CAM 6

CIVIL AERONAUTICS MANUALS—Volume II

U. S. Department of Commerce — Civil Aeronautics Administration

Civil Aeronautics Manuals and supplements thereto are issued by the Office of Flight Operations and Airworthiness, Civil Aeronautics Administration, for the guidance of the public and are published in the Federal Register and the Code of Federal Regulations.

Supplement No. 16 — January 15, 1958

SUBJECT: Revisions to CAM 3 dated October 1956, and CAM 6 dated November 1956.

The supplement to CAM 3 includes appendix D which provides a simplified procedure for determining wing load distribution for airplanes incorporating wing tip tanks.

The supplement to CAM 6 explains standards applicable to anticollision lights when installed in rotorcraft.

The new material is indicated by brackets.

Remove and destroy the following pages:	*Insert the following new pages:*
CAM 3—v and vi	CAM 3—v and vi
xvii and xviii	xvii and xviii
27 and 28	27 through 28–1
	123 through126
CAM 6—ix and x	CAM 6—ix and x
34–1	34–1

Roy Keeley

ROY KEELEY,
Director, Office of Flight Operations and Airworthiness.

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pilot in power-off landings at normal landing speed and during which brakes or engine power are not used to maintain a straight path.

(c) Means shall be provided for adequate directional control during taxying.

3.146 *Shock absorption.* The shock-absorbing mechanism shall not produce damage to the structure when the airplane is taxied on the roughest ground which it is reasonable to expect the airplane to encounter in normal operation.

3.147 *Spray characteristics.* For seaplanes, spray during taxying, take-off, and landing shall at no time dangerously obscure the vision of the pilots nor produce damage to the propeller or other parts of the airplane.

Flutter and Vibration

3.159 *Flutter and vibration.* All parts of the airplane shall be demonstrated to be free from flutter and excessive vibration under all speed and power conditions appropriate to the operation of the airplane up to at least the minimum value permitted for V_a in section 3.184. There shall also be no buffeting condition in any normal flight condition severe enough to interfere with the satisfactory control of the airplane or to cause excessive fatigue to the crew or result in structural damage. However, buffeting as stall warning is considered desirable and discouragement of this type of buffeting is not intended.

Subpart C—Strength Requirements

General

3.171 *Loads.*

(a) Strength requirements are specified in terms of limit and ultimate loads. Limit loads are the maximum loads anticipated in service. Ultimate loads are equal to the limit loads multiplied by the factor of safety. Unless otherwise described, loads specified are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads shall be placed in equilibrium with inertia forces, considering all items of mass in the airplane. All such loads shall be distributed in a manner conservatively approximating or closely representing actual conditions. If deflections under load would change significantly the distribution of external or internal loads, such redistribution shall be taken into account.

(c) Simplified structural design criteria shall be acceptable if the Administrator finds that they result in design loads not less than those prescribed in sections 3.181 through 3.265.

3.171–1 *Design criteria (CAA policies which apply to sec. 3.171 (c)).* The Administrator finds that the simplified structural design criteria contained in Appendix A to Civil Aeronautics Manual 3, result in design loads not less than those prescribed in sections 3.181 through 3.265.

(Supp. 16, effective Jan. 31, 1953, 17 F. R. 11786, Dec. 30, 1952.)

[3.171–2 *Design loads and load distributions (CAA policies which apply to sec. 3.171 (b)).* The simplified method in appendix D to Civil Aeronautics Manual 3 may be used to determine the air loads and air load distributions resulting from the use of tip stores for low speed, low altitude (design Mach number less than 0.4; design altitude less than 15,000 ft.) airplanes with small amounts of sweep (i. e., midchord angles of sweep less than 15 degrees).]

(22 F. R. 10016, Dec. 13, 1957, effective Jan. 15, 1958.)

3.172 *Factor of safety.* The factor of safety shall be 1.5 unless otherwise specified.

3.173 *Strength and deformations.* The structure shall be capable of supporting limit loads without suffering detrimental permanent deformations. At all loads up to limit loads, the deformation shall be such as not to interfere with safe operation of the airplane. The structure shall be capable of supporting ultimate loads without failure for at least 3 seconds, except that when proof of strength is demonstrated by dynamic tests simulating actual conditions of load application, the 3-second limit does not apply.

