TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 581

LOAD ASSUMPTIONS FOR CALCULATING THE STRENGTH OF AIRPLANES

From D.V.L. Building Specifications for Airplanes

Washington
September, 1930

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 581.

LOAD ASSUMPTIONS FOR CALCULATING THE STRENGTH OF AIRPLANES.*

The following load assumptions shall be taken as the basis of the strength calculations. Deviations from the load assumptions are allowable or necessary, however, when based on incontestible investigations and approved by the D.V.L. (German Institute for Aeronautical Research). (9001**)

Certain definite load conditions (e.g., of flight, control, landing and transport) shall be assumed. The loads thus occasioned shall be the safe loads, that is, it is assumed that they may occur in the operation of the airplane. (9002)

The loads shall be assumed to be constant or only slowly variable. Inertia forces due to elastic deformation are accordingly disregarded. The external forces, the force of gravity and the inertia forces on the whole airplane shall produce a condition of equilibrium. (9003)

The safe loads referred to in 9002 can be increased by unfavorable conditions of various kinds. This increase is taken care of by the introduction of a safety factor s_S against exceeding the yield limit. (Cf. 9005.) Another safety factor

*"Belastungsannahmen für die Festigkeitsberechnung von Flugzeugen." From D.V.L. Building Specifications for Airplanes.
**Number of the original specification.

s_{Br} is necessary, in order to keep the stress, with a safe load, at the corresponding distance from the ultimate load (Cf. 9008). Regarding safe stresses in the materials, see "Building Specifications for Airplanes" 5501, etc. (9004)

The following sources of error necessitate the safety factor against exceeding the 0.2 limit s_{02}: (The 0.2 limit is the stress after the removal of which an elongation of 0.2% remains.)

1. Inaccuracies and incompleteness of calculation, of design and of construction, and defects in the material. These are provided for by the introduction of a safety coefficient $s_{S_1} = 1.10$.

2. Changes in the material while in use (corrosion, etc.). These are provided for by the introduction of a safety factor $s_{S_2} = 1.10$.

3. Deviations of the load assumptions from the load conditions actually occurring in practice. These are provided for by the introduction of a safety factor $s_{S_3} = 1.15$.

From the above, we obtain the combined safety factor against exceeding the 0.2 limit

$$s_{02} = s_{S_1} \times s_{S_2} \times s_{S_3} = 1.4 \qquad (9005)$$

The load tests of new airplanes or their structural components shall be made with the $s_{S_2} \times s_{S_3} = 1.26$ times the calculated safe load. There must not be any permanent deformations exceeding 5% of the total deformations occurring under 1.26 times the safe load. Before the regular load test the structural component shall be subjected to a preliminary load of 50% of the safe load. Any permanent deformation from this preliminary test shall be determined, but not taken into consideration. The preliminary assumption for the admissibility of all the permanent deformations is that they do not occur in any part in which slight deformations are dangerous. In loading tests of used airplanes or their structural components, the safety factor s_{S_2} can be reduced somewhat (not to exceed 1) on agreement with the D.V.L. (9006)

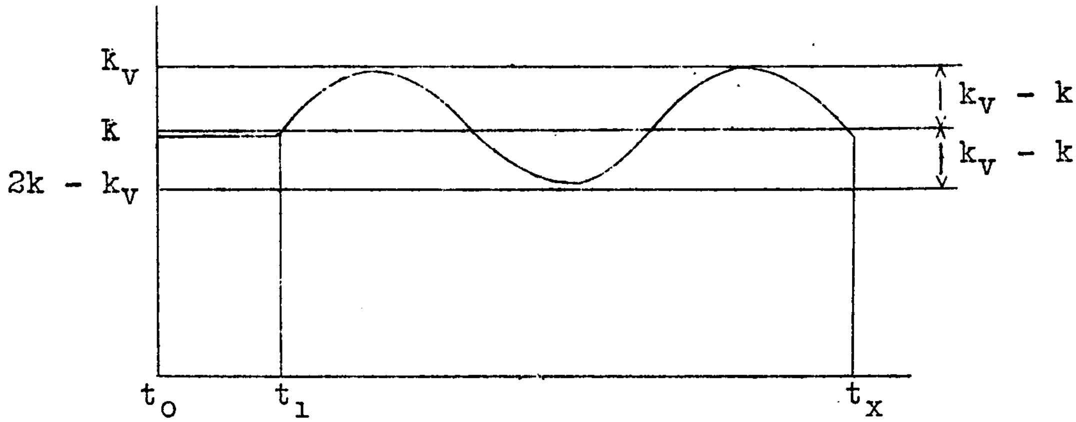
Loading tests must show that, for every structural component in the safe load condition, the safety factor against failure is at least 1.8. The ratio of the ultimate load to the safe load shall be regarded as the structural safety factor. If a part is given a static load test, the load it can support for a minute before breaking shall generally be regarded as the breaking or ultimate load. (9007)

In statically vital joints provision shall be made by suitable oversizing for additional stresses which may occur through attendance, assembling, or during flight. (9008)

Any vital airplane part, whose strength cannot be definitely determined by calculation, shall be subjected to a loading test. Any part shall be regarded as statically vital, whose failure reduces the structural safety factor of the airplane at any point to half the required safety factor. The test for statically vital parts shall be made, for the stress groups 1, 2 and 3, only for the A and B flight cases, and for the stress groups 4 and 5 for all the flight cases. (9009)

Deviations from the safety factors given under the specification numbers 9005-9008, shall be taken into account in the load assumptions for landing gears (9104), flotation gears (9145), fuselages (9153), power plants (9163) and equipment (9172). (9010)

For structural parts subjected to vibrations, such as power-plant installations, wing and tail-surface connections (in which regular stress variations occur about a fatigue stress due to a permanent load condition), there must not occur, in any safe continuous load condition, any stress exceeding 0.8 of the vibration strength. "Continuous load conditions" shall be understood to mean the conditions of normal flight, but not load conditions where there are high transient accelerations. "Vibration strength" (k_v) shall be understood to denote the maximum stress which the material can withstand without impairment in the case of frequent load oscillations about the constant load k between the values k_v and $2k - k_v$ (See figure). In determining the vibration strength, special conditions, resulting from the shaping and working of the material, must be taken into account.



In the time interval from t_o to t_1 the part suffers a static stress k from the constant static load. After reaching t_1, k is increased by a vibrational stress $k_v - k$, due to some vibration source, such as an engine.

