$$

for a pin ended beam of span zG as appropriate. The modulus is determined in the usual way for the section selected having regard to the width of the bottom flange.

G.11.7 To determine the scantlings of a deck beam, using the selected head of water on deck, and the assumed deck beam spacing the uniformly distributed load on the beam is determined. From the loading, the maximum bending moment, modulus and effective width of flange are determined. An appropriate section for the beam is then selected.

G.11.8 In determining the scantlings of side framing, to allow for wave impact use a mean of the design pressure for the deck and bottom framing. The section scantlings are determined as for G.11.6 and G.11.7 above.

G.11.9 Bottom longitudinals are designed as fixed ended beams with span equal to the frame spacing. The design pressure is determined from

$$p_L = (p_1 \times F_I \times F_L) + P_h$$

The impact factor F_I is determined from Figure 1 and the longitudinal load distribution factor F_L from Figure 5. The effective flange width and appropriate section are selected as for G.11.6 and G.11.7 above.

G.11.10 The deck longitudinals are designed for the same pressure as the beams and using a similar approach.

G.11.11 The midship section may now be developed and the moment of inertia, neutral axis and section moduli for deck and keel determined.

G.11.12 The bending moment amidships is determined from

Bending moment kilogram metres

$$= \frac{W \times L}{1920} \left(160 \frac{a_{CG}}{g} - 41 \frac{a_B}{g} - 169 \frac{a_S}{g} - 50 \right)$$

From the bending moment, the primary stresses at the deck and keel can be determined.

G.11.13 The secondary stress in the bottom will be calculated by determining the fibre stress caused by the bending of the bottom longitudinals when subjected to the pressure corresponding to the maximum force condition.

Effective pressure

$$P_2 = \frac{Pog}{G}$$

Equivalent static pressure $p = (p_2 \times F_I \times F_L) + P_h$

Using this pressure, the uniformly distributed load, maximum bending moment $\left(\frac{pf^2}{12}\right)$ (at ends of longitudinals since they are regarded as fixed beams of length f) modulus and secondary stress are determined.

G.11.14 The tertiary stress in the bottom plating is then calculated.

$$P_2 = \frac{Pog}{G}$$

$$p = (p_2 \times F_I \times F_T) + P_h$$

$$\sigma_3 = 5.46\, Kp \left(\frac{b}{h}\right)^2$$

For a plate of aspect ratio 4 clamped on all four edges, to determine the longitudinal stress at the midpoint of short side K = 0.0627.

G.11.15 The sum of the three stresses is compared with the yield stress

$$\sigma_1 + \sigma_2 + \sigma_3 < \sigma_y$$

If the sum is less than the yield stress the overall strength of the craft is satisfactory.

G.12 Superstructures and Deckhouses

Reference should be made to Clause G.7.

G.13 Bulkheads

Reference should be made to Clause G.6.