3.173–1 *Dynamic tests (CAA policies which apply to sec. 3.173).*

(a) Section 3.173 permits dynamic testing in lieu of stress analysis or static testing in the proof of compliance of the structure with strength and deformation requirements. In demonstrating, by dynamic tests, proof of strength of landing gears for the stipulated landing conditions contained in sections 3.245, 3.246, and 3.247, it is necessary to employ a procedure which will not result in the accepting of landing gears weaker than those qualified for acceptance under present procedures, i. e., stress analysis or static testing.

(b) The Administrator will accept, as an adequate procedure for this purpose, the following dynamic tests:

The structure shall be dropped a minimum of 10 times from the limit drop height, and at least one time from the ultimate drop height, for each basic design condition for which proof of strength is being made by drop tests.

(c) With regard to the extent to which the structure can be proved by dynamic tests, such dynamic tests shall be accepted as proof of strength for only those elements of the structure for which it can be shown that the critical limit and ultimate loads have been reproduced.

(Supp. 1, 12 F. R. 3435, May 28, 1947, as amended by Amdt. 1, 14 F. R. 36, Jan. 5, 1949.)

3.174 *Proof of structure.* Proof of compliance of the structure with the strength and deformation requirements of section 3.173 shall be made for all critical loading conditions. Proof of compliance by means of structural analysis will be accepted only when the structure conforms with types for which experience has shown such methods to be reliable. In all other cases substantiating load tests are required. Dynamic tests including structural flight tests shall be acceptable, provided that it is demonstrated that the design load conditions have been simulated. In all cases certain portions of the structure must be subjected to tests as specified in Subpart D of this part.

3.174–1 *Material correction factors (CAA policies which apply to sec. 3.174).*

(a) In tests conducted for the purpose of establishing allowable strengths of structural elements such as sheet, sheet stringer combinations, riveted joints, etc., test results should be reduced to values which would be met by elements of the structure if constructed of materials having properties equal to design allowable values. Material correction factors in this case may be omitted, however, if sufficient test data are obtained to permit a probability analysis showing that 90 percent or more of the elements will either equal or exceed in strength the selected design allowable values. The number of individual test specimens needed to form a basis of "probability values" cannot be definitely stated but must be decided on the basis of consistency of results; i. e., "spread of results", deviations from mean value, and range of sizes, dimensions of specimens, etc., to be covered. This item should therefore be a matter for decision between the manufacturer and the CAA. (Secs. 1.654 and 1.655 of ANC–5a 1949 edition [7] outline two means of accomplishing material corrections in element tests; these methods, however, are by no means considered the only methods available.)

(b) In cases of static or dynamic tests of structural components, no material correction factor is required. The manufacturer, however, should use care to see that the strength of the component tested conservatively represents the strength of subsequent similar components to be used on aircraft to be presented for certification. The manufacturer should, in addition, include in his report of tests of major structural components, a statement substantially as follows:

The strength properties of materials and dimensions of parts used in the structural component(s) tested are such that subsequent components of these types used in aircraft presented for certification will have strengths substantially equal to or exceeding the strengths of the components tested.

(Supp. 6, 15 F. R. 619, Feb. 4, 9050.)

3.174–2 *Structural testing of new projects (CAA policies which apply to sec. 3.174).*

(a) The following is a general procedure that may be followed for determining the extent of required structural testing of a new project:

(1) As the initial step to determine the structural testing of a new project, a meeting between representatives of the manufacturer, the Civil Aeronautics Administration project engineer, and (if practicable) the pertinent Branch Chief of the Aircraft Division should be arranged. The question of minimum tests should be reviewed first. This will include generally such tests as proof and operation tests of control surfaces and systems, drop

[7] ANC–5a, "Strength of Aircraft Elements" is published by the Army-Navy-Civil Committee on Aircraft Design Criteria and may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

tests of landing gear, vibration tests, and wing torsional stiffness tests.

