G. Design loadings

Contents

G.1 Part 1

G.1.1 General

All vessels designed and constructed under this section shall be required to contain sufficient structural strength for safe operation in the intended service and sea conditions. The vessels shall meet the relevant requirements of parts 2 and 3 of this sub-section.

G.2 Part 2

G.2.1 Introduction

Scantlings for displacement vessels shall be determined by first principles and vessels less than 35m in length shall use the minimum loadings determined in the following parts. Vessels that are 35m or greater in length shall require special consideration by AUSCLASS.

G.2.2 Shell

A head of saltwater shall be used, of 1.25m above the exposed deck at the bow, linearly reduced to a head of 0.625m at the forward quarter point and constant at 0.625m from the forward quarter point to the transom.

G.2.3 Decks

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

Vessels of class A, B or C

- Exposed freeboard deck – $(0.02L + 0.76) * 1025$
- Forecastle deck or superstructure deck forward 0.5L of amidships – $(0.02L + 0.46) * 1025$
- Freeboard deck within superstructure or deckhouse, any deck below freeboard deck or superstructure deck between 0.25L forward and 0.2L aft of amidships – $(0.1L + 0.61) * 1025$
- All other locations – $(0.1L + 0.3) * 1025$

Vessels of classes D and 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 and cargo decks of all vessels

For a deck or a portion of a deck forming a tank top, the greater of the following shall be used:

- Two thirds of the distance (m) between the tank top to the top of the overflow
- Two thirds of the distance (m) between the tank top to the bulkhead or freeboard deck

For a deck on which cargo or stores are carried is the ‘tween deck height inside, where the cargo masses exceed 720 kg/m^3 the design head in metres shall 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 is to be increased in proportion to the added loads.

G.2.4 Longitudinal bending stress

Additionally, to the previous loadings, excluding the 1785kg/m loading on deck panels, it shall be assumed that the bending stress due to loading acting at the extreme hull fibres tapers to zero at the neutral axis.

The longitudinal extent of this bending shall be uniformly tapered to zero at the ends of the hull.

G.2.5 Bulkheads

In general, the design and construction of main sub-division bulkheads located below the main deck shall be to withstand a combined head of the main deck, live load and dead load from the deck at the top of the bulkhead. The design and construction of structural non-tight bulkheads below the main deck shall be to withstand a uniform load of 350kg/m^2 in addition to the water and deck loads.

G.2.6 Superstructures and deckhouses

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

Front ends

- Vessels of classes A, B and C $(0.0199L + 0.51) * 1025$
- Vessels of classes D and E $(0.0199L + 0.30) * 1025$

Side and aft ends

- Vessels of classes A, B and C $(0.0159L + 0.27) * 1025$
- Vessels of classes D and E $(0.0093L + 0.19) * 1025$

G.3 Part 3

G.3.1 Introduction

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 449).

In the case where alternative principles are used for the design and calculations of a vessel, these principles, plans and calculations for the proposed vessel shall be submitted to AUSCLASS for special consideration.

G.3.2 Basic assumptions

It is assumed that:

- The structure can be idealised as a system with a single degree of freedom
- Equivalent static loads may be determined for application to the structure
- Rigid body acceleration varying linearly from 4.0g at the bow to 0.0g at the stern with acceleration at the centre of gravity (assumed at midships) of 2.0g, are applicable for commercial planing craft
- Increased rigid body accelerations shall be assumed for design of planing craft designed for more rigorous service than those of the conventional commercial planning craft
- The peak pressure resulting from any impact, when multiplied by the corresponding dynamic factor shall 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
- The pressure distribution shall be assumed to be stationary but with pressure varying in respect to time
- The hull is a rigid body subject to external forces of gravity loads, buoyancy and impact pressures, the vertical components only, being considered

G.3.3 Symbols

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

G.3.4 Design Procedures

Maximum load per unit length along the hull

$$P_0 = \frac{3W}{2L}\left(1 + \frac{a_{CG}}{g}\right)$$

Peak Pressure for application to local strength of a structural element

$$P_0 = \frac{3P_0 g}{G}$$

Maximum effective pressure

$$\mathrm{P_I} = \mathrm{p_o} * \text{dynamic load factor}$$

The value 1.1 shall be used as the dynamic load factor, in the case where full-scale experimental values are unobtainable.

The equivalent static pressure for the design of plating (or shall panel)

$$P = (p_I * F_I * F_T) + P_h$$

F_I shall be determined from figure 1 and us the impact factor as a function of distance from the bow.

