

DESIGN AND PERFORMANCE  
STANDARDS FOR A PERSONAL  
LIGHT  
AEROPLANE  
(PLA)

*DRAFT 01*  
Subject to review.

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This standard is offered for review by members of LAMAC, CRAC, Transport Canada and any other interested parties until 31 July 2005. All parties reviewing this document are requested to fill in the form below giving name, date and general comments. Subsequent drafts are to be entered in the table below, and appended to this 01 draft for final editing.

Reviewed by:

Name	Date	Comment

Draft 01	Completed 30 April 2005, submitted to TC, CRAC, LAMAC Technical Committee and membership for review.



## PREAMBLE

### General

The contents of this draft are based on the ASTM F-2245 Design and Performance Standards for the Light Sport Plane, DS-10141 Design Standards for Advanced Ultra-light Aeroplane, and FAA Part 23 Appendix A Simplified Design Load Criteria. This draft is being presented to Transport Canada as part of the Proposal for the introduction of the Personal Aircraft.

### Notes from Author: Chris Heintz DAR#113

1. Most of the LSA ASTM F2245 (04) has been used as a basis for these standards, but the sections which are duplicated from the VLA or FAR 23 (CAR 523) have been deleted, and replaced with the Appendix X.1. of the ASTM F2245. This is more appropriate to the Canadian DS 10141 format.
2. If this standard is accepted, it should be noted that:
  - (a) In the case of single and two seat aeroplanes with  $W_{\max} < 600$  kg (1320 lbs) land and  $< 650$  kg (1430 lbs.) water;  $V_{SI} < 45$  kts (stall in cruise configuration), the PLA and LSA standards are the same. (ie the PLA can be exported to the USA and will comply with the F-2245 LSA standard, and LSA compliant airplanes can be imported and registered as a PLA) If the Max Level speed of our PLA exceeds the  $V_H = 120$  kts of the LSA, a finer pitch fixed or ground adjustable propeller may be installed to meet the US LSA rules as per 14 CFR Part 1
  - (b) If an AULA meets the DS 10141 (03) standard, it could also meet the present PLA standard. (The flight and POH requirements are more stringent for the PLA and the rest of the requirement pertaining to QA, and Certificates for Manufacture would have to be met)
  - (c) All aeroplanes meeting CAR 523 or equivalent such as JAA-VLA will meet the PLA standard, as long as  $V_{SI}$  and  $W_{\max}$  are not exceeded.
  - (d) Twin Engines: The flight testing will need extra investigation and should be addressed in the flight testing standards.
  - (e) Stall Warning: If installed, should meet VLA 231.
  - (f) If applicant aircraft was designed to FAR Part 23, or JAA-VLA, flight tests must show the compliance with the smaller loads of Table 1.
  - (g) Chapter C "Structure" of this standard up to and including Section 29 may be replaced with CAR 523 or VLA paragraph 321 to 459 as long as  $n=4$  (not 3.8)
  - (h) 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 and health practices and determine the applicability of regulatory requirements prior to use.

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## ABBREVIATIONS AND DEFINITIONS

$$\text{AR} = \text{aspect ratio} = \frac{b}{\text{MAC}} = \frac{b^2}{S}$$

b = wing span m (ft.)

BHP = brake horse power

c = chord m (ft.)

CAS = calibrated air speed

$C_L$  = lift coefficient

$C_D$  = drag coefficient

CG = centre of gravity

$C_m$  = moment coefficient ( $C_m$  is with respect to C/4 point, positive = nose up)

$C_{M0}$  = zero lift moment coefficient

$C_n$  = normal coefficient

daN = decaNewton

deg. = degrees =  $2 \times 3.1416/360 = .0174$  radian = 1 = 1/57.3 per radian

FPM = feet per minute

g = acceleration due to gravity =  $9.81 \text{ m/s}^2$  ( $32.2 \text{ ft/s}^2$ )

IAS = indicated air speed

ICAO = International Civil Aviation Organization

MAC = Mean Aerodynamic Chord

$\underline{M(W)}$  = gross (maximum design) mass (weight) kgs (lbs)

$m(w)$  = average design surface load  $\text{kgs/m}^2$  (PSF)

n = load factor

$$q = \text{dynamic pressure} - \rho \times \frac{V^2}{2} = \frac{V^2}{1.632} \quad (q = \text{KPa and } V = \text{m/s})$$

$$\left( = \frac{V^2}{391} \quad (q = \text{lb/in}^2 \text{ and } V = \text{mph}) \right)$$

S = wing area in square meters (square ft.)

$V_A$  = design manoeuvring speed

$V_C$  = design cruising speed

$V_D$  = design diving speed

$V_{DF}$  = demonstrated flight diving speed ( $V_{DF} \leq V_D$ )

$V_f$  = design flap speed

$V_{FE}$  = maximum flap extended speed

$V_H$  = maximum speed in level flight with maximum continuous power (corrected for sea level standard conditions)

$V_{NE}$  = never-exceed speed

- $V_S$  = stalling speed or minimum steady flight speed at which the aeroplane is controllable (flaps retracted)
- $V_{S0}$  = stalling speed or minimum steady flight speed in the landing configuration (flaps extended)
- $V_{SP}$  = maximum spoiler/speed brake extended speed
- $V_{SI}$  = stalling speed or minimum steady flight speed obtained with the flaps in a specific configuration
- $V_X$  = speed for best angle of climb
- $V_Y$  = speed for best rate of climb
- $V_R$  = ground gust speed
- $W$  = Maximum takeoff or maximum design weight
- $W_E$  = maximum empty aircraft weight
- $W_u$  = minimum useful load
- $W$  = average design surface load (PSF)

## Chapter A - Definition

### 1. Applicability

- (a) This publication contains standards for the design of a Personal Light Aeroplane (PLA).
- (b) Each person who manufactures an aeroplane for subsequent registration in the Personal Light Aeroplane category shall demonstrate compliance with the applicable requirements of this publication.

### 2. Personal Light Aeroplane

A Personal Light Aeroplane is an aeroplane which:

- (a) Is powered by a maximum of 2 reciprocating engines.
- (b) Is designed to carry a maximum of six persons, including the pilot;
- (c) Has a maximum take-off mass,  $M_{TOmax}$ , (weight,  $W_{TOmax}$ ) of:
  - 1800 Kg (3960 lb) for land or water operations
- (d) A maximum stalling speed in the cruise configuration,  $V_{S1}$ , at manufacturer's recommended maximum take-off mass (weight) not exceeding 60 kts (69 mph) (IAS).

### 3. Minimum Useful Load

- (a) Personal Light Aeroplane shall have a Minimum Useful Load,  $M_U$  ( $W_U$ ) computed as follows:

$$(W_U = 190 \times k + \frac{BHP}{2}, \text{ in lb; where}$$

$k$  = Number of occupants

BHP = engine(s) Brake Horsepower (Ignition or Diesel engines)

## Chapter B – Flight

### 4. Proof of Compliance

Each of the following requirements shall be met at the most critical mass (weight) and CG configuration. Unless otherwise specified, the speed range from stall to  $V_D$  or the maximum allowable speed for the configuration being investigated shall be considered.

### 5. Load Distribution Limits

5.1 The following shall be determined:

- (a) the minimum flying weight
- (b) the most forward CG and most rearward CG.

Note: For reference, standard occupant weight = 71 kg (190 lbs);  
For the minimum flying weight, standard occupant weight = 45 kg (120 lb.)  
Fuel density = .72 kg/l (6 lb/US gal.)  
Fixed and/or removable ballast, or both, may be used if properly installed and placarded.

### 6. Propeller Speed and Pitch Limits

- 6.1 Propeller configuration shall not allow the engine to exceed safe operating limits established by the engine manufacturer under normal conditions.
- 6.2 Maximum RPM shall not be exceeded with full throttle during takeoff, climb, or flight at  $0.9 V_H$  and 110% of maximum continuous RPM shall not be exceeded during a glide at  $V_{NE}$  with throttle closed.

### 7. Performance, General

- 7.1 All performance requirements apply in standard ICAO atmosphere in still air conditions and at sea level. Speeds shall be given in indicated (IAS) and calibrated (CAS) airspeeds.

### 8. Stalling Speeds

- 8.1 Wing level stalling speeds shall be determined by flight test at a rate of speed decrease of 1 knot/sec. or less, throttle closed, with maximum takeoff weight, and most unfavourable CG.

### 9. Take-off

- 9.1 With aircraft at maximum take-off weight, full throttle, sea level, the following shall be measured:
  - (a) Ground roll distance to takeoff on a runway with minimal grade; and,

- (b) Distance to clear a 15.2 m (50 ft.) obstacle at a climb speed of at least  $1.3 V_{S1}$ .

Note: The aeroplane configuration, including flap position, shall be specified in the Pilot Operating Handbook (POH)

## 10. Climb

10.1 At maximum takeoff weight, flaps in the position specified for climb within the POH, and full throttle

- (a) Best rate of climb ( $V_Y$ ) shall exceed 93 m (300 ft) per minute; and,  
 (b) Best angle of climb ( $V_X$ ) shall exceed 1/12.

