UNITED STATES OF AMERICA
CIVIL AERONAUTICS BOARD
WASHINGTON, D. C.

CIVIL AIR REGULATIONS PART 4b
AIRPLANE AIRWORTHINESS—TRANSPORT CATEGORIES

To go into effect 20 July 1950.

UNITED STATES OF AMERICA
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Civil Air Regulations Revised Part 4b
Effective: July 20, 1950
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PART 4b - AIRPLANE AIRWORTHINESS—TRANSPORT CATEGORIES

This revision of Part 4b is basically an editorial revision of the part in line with current Federal Register requirements and the new regulation format recently established for the Civil Air Regulations. There has been some rearrangement of material, some clarification of language, and a few substantive modifications with which we believe there is little disagreement. It is the Board's opinion that this revision will be useful in considering any changes to be proposed during this year's annual review of this part of the airworthiness regulations.

It will be noted that the procedural provisions for changes in type design have been modified to describe current practice more adequately. Thus, specific authority is provided for mandatory changes in type design (e.g. CAA airworthiness directives) only in those instances where service experience indicates that a definite hazard exists. In other situations changes may be recommended but there is no authority given to exact compliance.

The following are the more important substantive changes contained in this revision. There is included a new provision (§ 4b.103) which will require a manufacturer to consider the effect of spanwise weight distribution on the controllability of the aircraft. This change is considered appropriate because experience indicates that spanwise weight distribution is more critical in larger transport category airplanes.

In Subpart C there has been included a provision permitting proof of strength by means of dynamic tests in addition to the currently provided static test (§ 4b.201). A new requirement designed to assure the proper mating of propeller and powerplant has been added to Subpart E (§ 4b.402), and the fuel tank strainer requirements have been revised to require a somewhat finer mesh screen in accordance with the current practice under this provision. The de-icer requirement of Subpart F has been changed to require two independent sources of power and a positive means for deflation when pneumatic boot-type de-icers are used. In Subpart G additional provisions have been inserted requiring entry in the Airplane Flight Manual of two new speed limitations, the landing gear operating speed and the landing gear extended speed.

Interested persons have been afforded an opportunity to participate in the making of this revision, and due consideration has been given to all relevant matter presented.

In consideration of the foregoing the Civil Aeronautics Board hereby adopts revised Part 4b (14 CFR, Part 4b) to read as follows, effective July 20, 1950:

PART 4b - AIRPLANE AIRWORTHINESS; TRANSPORT CATEGORIES

SUBPART A - GENERAL

APPLICABILITY AND DEFINITIONS

4b.0 Applicability of this part. This part establishes standards with which compliance shall be demonstrated for the issuance of a type certificate for transport category airplanes. This part, until superseded or rescinded, shall apply to all transport category airplanes for which applications for type certification in the transport category are made after the effective date of this part.

4b.1 Definitions. Unless otherwise noted, terms used in this part of the regulations are defined as follows.

(a) Administration.

(1) Administrator. The Administrator is the Administrator of the Civil Aeronautics.

(2) Applicant. An applicant is a person or persons applying for approval of an airplane or any part thereof.

(3) Approved. Approved, when used alone or as modifying terms such as means, devices, specifications, etc., shall mean approved by the Administrator.

(b) General design.

(1) Standard atmosphere. The standard atmosphere is an atmosphere defined as follows:

(i) the air is a dry, perfect gas,

(ii) the temperature at sea level is 59° F,

(iii) the pressure at sea level is 29.92 inches Hg,

(iv) the temperature gradient from sea level to the altitude at which the temperature equals -67° F is -0.003566° F/ft and zero thereabove,

(v) the density ρ_0 at sea level under the above conditions is 0.002378 lbs sec^2/ft^4.

(2) Maximum anticipated air temperature. The maximum anticipated air temperature is a temperature specified for the purpose of compliance with the powerplant cooling standards. (See § 4b.451 (b).)

(3) Airplane configuration. Airplane configuration is a term referring to the position of the various elements affecting the aerodynamic characteristics of the airplane (e.g. wing flaps, landing gear).

(4) Aerodynamic coefficients. The aerodynamic coefficients as used herein are nondimensional coefficients for forces and moments. They correspond with those adopted by the U.S. National Advisory Committee for Aeronautics.

(5) Critical engine(s). The critical engine is that engines(s) the failure of which gives the most adverse effect on the airplane flight characteristics relative to the case under consideration.