(2) If the structure is of a type on which the manufacturer has a thorough background of experience, analysis and proof tests can usually be considered acceptable. If, in addition, the analysis has a high degree of conservatism, proof tests other than those specifically required by regulation may be omitted at the discretion of the CAA.

(b) If the structure or parts thereof are definitely outside the manufacturer's previous

[Appendix D

[Simplified Method for Determining Air Loads and Air Load Distributions for Wing-Store Combinations

[The following simplified approach may be used to determine the loads and load distributions resulting from the use of tip stores for low speed, low altitude (design Mach number less than 0.4; design altitude less than 15,000 ft.) aircraft with small amounts of sweep (i. e., mid-chord angles of sweep less than 15 degrees).

[*Lift distribution on wing-store combination*

$L_{TOTAL} = L_W + \Delta L$.

where:

L_{TOTAL} = total spanwise load distribution expressed in terms of unit wing loading parameter $\frac{C_l c}{C_L \bar{c}}$ for the wing-store combination.

L_W = spanwise load distribution for wing alone expressed in terms of $\left(\frac{C_l c}{C_L \bar{c}}\right)$ which is obtained by standard methods.

ΔL = additional lift due to tank alone and induced effects of tank on the wing and the wing on the tank expressed in terms of $\left(\frac{\Delta C_l c}{C_L \bar{c}}\right)$. (Obtain from fig. 1.)

[See figure 2 for typical wing with tip-tank air load distribution as determined by above simplified method. For this example, a typical air load distribution for a wing with aspect ratio of 6.17 and span of 400 inches was used. To this wing, a 20-inch diameter tip-tank 80 inches in length was added. It was further assumed that the wing-tip-tank configuration and the wing torsional rigidity are such that deflections under load will not significantly change the air load distribution (i. e., sec. 3.171 (b) is complied with). Note that the ordinates of the $\frac{C_l c}{C_L \bar{c}} + \frac{\Delta C_l c}{C_L \bar{c}}$ curve should be modified so that the area under the new curve will equal the area under the original wing alone curve (i. e., total lift to remain constant).

[*Moment due to stores*

$M_T = M_1 + M_2$.

where M_T = total aerodynamic store moment about the wing tip elastic axis.

$M_1 = 2\ K_1 q \alpha V_o$ = moment of load on store which is independent of the wing.

$M_2 = .4\ L_5\ C_t$ = moment of load on store which is induced by the wing.

K_1 = factor proportional to length of tank expressed in diameters. (See table 1.)

q = dynamic pressure (p. s. f.).

α = angle of attack (radians).

V_o = volume of store.

L_5 = total load on store induced by wing obtained from distrubution of tank load of figure 1.

C_t = tip chord.

NOTE: Moment coefficient, C_M, of the wing may be assumed not to be changed by presence of tip stores.

[*Lift curve slope*

[The slope of the lift curve for the wing-store combination may be approximated by the formula:

$m_T = [K_2(2D/b) + 1]m_w$.

where m_T = slope of the lift curve of the wing-store combination.

m_w = slope of the lift curve of the wing alone.

D = store diameter.

b = wing span.

K_2 = 1.58 for aspect ratio 5.

K_2 = 1.25 for aspect ratio 7.

K_2 = 1.12 for aspect ratio 10 with straight line variation for intermediate aspect ratios.

[TABLE 1.—*Aerodynamic factor* K_1

L/D [1]	K_1	L/D [1]	K_1
1	0	6. 01	0. 873
1. 5	. 316	6. 97	. 897
2. 0	. 493	8. 01	. 916
2. 51	. 607	9. 02	. 930
2. 99	. 681	9. 97	. 939
3. 99	. 778	∞	1. 000
4. 99	. 836		

[1] L=length of store (ft.).
D=diameter of store (ft.).