## 11. Landing

11.1 For landing with throttle closed and flaps extended, the following shall be determined:

- (a) Landing distance from 15.2 m (50 ft.) at  $1.3 V_{S0}$ ; and  
 (b) Ground roll distance with reasonable braking if so equipped.

## 12. Balked Landing

12.1 The aeroplane shall demonstrate a full-throttle angle of climb at  $1.3 V_{S0}$  which shall exceed 1/30 within 5 s of power application from aborted landing. If the flaps may be promptly and safely retracted without loss of altitude and without sudden changes in attitude, they may be retracted.

## 13. Controllability and Manoeuvrability

### General

- 13.1 The aeroplane shall be safely controllable and manoeuvrable during take-off, climb, level flight (cruise), dive to VD, approach and landing (power off and on, flaps retracted and extended) through the use of primary controls and normal displacements for the aircraft type.  
 13.2 Smooth transition between all flight conditions shall be possible without excessive pilot skills nor exceeding pilot force as shown in Table 1.

Values in decaNewtons (pounds) of force as applied to the control wheel or rudder pedals	Pitch (lb)	Roll (lb)	Yaw (lb)
(1) For temporary application:			
Stick .....	45	22	.....
Wheel (applied to rim)....	45	22	.....
Rudder pedal .....	.....	.....	90
(2) For prolonged application:	5	5	25
Limit Design Loads	100	40	130

Table 1 Pilot Forces

- 13.3 It shall be possible to trim the aeroplane for level cruise at an average weight and CG.
- 13.4 Full control shall be maintained when retracting and extending flaps within their normal operating speed range ( $V_{SO}$  to  $V_{FE}$ ).
- 13.5 Lateral, directional and longitudinal control shall be possible down to  $V_{SO}$

#### **14. Longitudinal Control**

- 14.1 With the aeroplane trimmed for steady flight at  $1.3V_{SI}$ , it must be possible at any speed between  $1.1V_{SI}$  and  $1.3V_{SI}$  to pitch the nose downward so that a speed not less than  $1.3V_{SI}$  can be reached promptly. This must be shown with the airplane in all possible configurations, with simultaneous application of full power and nose down pitch control, and with power at idle.
- 14.2 Longitudinal control forces shall increase with increasing load factor.

#### **15. Directional and Lateral Control**

- 15.1 It must be possible to reverse a steady  $30^\circ$  banked coordinated turn through an angle of  $60^\circ$  from both directions:
  - (a) within 5 s from initiation of roll reversal, with the airplane trimmed at  $1.3V_{SI}$ , flaps in the takeoff position, and maximum takeoff power; and
  - (b) within 4 s from initiation of roll reversal, with the airplane trimmed at  $1.3V_{SO}$ , flaps fully extended, and engine at idle.
- 15.2 With and without flaps deployed, rapid entry into, or recovery from, a maximum cross-controlled slip shall not result in uncontrollable flight characteristics.
- 15.3 Lateral and directional control forces shall not reverse with increased deflection.

#### **16. Static Longitudinal Stability**

- 16.1 The aeroplane shall demonstrate the ability to trim for steady flight at speeds appropriate to the climb, cruise, and landing approach configurations; at minimum and maximum weight; and forward and aft CG limits.
- 16.2 The aeroplane shall exhibit positive longitudinal stability characteristics at any speed above  $V_{SI}$ , up to the maximum allowable speed for the configuration being investigated, and at the most critical power setting and CG combination.
- 16.3 Stability shall be shown by a tendency for the airplane to return toward trimmed steady flight after:
  - (a) a “push” from trimmed flight that results in a speed increase, followed by a non-abrupt release of the pitch control;
  - (b) a “pull” from trimmed flight that results in a speed decrease, followed by a non-abrupt release of the pitch control.
- 16.4 The aeroplane shall demonstrate compliance with this section while in trimmed steady flight for each flap and power setting appropriate to the following configurations:
  - (a) climb (flaps set as appropriate and maximum continuous power)
  - (b) cruise (flaps retracted and 75% maximum continuous power)
  - (c) approach to landing (flaps fully extended and engine at idle).
- 16.5 While returning toward trimmed steady flight, the aeroplane shall:
  - (a) not decelerate below stalling speed  $V_{SI}$ ;
  - (b) not exceed  $V_{NE}$  or the maximum allowable speed for the configuration being investigated;
  - (c) exhibit decreasing amplitude for any long-period oscillations. (see 18)

#### **17. Static Directional and Lateral Stability**

- 17.1 The aeroplane must maintain a trimmed condition around the roll and yaw axis with respective controls fixed.

- 17.2 The aeroplane shall exhibit positive directional and lateral stability characteristics at any speed above  $V_{SI}$ , up to the maximum allowable speed for the configuration being investigated, and at the most critical power setting and CG combination.
- 17.3 Directional stability shall be shown by a tendency for the aeroplane to recover from a skid condition after release of the yaw control.
- 17.4 Lateral stability shall be shown by a tendency for the airplane to return toward a level-wing attitude after release of the roll control from a slip condition
- 17.5 The aeroplane shall demonstrate compliance with this section while in trimmed steady flight for each flap and power setting appropriate to the following configurations:
- (a) climb (flaps as appropriate and maximum continuous power);
  - (b) cruise (flaps retracted and 75% maximum continuous power);
  - (c) approach to landing (flaps fully extended and engine at idle).

### **18. Dynamic Stability**

- 18.1 Any oscillations shall exhibit decreasing amplitude within the appropriate speed range ( $V_{SO}$  to  $V_{FE}$  flaps extended and  $V_S$  to  $V_{DF}$  flaps retracted).

### **19. Wings Level Stall**

- 19.1 It shall be possible to prevent more than  $20^\circ$  of roll or yaw by normal use of the controls during the stall and the recovery at all weight and CG combinations.

### **20. Turning Flight and Accelerated Stalls**

- 20.1 Turning flight and accelerated stalls shall be performed in both directions as follows:
- (a) after establishing a  $30^\circ$  coordinated turn, the turn shall be tightened until the stall. After the turning stall, level flight shall be regained without exceeding  $60^\circ$  of additional roll in either direction. No excessive loss of altitude, nor tendency to spin, or speed build-up shall be associated with the recovery. The rate of speed reduction must be constant, and may not exceed 1 knot/s for a turning flight stall, and be 3 to 5 knots/s with steadily increasing load factor for an accelerated stall.
- 20.2 Both turning flight and accelerated stalls shall be performed:
- (a) with flaps retracted, at 75% maximum continuous power and at idle;
  - (b) with flaps extended, at 75% maximum continuous power and at idle (speed not to exceed  $V_{FE}$ ).

### **21. Spinning**

- 21.1 For aeroplanes placarded “no intentional spins,” the aeroplane must be able to recover from a one- turn spin or a 3-s spin, whichever takes longer, in not more than one additional turn, with the controls used in the manner normally used for recovery.
- 21.2 For aeroplanes in which intentional spinning is allowed, the aeroplane must be able to recover from a three-turn spin in not more than one and one-half additional turn.
- 21.3 In each of the above cases:
- (a) For both flaps-retracted and flaps-extended conditions, the applicable airspeed limit and limit manoeuvring load factor may not be exceeded.
  - (b) There may be no excessive control forces during the spin or recovery.
  - (c) It must be impossible to enter an uncontrollable spin from any control input or flight condition.
  - (d) If flaps have been extended, they may be retracted during recovery.
- 21.4 If the aeroplane design is inherently spin resistant:
- (a) This must be proven by test and documented.
  - (b) The aeroplane must be placarded “no intentional spins”

(c) The aeroplane need not comply with 21.1 and 21.3.

**22. Ground Handling Control and Stability**

22.1 It must be possible to taxi, takeoff, and land while maintaining control of the aeroplane, up to the maximum crosswind component specified within the POH.



## Chapter C – Structure

### General:

#### 23. Loads

- 23.1 Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.
- 23.2 Unless otherwise provided, the air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the airplane. These loads must be distributed to conservatively approximate or closely represent actual conditions.
- 23.3 If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

#### 24. Factor of Safety

- 24.1 Unless otherwise provided in 24.2, an ultimate load factor of safety of 1.5 must be used.
- 24.2 Special ultimate load factors of safety shall be applied to the following:

2.0	x 1.5 = 3.	on castings;
1.2	x 1.5 = 1.8	on fittings;
2.0	x 1.5 = 3.0	on bearings at bolted or pinned joints subject to rotation
4.45	x 1.5 = 6.67	on control surface hinge-bearing loads except ball and roller bearing hinges
2.2	x 1.5 = 3.3	on push-pull control systems;
1.33	x 1.5 = 2	on cable control systems, seat belts and harness/harness fittings

#### 25. Strength and Deformation

- 25.1 The structure must be able to support limit loads without permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.
- 25.2 The structure must be able to support ultimate loads without failure for at least 3-s. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the 3 s limit does not apply.

#### 26. Proof of Structure

Each design requirement must be verified by means of conservative analysis or test (static, component, or flight), or both.

- 26.1 Compliance with the strength and deformation requirements of Section 25 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests are acceptable if the design load conditions have been simulated. Substantiating load tests should normally be taken to ultimate design load.