(6) Critical-engine-failure speed. The critical-engine-failure speed is the airplane speed used in the determination of the take-off at which the critical engine is assumed to fail. (See § 4b.114.)

(c) Weights.

(1) Maximum weight. The maximum weight of the airplane is that maximum at which compliance with the requirements of this part of the Civil Air Regulations is demonstrated. (See § 4b.101 (a).)

(2) Minimum weight. The minimum weight of the airplane is that minimum at which compliance with the requirements of this part of the Civil Air Regulations is demonstrated. (See § 4b.101 (c).)

(3) Empty weight. The empty weight of the airplane is a readily reproducible weight which is used in the determination of the operating weights. (See § 4b.104.)

(4) Design maximum weight. The design maximum weight is the maximum weight of the airplane used in structural design for flight load conditions. (See § 4b.210.)

(5) Design minimum weight. The design minimum weight is the minimum weight of the airplane at which compliance is shown with the structural loading conditions. (See § 4b.210.)

(6) Design take-off weight. The design take-off weight is the maximum airplane weight used in structural design for taxying conditions, and for landing conditions at a reduced velocity of descent. (See § 4b.210.)

(7) Design landing weight. The design landing weight is the maximum airplane weight used in structural design for landing conditions at the maximum velocity of descent. (See § 4b.230 (b).)

(8) Design unit weight. The design unit weight is a representative weight used to show compliance with the structural design requirements.

(i) Gasoline 6 lbs per U.S. gallon.

(ii) Lubricating oil 7.5 lbs per U.S. gallon.

(iii) Crew and passengers 170 lbs per person.

(d) Speeds.

(1) IAS – indicated air speed is equal to the pitot static air-speed indicator reading as installed in the airplane without correction for air-speed indicator system errors but including the sea level standard adiabatic compressible flow correction. (This latter correction is included in the calibration of the air-speed instrument dials.) (See §§ 4b.612 (a) and 4b.710.)

(2) CAS – calibrated air speed is equal to the air-speed indicator reading corrected for position and instrument error. (As a result of the sea level adiabatic compressible flow correction to the air-speed instrument dial, CAS is equal to the true air speed TAS in standard atmosphere at sea level.)

(3) EAS – equivalent air speed is equal to the air-speed indicator reading corrected for position error, instrument error, and for adiabatic compressible flow for the particular altitude. (EAS is equal to CAS at sea level in standard atmosphere.)

(4) TAS – true air speed of the airplane relative to undisturbed air. (TAS = EAS $(\rho_o/\rho)^{\frac{1}{2}}$)

(5) V_A – the design maneuvering speed. (See § 4b.210 (b) (2).)

(6) V_B – the design speed for maximum gust intensity. (See § 4b.210 (b) (3).)

(7) V_C – the design cruising speed. (See § 4b.210 (b)(4).)

(8) V_D – the design diving speed. (See § 4b.210 (b)(5).)

(9) V_{DF} – the demonstrated flight diving speed. (See § 4b.190.)

(10) V_F – the design flap speed for flight loading conditions with wing flaps in the landing position. (See § 4b.210 (b) (1).)

(11) V_{FE} – the flap extended speed is a maximum speed with wing flaps in a prescribed extended position. (See § 4b.714.)

(12) V_{LE} – the landing gear extended speed is the maximum speed at which the airplane can be flown safely with the landing gear extended. (See § 4b.716.)

(13) V_{LO} – the landing gear operating speed is a maximum speed at which the landing gear can be raised or lowered safely. (See § 4b.715.)

(14) V_{MC} – the minimum control speed with the critical engine inoperative. (See § 4b.133.)

(15) V_{NE} – the never-exceed speed. (See § 4b.711.)

(16) V_{NO} – the normal operating limit speed. (See § 4b.712.)

(17) V_{s_o} - the stalling speed or the minimum steady flight speed with wing flaps in the landing position. (See §§ 4b.112 (a) and 4b.160.)

(18) V_{s_1} - the stalling speed or the minimum steady flight speed obtained in a specified configuration. (See § 4b.112 (b).)

(19) V_1 - the critical-engine-failure speed. (See § 4b.114.)

(20) V_2 - the take-off safety speed. (See § 4b.114 (b).)

(e) Structural.

(1) Limit load. A limit load is the maximum load anticipated in normal conditions of operation. (See § 4b.200.)

(2) Ultimate load. An ultimate load is a limit load multiplied by the appropriate factor of safety. (See § 4b.200.)