F_T shall be determined from figure 2.

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

- The yield strength (σ_y) of plate shall be welded, then the yield strength of the heat affected material shall be used.
- The ratio of the allowable permanent set to the length of the shorter side of the panel. A ratio of 0.005 shall generally be adopted (wm/b).
- Permanent set coefficient $\frac{wm}{b} \quad \sqrt{\frac{E}{\sigma_y}}$
- Width to thickness coefficient $\frac{b}{h} \quad \sqrt{\frac{\sigma_y}{\mathrm{E}}}$
- Non-dimensional pressure coefficient $\frac{pE}{{\sigma_y}^2}$

Figure 3 may be used as a guide to determine the thickness of plate required and additional allowances should be determined to allow for fatigue of the material. Figure 4 may be used to for aluminium plating.

To determine the scantlings of a bottom frame:

- A frame shall be treated as a beam of length equal to the half girth if the frame is continuous from keel to chine and is slotted to pass over the longitudinal frame. The transverse load distribution factor for pin ended beams shall be used.
- A frame shall be treated as a fixed ended beam of length equal to the longitudinal spacing if the transvers frame is continuous from keel the chine and passes through longitudinals and is bracketed at the ends. The transverse load distribution factor for fixed ends shall be used.
- A strip of plating of width $2h\sqrt{\frac{E}{\sigma_y}}$ mm or the spacing of adjacent transverse, whichever is less should be taken as the bottom flange of the frame.
- A uniformly distributed load equal to the product of the design pressure and the spacing of the transverse should be used i.e. $w = p * spacing$. Then $maximum\ bending\ moment = \frac{w(zG)^2}{8}$ 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.

To determine the scantlings of a deck beam.

The relevant head of saltwater in combination with the deck beam spacing to determine the uniformly distributed load on the deck beams. The uniformly distributed load shall then be used to determine the maximum bending moment, modulus and effective width of flange. The results obtained shall be used to select the appropriate beam.

scantlings of side framing

To allow for wave impact, use a mean of the design pressure for the deck and bottom framing in the determination of side scantlings. The section scantlings are determined as previous.

Bottom longitudinals

The bottom longitudinals shall be considered fixed end beams that span a width equal to the frame spacing and the design pressure shall be determined from the following equation:

$$P_L = (p_I * F_I * F_T) + P_h$$

Use figure 1 to determine the impact factor F_I and figure 5 to determine the longitudinal load factor F_L. The effective flange width and appropriate section shall be selected in the same manner as previously stated in the prior paragraphs.

The deck longitudinals shall be designed for the same pressure as the beams and using a similar approach.

From previous information the midship section shall now be developed by determining the moment of inertia, neutral axis and section moduli of the deck and keel.

The bending moment amidships is determined from:

$$Bending\ moment = \frac{w * L}{1920}\left(\frac{160 * a_{CG}}{g} - \frac{41 * a_g}{g} - \frac{169 * a_s}{g} - 50\right)$$

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

The secondary stress in the bottom

The secondary stress shall be determined from the fibre stress caused due to the bending moment of the bottom longitudinals when subjected the maximum pressure due to the maximum force condition.

Effective pressure: $P_2 = \frac{Po*g}{G}$

Equivalent static pressure: p= $(p_2 * F_I * F_T) + P_h$

Using the pressure, uniformly distributed load and maximum bending moment $\left(\frac{pf^2}{12}\right)$ at ends of longitudinals due to the longitudinals being considered as fixed beams of constant length, to determine the modulus and secondary stress.

The tertiary stress in the bottom plating is then calculated:

$$P_2 = \frac{Po * g}{G}$$

$$p = (p_2 * F_I * F_T) + P_h$$

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

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

The sum of the stresses shall be compared against the yield stress.

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

If the sum is less than the yield stress, then the vessel has sufficient overall strength.

G.3.5 Superstructures and Deckhouses

Reference should be made to part 2, Superstructures and Deckhouses.

G.3.6 Bulkheads

Reference should be made to part 2, Bulkhead.