**Table 2 Load Factor and Minimum Design Speed Definitions:**

$n_1$	= Aeroplane Positive Manoeuvring Limit Load Factor
$n_2$	= Aeroplane Negative Manoeuvring Limit Load Factor.
$n_3$	= Aeroplane Positive Gust Limit Load Factor at $V_C$ .
$n_4$	= Aeroplane Negative Gust Limit Load Factor at $V_C$ .
$n_{flap}$	= Aeroplane Positive Limit Load Factor With Flaps Fully Extended at $V_F$ .
$V_{F \min}$	= Minimum Design Flap Speed = $11.0 \sqrt{n_1 W / S}$ kts.
$V_{A \min}$	= Minimum Design Manoeuvring Speed = $15.0 \sqrt{n_1 W / S}$ kts., but shall not exceed $V_C$ used in the design.
$V_{C \min}$	= Minimum Design Cruising Speed = $17.0 \sqrt{n_1 W / S}$ kts. but need not exceed $0.9 V_H$
$V_{D \min}$	= Minimum Design Dive Speed = $24.0 \sqrt{n_1 W / S}$ kts. but need not exceed $1.4 \sqrt{\frac{n_1}{3.8}} V_{C \min}$ = 1.436 x $v_c$

Table 2

## 26. Flight Loads

- 26.1 Each flight load may be considered independent of altitude and, except for the local supporting structure for dead weight items, only the maximum design weight conditions must be investigated.
- 26.2 Table 2 must be used to determine values of  $n_1$ ,  $n_2$ ,  $n_3$ , and  $n_4$ , corresponding to the maximum design weights.
- 26.3 Fig. 1 and Fig. 2 must be used to determine values of  $n_3$  and  $n_4$ , corresponding to the minimum flying weights, and, if these load factors are greater than the load factors at the design weight, the supporting structure for dead weight items must be substantiated for the resulting higher load factors.
- 26.4 Each specified wing and tail loading is independent of the centre of gravity range. The applicant, however, must select a CG range, and the basic fuselage structure must be investigated for the most adverse dead weight loading conditions for the CG range selected.
- 26.5 The following loads and loading conditions are the minimums for which strength must be provided in the structure.
- Aeroplane Equilibrium* – The aerodynamic wing loads may be considered to act normal to the relative wind and to have a magnitude of 1.05 times the airplane normal loads (as determined from 25.2 and 25.3) for the positive flight conditions and magnitude equal to the airplane normal loads for the negative conditions. Each chord-wise and normal component of this wing load must be considered.
  - Minimum Design Airspeeds* - The minimum design airspeeds may be chosen by the applicant except that they may not be less than the minimum speeds found in Table 1. In addition,  $V_{C \min}$  need not exceed values of  $0.9 V_H$  actually obtained at sea level for the lowest design weight. In computing these minimum design airspeeds,  $n_1$  may not be less than 4.0
  - Flight Load Factor* – The limit flight load factors specified in Table 3 represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the aeroplane) to the weight of the aeroplane. A positive flight load factor is an aerodynamic force acting upward, with respect to the aeroplane.



**Table 3- Minimum Design Limit Flight Load Factors**

Limit Flight Load Factors			
		Normal Category	
Flight Load Factors	Flaps Up	n1	4.0
		n2	-0.5n1
		n3	Find n3 from Fig. 2
		n4	Find n4 from Fig. 3
	Flaps Down	nflap	0.5n1
		nflap	Zero*

\*Vertical wing load may be assumed equal to zero and only the flap part of the wing need be checked for this condition.

Table 3

## 27. Flight Conditions:

### 27.1 General

Each design condition in 27.2 to 27.4 must be used to assure sufficient strength for each condition of speed and load factor on or within the boundary of a flight envelope diagram for the airplane similar to the diagram in Fig. 3. This diagram must also be used to determine the airplane structural operating limitations.

### 27.2 Symmetrical Flight Conditions

The aeroplane must be designed for symmetrical flight conditions as follows:

- (a) The aeroplane must be designed for at least the four basic flight conditions, “A”, “D”, “E”, and “G” as noted on the flight envelope of FigA3. In addition, the following requirements apply:
  - (1) The design limit flight load factors corresponding to Conditions “D” and “E” of Fig. 3 must be at least as great as those specified in Table 2, and the design speed for these conditions must be at least equal to the value of  $V_{D \min}$  from Table 2.
  - (2) For conditions “A” and “G” of FigA3, the load factors must correspond to those specified in Table 2, and the design speeds must be computed using these load factors with the maximum static lift coefficient  $C_{AN}$  determined by the applicant. However, in the absence of more precise computations, these latter conditions may be based on a value of  $C_{AN} = \pm 1.35$  and the design speed for Condition “A” may be less than  $V_A \min$ .
  - (3) Conditions “C” and “F” of Fig.A3 need only be investigated when  $n3W/S$  or  $n2W/S$  respectively.
- (b) If the flaps or other high-lift devices intended for use at the relatively low airspeed of approach, landing, and takeoff are installed, the airplane must be designed for the two flight conditions corresponding to the values of limit flap-down factors specified in Table 2 with the flaps fully extended at not less than the design flap speed  $V_{F \min}$  from Table 2.

### 27.3 Unsymmetrical Flight Conditions

Each affected structure must be designed for unsymmetrical loadings as follows:

- (a) The aft fuselage-to-wing attachment must be designed for the critical vertical surface load determined in accordance with 28.

- (b) The wing and wing carry-through structures must be designed for 100% of Condition “A” loading on one side of the aeroplane’s plane of symmetry and 70% of the positive manoeuvring wing loading on both sides of the plane of symmetry and the maximum
- (c) wing torsion resulting from aileron displacement. The effect of aileron displacement on wing torsion at  $V_C$  or  $V_A$  using the basic airfoil moment coefficient modified over the aileron portion of the span, must be computed as follows:
- (1)  $C_m = C_m + 0.01d_u$  (up aileron side) wing basic airfoil.
  - (2)  $C_m = C_m - 0.01d_d$  (down aileron side) wing basic airfoil, where  $d_u$  is the up aileron deflection and  $d_d$  is the down aileron deflection.
- (d)  $\Delta$  critical, which is the sum of  $d_u + d_d$  must be computed as follows:
- (1) Compute  $\Delta_a$  and  $\Delta_b$  from the formulas:

$$\Delta_a = \frac{V_A}{V_C} \times \Delta_p \quad \text{and} \quad \Delta_b = 0.5 \frac{V_A}{V_D} \times \Delta_p$$

where:  $\Delta_p$  = the maximum total deflection (sum of both aileron deflections) at  $V_A$  with  $V_A$ ,  $V_C$ , and  $V_D$  described in 26.6(c)

- (2) Compute  $K$  from the formula:

$$K = \frac{(C_m - 0.01d_b)V_D^2}{(C_m - 0.01d_a)V_C^2}$$

where  $d_a$  is the down aileron deflection corresponding to  $\Delta_a$  and  $d_b$  is the down aileron deflection corresponding to  $\Delta_b$  as computed in step (1).

- (3) If  $K$  is less than 1.0,  $\Delta_a$  is  $\Delta$  critical and must be used to determine  $d_u$  and  $d_d$ . In this case,  $V_C$  is the critical speed which must be used in computing the wing torsion loads over the aileron span.

- (4) If  $K$  is equal to or greater than 1.0,  $\Delta_b$  is  $\Delta$  critical and must be used to determine  $d_u$  and  $d_d$ . In this case,  $V_D$  is the critical speed which must be used in computing the wing torsion loads over the aileron span.

## 27.4 Supplementary Conditions

*Rear Lift Truss; Engine Torque; Side Load on Engine Mount-* Each of the following supplementary conditions must be investigated:

- (a) In designing the rear lift truss, the following special condition may be investigated instead of Condition “G” of Figure A-3. The rear lift truss must be designed for conditions of reversed airflow at a design speed of  $V=39$  kts. Either aerodynamic data for a particular wing section used, or a value of  $C_L$  equalling  $-0.8$  with a chord-wise distribution that is triangular between a peak at the trailing edge and zero at the leading edge must be used.