(3) Factor of safety. The factor of safety is a design factor used to provide for the possibility of loads greater than those anticipated in normal conditions of operation and for uncertainties in design. (See § 4b.200 (a).)

(4) Load factor. The load factor is the ratio of a specified load to the total weight of the airplane; the specified load may be expressed in terms of any of the following: aerodynamic forces, inertia forces, or ground or water reactions.

(5) Limit load factor. The limit load factor is the load factor corresponding with limit loads.

(6) Ultimate load factor. The ultimate load factor is the load factor corresponding with ultimate loads.

(7) Checked pitching maneuver. A checked pitching maneuver is one in which the pitching control is suddenly displaced in one direction and then suddenly moved in the opposite direction, the deflections and timing being such as to avoid exceeding the limit maneuvering load factor.

(8) Design wing area. The design wing area is the area enclosed by the wing outline (including wing flaps in the retracted position and ailerons, but excluding fillets or fairings) on a surface containing the wing chords. The outline is assumed to be extended through the nacelles and fuselage to the plane of symmetry in any reasonable manner.

(9) Balancing tail load. A balancing tail load is that load necessary to place the airplane in equilibrium with zero pitch acceleration.

(10) Fitting. A fitting is a part or terminal used to join one structural member to another. (See § 4b.307 (c).)

(f) Power installation. 1/

(1) Brake horsepower. Brake horsepower is the power delivered at the propeller shaft of the engine.

(2) Take-off power. Take-off power is the brake horsepower developed under standard sea level conditions, under the maximum conditions of crankshaft rotational speed and engine manifold pressure approved for use in the normal take-off, and limited in use to a maximum continuous period as indicated in the approved engine specification.

1/ For engine airworthiness requirements see Part 13, for propeller airworthiness requirements see Part 14.

(3) Maximum continuous power. Maximum continuous power is the brake horsepower developed in standard atmosphere at a specified altitude under the maximum conditions of crankshaft rotational speed and engine manifold pressure approved for use during periods of unrestricted duration.

(4) Manifold pressure. Manifold pressure is the absolute pressure measured at the appropriate point in the induction system, usually in inches of mercury.

(5) Critical altitude. The critical altitude is the maximum altitude at which in standard atmosphere it is possible to maintain, at a specified rotational speed, a specified power or a specified manifold pressure. Unless otherwise stated, the critical altitude is the maximum altitude at which it is possible to maintain, at the maximum continuous rotational speed, one of the following:

(i) the maximum continuous power, in the case of engines for which this power rating is the same at sea level or at the rated altitude,

(ii) the maximum continuous rated manifold pressure, in the case of engines the maximum continuous power of which is governed by a constant manifold pressure.

(6) Pitch setting. Pitch setting is the propeller blade setting determined by the blade angle measured in a manner, and at a radius, specified in the instruction manual for the propeller.

(7) Feathered pitch. Feathered pitch is the pitch setting, chosen by the applicant, which in flight, with the engines stopped,

gives approximately the minimum drag and corresponds with a windmilling torque of approximately zero.

(8) Reverse pitch. Reverse pitch is the propeller pitch setting for any blade angle used **beyond zero pitch** (e.g. the negative angle used for reverse thrust).

(g) Fire protection.

(1) Fireproof. Fireproof material means a material which will withstand heat at least as well as steel in dimensions appropriate for the purpose for which it is to be used. When applied to material and parts used to confine fires in designated fire zones, fireproof means that the material or part will perform this function under the most severe conditions of fire and duration likely to occur in such zones.

(2) Fire-resistant. When applied to sheet or structural members, fire-resistant material means a material which will withstand heat at least as well as aluminum alloy in dimensions appropriate for the purpose for which it is to be used. When applied to fluid-carrying lines, other flammable fluid system components, wiring, air ducts, fittings, and powerplant controls, this term refers to a line and fitting assembly, component, wiring or duct, or controls which will perform the intended functions under the heat and other conditions likely to occur at the particular location.

(3) Flame-resistant. Flame-resistant material means material which will not support combustion to the point of propagating, beyond safe limits, a flame after the removal of the ignition source.

(4) Flash-resistant. Flash-resistant material means material which will not burn violently when ignited.

(5) Flammable. Flammable pertains to those fluids or gases which will ignite readily or explode.

(h) Miscellaneous.