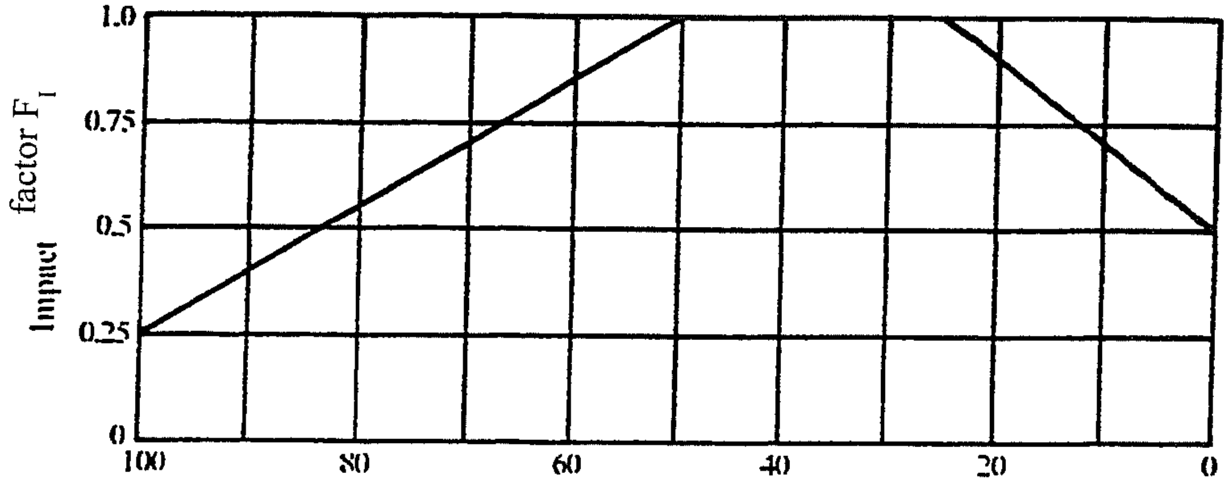

Figure 1 Percentage of length from bow

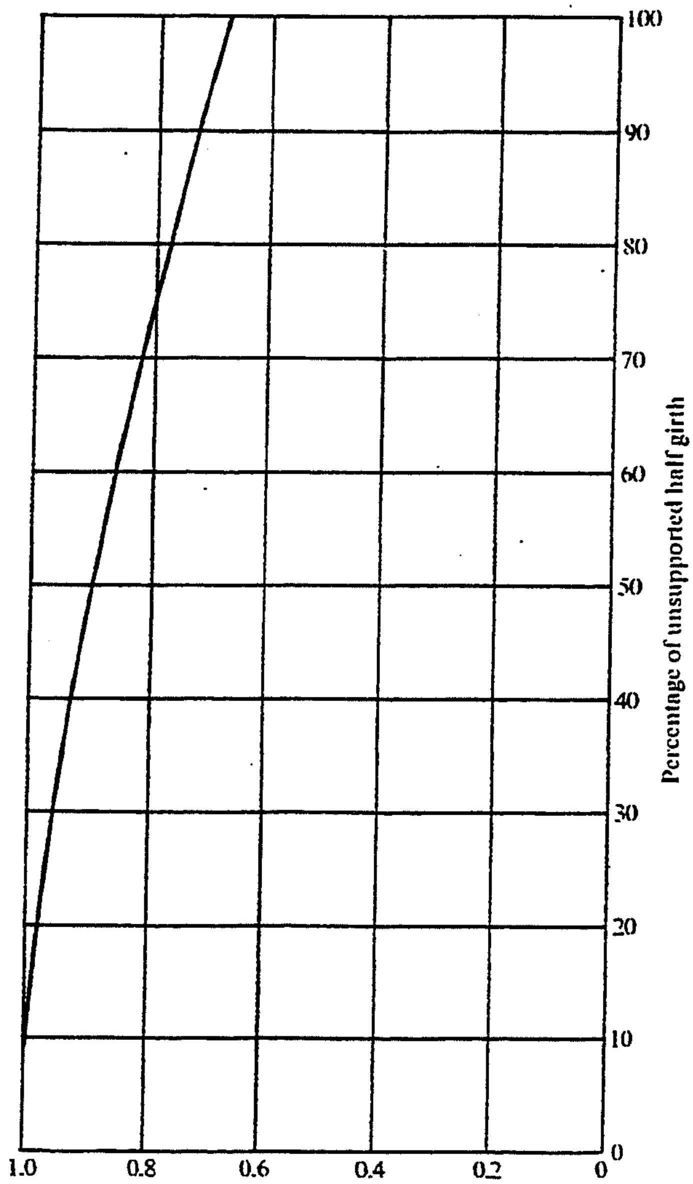