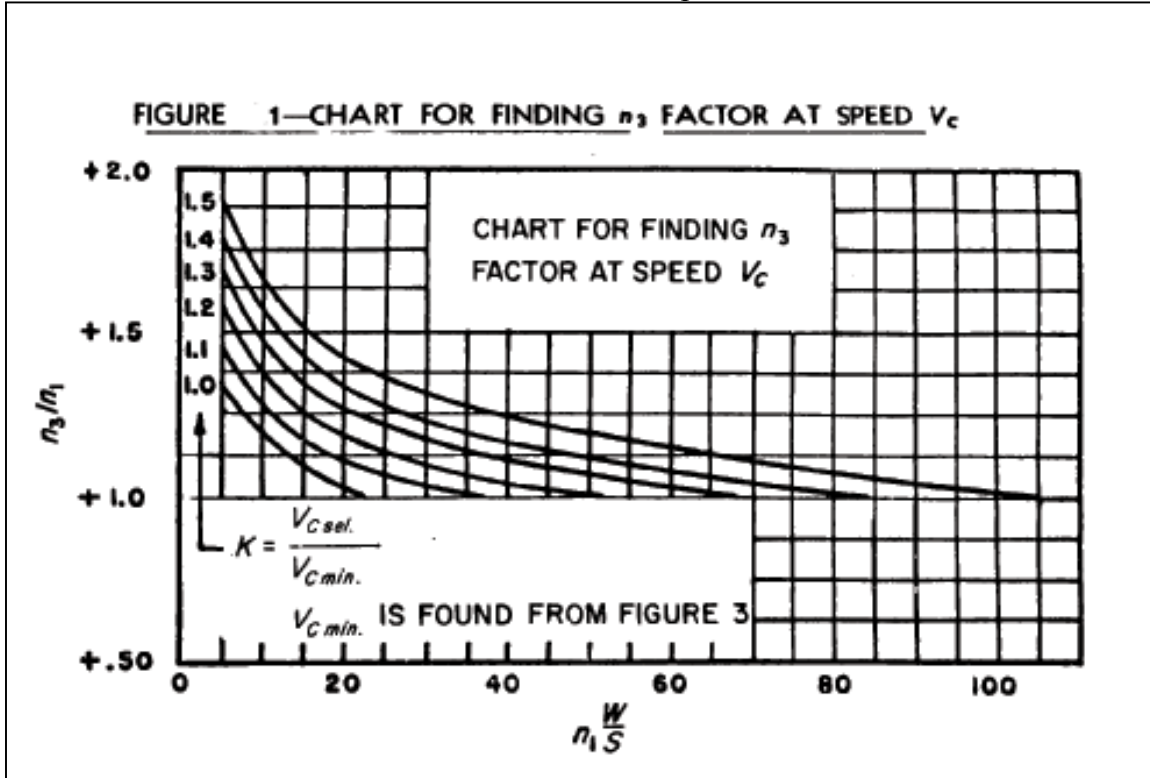


Figure 1

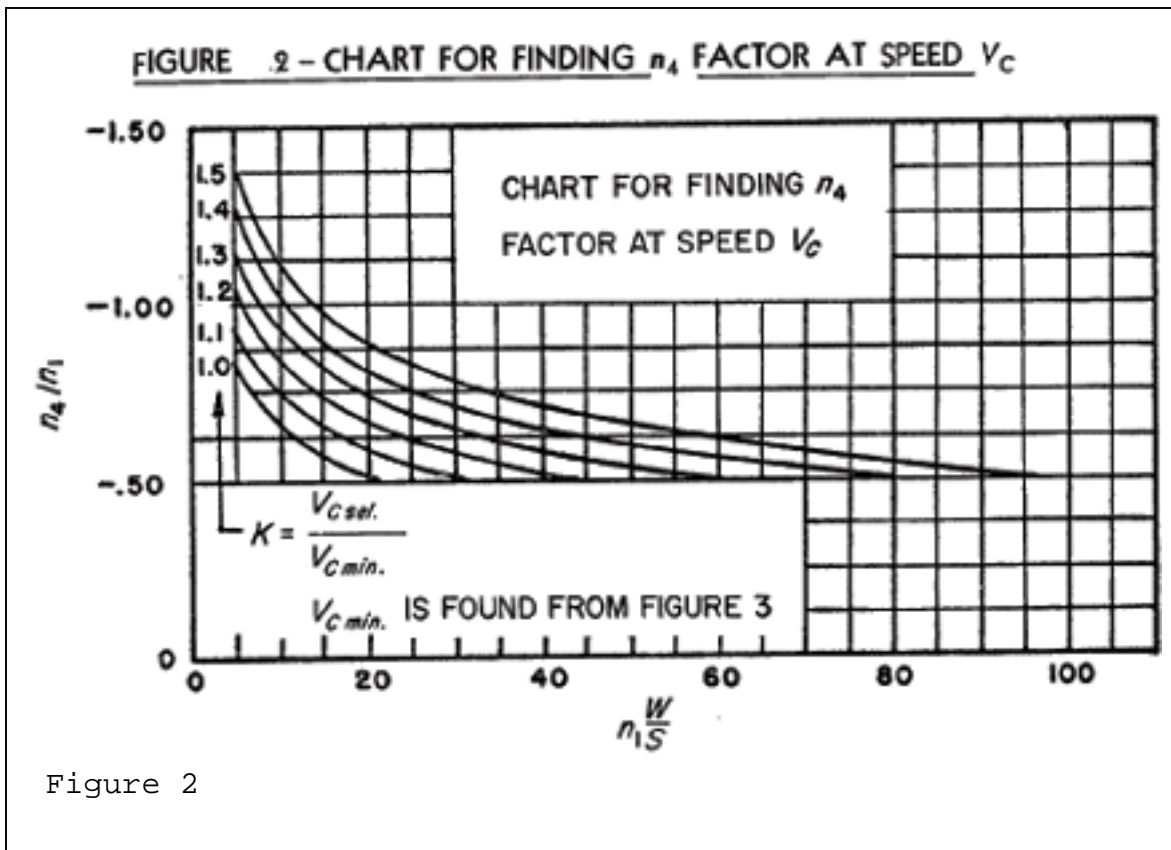


Figure 2

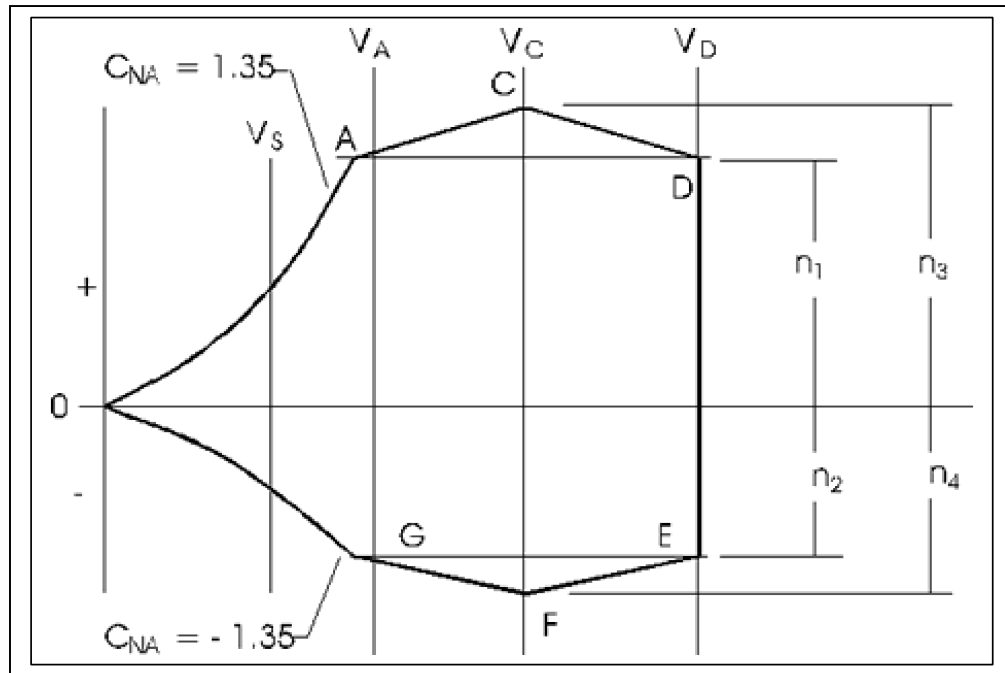


Figure 3 Flight Envelope

## 28. Control Surface Loads

### 28.1 General

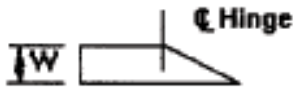
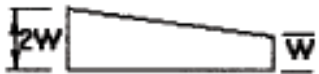
Each control surface load must be determined using the criteria of 28.2 and must lie within the simplified loadings of 28.3.

### 28.2 Limit Pilot Forces

In each control surface loading condition described in 28.3, the air loads on the movable surfaces and the corresponding deflections need not exceed those which could be obtained in flight by using the maximum limit pilot forces specified in Table 1 Pilot Forces.

### 28.3 Surface Loading Conditions

Each surface loading condition must be investigated as follows: Simplified limit surface loadings and distributions for the horizontal tail, vertical tail, aileron, wing flaps, and trim tabs are specified in Table 5. and Figs.5 and 6. If more than one distribution is given, each distribution must be investigated.