(1) Supplemental breathing equipment. Supplemental breathing equipment is equipment designed to supply the supplementary oxygen required to protect against anoxia at altitudes where the partial pressure of oxygen in ambient air is reduced. (See § 4b.651.)

(2) Protective breathing equipment. Protective breathing equipment is equipment designed to prevent the breathing of noxious gases which might be present as contaminants in the air within the airplane in emergency situations. (See § 4b.651.)

CERTIFICATION

4b.10 Eligibility for type and airworthiness certificates. An airplane shall be eligible for type and airworthiness certification under the provisions of this part if it complies with the airworthiness provisions hereinafter established, or if the Administrator finds that the provision or provisions not complied with are compensated for by other design features which provide an equivalent level of safety, provided that the Administrator finds no feature or characteristic of the airplane which renders it unsafe for the transport category.

4b.11 Amendment. Unless otherwise specified, an amendment of this part shall be effective with respect to airplanes for which applications for type certificates are filed after the effective date of the amendment.

4b.12 Type certificate. An applicant shall be issued a type certificate when he demonstrates the eligibility of the airplane by complying with the requirements of §§ 4b.13 through 4b.15 in addition to those contained in Part 2 of the Civil Air Regulations.

4b.13 Data required. The applicant for a standard type certificate shall submit to the Administrator such descriptive data, test reports, and computations as are necessary to demonstrate that the airplane complies with the airworthiness requirements. The descriptive data shall be known as the type design and shall consist of drawings and specifications disclosing the configuration of the airplane and all design features covered in the airworthiness requirements as well as sufficient information on dimensions, materials, and processes to define the strength of the structure. The type design shall describe the airplane in sufficient detail to permit the airworthiness of subsequent airplanes of the same type to be determined by comparison with the type design.

4b.14 Inspections and tests. Inspections and tests shall include all those found necessary by the Administrator to insure that the airplane complies with the applicable airworthiness requirements and conforms to the following:

(a) all materials and products are in accordance with the specifications in the type design,

(b) all parts of the airplane are constructed in accordance with the drawings in the type design,

(c) all manufacturing processes, construction, and assembly are such that the design strength and safety contemplated by the type design will be realized in service.

4b.15 Flight tests. After proof of compliance with the structural requirements contained in this part, and upon completion of all necessary inspections and testing on the ground, and proof of the conformity of the airplane with the type design, and upon receipt from the applicant of a report of flight tests performed by him, the following shall be conducted:

(a) such official flight tests as the Administrator finds necessary to determine compliance with the requirements of this part,

(b) after the conclusion of flight tests specified in paragraph (a) of this section, such additional flight tests as the Administrator finds necessary to ascertain whether there is reasonable assurance that the airplane, its components, and equipment are reliable and function properly. The extent of such additional flight tests shall depend upon the complexity of the airplane, the number and nature of new design features, and the record of previous tests and experience for the particular airplane type, its components, and equipment. If practicable, these flight tests shall be conducted on the same airplane used in the flight tests specified in paragraph (a) of this section.

4b.16 Airworthiness certificates. An airplane manufactured in accordance with a type certificate (see § 4b.12) and conforming to the type design shall become eligible for an airworthiness certificate when, upon inspection of the airplane, the Administrator finds that it so conforms and that it is in a condition for safe operation. For each newly manufactured airplane this finding shall include a flight check by the applicant.

4b.17 Experimental certificate. An airplane shall become eligible for an experimental type and airworthiness certificate when the applicant presents evidence that the airplane is intended only for experimental purposes, and the Administrator finds that with appropriate restrictions it can be so operated without endangering the general public. The applicant shall submit data to identify the airplane and, upon inspection of the airplane, any other pertinent information found necessary by the Administrator to safeguard the general public.

4b.18 Production certificate. (For requirements with regard to production certificates see Part 2.)

4b.19 Approval of materials, parts, processes, and appliances.

(a) Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the Civil Air Regulations. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.

(b) Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

CHANGES

4b.20 General. When the type design is changed, the applicant or holder of the type certificate shall demonstrate that the airplane complies with the applicable airworthiness requirements.

4b.21 Classification of changes. Changes shall be classified as minor and major. A minor change shall be one which has no appreciable effect on the weight, balance, structural strength, powerplant operation, flight characteristics, or other characteristic affecting the airworthiness of the airplane. A major change shall be one not classified as a minor change.

4b.22 Approval of minor changes. Minor changes to type designs may be approved by an authorized representative of the Administrator prior to the submittal to the Administrator of any revised drawings.