Figure 2 Transverse load distribution factor F_T

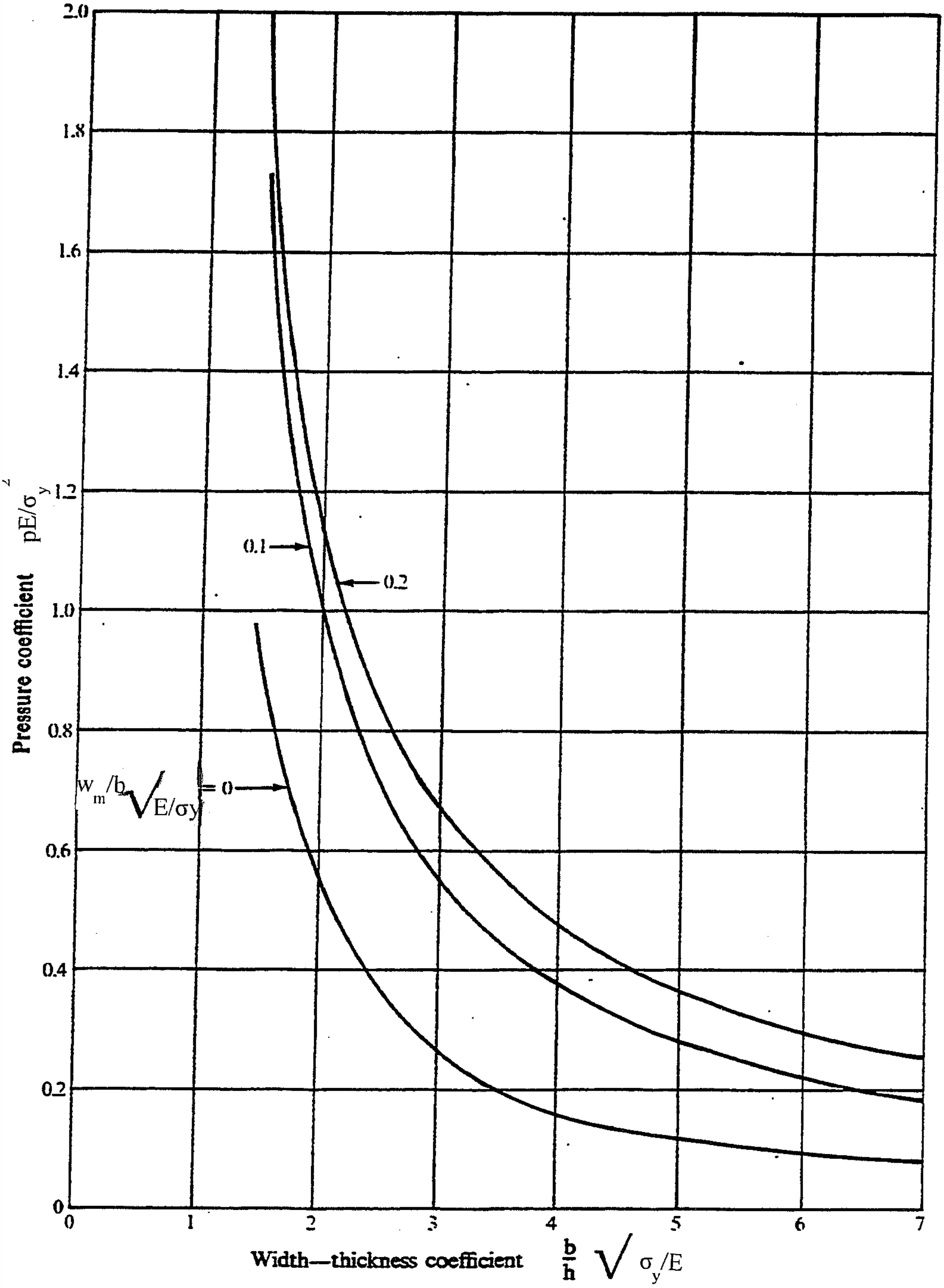

Figure 3

For definition of coefficients see Clauses 10 and 11.5