Average limit control surface loading			
AVERAGE LIMIT CONTROL SURFACE LOADING			
SURFACE	DIRECTION OF LOADING	MAGNITUDE OF LOADING	CHORDWISE DISTRIBUTION
Horizontal Tail I	a) Up and Down	Figure A5 Curve (2)	See Figure . 7'
	b) Unsymmetrical Loading (Up and Down)	100% $\bar{w}$ on one side of airplane $\zeta$ 65% $\bar{w}$ on other side of airplane $\zeta$ for normal and utility categories. For acrobatic category see A23.11(c)	
Vertical Tail II	Right and Left	Figure A5 Curve (1)	Same as above
Aileron III	a) Up and Down	Figure A6 Curve (5)	(C) 
Wing Flap IV	a) Up	Figure A6 Curve (4)	(D) 
	b) Down	.25 x Up Load (a)	
Trim Tab V	a) Up and Down	Figure A6 Curve (3)	Same as (D) above

**NOTE:** The surface loading I, II, III, and V above are based on speeds  $V_A$  min and  $V_C$  min.  
The loading of IV is based on  $V_F$  min.  
If values of speed greater than these minimums are selected for design, the appropriate surface loadings must be multiplied by the ratio  $\left(\frac{V_{selected}}{V_{minimum}}\right)^2$ .  
For conditions I, II, III, and V the multiplying factor used must be the higher of  $\left(\frac{V_A \text{ sel.}}{V_A \text{ min.}}\right)^2$  or  $\left(\frac{V_C \text{ sel.}}{V_C \text{ min.}}\right)^2$

Table 5

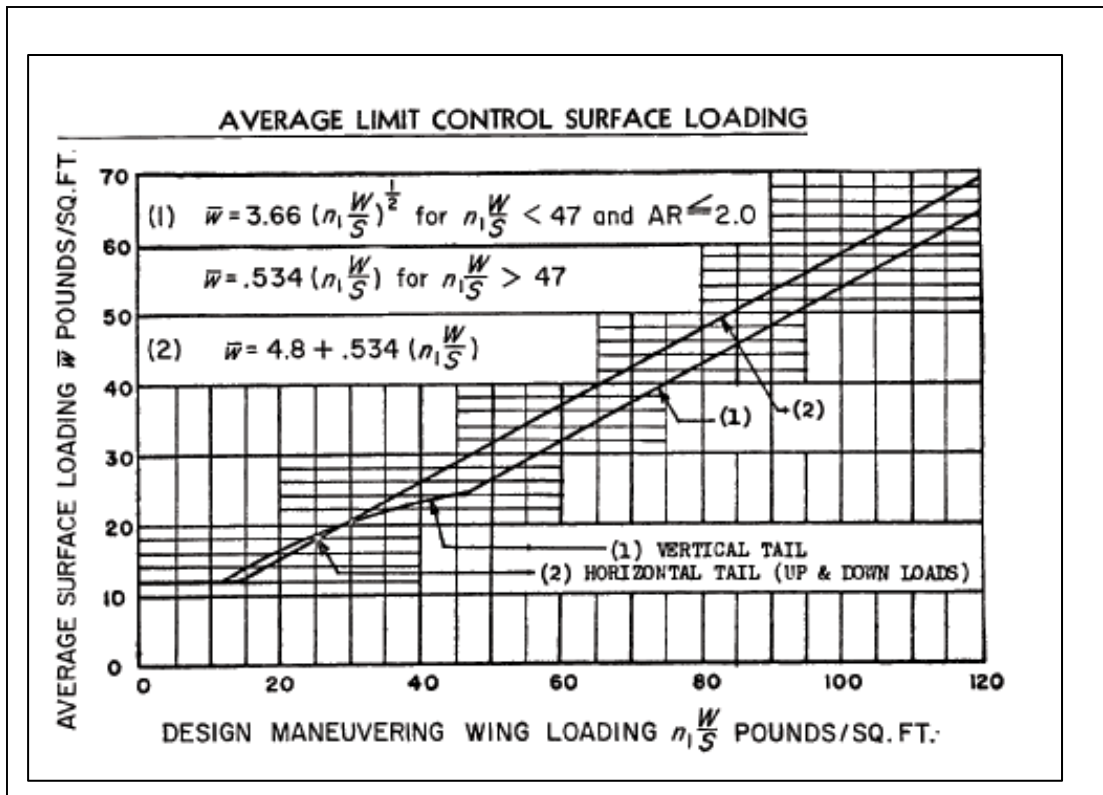
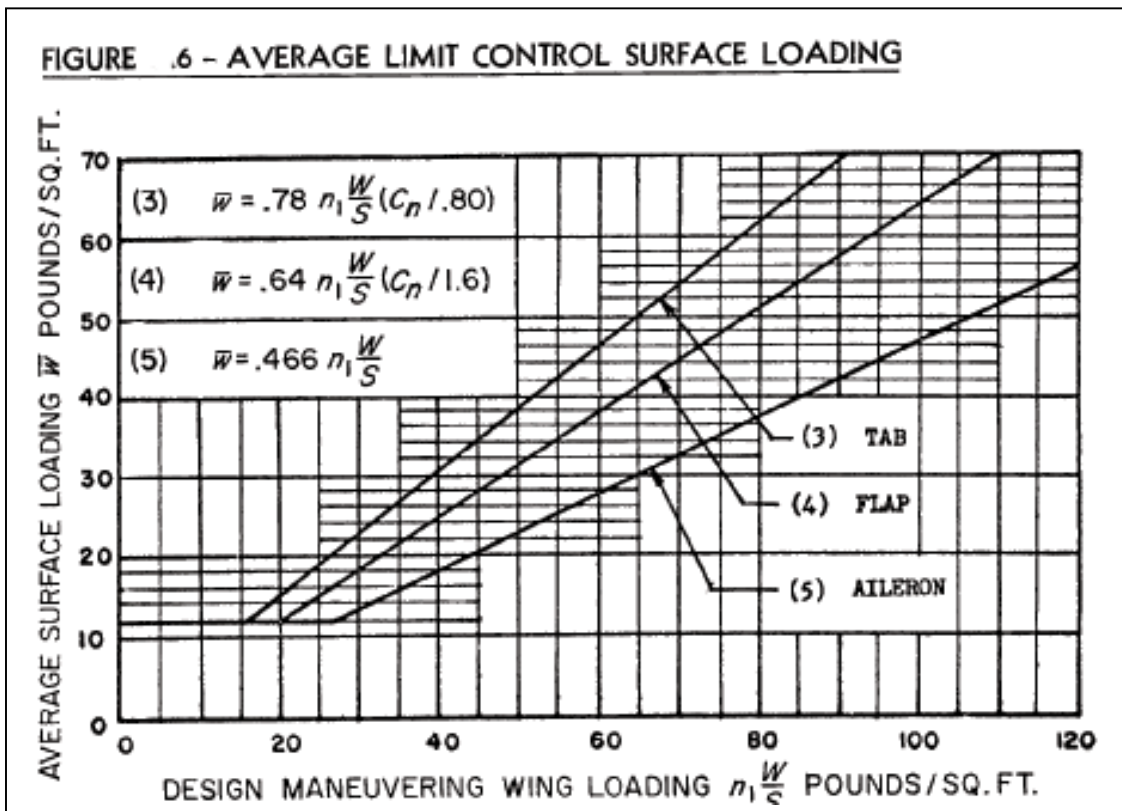


Figure 4



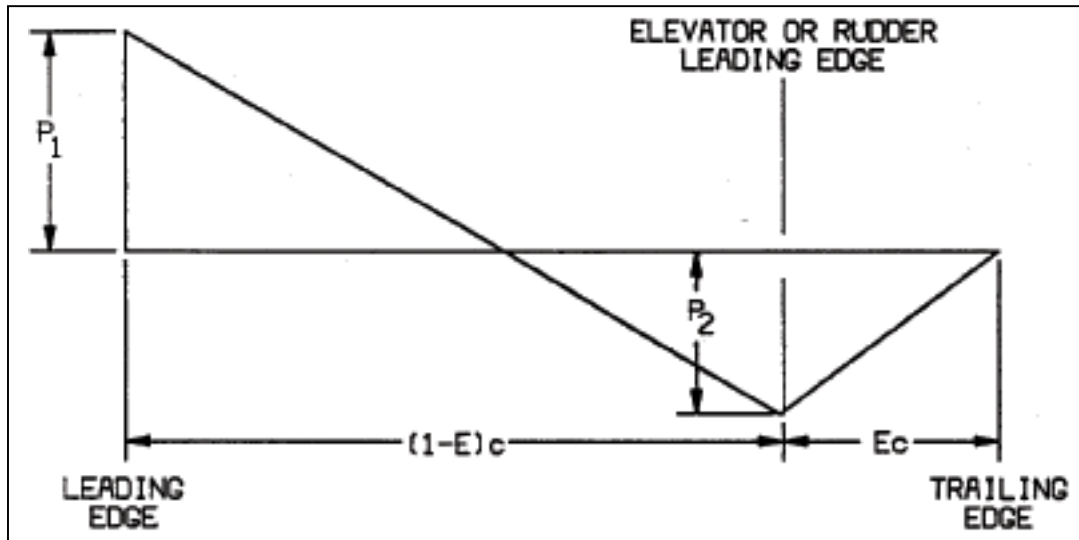


Figure 6

## 29. Control System Loads

### 29.1 Primary Flight Controls and Systems

Each Primary Flight Control and System must be designed as follows:

- The flight control system and its supporting structure must be designed for loads corresponding to 125% of the computed hinge moments of the movable control surface in the conditions prescribed in 28.
- The system limit loads need not exceed those that could be produced by the pilot and automatic devices operating the controls.
- The design must provide a rugged system for service use, including jamming, ground gusts, taxiing downwind, control inertia, and friction.

### 29.2 Dual-Control Systems

Dual-control systems must be designed for the loads resulting from each pilot applying 0.75 times the load specified in 28 with the pilots acting in opposition.