4b.23 Approval of major changes. Major changes to type designs shall be approved only after receipt by the Administrator of substantiating data and necessary descriptive data for inclusion in the type design.

4b.24 Service experience changes.

(a) Where the Administrator finds as a result of service experience, that an unsafe condition exists with respect to a design feature, part, or characteristic of any airplane certificated under this part, he shall furnish notice [1/] thereof to all operators of airplanes of that type, and the airplanes shall not thereafter be operated until the unsafe condition has been corrected, unless otherwise authorized by the Administrator under specified conditions and limitations.

1/ Operators of airplanes are notified of any unsafe condition, of the required corrective action, and of compliance dates through the medium of Airworthiness Directives issued by the Administrator.

(1) When the Administrator finds that design changes are necessary to correct the unsafe condition of the airplane, the holder of the type certificate, upon request of the Administrator, shall submit appropriate design modifications for the approval of the Administrator.

(2) Upon approval, such changes shall be made a part of the type design of the type certificate, and descriptive data covering the changes shall be made available by the holder of the type certificate to all operators of airplanes previously certificated under such type certificate.

(3) All airplanes of the same type shall be modified in accordance with such amended type certificate.

(b) Where no current unsafe condition exists but the Administrator or the holder of the type certificate finds through service experience that changes in type design will contribute to the safety of the airplane, the holder of the type certificate may submit appropriate design modifications for the approval of the Administrator. Upon approval of such modifications, the type design of the type certificate shall be amended accordingly, and all airplanes manufactured thereafter shall be modified in accordance with such amended type certificate. The manufacturer shall make available to all operators of the same type of airplane information on the design modifications.

SUBPART B - FLIGHT

GENERAL

4b.100 Proof of compliance.

(a) Compliance with the requirements prescribed in this subpart shall be established by flight or other tests conducted upon an airplane of the type for which a certificate of airworthiness is sought or by calculations based on such tests, provided that the results obtained by calculations are equivalent in accuracy to the results of direct testing.

(b) Compliance with each requirement shall be established at all appropriate combinations of airplane weight and center of gravity position within the range of loading conditions for which certification is sought by systematic investigation of all these combinations, except where compliance can be inferred reasonably from those combinations which are investigated.

(c) The controllability, stability, trim, and stalling characteristics of the airplane shall be established at all altitudes up to the maximum anticipated operating altitude.

(d) The applicant shall provide a person holding an appropriate pilot certificate to make the flight tests, but a designated representative of the Administrator shall pilot the airplane when it is found necessary for the determination of compliance with the airworthiness requirements.

(e) Official type tests shall be discontinued until corrective measures have been taken by the applicant when either:

(1) the applicant's test pilot is unable or unwilling to conduct any of the required flight tests, or

(2) it is found that requirements which have not been met are so substantial as to render additional test data meaningless or are of such a nature as to make further testing unduly hazardous.

(f) Adequate provision shall be made for emergency egress and for the use of parachutes by members of the crew during the flight tests.

(g) The applicant shall submit to the Administrator's representative a report covering all computations and tests required in connection with calibration of instruments used for test purposes and correction of test results to standard atmospheric conditions. The Administrator's representative shall conduct any flight tests which he finds necessary to check the calibration and correction report.

4b.101 Weight limitations. The maximum and minimum weights at which the airplane will be suitable for operation shall be established as follows:

(a) Maximum weights shall not exceed any of the following:

(1) the weight selected by the applicant,

(2) the design weight for which the structure has been proven,

(3) the maximum weight at which compliance with all of the applicable flight requirements has been demonstrated.

(b) It shall be acceptable to establish maximum weights for each altitude and for each practicably separable operating condition (e.g. take-off, en route, landing.)

(c) Minimum weights shall not be less than any of the following:

(1) the minimum weight selected by the applicant,

(2) the design minimum weight for which the structure has been proven,

(3) the minimum weight at which compliance with all of the applicable flight requirements has been demonstrated.

4b.102 Center of gravity limitations. Center of gravity limits shall be established as the most forward position permissible for each weight in accordance with § 4b.101 and the most aft position permissible for each such weight. Limits of the center of gravity range shall not exceed any of the following:

(a) the extremes selected by the applicant,

(b) the extremes for which the structure has been proven,

(c) the extremes at which compliance with all of the applicable flight requirements has been demonstrated.

