SUBJECT	**:**	**Water Load Conditions**
CERTIFICATION SPECIFICATION	**:**	VLA.521
PRIMARY GROUP / PANEL	**:**	03 (Structure)
SECONDARY GROUPE / PANEL	**:**	--
NATURE	**:**	SCN

SPECIAL CONDITION

Water Load Conditions

VLA.521 is to be replaced by SC VLA.0521-01

SC VLA.0521-01, Water Load Conditions

1.1. General

(a) The structure of seaplanes and amphibians must be designed for water loads developed during takeoff and landing with the seaplane in any attitude likely to occur in normal operation at appropriate forward and sinking velocities under the most severe sea conditions likely to be encountered.

(b) Unless a more rational analysis of the water loads is made, paragraph 1.2. through paragraph 1.9. apply.

(c) The externally applied loads specified in paragraph 1.2. through paragraph 1.9. are based upon treatment of the seaplane (amphibian) as a rigid body. Seaworthiness aspects and loads on individual components should be defined accordingly (see also Appendix 2, AMC to 1.1)

1.2. Design weights and centre of gravity positions

(a) *Design weights.* The water load requirements must be met at each operating weight up to the design landing weight except that, for the takeoff condition prescribed in paragraph 1.6, the design water takeoff weight (the maximum weight for water taxi and takeoff run) must be used.

(b) *Centre of gravity positions.* The critical centres of gravity within the limits for which certification is requested must be considered to reach maximum design loads for each part of the seaplane structure.

1.3. Application of loads

(a) Unless otherwise prescribed, the seaplane as a whole is assumed to be subjected to the loads corresponding to the load factors specified in paragraph 1.4.

(b) In applying the loads resulting from the load factors prescribed in paragraph 1.4, the loads may be distributed over the hull or main float bottom (in order to avoid excessive local shear loads and bending moments at the location of water load application) using pressures not less than those prescribed in subparagraph 1.7(b).

(c) For twin float seaplanes, each float must be treated as an equivalent hull on a fictitious seaplane with a weight equal to one-half the weight of the twin float seaplane.

(d) Except in the takeoff condition of paragraph 1.6, aerodynamic lift on the seaplane during the impact is assumed to be 2/3 of the weight of the seaplane.

1.4. Hull and main float load factors

(a) Water reaction load factors n_w must be computed in the following manner:

(1) For the step landing case:

$$n_w = \frac{C_1 V_{S0}^2}{(\tan(\beta))^{\frac{2}{3}} W^{\frac{1}{3}}}$$

(2) For the bow and stern landing cases:

$$n_w = \frac{C_1 V_{S0}^2}{(\tan(\beta))^{\frac{2}{3}} W^{\frac{1}{3}}} \cdot \frac{K_1}{\left(1 + r_x^2\right)^{\frac{2}{3}}}$$

(b) The following values are used:

(1) n_w = water reaction load factor (that is, the water reaction divided by seaplane weight).

(2) C_1= empirical seaplane operations factor equal to 0.012 (except that this factor may not be less than that necessary to obtain the minimum value of step load factor of 2.33).

(3) V_{S0} = seaplane stalling speed in knots with flaps extended in the appropriate landing position and with no slipstream effect.

(4) β = angle of dead rise at the longitudinal station at which the load factor is being determined, in accordance with figure 1 of Appendix 1.

(5) W = seaplane design landing weight in pounds.

(6) K_1 = empirical hull station weighing factor, in accordance with figure 2 of Appendix 1.

(7) r_x = ratio of distance, measured parallel to hull reference axis, from the centre of gravity of the seaplane to the hull longitudinal station at which the load factor is applied to the radius of gyration in pitch of the seaplane, the hull reference axis being a straight line, in the plane of symmetry, tangential to the keel at the main step.

(c) For a twin float seaplane, because of the effect of flexibility of the attachment of the floats to the seaplane, the factor K_1 may be reduced at the bow and stern to 0.8 of the value shown in figure 2 of Appendix 1. This reduction applies only to the design of the carry-through and seaplane structure.