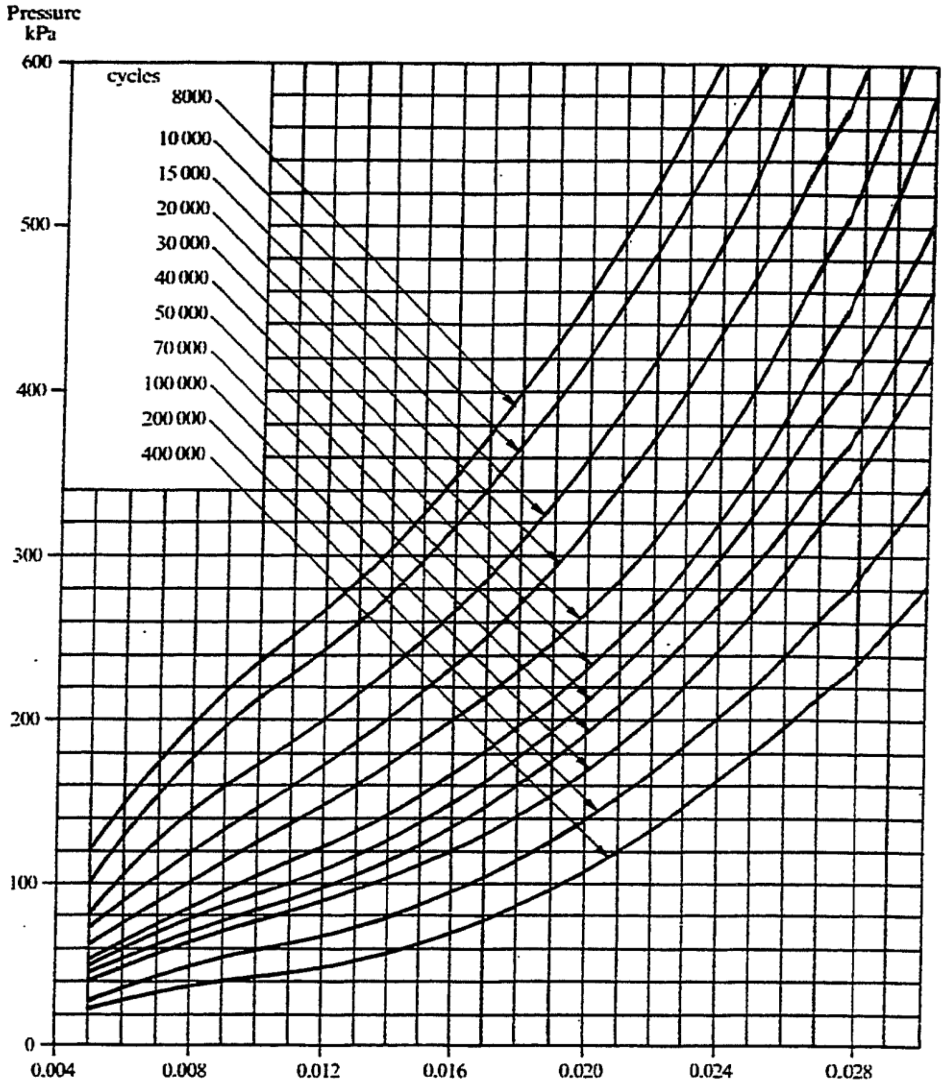

Figure 4 **CONSTANT LIFE CURVES — ALUMINIUM PLATING**

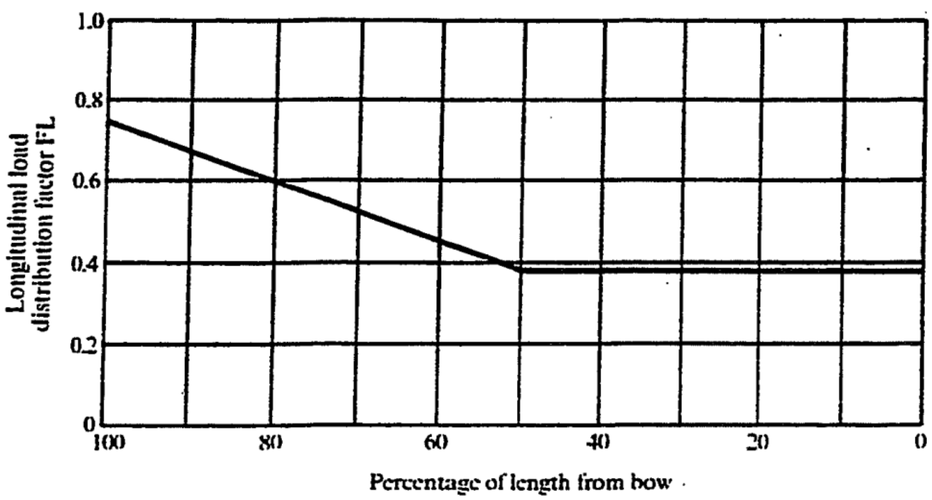

Figure 5