The airplanes shall be divided, according to the anticipated flight stresses, into the following groups:

Group 1 - Airplanes for very small stresses.
" 2 - " " small stresses.
" 3 - " " normal stresses.
" 4 - " " high stresses.
" 5 - " " very high stresses.

(9020)

Notation

G (metric tons),	gross weight used as basis of calculations.
m $\left(\frac{kg}{m} s^2\right)$,	mass of airplane (corresponding to G).
F (m^2),	wing area.
t (m),	wing chord.
$c_{a\ max}$,	maximum positive lift coefficient.
$c_{a\ min}$,	maximum negative lift coefficient.
V_L (km/h),	landing speed.
v_L (m/s),	" "
$v_{A\ to\ E}$ (m/s),	speeds in flight cases A to E.
v_H (m/s),	maximum horizontal speed at sea level.
q (kg/m^2),	dynamic pressure.
M_x (kg-m),	moments.
n,	load factor.
c,	general coefficients.
e,	impact factor.
P (kg),	force.
S,	center of gravity (C.G.).
l, (m),	length.
A (m-kg),	energy absorbed.
s,	safety factor.
P_s (kg),	traction (towing). (9026)

For the distribution of the gross weight, see DIN (German Engineering Standards) L 22. (9027)

in which G is expressed in kilograms. For rough estimates $c_{g_A} = c_{a_A}$ can be used. The lift coefficient c_{a_A} shall be taken from the polar curves.

Case B.- The safe load factor is

$$n_B = 0.67\ n_A$$

The point of application of the load shall be coordinated to the lift coefficient

$$c_{a_B} = 0.22\ c_{a_A}.$$

From this we obtain:

The safe dynamic pressure $q_B = 3.00\ q_A$

The safe gliding speed $v_B = 1.75\ v_A$ (9033)

Case C.- The safe dynamic pressure shall be put equal to the final dynamic pressure, not exceeding $q_C = 4.00\ q_A$, however. Hence the safe flight speed equals the final speed, but not to exceed $v_C = 2.00\ v_A$. The point of application of the load shall be determined by the value $c_{a_C} = 0$. Under the action of the safe dynamic pressure, the distortion of the wing shall not exceed 3.5° at any point. (Experimental verification is allowable.) If the distortion is greater, proof may be required that no wing fluttering can result. (9034)

Case D.- The safe load factor is

$$n_D = \sim 0.33\ n_A$$

The application of the load shall be coordinated to the lift coefficient

$$c_{a_D} = -\ 0.11\ c_{a_A}.$$

From this we obtain:

The safe dynamic pressure $q_D = 3.00\ q_A$

The safe gliding speed $v_D = 1.75\ v_A$ (9035)

Case E.- (only for stress groups 4 and 5).- This case shall be considered only when the wing polars show negative lift values exceeding $c_a = -\ 0.3$. This case requires the determination of the profile coefficients (c_a, c_w, and c_m) down to the smallest lift coefficient $c_{a\ min}$. For its reliable determination, it is necessary to make profile tests to an angle of attack of about -70°. The point of application of the load shall be chosen to correspond to the maximum negative lift coefficient $c_{a\ min} = c_{a_E}$. The safe load factor is

$$n_E = -\ 0.50\ n_A.$$

From this we obtain:

The safe dynamic pressure $q_E = \dfrac{n_E \times \frac{G}{F}}{c_g}$

The safe levelling off speed $v_E = 4 \times v\ \dfrac{E}{q_E}$ (9036)

Landing case.- All the parts of the wing structure, including all installations, shall be calculated with no lower safety factors than those required for the landing gear or flotation gear. (9037)

Strength of trailing edge.- The trailing edge must be able to withstand at any point a safe force of at least 7.5 kg perpendicular to the wing chord. (9038)

Load Distribution

The distribution of the air forces on the wings shall correspond to the results of the wind-tunnel tests. It would be expedient to use for this purpose the form sheets prepared by the D.V.L. (9041)

The distribution of the air forces per square meter shall be so adjusted along the wing span that the lift coefficient will be constant in the central portion of the wing, provided a less favorable load distribution does not have to be adopted, due to a special form of wing. On the other hand, the assumption is permissible, that the lift coefficient is reduced one-half toward the wing tip, beginning at a point where the length of the chord is equal to its distance from the wing tip. (9042)

The air-force distribution along the wing chord shall be made on the basis of the wind-tunnel data of the profile used. Lacking these, the suitably adapted simplified assumptions of Heimann and Madelung may be used (Cf. Technische Berichte, Vol. I, page 81). (9043)

Load Assumptions for the Tail Surfaces

(Under revision)

Horizontal Tail Surfaces

The mean safe load of the tail shall be determined, from the equilibrium conditions (balancing of the longitudinal moments), from flight cases A to E for the wing structure. It is advisable to use the form sheets prepared by the D.V.L. for determining the stability. (9051)

The safe moment M_{H_1} determined from the balancing of the longitudinal moments is superposed by an additional safe moment due to control errors which increases the mean tail load. This additional moment, in the B case, is

$$M_{H_2} = 0.02\ q_B\ F^{1.5}.$$

The total moment to be exerted by the horizontal tail surfaces in the B case, is

$$M_H = M_{H_1} + M_{H_2}$$

No supplementary loads, due to control errors, shall be accepted in cases A, C, D and E. (9052)

Vertical Tail Surfaces

On airplanes with central power plant, the total mean safe tail-surface load shall be found from the safe turning moment about the vertical axis

$$M_S = 0.012\ q_B\ F^{1.5}$$

On an airplane with a decentralized power plant, it is necessary to choose the less favorable of the two load assumptions, from the case under 9056 or from the fact that a turning moment is produced about the vertical axis, due to the stopping of the engine or engines on one side. The thrust at a fixed point shall be adopted as the effective thrust. (9057)

A i l e r o n s

The mean safe load shall be determined from the pressure distribution in case B or C. In case B it will be superposed by a safe turning moment about the longitudinal axis of the airplane resulting from the operation of the controls

$$M_Q = 0.012\ q_B\ F^{1.5}.$$

C o n t r o l s

The strength of the elevator and rudder controls and their supports, under direct hand operation of the controls, shall be calculated according to the following assumptions.

a) Elevator.- 50 kg (110 lb.) safe hand pressure with symmetrical application to the control column.

b) Ailerons.- With control stick, 25 kg (55 lb.) safe hand pressure; with control wheel, turning moment of at least 40 d (kg m).

c) Cases a and b, when in superposition, shall have 75% of their individual forces.