1.5. Hull and main float landing conditions

(a) *Symmetrical step, bow, and stern landing.* For symmetrical step, bow, and stern landings, the limit water reaction load factors are those computed under paragraph 1.4. In addition:

(1) For symmetrical step landings, the resultant water load must be applied at the keel, through the centre of gravity of loading surface and must be directed perpendicularly to the keel line;

(2) For symmetrical bow landings, the resultant water load must be applied at the keel, one-fifth of the longitudinal distance from the bow to the step, and must be directed perpendicularly to the keel line; and

(3) For symmetrical stern landings, the resultant water load must be applied at the keel, at a point 85% of the longitudinal distance from the step to the stern post, and must be directed perpendicularly to the keel line.

(b) *Unsymmetrical landing for hull and single float seaplanes.* Unsymmetrical step, bow, and stern landing conditions must be investigated. In addition--

(1) The loading for each condition consists of an upward component and a side component equal, respectively, to 0.75 and $0.25 \cdot \tan(\beta)$ times the resultant load in the corresponding symmetrical landing condition; and

(2) The point of application and direction of the upward component of the load is the same as that in the symmetrical condition, and the point of application of the side component is at the same longitudinal station as the upward component but is directed inward perpendicularly to the plane of symmetry at a point midway between the keel and chine lines.

(c) *Unsymmetrical landing; twin float seaplanes.* The unsymmetrical loading consists of an upward load at the step of each float of 0.75 and a side load of $0.25 \cdot \tan(\beta)$ at one float times the step landing load reached under paragraph 1.4. The side load is directed inboard, perpendicularly to the plane of symmetry midway between the keel and chine lines of the float, at the same longitudinal station as the upward load.

1.6. Hull and main float takeoff condition

For the wing and its attachment to the hull or main float--

(a) The aerodynamic wing lift is assumed to be zero; and

(b) A downward inertia load, corresponding to a load factor computed from the following formula, must be applied:

$$n = \frac{C_{TO} V_{S1}{}^2}{(\tan(\beta))^{\frac{2}{3}} W^{1/3}}$$

where

n = inertia load factor;

C_{TO} = empirical seaplane operations factor equal to 0.004;

V_{S1} = seaplane stalling speed (knots) at the design takeoff weight within the flaps extended in the appropriate takeoff position;

β = angle of dead rise at the main step (degrees); and

W = design water takeoff weight in pounds.

1.7. Hull and main float bottom pressures

(a) *General.* The hull and main float structure, including frames and bulkheads, stringers, and bottom plating, must be designed under this paragraph.

(b) *Local pressures.* For the design of the bottom plating and stringers and their attachments to the supporting structure, the following pressure distributions must be applied:

(1) For an unflared bottom, the pressure at the chine is 0.75 times the pressure at the keel, and the pressures between the keel and chine vary linearly, in accordance with figure 3 of Appendix 1. The pressure at the keel (psi) is computed as follows:

$$p_k = C_2 \frac{K_2 V_{S1}{}^2}{\tan(\beta_k)}$$

where

p_k = pressure (psi) at the keel;

C_2 = 0.00213;

K_2 = hull (float) station weighing factor, in accordance with figure 2 of Appendix 1;

V_{S1} = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and

β_k = angle of dead rise at keel, in accordance with figure 1 of Appendix 1.

(2) For a flared bottom, the pressure at the beginning of the flare is the same as that for an unflared bottom, and the pressure between the chine and the beginning of the flare varies linearly, in accordance with figure 3 of Appendix A. The pressure distribution is the same as that prescribed in subparagraph (b)(1) for an unflared bottom except that the pressure at the chine is computed as follows:

$$P_{ch} = C_3 \frac{K_2 V_{S1}^{\;2}}{\tan(\beta)}$$

where:

P_{ch} = pressure (psi) at the chine;

C_3 = 0.0016;

K_2 = hull station weighing factor, in accordance with figure 2 of Appendix 1;

V_{S1} = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and

β = angle of dead rise at appropriate station.

