

CHAPTER III.—STRENGTH REQUIREMENTS BASED ON OTHER THAN FLIGHT
CONDITIONS

1. Tabular summary

The requirements dealt with in this Chapter are summarized in Table I.

TABLE I.—SUMMARY OF STRENGTH REQUIREMENTS BASED ON OTHER THAN FLIGHT CONDITIONS

Note.—The contents of Chapters II and III have been completely rearranged by A.L. No. 3

CHAPTER III—PARA. 1
Amended by A.L. No. 3

Loading case	Factor required unless otherwise specified	Components for which the loading case will usually give design loads (subject to Chapter I, para. 4)	For description of case, see Chapter III
Energy absorption (landing tail up)—Landplanes.— With specified vertical velocity and vertical ground reaction not exceeding $3W$. (W = all up weight of aeroplane.)	—	—	Para. 2
Tyre loading : not to exceed NDb per wheel	Value of N as laid down in specification.	Tyre and wheel	Para. 3
Strength requirements for landing—Landplanes.—			
(i) Landing tail down—ground reaction vertical and equal to $3W$	1.33 on under carriage. 1.5 on remainder of structure	Undercarriage, fuselage	Para. 4 (i)
(ii) Side load at axle = $W \div$ number of main landing wheels.	1 throughout ..	Undercarriage and centre section ..	Para. 4 (ii)
(iii) Landing tail up with vertical ground reaction of $3W$ and total horizontal drag force of $0.75W$ at hubs.	As for (i) above ..	Undercarriage and fuselage.. ..	Para. 4 (iii)
(iv) One wheel landing, tail down attitude—ground reaction vertical and equal to $1.5W$.	1 throughout ..	Undercarriage, fuselage main planes, and centre section.	Para. 4 (iv)
(v) Combined $4W$ vertically upwards, $0.4W$ horizontally sideways acting inwards, $0.35W$ acting outwards and $1W$ horizontally backwards applied at axle. Both tail up and tail down attitudes are to be taken.	1 on undercarriage. 1.1 on remainder of structure.	Undercarriage, fuselage	Para. 4 (v)
Additional cases when wheel brakes are fitted.—			
(vi) Landing with brakes on and tail skid just clear of ground. Total ground reaction $4W$ vertical and $1W$ horizontally backwards.	1 throughout ..	Undercarriage, fuselage	Para. 4 (vi)
(vii) One wheel braked landing with tail down. Total ground reaction $1.5W$ vertical and $0.375W$ horizontally backwards.	1 throughout ..	Undercarriage, fuselage, main planes and centre section.	Para. 4 (vii)
(viii) Application of brakes to prevent aeroplane rolling backwards. Unit gravity loads and twice braking torque.	1 throughout ..	Undercarriage, brake mechanism ..	Para. 4 (viii)
(ix) Same as (v) except backwards load is applied at points of type contact	1 on undercarriage. 1.1 on remainder of structure.	Undercarriage, fuselage	Para. 4 (ix)
Strength requirements for landing—Seaplanes.— Boat seaplanes.—	—	—	Para. 5
(i) Landing tail up, with water reaction $3.5W$	1 throughout structure	Hull, main planes, engine mounting	Para. 6 (i)

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Strength requirements for landing—Seaplanes—contd.**Boat seaplanes—contd.**

- (ii) Two wave landing, with water reaction $3.5 W$.. 1 throughout structure
 (iii) Pressure over planing bottom 1
 (iv) Wing tip floats—side load of 150 lb./sq. ft. (not applicable to float structure). 1

Float seaplanes.—

- (i) Landing tail up, with water reaction $3.5 W$.. 1 throughout structure
 (ii) Two wave landing, with water reaction $5 W$.. 1 throughout structure
 (iii) Side load = $\frac{W-f}{n}$ per float 1 throughout ..
 f = weight of floats,
 n = number of floats (not criterion for float structure).
 (iv) Pressure over planing bottom 1
 (v) Wing tip floats—as for boat seaplanes 1 throughout ..

Amphibians

As for landplanes and seaplanes.

Tail skid and tail wheel loads.—

- (i) Vertical reaction with aeroplane at rest on the ground. For tracking tail skid or wheel all possible positions should be considered. 4 on tail skid or wheel.
 4.5 on remainder of structure.
 (ii) Vertical reaction as in (i) above combined with horizontal fore-and-aft drag force equal to half vertical reaction. 4 on tail skid, 4.5 on remainder of structure.
 (iii) For unbraked tail wheel vertical reaction as in (i) combined with horizontal drag force of one quarter vertical reaction, resultant force passing through hub of wheel. 4 on tail wheel, 4.5 on remainder of structure.

Catapulting.—

- (i) Acceleration, increment of velocity and component of wind plus ship speed as laid down in specification. Usually 2
 (ii) Aeroplane at rest on catapult, engine off, under most adverse combinations of specified head and side winds (a) engine off (b) engine at full throttle. 2

Arrested landing.—Speed, landing run and deceleration as laid down in specification**Slinging and handling loads**

4

Somersault landing.—

- (i) Leading edge of centre section (or pylon in the case of a low wing monoplane) and nose of aeroplane on ground 2
 (ii) Aeroplane fully over 4

Salvage

6

Hull Para. 6 (ii)

Hull Para. 6 (iii)

Wing tip float attachments, main planes. Para. 6 (iv)

Floats, float undercarriage, fuselage, main planes. Para. 7 (i)

Floats, float undercarriage, fuselage Para. 7 (ii)

Float undercarriage, main planes .. Para. 7 (iii)

Floats Para. 7 (iv)

Wing tip float attachments main planes. Para. 7 (v)

— Para. 8

Tail skid or wheel, fuselage Para. 9 (i) (a)

Tail skid, fuselage Para. 9 (i) (b)

Tail wheel, fuselage Para. 9 (i) (c)

Fuselage, main planes, bomb racks.. Para. 10 (i)

Fuselage, centre section Para. 10 (ii)

Fuselage, undercarriage .. Para. 11

Centre section Para. 12

Centre section Para. 13

Centre section Para. 13

Cables and parts of aeroplane connecting them to large masses in the fuselage such as engines, etc. Para. 14

TABLE I.—SUMMARY OF STRENGTH REQUIREMENTS BASED ON OTHER FLIGHT CONDITIONS—*contd*

Note.—The contents of Chapters II and III have been completely revised by A.L. No. 3