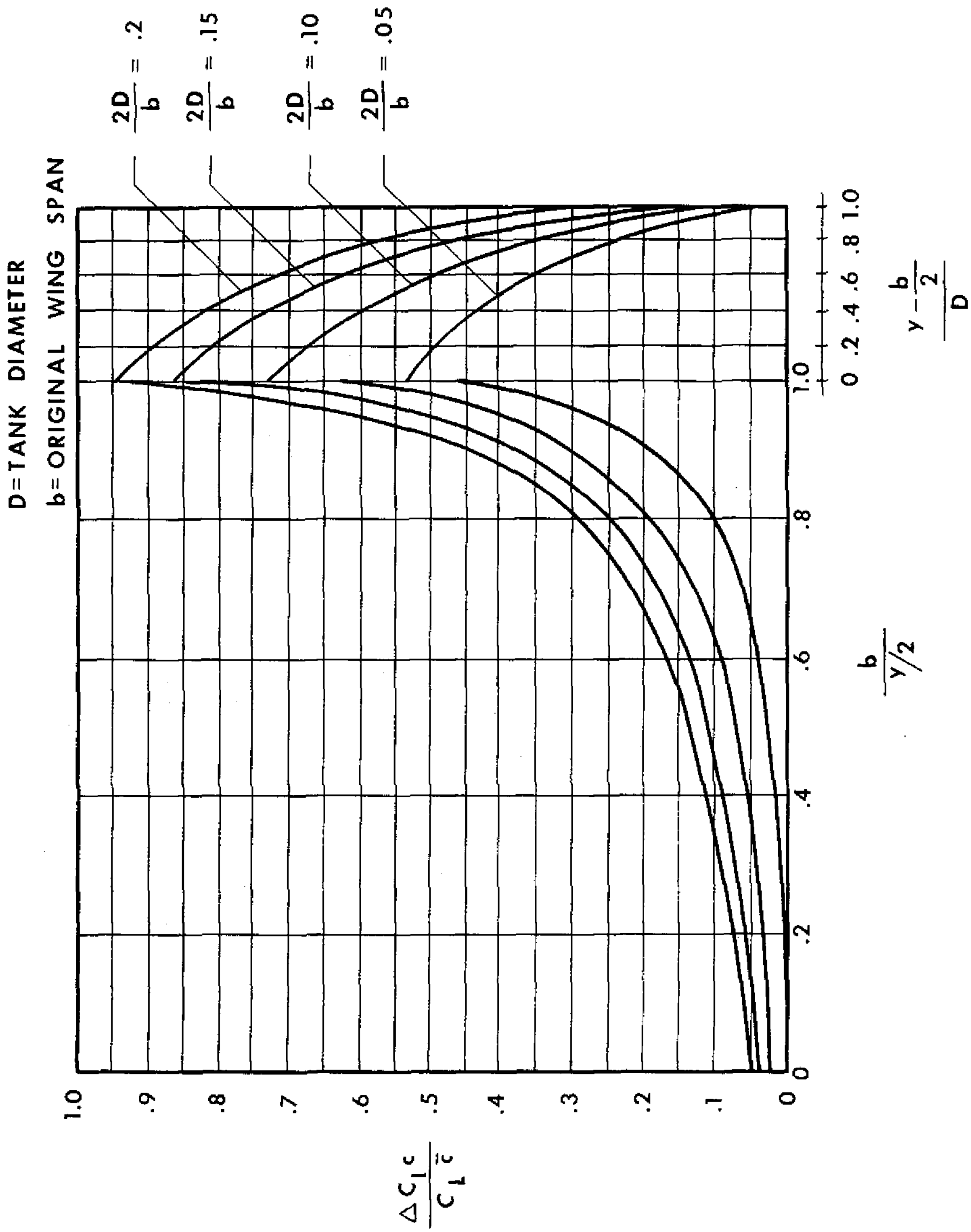
[The requirements of section 3.171(b) concerning deflections under load which could change the distribution of external or internal loads should be considered in evaluating each wing-tip-tank configuration. Inertia loads of tip-tanks with varying fuel quantities, different fuel c. g. locations, and the wing torsional rigidity should be considered.