The area over which these pressures are applied must simulate pressures occurring during high localized impacts on the hull or float, but need not extend over an area that would induce critical stresses in the frames or in the overall structure.

(c) *Distributed pressures.* For the design of the frames, keel, and chine structure, the following pressure distributions apply:

(1) Symmetrical pressures are computed as follows:

$$P = C_4 \frac{K_2 \cdot V_{S0}^{\;2}}{\tan(\beta)}$$

where

P = pressure (psi);

C_4 = 0.078 C_1 (with C_1 computed under paragraph 1.4);

K_2 = hull station weighing factor, in accordance with figure 2 of Appendix 1;

V_{S0} = seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effects; and

β = angle of dead rise at appropriate station.

(2) The unsymmetrical pressure distribution consists of the pressures prescribed in subparagraph (c)(1) on one side of the hull or main float centreline and one-half of that pressure on the other side of the hull or main float centreline, in accordance with figure 3 of Appendix 1.

(3) These pressures are uniform and must be applied simultaneously over the entire hull or main float bottom. The loads obtained must be carried into the sidewall structure of the hull proper, but need not be transmitted in a fore and aft direction as shear and bending loads.

1.8. Auxiliary float loads

(a) General. Auxiliary floats and their attachments and supporting structures must be designed for the conditions prescribed in this paragraph. In the cases specified in subparagraphs (b) through (e), the prescribed water loads may be distributed over the float bottom to avoid excessive local loads, using bottom pressures not less than those prescribed in subparagraph (g).

(b) *Step loading.* The resultant water load must be applied in the plane of symmetry of the float at a point three-fourths of the distance from the bow to the step and must be perpendicular to the keel. The resultant limit load is computed as follows, except that the value of *L* need not exceed three times the weight of the displaced water when the float is completely submerged:

$$L = C_5 \frac{V_{S0}{}^{2} \cdot W^{2/3}}{(\tan(\beta_s))^{\frac{2}{3}}\left(1 + r_y^2\right)^{\frac{2}{3}}}$$

where

L = limit load (lb.);

C_5 = 0.0053;

V_{S0} = seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect;

W = seaplane design landing weight in pounds;

β_s = angle of dead rise at a station ¾ of the distance from the bow to the step, but need not be less than 15 degrees; and

r_y = ratio of the lateral distance between the centre of gravity and the plane of symmetry of the float to the radius of gyration in roll.

(c) *Bow loading.* The resultant limit load must be applied in the plane of symmetry of the float at a point one-fourth of the distance from the bow to the step and must be perpendicular to the tangent to the keel line at that point. The magnitude of the resultant load is that specified in subparagraph (b).

(d) *Unsymmetrical step loading.* The resultant water load consists of a component equal to 0.75 times the load specified in subparagraph (b) and a side component equal to 0.25·tan(β) times the load specified in subparagraph (b) The side load must be applied perpendicularly to the plane of symmetry of the float at a point midway between the keel and the chine.

(e) *Unsymmetrical bow loading.* The resultant water load consists of a component equal to 0.75 times the load specified in subparagraph (b) and a side component equal to 0.25·tan(β) times the load specified in subparagraph (b). The side load must be applied perpendicularly to the plane of symmetry at a point midway between the keel and the chine.

(f) *Immersed float condition.* The resultant load must be applied at the centroid of the cross section of the float at a point one-third of the distance from the bow to the stern. The limit load components are as follows:

vertical = ρ g V

aft = $C_x \frac{\rho}{2} V^{\frac{2}{3}} (k \ V_{S0})^2$

side = $C_y \frac{\rho}{2} V^{\frac{2}{3}} (k \ V_{S0})^2$

where

ρ = mass density of water (slugs/ft^3);

V = volume of float (ft^3);

C_x = coefficient of drag force, equal to 0.133;

C_y = coefficient of side force, equal to 0.106;

K = 0.8, except that lower values may be used if it is shown that the floats are incapable of submerging at a speed of 0.8·V_{S0} in normal operations;

V_{S0} = seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect; and

g = acceleration due to gravity (ft/sec^2).