CHAPTER III.—PARA. 1
Amended by A.L. No. 3

Loading case	Factor required unless otherwise specified	Components for which the loading case will usually give design loads (subject to Chapter I, para. 4)	For description of case, see Chapter III
Jacking loads	3	Main planes, fuselage, centre section	Para. 15
Wings folded (tail on ground)	3	Main planes, centre section, undercarriage.	Para. 16
Static thrust and torque (applicable to both landplanes and seaplanes).	2	Engine mounting, undercarriage ..	Para. 17
Strength of control surfaces and systems under wind loads when the aeroplane is picketed or taxied tail-to-wind.—			
(i) For elevator and aileron surface and circuits. Applied hinge moment tending to depress each control surface.	Proof factor 1.25, ultimate factor 2.	Control surfaces and circuits ..	Para. 18
(ii) For aileron surfaces and circuits. Applied hinge moment tending to raise ailerons on one side and depress them on the other.	Same as (i) ..	Control surfaces and circuits ..	Para. 18
(iii) For rudder surfaces and circuits	Same as (i)	Control surfaces and circuits ..	Para. 18
Fixing of ballast weights and other large masses	—	Fuselage	Para. 19
Safety belts and harness —			
(i) Pilots	Not less than 1 under $\frac{7g}{2}$ forwards and $\frac{Ng}{2}$ upwards.	—	Para. 20
(ii) Other members of crew	Not less than 1 under $\frac{2g}{2}$ forwards and $\frac{Ng}{2}$ upwards.	—	Para. 20
(iii) Seats and their attachments to the aeroplane, when belts and harness are anchored to the seat structure.	Greater than the above required factors.	—	Para. 20
Subsidiary structure (seats, bomb racks, generator attachments, fittings for stretchers, etc.).	As specified for adjacent main structure.	Subsidiary structure	Para. 21
Lateral stability of spars when unsupported over a length of two rib spacings —applicable to both main planes and tail planes.	As specified for all main and tail plane loading cases.	Main planes, tail unit	Para. 22
Ancillary equipment	4	—	Para. 23
Ribs (both main plane and tail unit). Strength by mechanical test.	As for main plane or tail unit.	Ribs	Para. 24
Openings in wing coverings	Loads due to openings to be provided in the design of the ribs.	—	Para. 25
Beaching chassis and tail trolleys	3	—	Para. 26
Fitting of ring cowlings	—	—	Para. 27

2. Energy absorption (landing tail up)—Landplanes

The undercarriage shock absorption capacity is to be such that the resultant ground reaction shall not exceed three times the weight of the aeroplane fully loaded when the aeroplane lands with the specified vertical velocity, thrust line horizontal. In addition to the ground reaction there will be air forces on the wings and tail, distributed as in the normal flight C.P. forward case and equal in total magnitude to $1W$. The vertical forces on the aeroplane resulting from the specified loads are therefore.—

- (a) The ground reaction NW upwards at the wheels.
- (b) The lift $1W$ upwards at the wings and tail.
- (c) Inertia and gravity forces $(N + 1)W$ downwards, the resultant passing through the C.G.

The angular velocity and angular acceleration of the aeroplane about all axes may be neglected. The airscrew thrust is to be assumed zero. Under these conditions the factor on the undercarriage, must not be less than $1.3\bar{3}$ and on the remainder of the structure must not be less than 1.5 (see para. 4). In the event of a bad landing it is required that alighting gears shall fail before the main structure, and factors are specified with this end in view. Actually minimum factors are detailed, but the same margin of excess strength of the structure (and the attachment fittings of the alighting gear) over the alighting gear itself must be given whether or not the factor for the alighting gear is kept down to the specified minimum. This point needs special attention during development, when alighting gears may become strengthened up without the attachment fittings and remaining structure being adequately modified.

3. Tyre loading*

The maximum weight of the aeroplane in pounds divided by the number of main landing wheels is not to exceed $N \times$ product of wheel and tyre diameter in inches, where N is as specified (see also Chapter IV, para. 15).

4. Strength requirements for landing—Landplanes (See also para. 9).

These requirements may need amplification for special types of undercarriage. Aeroplanes whether fitted with undercarriage wheel brakes or not are to have the factors specified in Table II below in loading cases (i) to (v). Aeroplanes fitted with wheel brakes are, in addition, to have the specified factors in loading cases (vi) to (ix). In all cases W = total weight of aeroplane.

(i) *Tail down.*—The aeroplane landing on an even keel so that the tail wheel and undercarriage wheels touch the ground simultaneously. Resultant ground reaction vertical and equal to $3W$ and distributed between the wheels of the undercarriage and the tail wheel so as to give zero moment on the aeroplane as a whole. Air loads on main planes and tail plane to be neglected. Airscrew thrust zero.

(ii) *Side load.*—A side load equal to $\frac{W}{m}$ applied in the same direction, to the hub of each of the m main landing wheels. This is the only external force acting on the aeroplane, it being balanced by the inertia forces introduced by the resulting linear and angular accelerations.

(iii) *Tail up.*—Landing tail up as described in para. 2 with vertical ground reaction equal to $3W$ and total horizontal drag force, applied at the wheel hubs, equal to $0.75W$.

(iv) *One wheel landing.*—Total ground reaction at point of tyre contact equal to $1.5W$ vertically upwards, distributed equally between all the wheels on one side of the centre line of the aeroplane, the ground reaction at the wheels on the other side being

*Note.—Requirements for tyres and wheels are not given in this handbook. Lists of approved tyres and wheels may be obtained on application to the Airworthiness Department.

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zero. The wing span is assumed to be horizontal and the tail skid resting on the ground. This case represents the unsymmetrical load which may arise in a one-wheel landing. This unsymmetrical load will give rise to angular and linear accelerations. It will usually be an acceptable approximation to consider only angular accelerations about the X (body) axis.

(v) *Combined vertical, backwards, sideways loads: tail up and tail down.*—Total ground reaction of $4 W$ vertically upwards, $0.4 W$ horizontally sideways acting inwards on one side, $0.35 W$ horizontally sideways acting outwards on the other side, applied at points of tyre contact with ground and total drag load of $1 W$ horizontally backwards, applied at the hubs. This case is to be met both when the thrust line is horizontal and when the tail skid or wheel is just clear of the ground, the aeroplane being assumed on an even keel. The vertical and drag loads are equally distributed between the main undercarriage wheels on either side of the aeroplane. The tyres are assumed to be fully compressed and the closure of the oleo leg is to correspond to the position at which maximum reaction is first developed in landing, with the proviso that the leg is not assumed more than half closed without the sanction of the Airworthiness Department.

When wheel brakes (see Chapter IV, para. 14) are fitted, the following additional requirements are to be complied with.—

(vi) *Tail down, with brakes.*—The aeroplane landing with brakes on and tail skid or wheel just clear of the ground. Total ground reaction at points of tyre contact $4 W$ vertically upwards and $1 W$ horizontally backwards, distributed equally between all the braked wheels of the main undercarriage. When calculating the braking torque corresponding to the force of $1 W$ horizontally backwards a tyre deflection corresponding to normal load (i.e. wheel load with aeroplane at rest on the ground) is to be assumed. A smaller backward force than $1 W$ with appropriate torque may, however, be taken where the type of brake is such that the maximum torque which can be generated is limited to a known value, provided that twice the braking torque corresponding to full use of brakes gives rise to a smaller backward force at the point of tyre contact than $1 W$ when the vertical reaction is $4 W$. In these circumstances twice the maximum possible braking torque may be used in strength calculations instead of the torque due to a tangential force of $1 W$ at the point of tyre contact. Overall balance of forces will be obtained by introducing horizontal and vertical inertia forces. Balance of moments will be obtained by introducing an aerodynamic load on the tail plane. This tail load will not be a criterion for the strength of any part of the structure.