d) Rudder.- A safe foot pressure of 50 kg (110 lb.) on either end of the rudder bar. As support for pilot in hard landings: a safe foot pressure of 100 kg (220 lb.) on either end of the rudder bar.

e) In dual control, when both controls are used simultaneously, the strength test shall show 75% of the individual forces. (9066)

The strength of all the control parts shall be adapted to the loads on the controls. (9067)

Load Distribution

The applied forces and the load distribution on the tail surfaces shall be determined from model tests or from experiments by the customary aerodynamic methods. The following cases must be considered.

a) The case of a neutral elevator and large angle of setting of the stabilizer at which the center of pressure is well advanced..

b) The case of a deflected elevator and a small positive or negative angle of setting of the stabilizer at which the center of pressure lies farther back. (9071)

Lacking the results of model tests or equivalent investigathe force required to operate the controls shall be used to overcome their friction. Experimental proof is permissible. (9083)

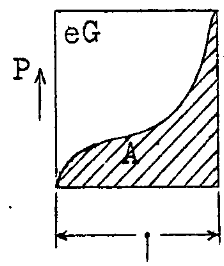
Load Assumptions for the Landing Gear

a) Energy Absorption by the Main Landing Gear, referred to case 9122 (from errata sheet).

The requisite energy absorption for impacts perpendicular to the engine axis is $A = c\ m\ v_L^2$.

c = 0.0030	for	stress	group	1
c = 0.0045	"	"	"	2
c = 0.0055	"	"	"	3
c = 0.0070	"	"	"	4
c = 0.0045	"	"	"	5

Energy absorption



Elastic deformation

Safe impact factor e follows from area of diagram for requisite energy absorption.

	Safety factor
Axle or corresponding part	1.45 to 1.55
Wheels and rest of landing gear	1.55 " 1.65
Rest of airplane	1.8
Motion guard	2.3

Ultimate strength = safe impact factor e x safety factor. (9101)

b) The figure for the superposition of 9123 and 9124 is to be assumed as horizontal corresponding to 9122 (from the errata sheet).

A diagram of the energy absorption must be plotted or calculated for the landing gear. The safe impact factor and the total spring travel (shock absorber plus tire) shall be determined from the diagram area corresponding to the requisite energy absorption. (9102)

In calculating the various parts of the landing gear, the safe impact factors shall be multiplied by the safety factors.

s_a = 1.45 - 1.55 for the axle or other parts designed for absorbing energy.

s_b = 1.55 - 1.65 for the wheels and the rest of the landing gear with the exception of the motion guard.

s_c = 1.8 for the rest of the airplane.

s_d = 2.3 for the motion guard.

If greater values are chosen for s_a and s_b, the remaining values must be proportionately increased. (9103)

Energy Absorption by the Tail Skid

In order to determine the requisite energy absorption, the vertical pressure of the skid (with the airplane resting on three points) divided by G is substituted for the mass of the airplane in the formula for the energy absorbed by the main landing gear. (9111)

The safe load factor e_{sp} for the skid and the requisite travel of the spring is determined from the energy diagram area as the energy absorption for the skid. (9112)

For the calculation of the skid and its support, the safe impact factors shall be multiplied by the safety factors:

s_b = 1.55 - 1.65 for the skid and

s_c = 1.8 for its support in the fuselage. (9113)

Load Cases

Three-point landing.- The wheel and skid pressures, as likewise the safe gross weight e G, are perpendicular to the plane of landing. (9121)

Normal wheel landing.- The external forces and safe gross weight e G pass through the C.G. of the airplane. (9122)

One-wheel landing.- The forces are distributed on the landing gear as in 9122, the safe airplane weight and reaction being 0.5 eG. (9123)

Lateral landing shock. only in superposition with 9123 to be introduced with 100% of the value of the individual loads. The airplane has a lateral motion in addition to the forward motion. The safe gross weight, acting both perpendicularly to the engine axis and horizontally, shall be represented by 0.1 eG. The reaction is against the lowest point of the wheel and in the direction of its axle. (9124)

Nose landing.- The nose of the fuselage is close to the ground. The safe airplane weight is 2G. The lines of force are vertical. (9125)

Towing.- The airplane is dragged backward with the wheels and skid on the ground. The vertically acting safe airplane weight of 1.5 G shall be represented as passing through the C.G. of the airplane. The reaction of the wheel slopes toward the nose of the fuselage at an angle of 15° to the vertical. The towing force P_S is applied to the skid. (9126)

Skid.- In skid calculations the requisite energy absorption according to 9111-9113 must be taken into account. (9127)

Lateral forces of skid.- In calculating the lateral forces of the skid occasioned by the taxying of the airplane, a horizontal safe load amounting to

$$0.15\ e_{sp}\ G_{sp}$$

shall be assumed as acting on the gliding surface of the skid perpendicularly to the longitudinal axis of the airplane. (9128)

Load Assumptions for the Flotation Gear

Impact Factor

The safe impact factor for the ordinary flat-bottom shape shall be assumed to be

$$e = c_o \frac{1 + a}{1 + a + a^2} V_L^{1.5}$$

$c_o = \frac{1}{125}$ for seaplanes designed for alighting on coastal and inland waters up to seaway 3.

$c_o = \frac{1}{95}$ for seaplanes designed for alighting on the high seas above seaway 3.

$$a = \frac{4}{\sqrt[3]{G}} .$$

Load Cases

I. Normal landing.- a) bow landing; b) step landing;
c) stern landing.

II. One-sided landing.- a) bow landing; b) step landing;
c) stern landing.

III. Side landing, only combined with II, lateral angle 1 : 2.
a) bow landing; b) step landing; c) stern landing.

The magnitude of the landing impacts to be assumed, as also their point of application and their direction can be determined from chart 9136. P = 0.08 eG (from errata sheet). (9136)

The effect of the V shape in the various load cases will be represented by the factor $c_1 = 1 - 0.7 \cos \frac{\beta}{2}$ (β = keel angle at point of impact). (9137)

The effect of a special bottom shape can be represented at the individual points of impact by a factor c_2 whose magnitude must be determined from experimental data. (9138)

The safety factor for the float superstructure as well as for the floats themselves is taken as 1.55, when the safety factor for rest of the airplane is 1.8. The standard safety factor for boat seaplanes is 1.8. (9139)

Parts belonging both to the flotation gear and to the wings, shall be calculated for the maximum forces developed in flight or in landing. (9140)

Bottom Pressure

The maximum bottom pressure for calculating the local strength at the main step is determined from the impact pressure at the step increased by 50% and distributed over 20% of the float area. (9146)

