



Designation: F3331 – 18 (Reapproved 2023)

Standard Practice for Aircraft Water Loads¹

This standard is issued under the fixed designation F3331; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides equations for calculating water loads for aeroplane dual floats and single hulls. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on Level 1, 2, 3, and 4 Normal Category aeroplanes. The content may be more broadly applicable; it is the responsibility of the Applicant to substantiate broader applicability as a specific means of compliance.

1.2 An applicant intended to propose this information as Means of Compliance for a design approval must seek guidance from their respective oversight authority (for example, published guidance from applicable CAAs) concerning the acceptable use and application thereof. For information on which oversight authorities have accepted this standard (in whole or in part) as an acceptable Means of Compliance to their regulatory requirements (hereinafter “the Rules”), refer to ASTM Committee F44 web page (www.astm.org/COMMITTEE/F44.htm).

1.3 *Units*—The values stated in inch-pound units are to be regarded as standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This practice is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.30 on Structures.

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2. Referenced Documents

2.1 *ASTM Standards*:²
F3060 Terminology for Aircraft

3. Terminology

3.1 A listing of terms, abbreviations, acronyms, and symbols related to aircraft covered by ASTM Committees F37 and F44 airworthiness design standards can be found in Terminology for Aircraft **F3060**. Items listed below are more specific to this standard.

4. Significance and Use

4.1 This practice provides one means for determining the aeroplane structural loads for either dual floats or single hulls when taxiing on, taking off from, or landing on water. This practice satisfies the water loads requirements set forth in the Design Loads and Conditions Specification for Normal Category Aeroplanes.

5. Calculation of Aeroplane Water Loads

5.1 *Design Weights and Center of Gravity Positions:*

5.1.1 *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 **5.5**, the design water takeoff weight (the maximum weight for water taxi and takeoff run) must be used.

5.1.2 *Center of Gravity*—The critical centers 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.

5.2 *Application of Loads:*

5.2.1 Unless otherwise prescribed, the seaplane as a whole is assumed to be subjected to the loads corresponding to the load factors specified in **5.3**.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

5.2.2 In applying the loads resulting from the load factors prescribed in 5.3, 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 5.6.3.

5.2.3 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.

5.2.4 Except in the takeoff condition of 5.5, the aerodynamic lift on the seaplane during the impact is assumed to be 2/3 of the weight of the seaplane.

5.3 Water Loads—Hull and Main Float Load Factors:

5.3.1 Water reaction load factors n_w must be computed in the following manner:

5.3.1.1 For the step landing case:

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

5.3.1.2 For the bow and stern landing case:

$$n_w = \frac{C_1 V_{S0}^2}{(\tan^{2/3} \beta) W^{1/3}} \times \frac{K_1}{(1 + r_x^2)^{2/3}} \quad (2)$$

5.3.2 The following values are used:

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

5.3.2.2 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).

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

5.3.2.4 β = angle of dead rise at the longitudinal station at which the load factor is being determined in accordance with Fig. 1.

5.3.2.5 W = seaplane design landing weight in pounds.

5.3.2.6 K_1 = empirical hull station weighing factor, in accordance with Fig. 2.

5.3.2.7 r_x = ratio of distance, measured parallel to hull reference axis, from the center of gravity of the seaplane to the hull longitudinal station at which the load factor is being computed 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.

5.3.3 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 Fig. 2. This reduction applies only to the design of the carry through and seaplane structure.

5.4 Hull and Main Float Landing:

5.4.1 Symmetrical Step, Bow, and Stern Landing—For symmetrical step, bow, and stern landings, the limit water reaction load factors are those computed under 5.3. In addition:

5.4.1.1 For symmetrical step landings, the resultant water load must be applied at the keel, through the center of gravity, and must be directed perpendicularly to the keel line.

5.4.1.2 For symmetrical bow landings, the resultant water load must be applied at the keel, one-fifth of the longitudinal