(vii) *One wheel landing, with wheel brakes.*—Total ground reaction at point of tyre contact equal to $1.5 W$ vertically upwards and $0.375 W$ horizontally backwards, distributed equally between all the braked wheels on one side of the centre line of the aeroplane, the ground reaction at the wheels on the other side being zero. The wing span is to be assumed horizontal and the tail skid or wheel resting on the ground. The yawing moment is to be balanced out by an arbitrary side force applied at the tail end of the fuselage.

(viii) *Backward load, with brakes.*—Application of brakes to check the aeroplane rolling backwards, due to wind or slope of ground. The aeroplane is assumed to be in the tail down attitude and is subjected to unit gravity loads combined with twice the braking torque corresponding to a coefficient of friction between the tyre and the ground of 0.5 . This requirement applies both to aeroplanes fitted with tail skids and to those fitted with tail wheels.

(ix) *Combined vertical, backwards, sideways loads: tail up and tail down, with brakes (backwards load applied at points of tyre contact instead of at axle).*—This is the same as case (v) except that the backward load is applied at the points of tyre contact. A smaller

* Previously A.D.M. 371.

backward force, at the point of tyre contact, than $1 W$ may be used in cases where twice the maximum braking torque gives rise to a backward load less than $1 W$. In these circumstances the backward force, at the point of tyre contact, corresponding to twice the maximum braking torque, may be used instead of $1 W$ at the point of tyre contact. The strength requirements given above are applicable to all types of brakes. The maximum possible braking torque referred to in (vi) should, if possible, be measured rather than calculated. An approximate measurement can sometimes be made by jacking up one wheel and lashing a lever to the rim. A spring balance will then give the force at the end of the lever necessary to rotate the wheel when full braking effort is being applied at the cockpit.

TABLE II.—FACTORS REQUIRED FOR THE LANDING CASES OF LANDPLANES

Case	Required factor	
	Alighting gear	Remainder of structure
(i)	1.33	1.5
(ii)	1.0	1.0
(iii)	1.33	1.5
(iv)	1.0	1.0
(v)		1.1
(vi)		1.0
(vii)		
(viii)		
(ix)	1.1	

5. Strength requirements for loading—Seaplanes

The factors specified in the following loading cases are, in general, applicable to seaplanes with a planing bottom keel angle of from 115° to 140° at the point of application of the water reaction. Evidence at present available is not sufficient to establish a satisfactory relation of specified factor with the planing bottom keel angle. Individual consideration will then be given to hulls and floats the planing bottom keel angles of which differ considerably from those given above.

6. Boat seaplanes

(i) *Landing tail up.*—The hull and aero-structure of boat seaplanes are to have a factor of at least 1 under the conditions of loading shown in fig. 1. The seaplane is assumed to be gliding into the water, the flight path being such that the main planes are at stalling incidence with the main plane chord horizontal. The seaplane is subjected to the following forces.

- (a) A water reaction R equal to N_1 times the total weight of the seaplane, acting as shown in fig. 1. N_1 is to be taken as 3.5 unless otherwise specified.
- (b) Air forces. As para. 2.
- (c) The weight of the seaplane acting vertically, i.e. normal to the chord of the main planes.
- (d) Inertia forces which balance the reaction R and the couple $G (= R a)$ turning the seaplane about its centre of gravity.

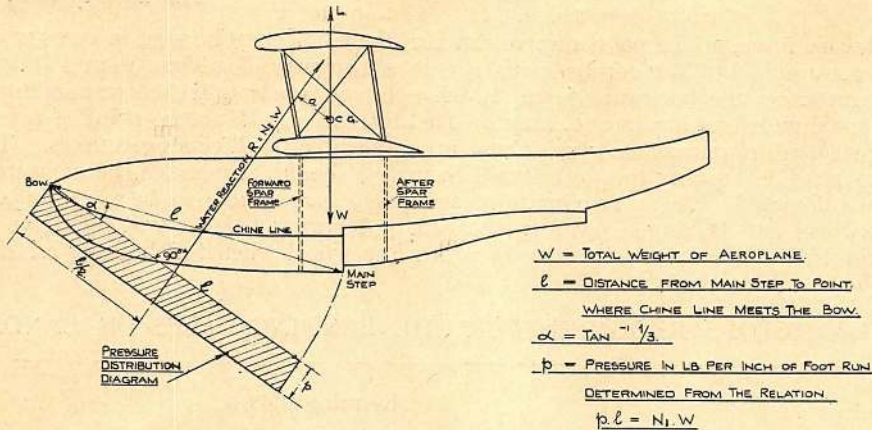


FIG. 1.—CHAP. III. Landing tail up: boat seaplanes.

The stresses in the structure are to be calculated corresponding to the instant of application of the force R . Thus the seaplane will have a linear and an angular acceleration, but the angular acceleration will not have had time to build up an angular velocity. Hence no centrifugal forces will be called into play. As regards the hull structure, this case is intended to check the strength of the hull forward of the forward spar frame in bending and shear, particularly in the neighbourhood of the point of attachment of the hull to the wing structure. In order that the bending moment and shearing force can be obtained at any section of the hull fore body, the water reaction R has been converted into a uniform pressure distribution extending from the bow to the main step as shown in fig. 1. This case is not intended to be any criterion for the strength of the planing bottom under water pressure, nor for any detail component of the hull remote from the point of attachment to the wing structure. The above system of loads will give rise to the forces on any component