4b.103 Additional limitations on weight distribution. If a weight and center of gravity combination is permissible only within certain load distribution limits (e.g. spanwise) which could be exceeded inadvertently, such limits shall be established together with the corresponding weight and center of gravity combinations, and shall not exceed any of the following:

(a) the limits selected by the applicant,

(b) the limits for which the structure has been proven,

(c) the limits for which compliance with all of the applicable flight requirements has been demonstrated.

4b.104 Empty weight.

(a) The empty weight and the corresponding center of gravity position shall be determined by weighing the airplane. This weight shall exclude the weight of the crew and payload, but shall include the weight of all fixed ballast, unusable fuel supply (see § 4b.416), undrainable oil, total quantity of engine coolant, and total quantity of hydraulic fluid.

(b) The condition of the airplane at the time of weighing shall be one which can be easily repeated and easily defined, particularly as regards the contents of the fuel, oil, and coolant tanks, and the items of equipment installed.

4b.105 Use of ballast. It shall be acceptable to use removable ballast to enable the airplane to comply with the flight requirements. (See §§ 4b.738 and 4b.741 (c).)

PERFORMANCE

4b.110 General. The performance prescribed in this subpart shall be determined, and compliance shall be shown, for standard atmospheric conditions and still air.

4b.111 Wing flap positions.

(a) The wing flap positions denoted respectively as the takeoff, en route, approach, and landing positions shall be selected by the applicant. (See also § 4b.323.)

(b) It shall be acceptable to make the flap positions variable with weight and altitude.

4b.112 Stalling speeds.

(a) The speed V_{s_0} shall denote the calibrated stalling speed, or the minimum steady flight speed at which the airplane is controllable, in miles per hour, with:

(1) engines idling, throttles closed (or not more than sufficient power for zero thrust at a speed not greater than 110 percent of the stalling speed),

(2) propeller pitch controls in the position normally used for take-off,

(3) landing gear extended,

(4) wing flaps in the landing position,

(5) cowl flaps closed,

(6) center of gravity in the most unfavorable position within the allowable landing range,

(7) the weight of the airplane equal to the weight in connection with which V_{s_0} is being used as a factor to determine a required performance.

(b) The speed V_{s_1} shall denote the calibrated stalling speed, or the minimum steady flight speed at which the airplane is controllable, in miles per hour, with:

(1) engines idling, throttles closed (or not more than sufficient power for zero thrust at a speed not greater than 110 percent of the stalling speed),

(2) propeller pitch controls in the position normally used for take-off, the airplane in all other respects (flaps, landing gear, etc.) in the particular condition existing in the particular test in connection with which V_{S_1} is being used,

(3) the weight of the airplane equal to the weight in connection with which V_{S_1} is being used as a factor to determine a required performance.

(c) Stalling speeds shall be determined by flight tests using the procedures outlined in § 4b.160.

4b.113 Take-off - general.

(a) The take-off data in §§ 4b.114 to 4b.116, inclusive, shall be determined under the following conditions:

(1) at all weights and altitudes selected by the applicant,

(2) with a constant take-off flap position for the particular weight and altitude,

(3) with the operating engines not exceeding their approved limitations at the particular altitude.

(b) All take-off data, when corrected, shall assume a level take-off surface, and shall be determined on a smooth, dry, hard-surfaced runway, in such a manner that reproduction of the performance does not require exceptional skill or alertness on the part of the pilot. (For temperature accountability data see § 4b.117. For wind and runway gradient corrections see appropriate operating rules of the Civil Air Regulations.)

4b.114 Take-off speeds.

(a) The critical-engine-failure speed V_1, in terms of calibrated air speed, shall be selected by the applicant, but it shall not be less than the minimum speed at which the controllability is demonstrated during the take-off run to be adequate to permit proceeding safely with the take-off, using normal piloting skill, when the critical engine is suddenly made inoperative.

(b) The minimum take-off safety speed V_2, in terms of calibrated air speed, shall be selected by the applicant so as to permit the rate of climb required in § 4b.120 (a) and (b), but it shall not be less than:

(1) 1.20 V_{s_1} for two-engine airplanes,

(2) 1.15 V_{s_1} for airplanes having more than two engines,

(3) 1.10 times the minimum control speed V_{MC} established under § 4b.133.

(c) If engine failure is assumed to occur at or after the attainment of V_2, the demonstration in which the take-off run is continued to include the take-off climb, as provided in paragraph (a) of this section, shall not be required.