(g) ***Float bottom pressures****.* The float bottom pressures must be established under paragraph 1.7**,** except that the value of K_2 in the formulae may be taken as 1.0. The angle of dead rise to be used in determining the float bottom pressures is set forth in subparagraph (b).

1.9. Seawing and wing loads at immersion

Seawing and wing design loads at immersion must be based on applicable test data.

ANNEX

Appendix 1 Figure 1 to 3

Appendix 2 Acceptable Means of Compliance to SC-VLA.0521-01 1.1 (c)

Appendix 1
GUIDANCE MATERIAL
Load Application

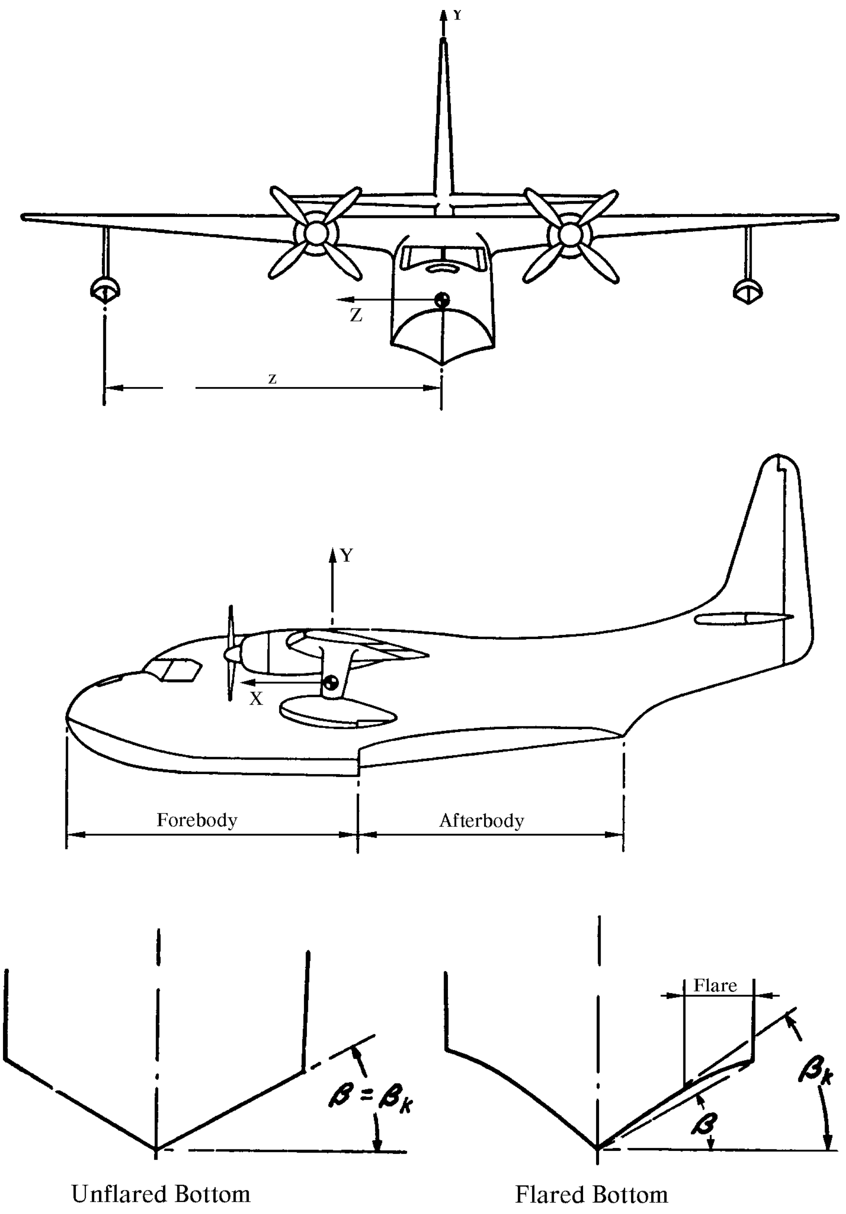

Fig.1. Pictorial definition of angles, dimensions, and directions on a seaplane

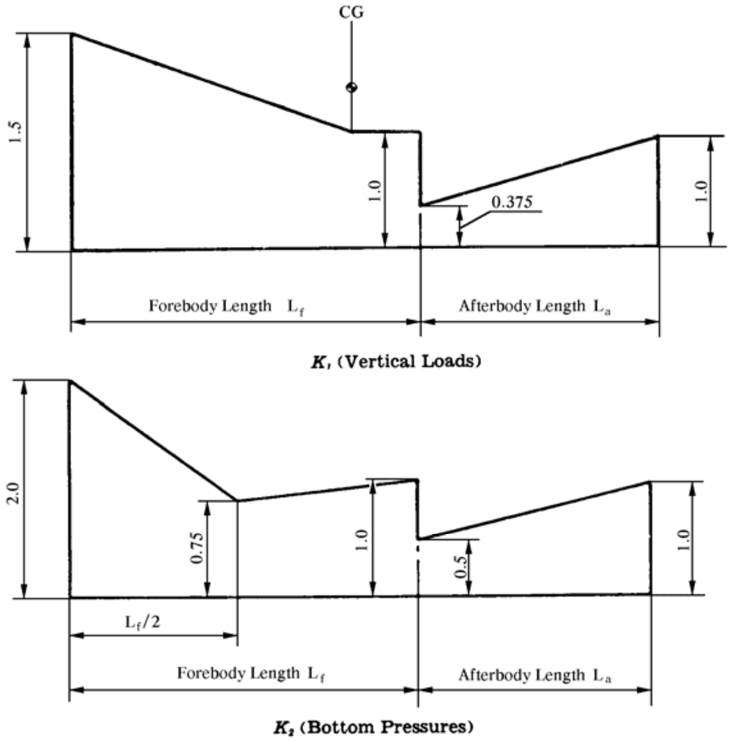

Fig.2. Hull station weighing factor

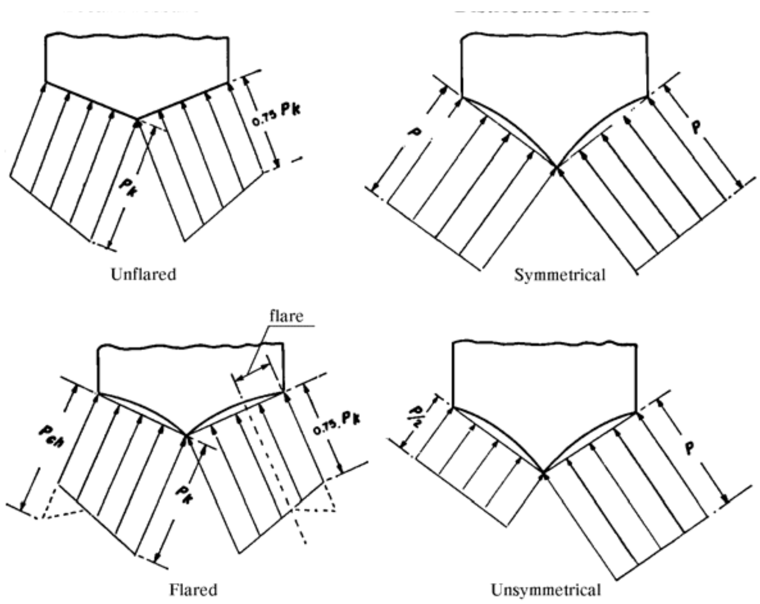

Fig.3. Transverse pressure distributions

Appendix 2
ACCEPTABLE MEANS OF COMPLIANCE
Load Values

AMC for paragraph 1.1.