G.14

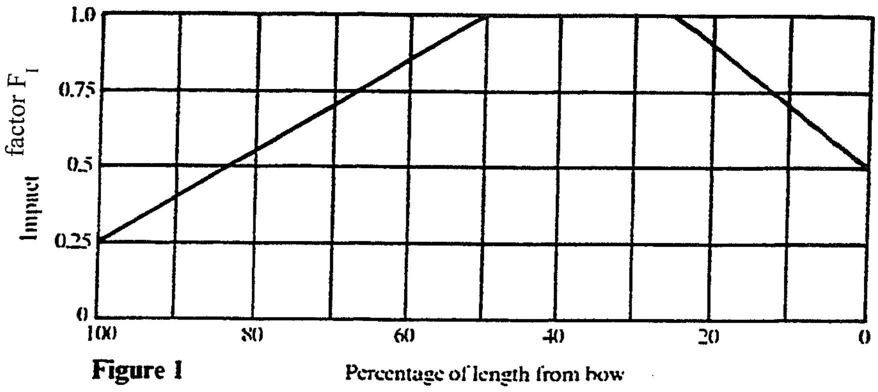

Figure 1

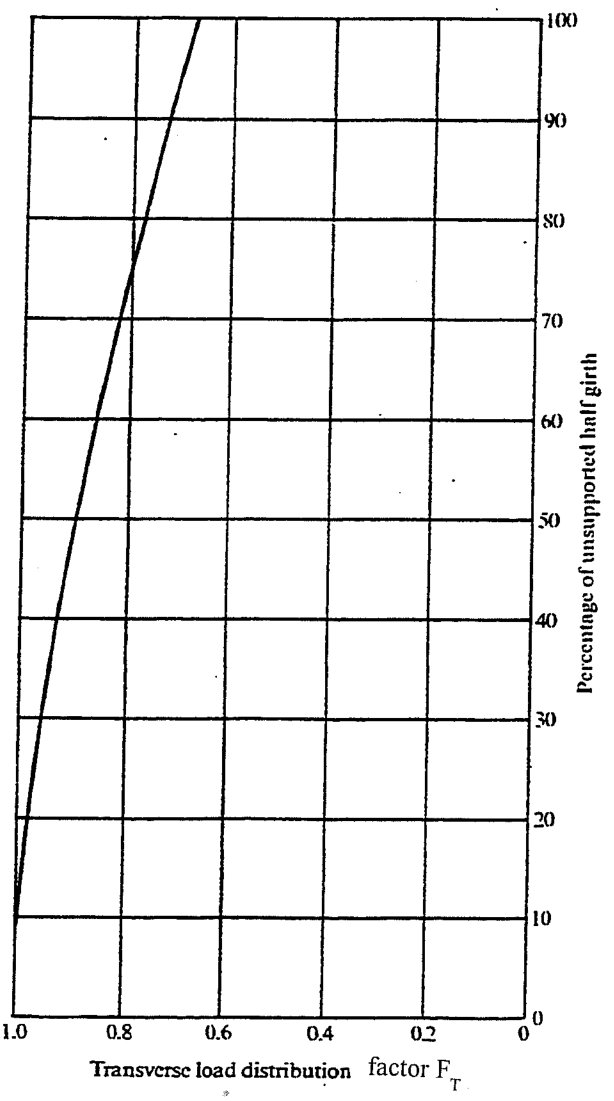

Figure 2

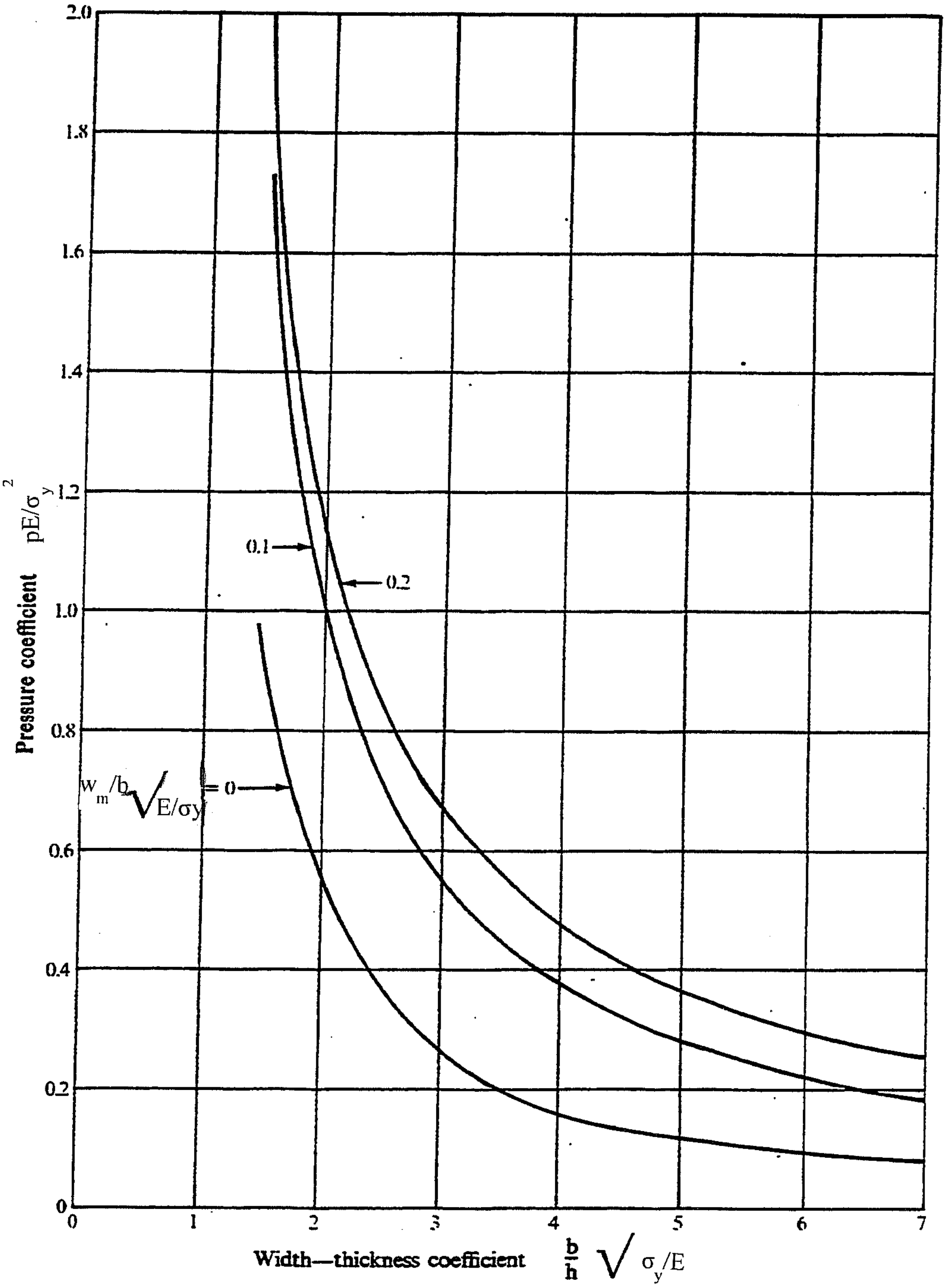

Figure 3