### 29.3 Ground Gust Conditions

The control system from the control surfaces to the stops or control locks must be designed for limit loads due to gusts corresponding to the following hinge moments:

$$M_s = k.C_s.S_s.q$$

Where:

- |       |  |
|-------|--|
| $M_s$ | = limit hinge moment   |
| $C_s$ | = mean chord of the control surface aft of the hinge line.       |
| $S_s$ | = area of the control surface aft of the hinge line.             |
| $q$   | = dynamic pressure corresponding to an airspeed of 39 knots, and |
| $k$   | = limit hinge moment coefficient due to ground gust = 0.75       |

### 29.4 Control Surface Mass Balance Weights

If applicable, shall be designed for:

- The  $n = 16$  limit load normal to the surface,

- (b) The  $n = 8$  limit load fore and aft and parallel to the hinge line.

29.5 The motion of wing flaps on opposite sides of the plane of symmetry must be synchronized by a mechanical interconnection unless the airplane has safe flight characteristics with the wing flaps retracted on one side and extended on the other.

29.6 All primary controls shall have stops within the system to withstand the greater of pilot force, 125% of surface loads, or ground gust loads (see 29.3)

### 30. Rear Fuselage Loads

The rear fuselage shall be substantiated for:

- (a) The symmetrical horizontal tail load of Table 5
- (b) The unsymmetrical horizontal tail load of Table 5
- (c) The vertical tail loads of Table 5 and
- (d) The tail wheel loads if applicable

### 31. Forward Fuselage Loads

The forward fuselage shall be substantiated for each of the following conditions:

31.1 Inertia forces of  $n = 4$  and  $n = -2$  (or for  $n_3$  and  $n_4$  if they are larger than 4 and  $-2$ ) (see also 35 if  $n_j$  is larger than 3.33. and

### 32. Engine Torque

The engine mount and its supporting structure must be designed for the effects of:

- (a) The limit torque corresponding to takeoff power and propeller speed acting simultaneously with 75% of the positive limit manoeuvring load factor  $n_1$  which shall not be less than 4.0 (Table 2)
- (b) The limit torque corresponding to maximum continuous power and propeller speed acting simultaneously with the limit loads of (Table 2)
- (c) For conventional reciprocating engines with positive drive to the propeller, the limit torque to be accounted for in (a) is obtained by multiplying the mean torque by one of the following factors:

For four-stroke engines:

- (1) 1.33 for engines with five or more cylinders: or
- (2) 2,3,4, or 8 for engines with four, three, two, or one cylinders, respectively.

For two-stroke engines

- (3) 2 for engines with three or more cylinders; or
- (4) 3 or 6 for engines with two or one cylinders respectively.

### 33. Side Load on Engine Mount

33.1 The engine mount and its supporting structure must be designed for a limit load factor in a lateral direction for the side load on the engine mount of not less than 1.5

33.2 The side load prescribed in 33.1 may be assumed to be independent other flight conditions.

33.3 If applicable, the nose wheel loads of 5.8.1.7 must also be considered.

### 34. Ground Load Conditions

#### 34.1 Basic Landing Conditions.

The requirements for the basic landing conditions are given in 34.1 (a) to 34.1.(c) Table 6 and Fig.7

(a) The load factor on the wheels  $n_j$ , may be computed as follows:

$$(b) n_j = \frac{h + d / 3}{ef \times d}$$

where:

$h$  = drop height. In. =  $3.6 \times \sqrt{W/S}$  with  $w/s$  lb/ft<sup>2</sup> but  $h$  larger than 9 in.,

$d$  = total shock absorber travel, in. =  $d_{\text{tire}} + d_{\text{shock}}$

$ef$  = shock efficiency, and

$ef \times d$  =  $0.5 \times d$  for tire and rubber or spring shocks, or

=  $0.5 \times d_{\text{tire}} + 0.65 \times d_{\text{shock}}$  for hydraulic shock absorbers.

- (c) If  $n_j$  is larger than 3.33, all concentrated masses (engine, fuel tanks, occupant seats, ballast, etc.) must be substantiated for a limit landing load factor of  $n_j + 0.67 = n$  which is greater than 4.
- (d) The usual ultimate factor of safety of 1.5 applies to these conditions, unless a drop test from the reserve energy height  $h_r = 1.44h$  shows that a lower factor may be used. If the shock absorber is of a fast energy absorbing type, the ultimate loads are the limit load multiplied by the conservative reserve energy factor of 1.2.
- (e) *Side Load Conditions* – The requirements for the side load conditions on the main wheels in a level attitude are given in Fig. 8
- (f) *Braked Roll Conditions* – The requirements for the braked roll conditions on the main wheels in a level attitude are given in Fig. 9
- (g) *Supplementary Conditions for Tail Wheel* – The requirements for the tail wheel conditions in a tail down attitude are given in Fig 10
- (h) *Supplementary Conditions for Nose Wheel* – The requirements for supplementary conditions for nose wheels are given in Fig. 11 (the static load is at the combination of weight and CG that gives the maximum loads).
- (i) For the conditions in (d) to (g) the shock absorbers and tires are assumed to be in their static position.

## BASIC LANDING CONDITIONS

Condition	Tail wheel Type		Nose wheel type		
	Level Landing	Tail-down Landing	Level Landing with inclined reactions	Level Landing with nose wheel just clear of ground	Tail-down Landing
Vertical component at c.g.	nW	nW	nW	nW	nW
Fore and aft component at c.g.	KnW	0	KnW	KnW	0
Lateral component in either direction at c.g.	0	0	0	0	0
Shock absorber extension (hydraulic shock absorber)	Note 2	Note 2	Note 2	Note 2	Note 2
Shock absorber deflection (rubber or spring shock absorber) percent	100%	100%	100%	100%	100%
Tire deflection	Static	Static	Static	Static	Static
Main wheel loads (both wheels) (Vr)	(n-L)W	(n-L)Wb/d	(n-L)Wa'/d'	(n-L)W	(n-L)W
Main wheel loads (both wheels) (Dr)	KnW	0	KnWa'/d'	KnW	0
Tail (nose) wheel loads (Vf)	0	(n-L)Wa/d	(n-L)Wb'/d'	0	0
Tail (nose) wheel loads (Df)	0	0	KnWb'/d'	0	0
Notes:	1,3,4,5	4,5	1	1,3,4,5	3 & 4,5

Table 6

Note 1. K may be determined as follows  $K=0.25$  for  $W=3,000$  pounds or less.

Note 2. For the purpose of design, the maximum load factor is assumed to occur throughout the shock absorber stroke from 25 percent deflection to 100 percent deflection unless otherwise shown and the load factor must be used with whatever shock absorber extension is most critical for each element of the landing gear.

Note 3. Unbalanced moments must be balanced by a rational conservative method

Note 4. L = ratio of the assumed wing lift to the aeroplane weight, but not more than 0.667

Note 5. n is the limit inertia load factor, at the c.g. of the aeroplane.

Definitions: Vf = Vertical load on Tail/Nose wheel  
 Vr = Vertical Load on Main Wheel  
 Df = Drag load on Tail/Nose wheel  
 Dr = Drag Load on Main Wheel

Where:

Vertical is a vector parallel and opposite to gravity

Drag is a vector 90 degrees to the vertical load and opposite to the direction of aircraft movement