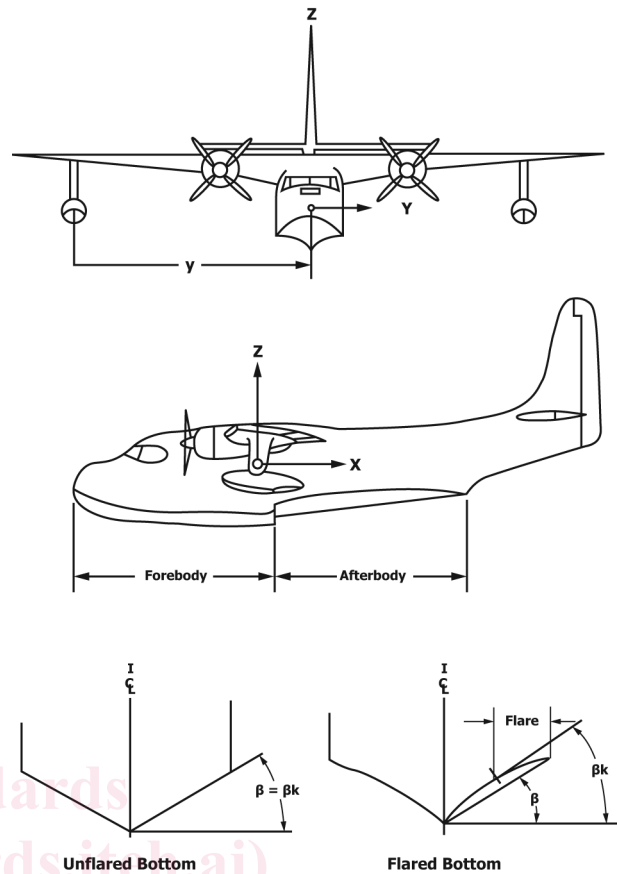


FIG. 1 Pictorial Definition of Angles, Dimensions, and Directions on a Seaplane

distance from the bow to the step, and must be directed perpendicularly to the keel line; and

5.4.1.3 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.

5.4.2 Unsymmetrical Landing for Hull and Single Float Seaplanes—Unsymmetrical step, bow, and stern landing conditions must be investigated. In addition:

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

5.4.2.2 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 the chine lines.

5.4.3 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 $\tan \beta$ at one float times the step landing load reached under 5.3. 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.

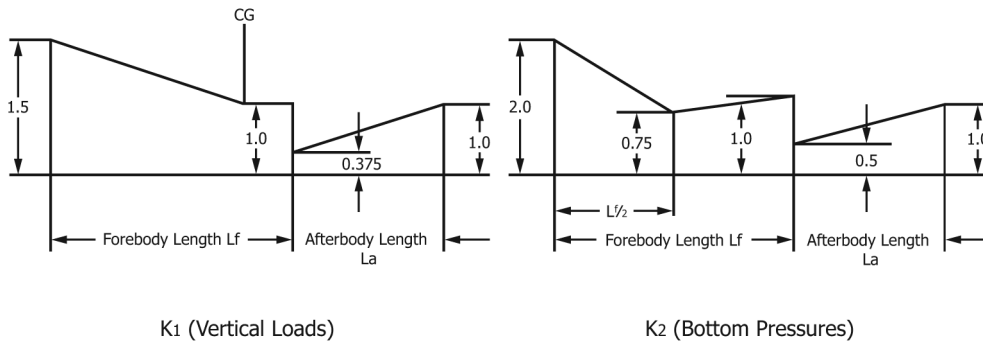


FIG. 2 Hull Station Weighing Factor

5.5 Water Loads-Hull and Main Float Takeoff Condition:

5.5.1 For the wing and its attachment to the hull or main float, the aerodynamic wing lift is assumed to be zero; and

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

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

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 with 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.

5.6 Hull and Main Float Bottom Pressures:

5.6.1 General—The hull and main float structure, including frames and bulkheads, stringers, and bottom plating, must be designed under this section.

5.6.2 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:

5.6.2.1 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 Fig. 3. The pressure at the keel (psi) is computed as follows:

$$P_K = \frac{C_2 K_2 V_{S1}^2}{\tan \beta_k} \quad (4)$$

where:

- P_K = pressure (psi) at the keel;
- C_2 = 0.00213;
- K_2 = hull station weighing factor, in accordance with Fig. 2;
- 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 Fig. 1.

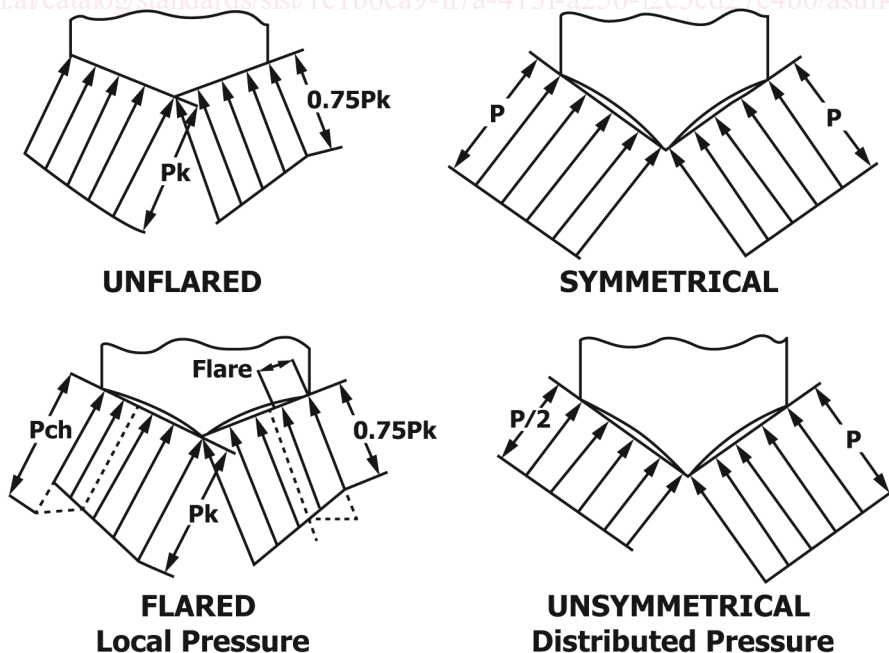


FIG. 3 Transverse Pressure Distributions