For definition of coefficients see Clauses 10 and 11.5

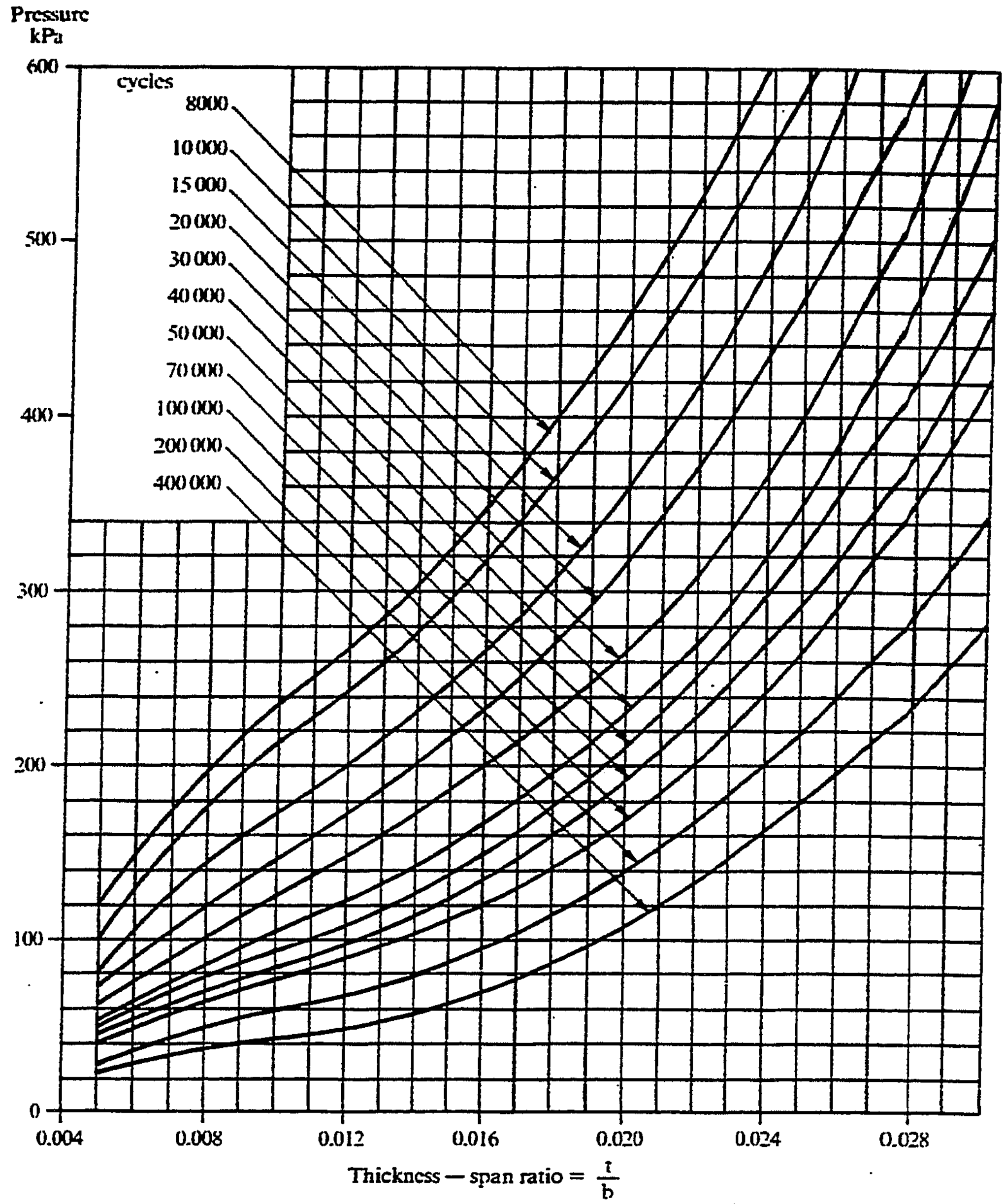

Figure 4 CONSTANT LIFE CURVES — ALUMINIUM PLATING