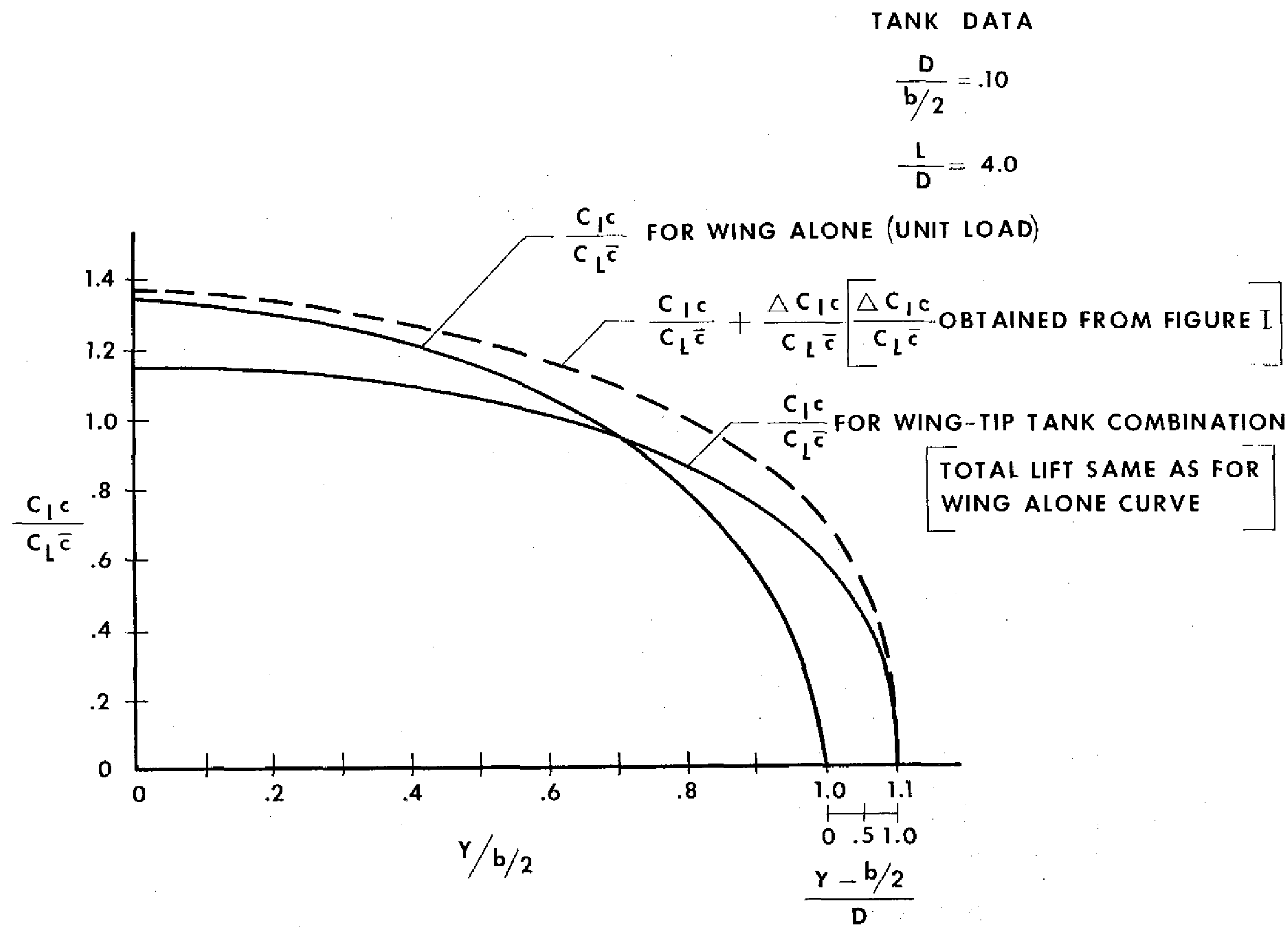
[For stores whose cross section is other than circular (e. g., elliptical), an equivalent store with circular cross section should be assumed. For example, for an elliptical cross section, the equivalent diameter may be assumed equal to the sum of the minor and major diameters divided by 2.

[The simplified procedures are based on the theoretical methods outlined in the following documents:

NACA Research Memorandum RM L53B18, "A Method for Calculating the Aerodynamic Loading on Wing-Tip-Tank Combinations in Subsonic Flow" by S. W. Robinson and M. Zlotnick.