**BASIC LANDING CONDITIONS**

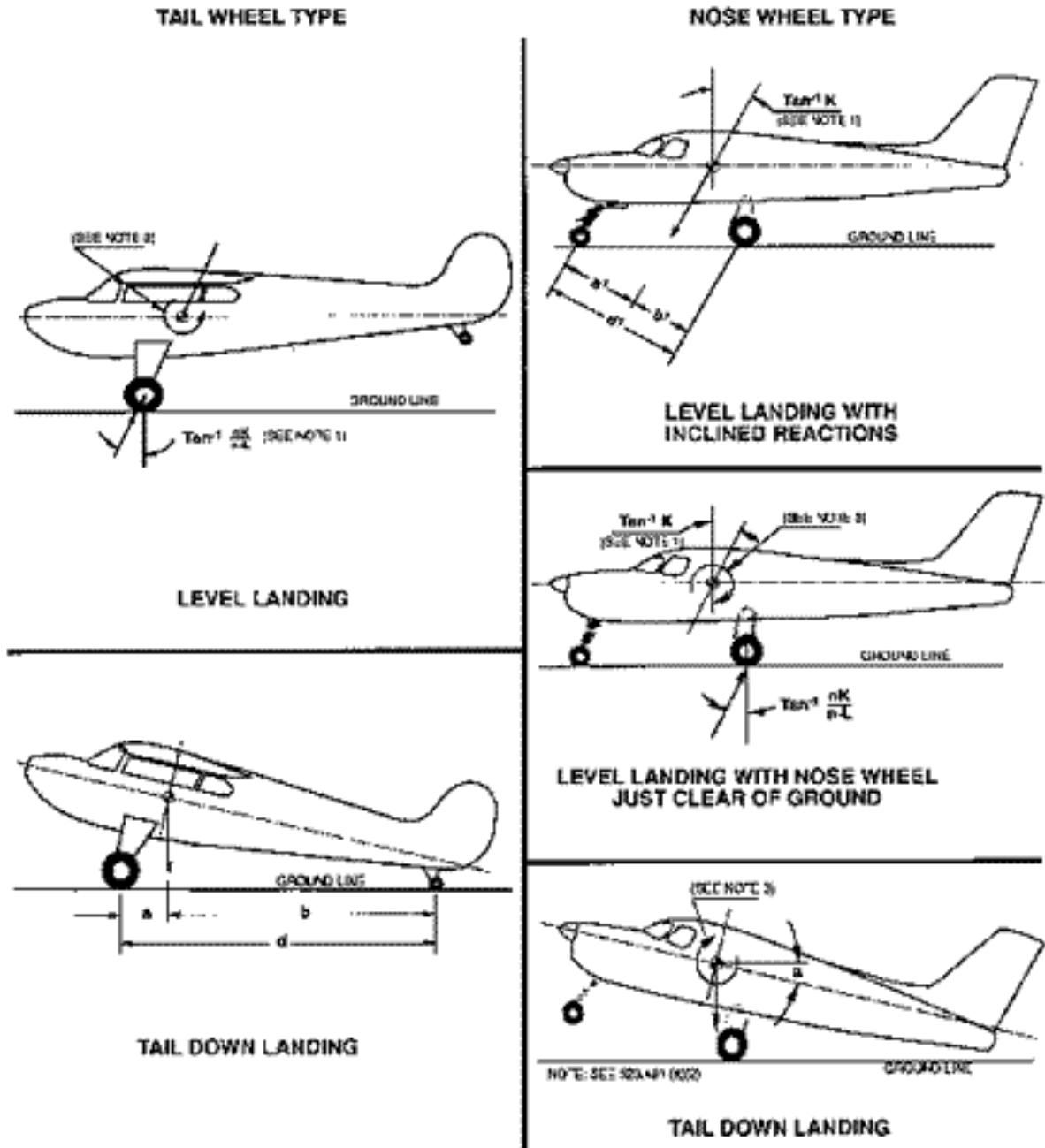


Figure 7

**35. Side Load Conditions**

Side load conditions on main wheels (level attitude) are given by the following:

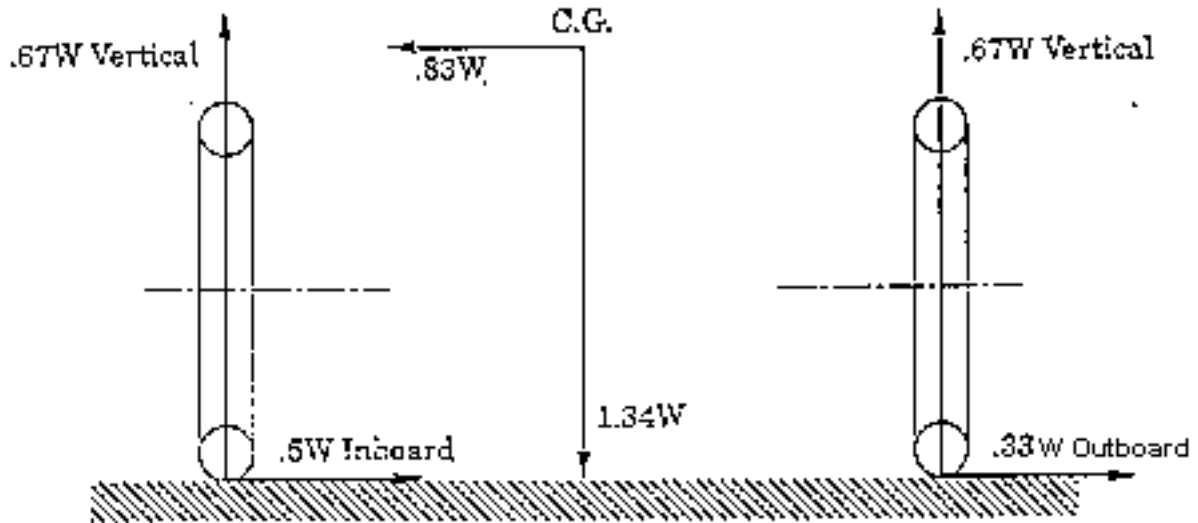


Figure 8

**36. Braked Roll Conditions**

Braked roll conditions on main wheels (level attitude) are given by the following:

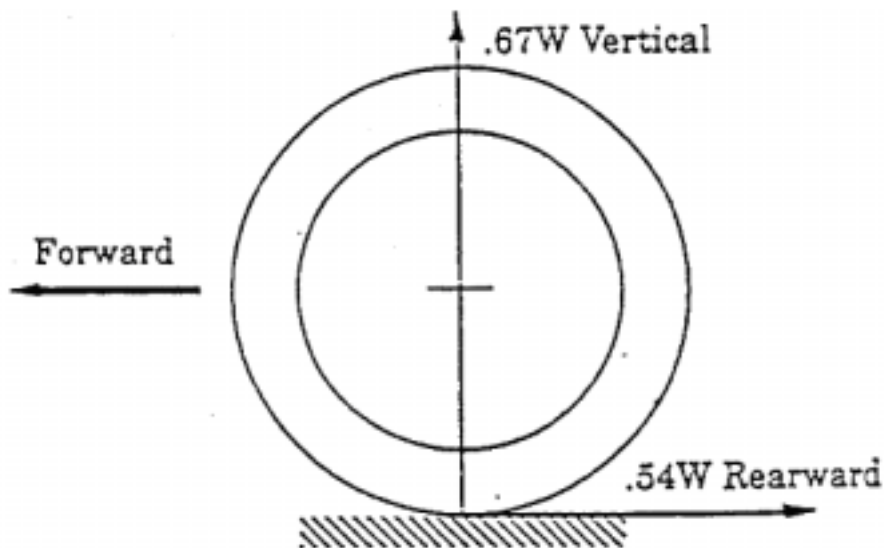


Figure 9

**37. Supplementary Conditions for Tail Wheel**

Tail wheel conditions (tail down attitude) are given by the following:

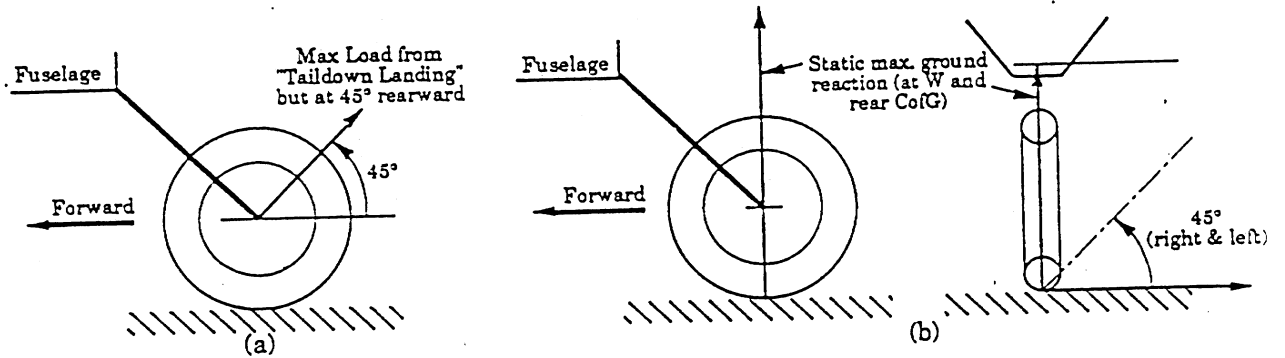


Figure 10

**38. Supplementary Conditions for Nose Wheel**

Supplementary conditions for nose wheel (static attitude) are given by the following (static load is maximum for weight and CG combination):

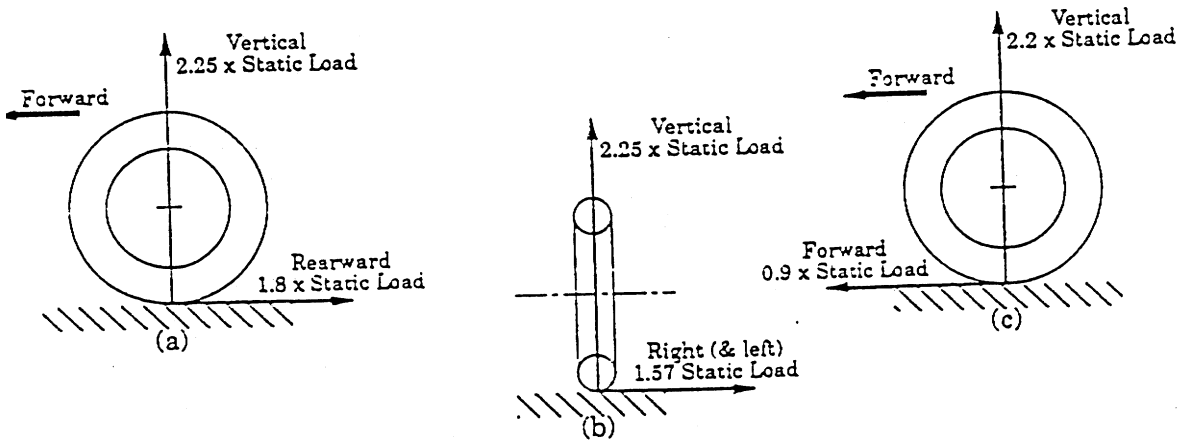


Figure 11

Note: Shock absorbers and tires in static position.