The bottom pressure at other points is determined on the basis of 9146 (see also 9136). (9147)

Load Assumptions for Fuselages and Hulls

The fuselage calculation shall be based on the following forces: a) Flight conditions A - E shall be investigated with the corresponding forces of inertia and of the horizontal tail surfaces; b) The force of the vertical tail surfaces acts alone; c) The force of the vertical tail surfaces is superposed by case B or C and both by 75%. (9151)

In landing, account shall be taken of all inertia forces with the safe impact factors for the landing or flotation gears.. (9151)

When a seaplane capsizes or lands on its nose, the forces acting on the nose of the fuselage shall be introduced with a safe load of at least 1.5 G. The safety factor for the foremost structural components shall be put at 1.55 and increased to 1.8

at the front end of the passenger cabin. If the nose of the fuselage is designed to be occupied by passengers, the safety factor shall then be 1.8 for the most advanced structural components. (9153)

Moreover, for landplanes up to five tons (metric), the inverted position must be considered. The airplane then rests on the top of its nose and on the highest structural component (upper wing, guard stirrup, rudder). Safe airplane weight of 2G. Lines of direction vertical. (9154)

Load Assumptions for the Power Plant

The power-plant installation shall be calculated for the maximum forces developed in flight or in landing. (9161)

The engine housing shall be subjected only to such forces as the engine type tests have shown to be permissible. (9162)

Safe load rotating at a fixed point.- The following forces act simultaneously:

Weight of engine, radiator and propeller;

Maximum propeller thrust;

Maximum engine torque.

In this case the safety factor is 3. (9163)

Safe Load in Flight

a) Levelling off with throttled engine.- The weights of the engine, radiator and propeller act simultaneously, together with the load factors of the wings in Case A.

b) Levelling off with peak performance of engine.- The following forces act simultaneously, in addition to the forces mentioned under a):

Maximum propeller thrust;

Maximum engine torque.

Propeller gyroscopic moment (narrowest vertical curve).

(9164)

Safe Load in Landing

a) Normal landing.- Position of airplane corresponding to 9121 and 9122. Safe load factor for engine, radiator and propeller not less than safe impact factor of landing gear on landplanes, flotation gear on float seaplanes, or of the boat or hull on boat seaplanes. Lines of direction as in 9121 and 9122.

b) Oblique sidewise landing.- Position of airplane corresponding to 9123 and 9124. (9165)

Load Assumptions for Installations

The safe load factor for stationary and movable installations (tanks, instruments, etc.) must correspond to the maximum safe flight and landing stresses. (9171)

provided for by the introduction of a safety factor $s_{S_1} = 1.05$.

2. Deviations of the load assumptions from the load conditions actually occurring in practice. These are provided for by the introduction of a safety factor $s_{S_2} = 1.05$.

From the above we obtain the combined safety factor against exceeding the 0.02 limit

$$s_{0.02} = s_{S_1} \times s_{S_2} = \text{about } 1.1.$$

(Point 2 of the original specification 9005 is hereby annulled.)

(9005)

The load tests of airplanes or their structural components shall be made with $s_{S_2} = 1.05$ times the calculated safe load. There must not be any permanent deformations exceeding 5% of the total deformations occurring under 1.05 times the safe load. There must be an interval of 24 hours between test and check of form changes. Before the regular load test, the structural component shall be subjected to a preliminary load of 50% of the safe load. Any permanent deformation from this preliminary test shall be determined, but not taken into consideration. The preliminary assumption for the admissibility of all the permanent deformations is that they do not occur in any part in which slight deformations are dangerous. (The last part of the original specification 9006 is hereby annulled.) (9006)

The last part of specification 9007 shall read as follows: If a part is given a static load test, the load it can support for at least a minute before breaking shall generally be regarded as the ultimate load. (9007)

Specification Nos. 9008-9010 remain unchanged.

In structural parts subjected to vibrations, such as power-plant installations, wing and surface connections (in which regular stress variations occur about a fatigue stress due to a permanent load condition), 0.8 times the fatigue strength k_v shall not be exceeded.

"Continuous load conditions" shall be understood to mean the conditions in normal cruising flight, but not load conditions where there are high transient accelerations.

"Fatigue strength" k_v shall be understood to mean the maximum stress to which the material is subjected in the case of frequent load oscillations about the normal stress k between the values k_v and $2k - k_v$.

In determining the fatigue strength, special conditions, resulting from the shaping and working of the material, must be taken into account. (9011)

SUPPLEMENT II.

Load Assumptions for the Tail Surfaces

Horizontal Tail Surfaces

The mean safe load of the tail surfaces shall be determined, for the flight cases A-E, from the balancing of the longitudinal moments. Therefore

$$M_{H_1} = c_m\ q\ F\ t$$

q represents the safe dynamic pressure of the case concerned. c_m is the moment coefficient of the wing with respect to the C.G. (dependent on the angle of attack). F is the wing area and t the chord. (9051)

The extreme positions of the center of gravity in actual flight shall be determined experimentally, and the moment balance shall be calculated for both positions. In each case the greater absolute value of c_m shall be used for the calculation of M_{H_1}. (9052)

The safe moment M_{H_1}, as determined from the balance of the longitudinal moments, is superposed by a safe added moment, due to control errors, which increases the mean load of the tail surfaces. In the B case, this added moment amounts to

$$M_{H_2} = 0.02\ q_B\ F^{1.5}$$

In the B case, the total moment to be exerted by the horizontal tail surfaces is

$$M_H = M_{H_1} + M_{H_2}$$

In cases A, C, D and E, no added loads due to control errors are assumed.