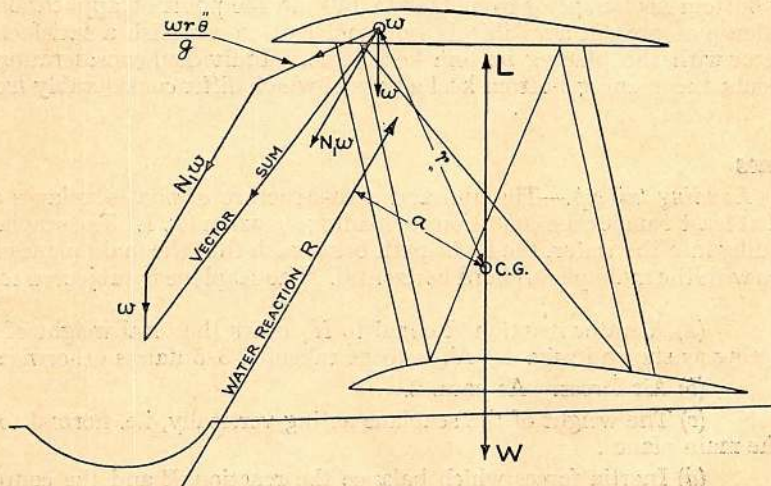
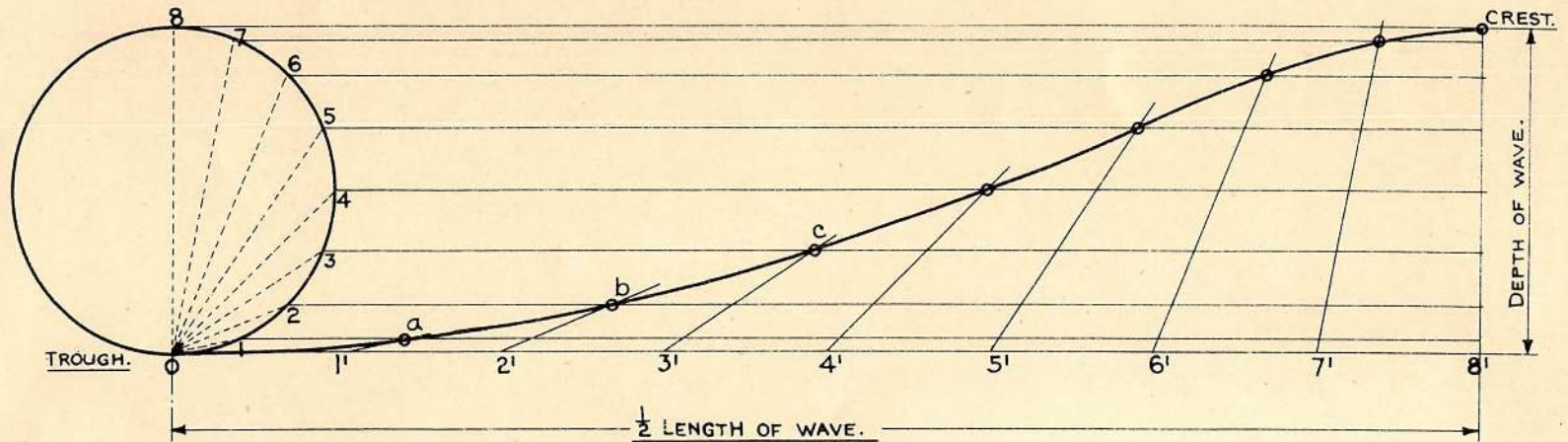


FIG. 2.—CHAP. III. Landing tail up: boat seaplanes.



METHOD:- DIVIDE HALF CIRCLE INTO ANY NUMBER OF EQUAL PARTS AT POINTS 0, 1, 2, 3.-----
JOIN 01, 02, 03-----
DIVIDE HALF LENGTH INTO SAME NUMBER OF EQUAL PARTS AT POINTS 0, 1', 2', 3'-----
THRO' POINTS 1', 2', 3'----- DRAW LINES 1'a, 2'b, 3'c----- PARALLEL TO 01, 02, 03----- TO CUT
HORIZONTALS THRO' 1, 2, 3----- IN POINTS a, b, c-----
THEN a, b, c----- ARE POINTS ON THE WAVE PROFILE.

FIG. 4. CHAP. III
METHOD OF CONSTRUCTING WAVE PROFILE. (TROCHOIDAL)

mass of weight w shown in fig. 2. The resultant force on any such component mass is the vector sum of.—

(a) A force due to the linear acceleration of magnitude $N_1 w$ acting through the C.G. of the mass, opposite and parallel to the direction of R .

(b) A force due to the angular acceleration of magnitude

$$\frac{w r \ddot{\theta}}{g}$$

where r = distance, in feet, in side elevation, between the C.G. of the mass and the C.G. of the seaplane.

$$\ddot{\theta} = \text{angular acceleration} = \frac{Gg}{B}$$

B = the pitching moment of inertia of the whole seaplane in lb. ft.²

(c) Gravity force.

(ii) *Two-wave landing.*—The hull and aero-structure are to have a factor of at least 1 under the loading shown in fig. 3, the total water reaction being 3.5 times the total weight of the seaplane (i.e. $N_2 = 3.5$).

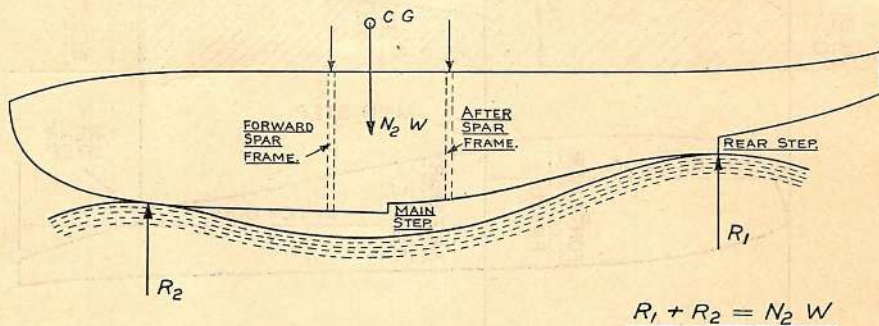


FIG. 3.—CHAP. III.—Two-wave landing : boat seaplanes.

The reaction R_1 is to be assumed to act at the rearmost step or, where only one step is fitted, at the point where the full load water-line at rest cuts the rear portion of the hull in profile. The point of application of the reaction R_2 is determined by drawing in a standard wave (*see below*), with one crest at the point of application of R_1 , and rotating the hull about this latter point until the fore part of the hull touches the surface of the water as shown in fig. 3.

The standard wave is trochoidal in form (for method of constructing trochoidal wave, *see* fig. 4), with a length from crest to crest equal to the length of the hull on the still water-line at maximum load, and a depth from crest to trough equal to 1/15th of the length. The intention of this case is to check the strength of the hull forward of the forward spar frame and aft of the after spar frame in bending and shear, the hull being considered as a beam simply supported at the spar frames. For this purpose it is immaterial how the reactions R_1 and R_2 are distributed over the bottom surface of the hull. This case should also be applied to the aero-structure but it will usually be a determining case for the hull only.

(iii) *Pressure over planing bottom*

(a) The planing bottom plating and internal bottom structure of the hull are to have a factor of at least 1 under the pressure distribution shown in fig. 5. When no rear step is fitted, the after ordinate of the pressure distribution curve is to be set up at that point where the full load water-line at rest cuts the rear portion of the hull in profile.

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(b) This type of loading will introduce inertia loads of the same type as those described for the landing tail up case (para. 6 (i)). In general, however, it will not be necessary to go into this complication as this case is intended only as a criterion for the plating, stringers, etc., of the planing bottom, and the inertia effects will be negligible for these components.