**39. Water Load Conditions**

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

39.2 Unless the applicant makes a rational analysis of the water loads, or uses the standards in ANC-3, or sufficient service experience is available, sections 525.523 through 525.537 of Chapter 525 of the Airworthiness Manual apply.

#### **40. Emergency Landing Conditions**

40.1 The structure must be designed to protect each occupant during emergency landing conditions when occupants (through seat belts or harnesses, or both) as well as any concentrated weight located behind or above the occupant (such as engine, baggage, fuel, ballast and so forth), experience the static inertia loads corresponding to the following ultimate load factors (these are three independent conditions):

- (a)  $n = 3$  up
- (b)  $n = 9$  ( $n = 10$  for engine forward, and
- (c)  $n = 1.5$  lateral

#### **41. Other loads.**

##### **41.1 Tie-Down Points**

Tie-down points shall be designed for the maximum wind at which the airplane may be tied down in the open.  $V_R = 38$  kts minimum as in accordance with 29.3 may be used.

##### **41.2 Parachute System Loads**

If the aeroplane is to be equipped with an emergency parachute system (Ballistic Recovery System), the attachment point(s) to the airframe must be designed in accordance with ASTM Specification F2316.

##### **41.3 Loads from Single Masses**

The attachment means for all single masses which are part of the equipment for the aeroplane must be designed to withstand loads corresponding to the maximum design load factors to be expected from the established flight and ground loads, including the emergency landing conditions of 40.

#### **42 Reserved**

## Chapter D - Design and Construction

### 43. General

The integrity of any novel or unusual design feature having an important bearing on safety, shall be established by test.

### 44. Materials and Workmanship

Materials shall be suitable and durable for the intended use and design values (strength) must be chosen so that the probability of any structure being under strength because of material variations is extremely remote. (MIL HDBK-5)

### 45. Fabrication Methods

Manufactured parts, assemblies, and completed airplanes shall be produced in accordance with the Certificate to Manufacturer quality assurance and test procedures.

### 46. Self-Locking Nuts

No self-locking nut shall be used on any bolt subject to rotation in operation unless a non-friction locking device is used in addition to the self-locking device.

### 47. Protection of Structure

Protection of the structure against weathering, corrosion, and wear, as well as suitable ventilation and drainage shall be provided.

### 48. Accessibility

Accessibility for principal structural and control system inspection, adjustment, maintenance, and repair shall be provided.

### 49. Rigging

Unless specified otherwise, rigging and de-rigging must be able to be performed by persons having no more than average skill. It must be possible to inspect the aeroplane easily for correct rigging and safe-tying.

### 50. Proof of Design

Fulfilment of the design requirements for the aeroplane shall be determined by conservative analysis, or tests, or a combination of both. Structural analysis alone may be used only if the structure conforms to those for which experience has shown this method to be reliable. Dynamic tests, including structural flight tests to limit load factors at maximum take-off weight and at speeds from VA to the maximum allowable speed for the configuration being investigated are an acceptable proof.

### 51. Control System - Operation Test

It must be shown by functional test that the control system is free from jamming, excessive friction, and excessive deflection when the control system limit design loads are applied to the controls and the surfaces. (see Table 1) The control system stops must withstand those loads.

### 52. Pilot Compartment

Pilot comfort, good visibility (instruments, placards and outside), accessibility, exit (fire), and ability to reach all controls for smooth and positive operation, as well as pilot protection as far as practical in emergency landing shall be provided.

## Chapter E - Powerplant

### 53. Installation

The powerplant installation shall be easily accessible for inspection and maintenance. The powerplant attachment to the airframe is part of the structure and shall withstand the applicable load factors.

### 54. Engines

Installed engines shall meet Practice ASTM F2339 LSA engine design and production standards, or shall be type and production certified under FAR-33, JAR-E or JAR-22 Subpart H. design and production standards.

### 58. Fuel Systems

- 58.1 The unusable fuel quantity for each tank must be established by tests and shall not be less than the quantity at which the first evidence of engine fuel starvation occurs under each intended flight operation and manoeuvre.
- 58.2 Fuel tanks must be protected against wear from vibrations and their installation shall be able to withstand the applicable inertia loads.
- 58.3 Fuel tanks shall be designed and manufactured to withstand a positive pressure of 3.5 PSI, 8 ft. water column and installed to withstand prescribed load factors. The fuel tank shall be pressure tested prior to installation.
- 58.4 Each tank must be vented. The vent must discharge clear of the aeroplane.
- 58.5 The filler must be located outside the passenger compartment and spilled fuel must be prevented from entering or accumulating in any enclosed part of the aeroplane.
- 58.6 There must be at least one drain to allow safe drainage. A drainable sediment bowl located at the lowest point in the fuel system may be used instead of the drainable sump in the fuel tank.
- 58.7 A fuel strainer or filter accessible for cleaning and replacement must be included in the system.
- 58.8 The fuel lines must be properly supported and protected from vibrations and water.
- 58.9 Fuel lines located in an area subject to high heat (engine compartment) must be fire resistant or protected with a fire-resistant covering.
- 58.10 There must be a fuel shutoff valve accessible to the pilot while wearing a seat belt or harness.

### 59. Oil System

If an engine is provided with an oil system it must be:

- 59.1 Capable of supplying the engine with an adequate quantity of oil at a temperature not exceeding the maximum established by the engine manufacturer.
- 59.2 The oil tank or radiator, or both, must be installed to withstand the applicable inertia loads and vibrations, and the oil breather (vent) must be resistant to blockage caused by icing. Oil foam from the breather shall not constitute a hazard.

### 60. Induction System

- 60.1 The engine air induction system shall be designed to minimize the potential of carburettor icing.

### 61. Fire Protection

The engine, if enclosed, must be isolated from the rest of the airplane by a firewall or shroud. It must be constructed as far as practical to prevent liquid, gas, or flames, or a combination thereof,

from entering the airplane. The use of any one of the following materials shall be acceptable without further testing:

61.1 Stainless steel, not less than .015 in. thick.

61.2 Mild steel (corrosion-protected), not less than 0.018 in. thick, or

61.3 Alternative materials that provide protection equivalent to 61.1 or 61.2.

## Chapter F - Equipment

The aircraft shall be designed with the following minimum instrumentation and equipment

### 62. Flight and Navigation Instruments

- (1) Airspeed indicator (*Note: see section 73.(a)*);
- (2) Altimeter; and
- (3) Magnetic compass

### 63. Powerplant Instruments

(a) The following powerplant instruments are required:

- (1) Fuel quantity indicator;
- (2) Tachometer (RPM);
- (3) Engine 'kill' switch; and
- (4) Engine instruments as required by engine manufacturer.

### 64. Miscellaneous Equipment

64.1 If installed, an electrical system shall include a master switch and electrical overload protective devices (fuses or circuit breakers).

64.2 The electric wiring shall be sized according to the load of each circuit.

64.3 The battery shall be installed to withstand the load factors of section 30, 38 (b) and 44 and to prevent corrosion.

64.4 Battery containers shall be vented outside of the aeroplane.

### 65. Safety Belts and Harnesses

65.1 There must be a seat belt and harness for each occupant and adequate means to restrain the baggage.

65.2 Occupant seat belts, harnesses and their attachments, baggage compartment and restraints shall be designed for the appropriate load factors.

## **Chapter G - Operating Limitations and Information**

### **66. General**

The operating limitations and other information necessary for safe operation shall be established and made available to the pilot, as prescribed in sections 67 through 74.

### **67. Weight and Centre of Gravity**

Weight and Centre of Gravity limitations shall be provided, including reference and levelling data.

### **68. Powerplant Limitations**

Powerplant limitations shall be provided.

### **69. Instructions for Continued Airworthiness**

Maintenance information for inspections shall be provided.

### **70. Control Markings**

Each control (except primary controls) shall be suitably placarded.

### **71. Miscellaneous Markings and Placards**

Baggage, ballast location, etc., shall be suitably indicated.

### **72. Aeroplane Manual**

Each aeroplane or kit shall be accompanied by an owners manual and/or information to be placarded on the aeroplane giving the data specified in this publication.

### **73. Operating Limitations**

(a) The following IAS information shall be provided:

- (1) Stall speed at gross weight ( $V_S$ );
- (2) Flap extended speed range ( $V_{SF}$  to  $V_F$ );
- (3) Manoeuvring speed ( $V_A$ ); and
- (4) Never exceed speed ( $V_{NE}$ ).

(b) Load factors, prohibited manoeuvres and operating limitations shall be provided.

### **74. Operating Procedures**

The following operating procedures and handling information shall be provided:

- (a) Loading procedures (occupants, baggage, fuel, ballast, weight, and CG as required) and their limitations;
- (b) Preflight check;
- (c) Engine starting

- (d) Taxiing
- (e) Take-off
- (f) Climb at  $V_X$  and  $V_Y$
- (g) Cruise
- (h) Approach
- (i) Landing
- (j) Cross-wind and wind limitations
- (k) Balked landing procedures
- (l) Information on stalls, spins and any other useful pilot information
- (m) Performances at various weights, CGs, altitudes, air temperatures
- (n) Take-off and landing distances, rate of climb, cruise speeds, RPMs and fuel consumption;
- (o) Tie-down instruction