Load Distribution on Horizontal and Vertical Tail Surfaces

The points of application of the forces and the load distribution on the tail surfaces shall be determined from model tests or by means of recognized methods of aerodynamic investigation. In this connection there shall be considered:

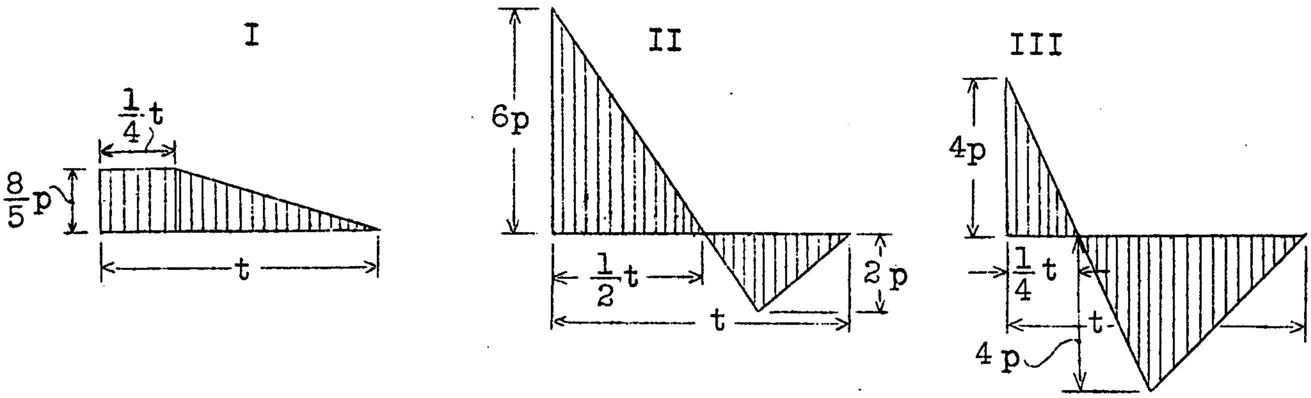
a) The case of the neutral position of the movable tail surface and a large angle of setting of the corresponding fixed surface, at which the C.P. is well advanced.

b) The case, the deflected position of the movable tail surface and a small positive or negative angle of setting of the fixed surface, at which the C.P. is farther back. (9066)

Lacking model tests or equivalent investigations, the following distributions shall be assumed, up or down according to the flight case:

a) Laterally: Rectangular load distribution based on the unit of area.

b) Vertically:



t , chord of combined fin and rudder (or stabilizer and elevator).

p , load per unit area with uniform load distribution. Hence

$$p = \frac{M}{F_1 \quad l_1}$$

M , moment about C.G. corresponding to 9053 and 9056.

F_1 , area of fin and rudder (or stabilizer and elevator).

l_1 , distance of leading edge of empennage from C.G. of airplane.

Load distribution III only for 9053.

The load ordinate on the leading edge of the rudder (or elevator) is found by extending the loading line forward along the rudder (or elevator) chord. (9067)

The load distribution on the ailerons: triangular rearward to O. (9068)

R i g i d i t y

The trailing edge of the tail surfaces must be able to withstand at every point a force of 7.5 kg (16.5 lb.) perpendicular to the chord. (9071)

C o n t r o l s

The strength of the elevator and rudder controls and their supports, under direct hand operation of the controls, shall be calculated according to the following assumptions.

a) Elevator.- 50 kg (110 lb.) safe hand pressure with symmetrical application to the control column.

b) Ailerons.- With stick control, 25 kg (55 lb.) safe hand pressure; with wheel control, turning moment of at least 40 d mkg. This turning moment may drop to 30 d mkg, if the maximum control pressure, increased by 25%, does not attain this value.

c) Cases a and b, even in superposition, shall have 75% of their individual forces.

Moreover, for cases a and b with wheel control, the control column, with handwheel and shaft and their supports, shall be tried for one-sided force application with one hand and indeed with half of the above-mentioned safe hand pressures.

d) Rudder.- A safe foot pressure of 50 kg (110 lb.) on either end of the rudder bar. As support for pilot in hard landings, a safe foot pressure of 110 kg (242 lb.) on either end of the rudder bar.

e) In dual control, when both controls are used simultaneously, the strength test shall show 75% of the individual forces. (9075)

The strength of all the control parts shall be adapted to the loads on the controls. (9076)

Load Assumptions for the Power Plant

In specification No. 9165 the following wording is suggested:

Safe Load in Landing

e = safe impact factor of landing gear or of flotation gear.

a) Normal landing.- Direction of force and position of landplanes corresponding to 9122. Direction of force and position of seaplanes corresponding to 9136, I b. Safe load factor for the power-plant components at least equivalent to e.

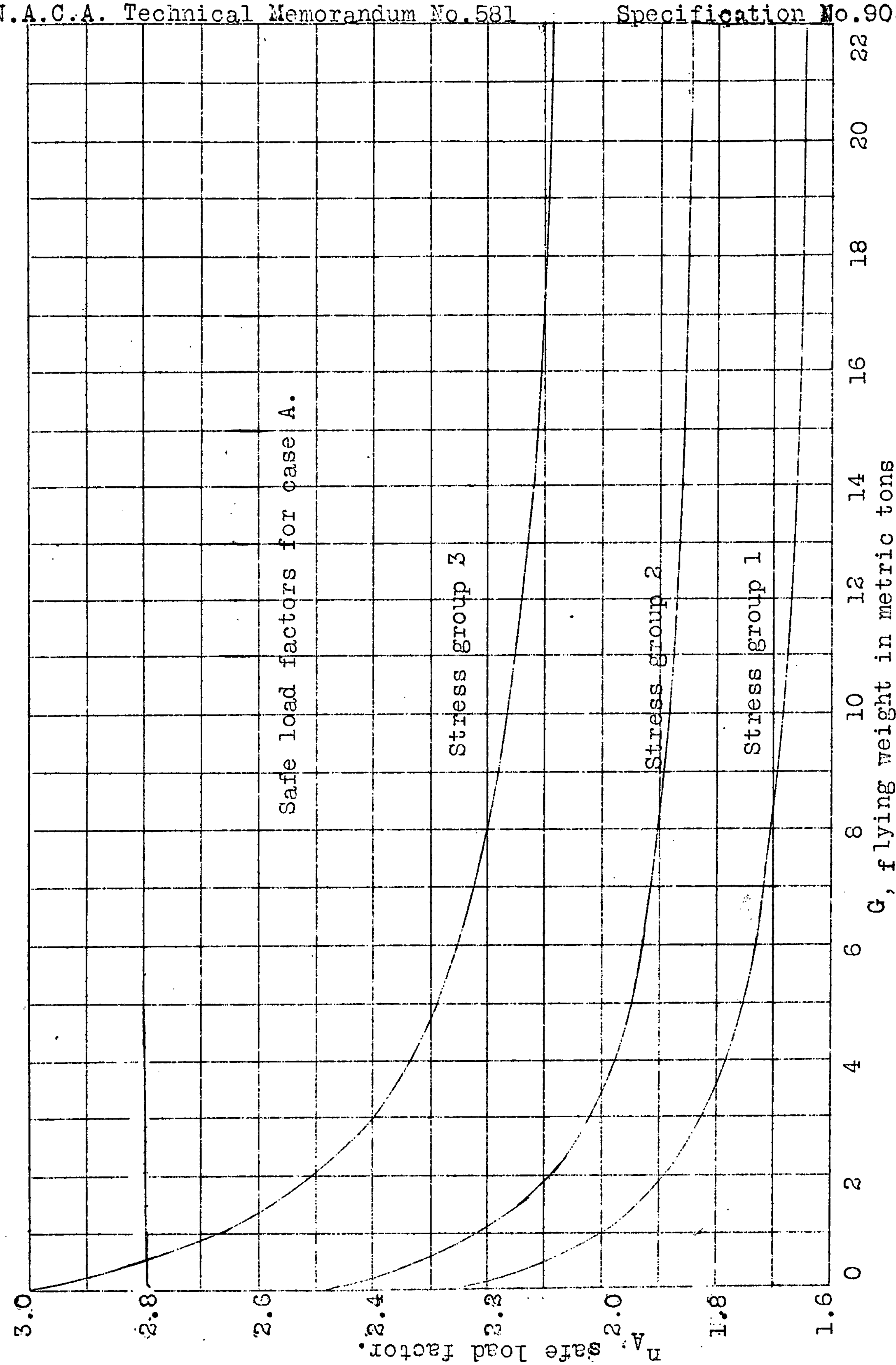
b) Oblique sidewise landing.- The load conditions are superposed by 100% of the individual forces: on landplanes corresponding to 9123 and 9124; on seaplanes corresponding to 9136, II b and III b.