(c) The pressure is assumed to be normal to the planing bottom surface, and to be uniformly distributed laterally from chine to chine.

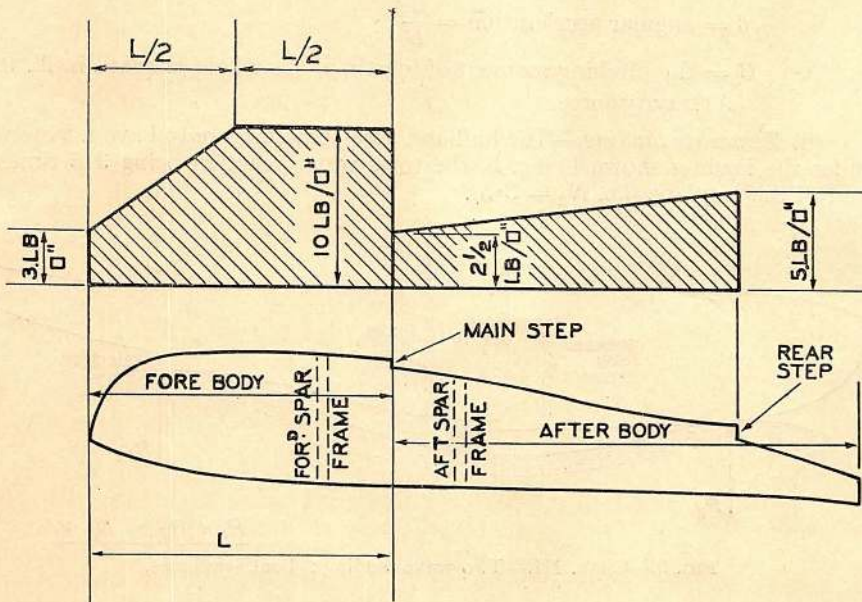


FIG. 5.—CHAP. III. Pressure over planing bottom : boat seaplanes.

(d) When applying this case full loading is to be used for checking the strength of the planing bottom plating and half loading for checking the strength of the internal bottom structure, viz. : keel, keelsons, stringers, bottom portion of transverse frames, etc.

(iv) *Wing tip floats, strength requirements under side load*

(a) The attachment of the wing tip floats and the adjacent main structure of the aeroplane must be capable of withstanding without failure a side load on the float of at least 150 lb. per sq. ft. of projected area of side elevation, the load acting at the centre of area of the side elevation in a direction parallel to the lower plane, and both towards and away from the centre line of the aeroplane.

(b) If a spring is incorporated in the mounting of the float so that the float can move relatively to the lower plane under a side load, the above figure of 150 lb. per sq. ft. may be reduced to 100 lb. per sq. ft.

(c) The above requirement does not apply to the structure of the wing tip float itself.

* Previously A.D.M. 337.

7. Float seaplanes

(i) Landing tail up

(a) The float, or floats, and the remainder of the structure of float seaplanes are to have a factor of at least 1 under the loading shown in fig. 6. This case is identical with the corresponding case for boat seaplanes (fig. 1) with the single exception that the water reaction R is as shown in fig. 6. N_1 is to be taken as 3.5 unless otherwise specified.

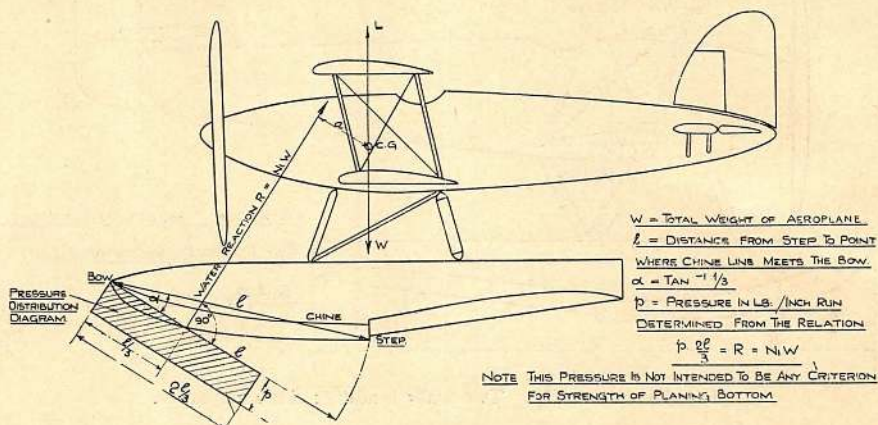


FIG. 6.—CHAP. III. Landing tail-up: float seaplanes.

(b) As regards the strength of the float structure, this case is intended to check the strength of the float as a whole in bending and shear, particularly in the neighbourhood of the point of attachment of the float to the forward undercarriage strut. It is not intended to be any criterion for the strength of the planing bottom under water pressure, nor for any detail component of the float remote from its point of attachment to the forward undercarriage strut. The full water reaction $R = N_1 W$ must be used when checking the strength of the float structure.

(c) When considering the strength of the float undercarriage, it will usually be sufficiently accurate to consider forces (a) and (c) of para. 6 (i) only, making \bar{R} equal to $N_1 (W - f)$ where W = total weight of seaplane and f = weight of floats. The weight of the floats acting perpendicularly to the chord of the main plane will relieve the load in the front undercarriage struts. This approximation involves neglecting the angular inertia of the floats themselves, and as this would usually be small and would be a relieving load on the struts in question, the approximation may safely be made.

(ii) Two-wave landing

(a) The float (or floats) and the remainder of the structure of float seaplanes are to have a factor of at least 1 under the loading shown in fig. 7. N_2 is to be taken as 5.0 unless otherwise specified. The attitude of the seaplane is that which it would take up when floating, fully loaded, at rest, in still water and the water reactions R_1 and R_2 are to be taken at $\frac{l}{6}$ from the bow and stern respectively, l being the overall length of the float.

(b) The intention of this case is to check the strength of the structure connecting floats to fuselage, and also the strength of the float(s) both forward and aft

of the undercarriage struts, and at intermediate points between the strut attachments, in bending and shear, the float being considered as a beam simply supported at the undercarriage strut connections. For this purpose it is immaterial how the reactions R_1 and R_2 are distributed over the bottom surface of the float.