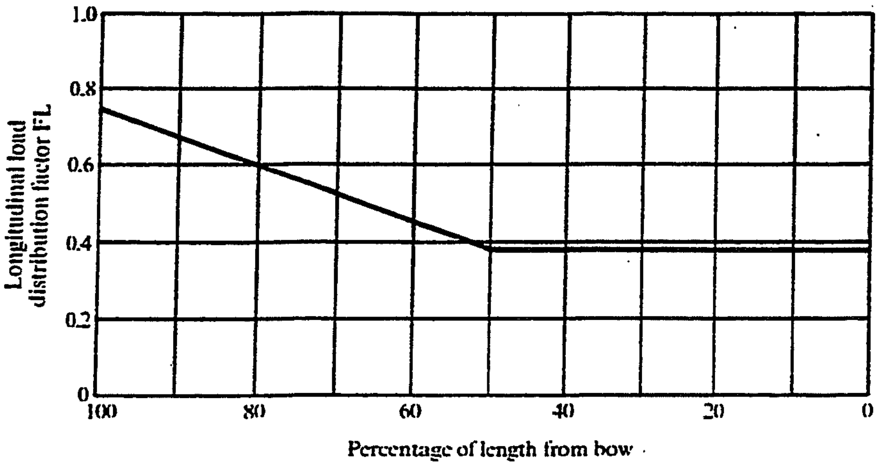
1.0
0.8
0.6
0.4
0.2
0
Longitudinal load distribution factor FL
100
80
60
40
20
0
Percentage of length from bow

Figure 5