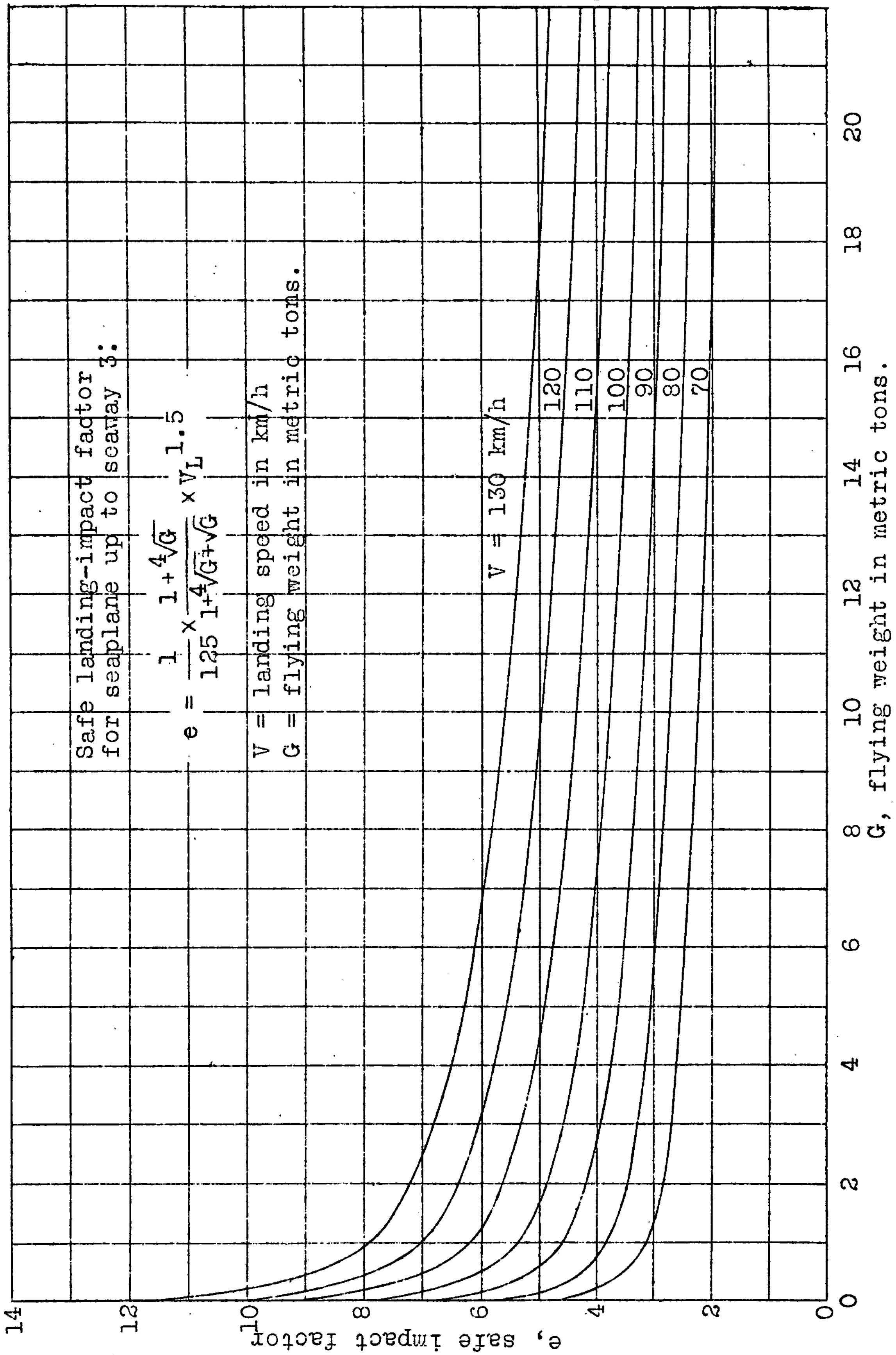
For the energy absorption under 9101, the following is to be substituted:

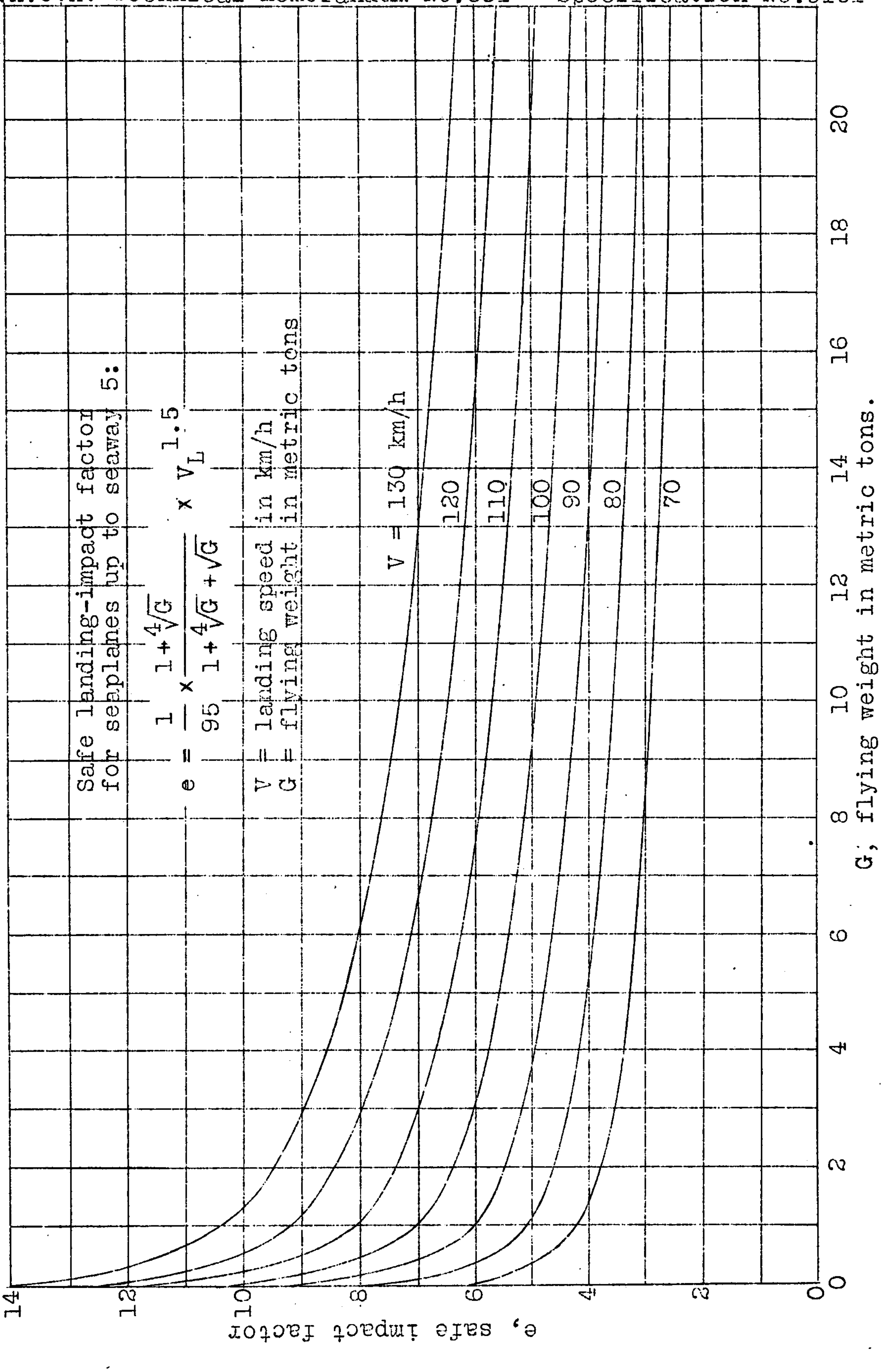
The requisite energy absorption, with impact direction corresponding to the landing case 9122, is

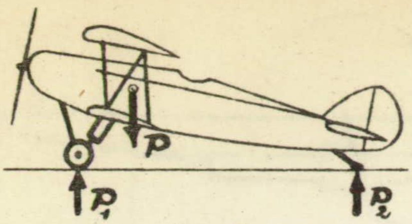
$$A = c\ m\ v_L^2 .$$

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.

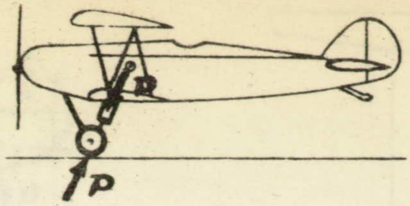

Safe load factors for case A.
Stress group 3
Stress group 2
Stress group 1
G, flying weight in metric tons
0
2
4
6
8
10
12
14
16
18
20
22
n_A, safe load factor.
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6


Safe landing-impact factor for seaplane up to seaway 3:
$e = \frac{1}{125} \times \frac{1 + \sqrt[4]{G}}{1 + \sqrt[4]{G} + \sqrt{G}} \times V_L^{1.5}$
V = landing speed in km/h
G = flying weight in metric tons.
V = 130 km/h
120
110
100
90
80
70
G, flying weight in metric tons.
e, safe impact factor
0
2
4
6
8
10
12
14
16
18
20

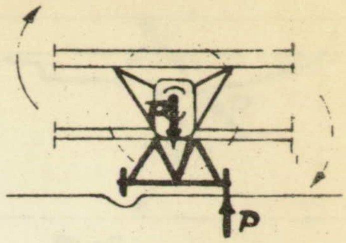

Safe landing-impact factor
for seaplanes up to seaway 5:
$e = \frac{1}{95} \times \frac{1 + \sqrt[4]{G}}{1 + \sqrt[4]{G} + \sqrt{G}} \times V_L^{1.5}$
V = landing speed in km/h
G = flying weight in metric tons
V = 130 km/h
120
110
100
90
80
70
e, safe impact factor
14
12
10
8
6
4
2
0
G, flying weight in metric tons.
0
2
4
6
8
10
12
14
16
18
20