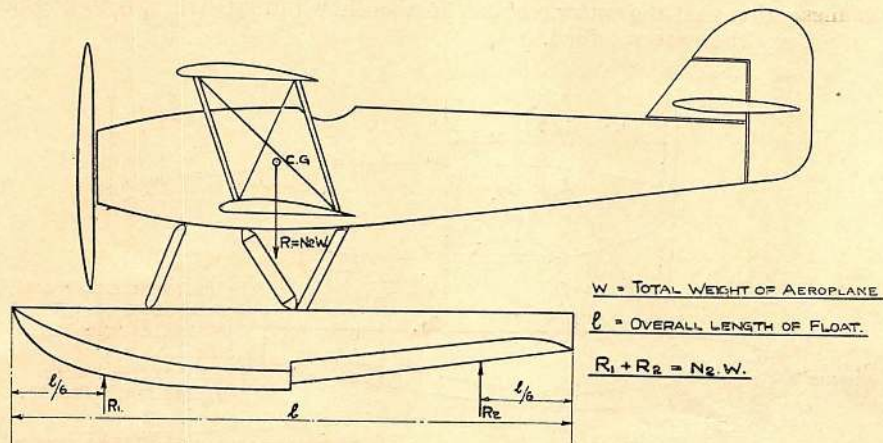


FIG. 7.—CHAP. III. Two-wave landing : float seaplanes.

(c) For strength of float structure the full water reaction $R = N_2W$ must be used, but for checking the strength of the undercarriage structure the weight of the floats may be deducted and the reaction taken equal to $N_2(W - f)$ where

W = all-up weight of seaplane.

f = weight of float or floats.

This case should also be applied to the aero-structure but it will usually be a determining case for float and structure connecting float to fuselage only.

(iii) *Side landing*

(a) The side load on each float is to be $\frac{W - f}{n}$,

where W = all-up weight of seaplane.

f = weight of floats.

n = number of main floats.

This force acts through the centroid of the float in side elevation. In the case of twin or multiple float seaplanes the side load is assumed to act simultaneously, and in the same direction, on each float. A factor of at least 1 is required.

(b) It should be noted that this side load is the *only* force acting, there being no vertical load.

(c) This case is not intended to be a criterion for the strength of the structure of the main float or floats.

(iv) *Pressure over float planing bottom.*—The planing bottom plating and internal bottom structure of each float are to have a factor of at least 1 under the pressure

distribution shown in fig. 8. The application of this case is identical with the corresponding case for boat seaplanes, i.e. half the specified loading only need be taken for checking the strength of internal bottom structure.

(v) *Wing tip floats. Strength requirements under side load.*—As specified for boat seaplanes.

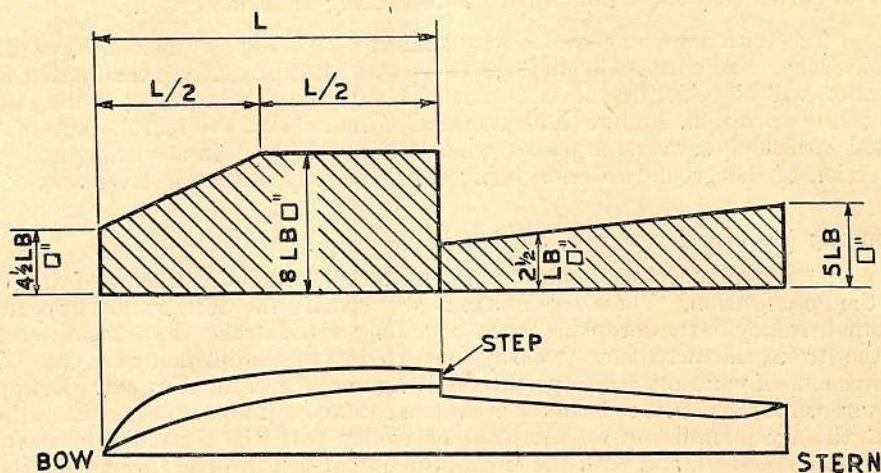


FIG. 8.—CHAP. III. Pressure over planing bottom : float seaplanes.

8. Strength requirements for landing—Amphibians

These are to fulfil the appropriate combination of requirements given in paras. 4, 6 and 7 above.

9. Tail skid and tail wheel loads (see also para. 4)

(i) The tail skid or wheel and remainder of the structure must comply with the following requirements.—

(a) The tail skid or wheel and its attachment fittings are to have a factor of at least 4, and the remainder of the structure a factor of at least 4·5, when the aeroplane is at rest on the ground. If a tracking tail skid or wheel is fitted this requirement should be fulfilled for all possible positions of the tail skid or wheel.†

(b) The tail skid and its attachment fittings are to have a factor of at least 4, and the remainder of the structure a factor of at least 4·5, when the vertical reaction at the tail skid, found as in (a) above, is combined with a horizontal fore-and-aft drag force of half the amount of the vertical force. If a tracking tail skid is fitted it is to be taken in its central position.

(c) If an unbraked tail wheel is fitted (b) above applies except that a horizontal drag force equal to a quarter of the vertical reaction is to be taken, the resultant force passing through the hub of the wheel.

(ii) The tail skid may be called upon to withstand a considerable side force when the aeroplane is turning or taxiing over a rutty aerodrome. It is left to the discretion of the designer to make adequate provision for such side forces, no specific requirements being considered warranted at present. When there is any doubt as to the strength of the tail skid and fuselage under side load, the pilot who carries out the approval flight trials will be

* Previously A.D.M. 337.

† See footnote to para. 16, Chapter II.

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instructed to carry out such taxiing manœuvres as will, in his opinion, prove the adequacy or otherwise of the structure under this type of loading, provisional clearance only being given pending such tests.

(iii) *General design considerations for the tail skid.*—It is important that some lateral springing should be provided for the tail skid, in addition to the usual vertical springing. This is particularly important when a non-tracking tail skid is used.

(iv) With aeroplanes which may land at a high angle of incidence, so that the tail skid touches before the main landing wheels, care must be taken to ensure that the ground reaction will be taken by the skid in such a way that the springing of the tail skid will come into operation. Failures have occurred of the tail skid and rear fuselage of aeroplanes fitted with slots on the main planes, when landing with tail skid touching first, due to the direction of the ground reaction being approximately along the lever arm of the skid.

10. Catapulting (*see also Chapter V, Section IV*)

(i) Aeroplanes must comply with the catapulting requirements, if any, laid down in the specification. These requirements will specify the acceleration imparted by the catapult trolley to the aeroplane at the beginning of the stroke, the acceleration at the end of the stroke, the increment of velocity imparted to the aeroplane by the catapult and the component of wind plus ship speed both along and across the catapult. In applying the requirements the C.G. is to be taken in the most unfavourable position and it is to be assumed that the aeroplane is set on the catapult trolley with the trust line horizontal, unless otherwise specified, and with the engine running at full throttle throughout the catapult stroke. Provision is to be made for the most unfavourable combinations of acceleration and front and side winds. A factor of 2 is usually required.

(ii) In addition to those specified above, all aeroplanes which are to be catapulted, must comply with the following requirements.—

(a) Aeroplane at rest on the catapult cradle. A factor of at least 2 is required under the most adverse combinations of specified head and side winds with engine off.

(b) As in (a) above with engine at full throttle.