Aeronautic Research Council Report No. 2469, "Theoretical Load Distributions on Wings with Cylindrical Bodies at the Tips" by D. E. Hartley. (British.)


D = TANK DIAMETER
b = ORIGINAL WING SPAN
2D/b = .2
2D/b = .15
2D/b = .10
2D/b = .05
$\frac{y - \frac{b}{2}}{D}$
$\frac{y}{b/2}$
$\frac{\Delta C_l c}{C_L \bar{c}}$
0
.2
.4
.6
.8
1.0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0



TANK DATA
D / b/2 = .10
L / D = 4.0
Cl c / CL c̄ FOR WING ALONE (UNIT LOAD)
Cl c / CL c̄ + ΔCl c / CL c̄ [ΔCl c / CL c̄ OBTAINED FROM FIGURE I]
Cl c / CL c̄ FOR WING-TIP TANK COMBINATION
[TOTAL LIFT SAME AS FOR WING ALONE CURVE]
Cl c / CL c̄
1.4
1.2
1.0
.8
.6
.4
.2
0
0
.2
.4
.6
.8
1.0
1.1
0 .5 1.0
Y/b/2
Y − b/2 / D

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[6.637-1 *Anticollision light standards (CAA policies which apply to sec. 6.637).* The anticollision light standards in section 6.637 apply to rotorcraft for which an application for a type certificate is made on or after April 1, 1957. When anticollision lights are installed on rotorcraft for which an application for a type certificate was made before April 1, 1957, the applicant may conform either to section 6.637 or to the standards listed below:

[(a) Anticollision lights (when installed) should be of the rotating beacon type installed on top of the fuselage in such a location that the light will not be detrimental to the crew's vision and will not detract from the conspicuity of the position lights. If there is no acceptable location on top of the fuselage, a bottom fuselage installation may be used.

[(b) The color of the anticollision light should be aviation red in accordance with the specifications of section 6.635.

[(c) The arrangement of the anticollision light, i. e., number of light sources, beam width, speed of rotation, etc., should be such as to give an effective flash frequency of not less than 40 and not more than 100 cycles per minute with an on-off ratio of not less than 1:75.]

(22 F. R. 10016, Dec. 13, 1957, effective Jan. 15, 1958.)

Safety Equipment

6.640 ***General.*** **Required safety equipment which the crew is expected to operate at a time of emergency, such as flares and automatic life-raft releases, shall be readily accessible. (See also sec. 6.738 (e).)**

6.641 ***Flares.*** **When parachute flares are installed, they shall be of an approved type, and their installation shall be in accordance with section 6.642.**

6.642 ***Flare installation.***

(a) Parachute flares shall be releasable from the pilot compartment and installed to minimize the danger of accidental discharge.

(b) It shall be demonstrated in flight that the flare installation is such that ejection can be accomplished without hazard to the rotorcraft and its occupants.

(c) If recoil loads are involved in the ejection of the flares, the structure of the rotorcraft shall be designed to withstand such loads.

6.643 ***Safety belts.*** **Rotorcraft manufactured on or after the effective date of this part shall be equipped with safety belts of an approved type. (See sec. 6.18.) In no case shall the rated strength of the safety belt be less than that corresponding with the ultimate load factors specified, taking due account of the dimensional characteristics of the safety belt installation for the specific seat or berth arrangement. Safety belts shall be attached so that no part of the anchorage will fail at a load lower than that corresponding with the ultimate load factors specified. (See sec. 6.260.)**

6.644 ***Emergency flotation and signaling equipment.*** **When emergency flotation and signaling equipment is required by the operating rules of the Civil Air Regulations, such equipment shall comply with the provisions of paragraphs (a) through (c) of this section.**

(a) Rafts and life preservers shall be of an approved type and shall be so installed as to be readily available to the crew and passengers.

(b) Rafts released automatically or released by the pilot shall be attached to the rotorcraft by means of lines to keep them alongside the rotorcraft. The strength of the lines shall be such that they will break before submerging the empty raft.

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