(I) ***Seaplane (amphibian) seaworthiness***.

Appropriate wind wave and swell wave limitations must be established such that the water loads do not exceed the structural capability of the aircraft. One acceptable means of compliance is outlined below.

Wave height $h_{3\%}$, that the seaplane must overcome, is defined from the condition of not exceeding the loads, prescribed in paragraph 1.4, by the following formulae:

Height of wind wave:

$$h_{3\%} = 0.055 \cdot L \left(0.3 + \sqrt{(1.33 \cdot H - 1)} \right)$$

Height of swell wave:

$$h_{3\%} = 0.0275 \cdot L \left(0.3 + \sqrt{(1.33 \cdot H - 1)} \right)$$

where:

$h_{3\%}$ = Wave height when 3 percent of waves are higher than $h_{3\%}$ [m];

L = Length of hull bottom [m];

H = $\dfrac{n}{C_6 C_7 C_8 \left(82 + V_{S0}^{3/2} \right)}$;

V_{S0} = Stalling speed with flaps in landing position [m/s];

n = Load factor for step landing condition, prescribed in paragraph 1.4(a);

C_6 = $1 - \dfrac{2\beta}{180}$, for unflared, flared and tunnel bottoms (see figure 1 of Appendix 1)

C_6 = $1 - \dfrac{2\beta - \beta_k}{90}$, for semi-tunnel bottoms (see figure 1 of Appendix 1);

C_7 = Specified in compliance with the following table. For intermediate values of weight the linear interpolation is used:

W	1,000	5,000	10,000	20,000	60,000	100,000
C_7	0.028	0.021	0.018	0.014	0.013	0.012

C_8 = $\frac{0.3 \cdot 10^6 \cdot B_{max}^6}{W^2} + 0.75$, but not more then 1.0;

W = Maximum Take-off Weight [kg];

B_{max} = Maximum width of hull bottom [m].

If the value of H for the limit load factor turns out to be equal or less than 0.875, then the height of wind wave is assumed to be 0.04·L, and height of swell wave 0.02·L. The increase of admissible wave height may be done by considering greater values of limit load factors (by increasing the coefficient C_1 in the formula of paragraph 1.4.).

(II) ***Loading conditions for seaplane (amphibian) components***.

(a) Loading of water rudder. Total limit load acting perpendicularly to the mean surface of water rudder is defined by following formula:

$P = 13 \cdot V^2 \cdot S$ (kgf)

where:

V = Speed at which the use of water rudder is permitted [m/s];

S = Area of water rudder [m^2].

Two positions of centre of pressure are considered: 15 and 30 percent of chord from leading edge. The distribution of total load along rudder length is assumed to be proportional to chords.

(b) Loading of spray-deflectors, gear folds and fairings. Spray-deflectors, gear folds and fairings must be designed for loads defined in model tests and specified in flight tests.

(c) Loading of towing devices. Limit loads on hooks, balladeers and other seaplane (amphibian) towing points, as well as hoist sling points used for towing, are defined by the following:

$$P = 0.2 \cdot W \quad \text{(kgf)}$$

This load acts in vertical plane at 10° up and 20° down and in any direction in horizontal plane, but the lateral component need not to be greater than $0.1 \cdot G$.

(d) Loading of fastening attachments at mooring. With the seaplane (amphibian) on mooring at anchor or on mooring gear the restraining force acting on the airframe attachment points is assumed to be:

$$P = 0.7 \cdot W \quad \text{(kgf)}$$

Factor of safety is 2.0. For hoist sling and non-airframe attachment points the factor of safety is 3.0.

(e) Loading on gears not used for landing and takeoff

(reserved)

(f) Loading of tail bogey

(reserved)

(III) *Seaplane (amphibian) dynamic loading*

(reserved)