11. Arrested landing

Certain aeroplanes are required to be designed to withstand the loads induced by a mechanical retardation of the motion after landing on the deck of an aeroplane carrier. The factor throughout the structure in these circumstances must not be less than 2. The speed of the aeroplane at the instant when the arresting hook engages the wire, the length of the landing run and the deceleration caused by the arresting device will be laid down in the specification.

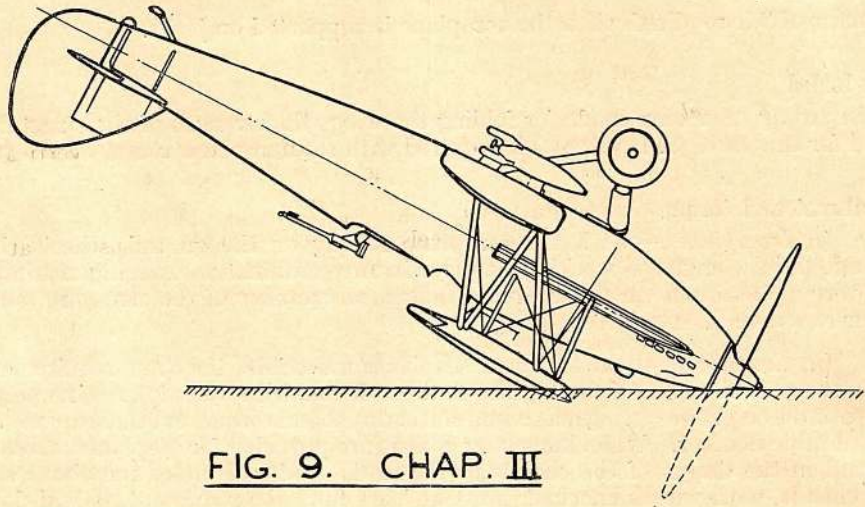
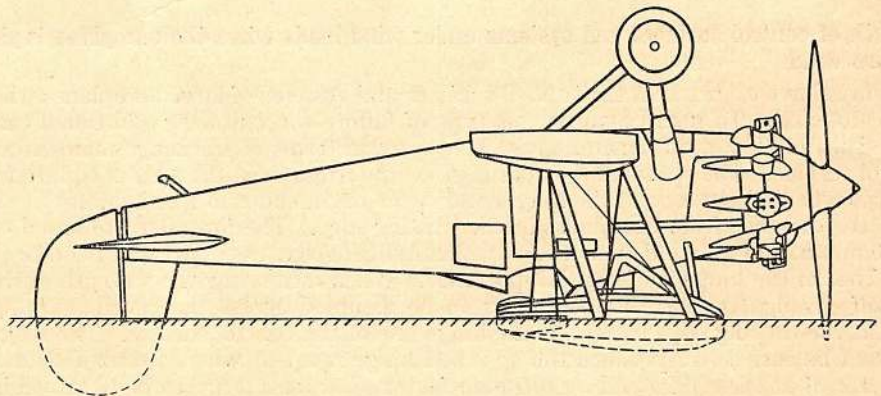
Note.—Details of a side load case can be obtained on application to the Airworthiness Department.

12. Slings and handling loads

Aeroplanes are required to have a factor of at least 4 under the loads incurred when hanging freely by their slinging gear. The sling when supporting the aeroplane fully loaded is to have the same factor.

13. Somersault landing

The centre section structure is to be sufficiently robust to ensure that the wings will not collapse on to the cockpit and imprison or severely injure the crew should the aeroplane turn over on its back when alighting. Two cases are to be considered. These are illustrated in fig. 9

Amended by A.L. No. 3FIG. 9. CHAP. IIIFIG. 10. CHAP. III

Somersault landing.

(leading edge of centre section and nose of aeroplane on ground) and fig. 10 (aeroplane fully over). The loads incurred in these cases are dependent on the precise attitude assumed by the aeroplane when inverted. It does not appear to be possible to specify these attitudes in general terms applicable to all aeroplanes and accordingly each aeroplane must be dealt with on its merits. In the case of a low wing monoplane, a pylon structure must be provided for this purpose in the absence of any alternative protection for the crew. The factors required are not less than 2 for the case shown in fig. 9 and not less than 4 for that shown in fig. 10, based on the fully loaded weight of the aeroplane supported as indicated.

14. Salvage

Salvage cables and those parts of the aeroplane connecting them to large masses in the fuselage such as engines, etc., are required to have a factor of not less than 6 under the loads due to the weight of the aeroplane fully loaded.

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15. Jacking loads

A factor of 3 is required when the aeroplane is supported on jacks.

16. Wings folded

When arrangements are made for folding the wings the strength of the structure is to be investigated for this case. A factor of 3 is required with the aeroplane at rest on the ground.

17. Static thrust and torque

(i) *Landplanes.*—With the aeroplane resting on the ground, wheels chocked or braked, and the engine(s) working singly or in any combination exerting maximum thrust and torque obtainable in these circumstances, no member of the structure must have a factor less than 2.

(ii) *Seaplanes.*—Boat and float seaplanes must fulfil the same requirements under static thrust and torque of the engines as those demanded for landplanes, namely, a factor of 2 with the engines exerting maximum static thrust and torque and the seaplane restrained in a suitable manner. When launching chassises are provided for seaplanes, attention must be paid in the design of the chassises to the loads produced under the above conditions. The chassises, with wheels chocked, must at least fulfil the requirements laid down above for the seaplane itself.

18. Strength of control surfaces and systems under wind loads when the aeroplane is picketed or taxied tail-to-wind

Failures have occurred in the control surfaces and systems of large aeroplanes when on the ground tail-to-wind. To guard against this type of failure the following additional cases are to be complied with. The requirements given below are in terms of the hinge moment applied to each control surface. The specified moment is given in terms of S_1 , the area in square feet of one control surface behind the axis of the hinges and c_1 the mean chord in feet behind the axis of the hinges, i.e. the distance from the hinges to the trailing edge. The formulae are based on a wind speed of 40 m.p.h. and on wind tunnel tests which indicate that the effect of a balance portion of aileron in front of the hinge is of small importance. When estimating the strength of the control surface itself, triangular load distribution is to be assumed across the chord, varying from a maximum at the trailing edge to zero at the hinge line of the control surface. The magnitude of the load is to be such as to produce the specified hinge moment when distributed in this way. A proof factor of at least 1.25 and an ultimate factor of at least 2 are to be obtained in each of the following three loading cases.—

Case (i).—The aileron and elevator control surfaces and circuits are to have the specified factor when a hinge moment H_1 is applied to each control surface in a direction tending to depress the surface.

$$H_1 = 3c_1S_1 \text{ lb. ft.}$$

For the aileron system the moments on each aileron will balance out through the balance circuit. In the case of the elevator circuit the strength of the system is to be examined both when the reaction is taken by a locked control column and when, with column free, the elevator has moved downwards to the extent allowed by the stops.