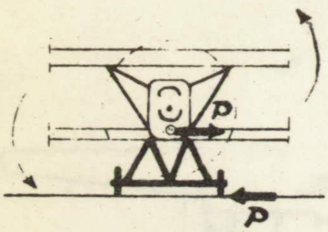
P=eG
9121 Three-point landing



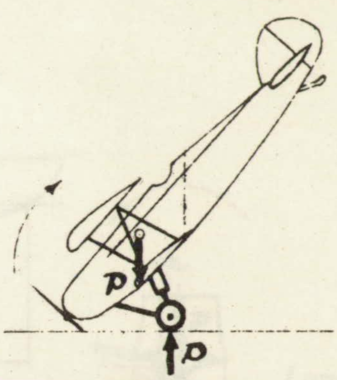
P=eG
9122 Wheel landing



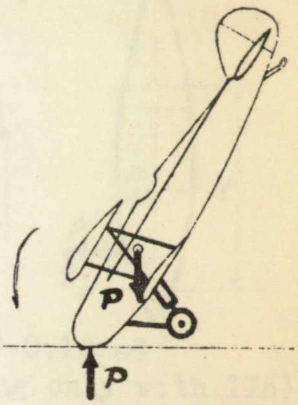
P=0.50 eG
9123 One-wheel landing



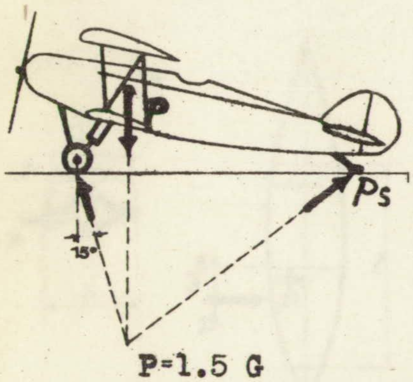
P=0.10 eG
9124 Lateral landing shock



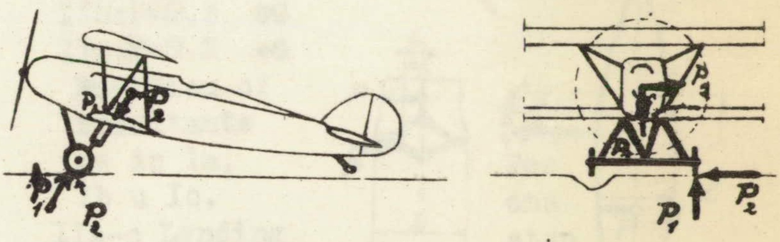
P=2.0 G
9125 Nose landing



P=1.5 G
9153 Bow impact

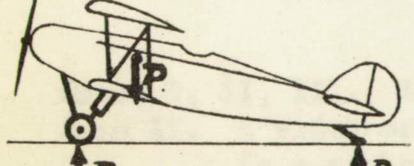


P=1.5 G
9126 Towing



P_1=0.5 eG P_2=0.1 eG
9123 & 9124 Overlapping of individual loads m. 100%

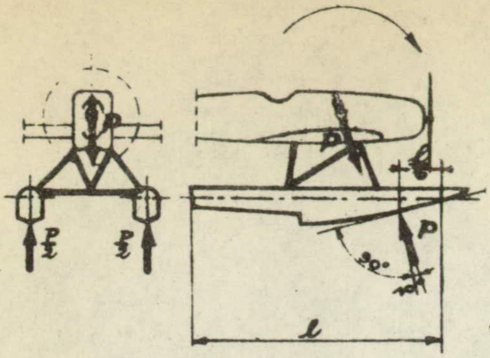
Specification Nos. 9121 to 9128 & 9153



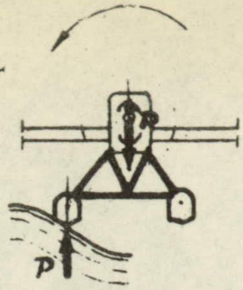
$P_2 = e_{sp}\ G_{sp}$ (9111 & 9112)
9127 Vertical impact of skid

Load cases (safe conditions)

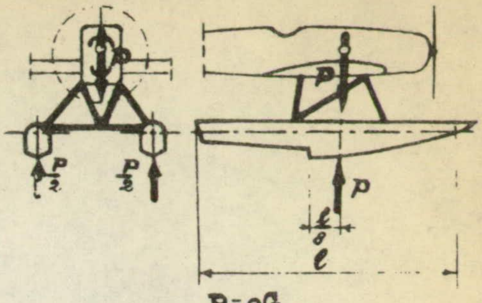
P=0.15 $e_{sp}\ G_{sp}$
9128 Lateral impact of skid



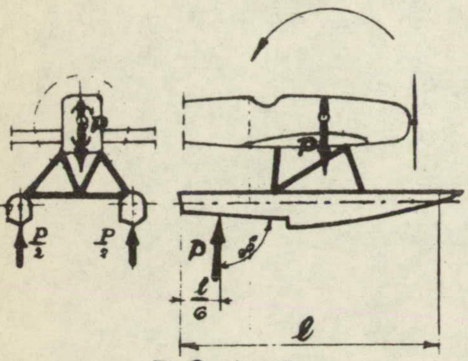
P=0.7 eG
Ia Bow landing



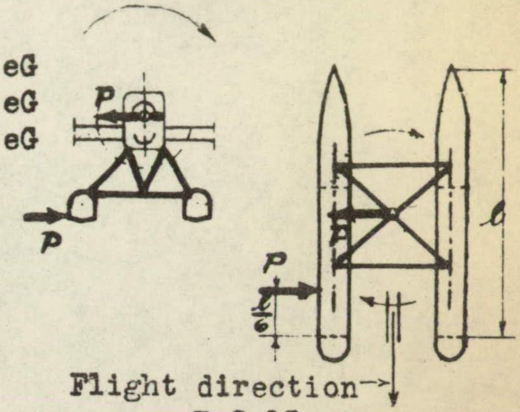
IIa:P=0.35 eG
IIb:P=0.5 eG
IIc:P=0.2 eG
Position of resultants as in Ia, Ib u Ic.
IIa-c Landing on one float



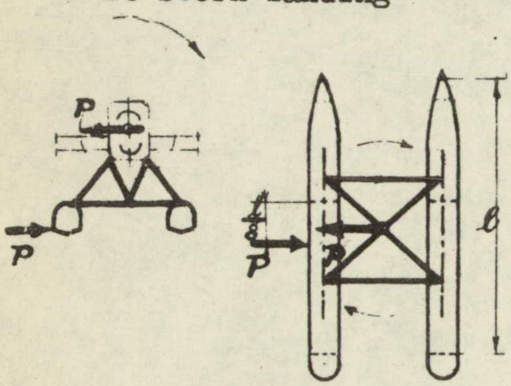
P=eG
Ib Step landing



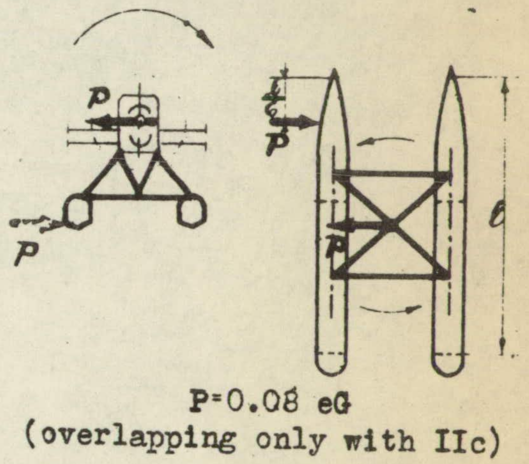
P=0.4 eG
Ic Stern landing



Flight direction→
P=0.12 eG
(overlapping only with IIa)
IIIa Side landing (bow)



P=0.25 eG
(overlapping only with IIb)
IIIb Side landing (step)



P=0.08 eG
(overlapping only with IIc)
IIIc Side landing (stern)

Cases I, II, III. l=water line.
Case II. b width of float or boat with all attached parts (e.g.stubs). According to specifications 9137-8 the impact forces in each load case must be multiplied respectively by c_1 or c_2.

Load cases for float seaplanes