Case (ii).—The aileron control surface and circuit are to have the specified factors when a hinge moment H_2 is applied to each aileron in a direction tending to raise the ailerons on one side of the aeroplane and to depress them on the other.

$$H_2 = 2c_1S_1 \text{ lb. ft.}$$

This case is to be investigated both for a locked control column and for a free column displaced to the full amount allowed by the stops.

Case (iii).—The rudder control surface and circuit are to have the specified factors when a hinge moment H_3 is applied to the rudder.

$$H_3 = 4c_1S_1 \text{ lb. ft.}$$

This requirement is to be fulfilled both with the rudder bar locked central in the cockpit and with the rudder bar free to move to the extent allowed by the stops.

* In cases where the control circuits are locked at the surfaces, the above requirements are to be complied with in order to provide for release of the locks by the pilot whilst taxiing (see Chapter IV, para. 10).

19. Fixing of ballast weights and other large masses (see also Chapter IV, para. 38)

(i) *Ballast weights.*—The fastenings of ballast weights and adjacent structure must be designed to withstand a deceleration of $10g$ applied in a direction parallel to the thrust line. This requirement will be waived for ballast weights placed so that no injury to occupants of the aeroplane is likely should the weights break loose in a crash. The attachments of such ballast weights need only be of the same strength as the main structure to which they are anchored.

(ii) *Other large masses.*—Satisfactory anchorages are to be provided for all such items of equipment as would, in the event of a heavy landing or crash, be liable to break from their positions and injure occupants of the aeroplane. The strength of the anchorages is to be at least as great as that of the structure to which they are attached under forward inertia forces acting parallel to the thrust line.

20. Safety belts and harness

(i) (a) *Belt or harness for pilot(s), including pupil (if any).*—The attachments must be capable of carrying the ultimate loads due to the following accelerations acting separately or together on the pilot.—

$$7g \text{ forwards}$$

$$\frac{Ng}{2} \text{ upwards.}$$

(b) *Belt or harness (see sub-para. (ii) (g) below) for all other members of the crew.*—The attachments must be capable of carrying the ultimate loads due to the following accelerations acting separately or together on the crew.—

$$2g \text{ forwards}$$

$$\frac{Ng}{2} \text{ upwards.}$$

(ii) *Notes.*

(a) N is the specified C.P. forward ultimate factor, or twice the factored acceleration in the specified down gust case, whichever is the greater.

(b) The forward direction is defined by the airscrew axis. The upward direction is at right angles to this.

(c) The pilot and crew are to be assumed to weigh 200 lb. each if wearing a seat type parachute; otherwise 180 lb. is to be assumed.

(d) Proper provision is to be made for carrying the loads through to the main airframe. It is desirable that the airframe should be stronger than the attachment lugs so that the latter would break first.

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(e) If the belt or harness is attached to the seat, and if the wearer normally sits upon his parachute, then the strength of the connection between seat and airframe is to be greater than that between belt and seat. This requirement arose out of an accident in which the seat connections broke and the pilot was thrown out still attached to the seat and consequently unable to use his parachute.

(f) Requirement (i) (b) applies to belt and harness attachments in rotating gun turrets. The loads are to be taken through the rotating mechanism on to the main airframe.

(g) Gunners and other members of the crew are not necessarily belted down into their seats the whole time as their duties require them to move about. The restraint when the belt is not used is by a wire or adjustable strap carried down to a strong point in the floor. The requirement of paragraph (i) (b) applies also to this strong point.

21. Subsidiary structure

Seats, bomb racks, generator attachments, fittings for stretchers, etc., must have at least the same factor as the main structure in all the appropriate stressing cases. Local loads at points of attachment to the main structure should be carefully considered to ensure that the main structure is not unduly weakened thereby.

22. Lateral stability of spars when unsupported over a length of two rib spacings

When the construction of main planes and tail planes is such that failure of a single rib by accidental damage or otherwise increases the length of the spar without lateral support, then such main planes and tail planes must comply with all specified strength requirements, with full factor, when the spars are entirely unsupported laterally over a length of two rib spacings the unsupported length being in the most adverse position.

23. Ancillary equipment

The ultimate factor for platforms or similar parts included in the aeroplane structure and for any item of ancillary equipment supplied by the contractor for lifting or supporting an engine, freight, personnel, etc., is to be not less than 4. If the item is so constructed that its strength cannot be accurately calculated from existing data it is to be subjected to a proof load equal to twice the maximum static load it is required to withstand. The inscription "Safe for loads up to (here insert the maximum static load figure)" is to be painted or otherwise marked on each such item at a clearly visible spot.

24. Ribs

(i) The strength of the main plane ribs is to be demonstrated by a mechanical test reproducing with reasonable accuracy the load distribution along the chord corresponding to the various flight conditions considered. If the spars to which the rib is attached are particularly flexible in the plane containing the spar minor axis, the rib test should be arranged to give an end load and/or torque along the inter-spar length of the rib representing the stabilizing force exerted by the rib on the spar.

(ii) A mechanical test for tail plane ribs will only be necessary when these ribs differ considerably from types whose strength characteristics are known.

(iii) These mechanical tests are to conform to the conditions stated in Chapter I, para. 3. Correction down to the standard component conditions will seldom be possible so that the 20 per cent. extra factor expedient will usually have to be adopted.

(iv) Vibration tests on metal ribs will also be required under approved conditions.

25. Openings in wing coverings

The existence of openings in the coverings of a wing may effect the static pressure within the wing to such an extent that the normal rib loads are exceeded very considerably. The making of permanent openings in the coverings of aeroplane wings (or control surfaces) is therefore to be avoided. Should this not be possible, the appropriate loads must be provided for when designing the ribs, so that the factor under such conditions shall not fall below the required standard. Alternatively, the form of construction at points where openings occur is to be such that the passage of air to or from the interior is prevented.

26. Beaching chassis and tail trolley of boat seaplanes (*see* also para. 17)

The main beaching chassis and tail trolley of a boat seaplane are to have an ultimate factor of 3 with the boat seaplane at full normal load under the following conditions.—

- (i) when standing on a level concrete apron ;
- (ii) when the main wheels of the chassis have just passed over the crest of a $7\frac{1}{2}^{\circ}$ slipway.
- (iii) when standing on a $7\frac{1}{2}^{\circ}$ slipway with the main wheels chocked.

27. Fitting of ring cowlings

Aerodynamic forces on ring cowlings obtained from wind tunnel experiments do not form a sufficient criterion for calculating the necessary strength of the ring and its attachments. Other loads such as those due to turbulence of the air behind the airscrew, engine vibration, landing shocks, etc., not susceptible to precise calculation will come upon the ring. The ring and its attachments should therefore be examined from a general engineering point of view and should be given ample strength in this respect as well as sufficient strength to take the maximum estimated anti-drag forces arising in terminal velocity conditions. The ring attachments to the engine should make provision for expansion.

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