4b.115 Accelerate-stop distance.

(a) The accelerate-stop distance shall be the sum of the following:

(1) the distance required to accelerate the airplane from a standing start to the speed V_1,

(2) assuming the critical engine to fail at the speed V_1, the distance required to bring the airplane to a full stop from the point corresponding with the speed V_1.

(b) In addition to, or in lieu of, wheel brakes, the use of other braking means shall be acceptable in determining the accelerate-stop distance, provided that such braking means shall have been proven to be safe and reliable, that the manner of their employment is such that consistent results can be expected under normal conditions of operation, and that exceptional skill is not required to control the airplane.

(c) The landing gear shall remain extended throughout the accelerate-stop distance.

4b.116 Take-off path. The take-off path shall be considered to consist of the following five consecutive elements.

(a) The distance required to accelerate the airplane to the speed V_2, assuming the critical engine to fail at the speed V_1.

(b) The horizontal distance traversed and the height attained by the airplane in the time required to retract the landing gear when operating at the speed V_2 with:

(1) the critical engine inoperative, its propeller:

(i) windmilling with the propeller control in a position normally used during take-off until (if applicable) its rotation has been stopped (see subparagraph (c) (1) of this section),

(ii) if applicable, stopped for the remainder of the gear retraction time,

(2) the landing gear extended.

(c) If applicable, the horizontal distance traversed and the height attained by the airplane in the time elapsed from the end of element (b) until the rotation of the inoperative propeller has been stopped when:

(1) the operation of stopping the propeller is initiated not earlier than the instant the airplane has attained a total height of 50 feet above the take-off surface,

(2) the airplane speed is equal to V_2,

(3) the landing gear is retracted,

(4) the inoperative propeller is windmilling with the propeller control in a position normally used during take-off.

(d) The horizontal distance traversed and the height attained by the airplane in the time elapsed from the end of element (c) until the time limit on the use of take-off power is reached, while operating at the speed V_2, with:

(1) the inoperative propeller stopped,

(2) the landing gear retracted.

(e) The slope of the flight path followed by the airplane in the configuration of element (d), but drawing not more than maximum continuous power on the operating engine(s).

4b.117 Temperature accountability. Operating correction factors for take-off weight and take-off distance shall be determined to account for temperatures above and below standard, and when approved by the Administrator they shall be included in the Airplane Flight Manual. These factors shall be obtained as follows:

(a) For any specific airplane type the average full temperature accountability shall be computed for the range of weights of the airplane, altitudes above sea level, and ambient temperatures required by the expected operating conditions. Account shall be taken of the temperature effect on both the aerodynamic characteristics of the airplane and on the engine power. The full temperature accountability shall be expressed per degree of temperature in terms of a weight correction, a take-off distance correction, and a change, if any, in the critical-engine-failure speed V_1.

(b) The operating correction factors for the airplane weight and take-off distance shall be at least one-half of the full accountability values. The value of V_1 shall be further corrected by the average amount necessary to assure that the airplane can stop within the runway length at the ambient temperature, except that the corrected value of V_1 shall not be less than a minimum at which the airplane can be controlled with the critical engine inoperative.

4b.118 Climb - general. Compliance shall be shown with the climb requirements of §§ 4b.119 through 4b.121.

4b.119 Climb - all engines operating.

(a) Cruising configuration. In the cruising configuration the steady rate of climb in feet per minute at 5,000 feet shall not be less than 8 V_{s_0}. In addition the steady rate of climb shall be determined at any altitude at which the airplane is expected to operate and at any weight within the range of weights to be specified in the airworthiness certificate. The cruising configuration shall be with:

(1) landing gear fully retracted,

(2) wing flaps in the most favorable position,

(3) cowl flaps (or other means of controlling the engine cooling) in the position which provides adequate cooling in the hot-day condition,

(4) center of gravity in the most unfavorable position,

(5) all engines operating within the maximum continuous power limitations,

(6) maximum take-off weight.

(b) Landing configuration. In the landing configuration the steady rate of climb in feet per minute shall not be less than $0.07\ V_{s_0}^{\ 2}$ at any altitude within the range for which landing weight is to be specified in the certificate, with:

(1) landing gear extended,

(2) wing flaps in the landing position (see §§ 4b.111 and 4b.323),

(3) cowl flaps in the position normally used in an approach to a landing,

(4) center of gravity in the most unfavorable position permitted for landing,

(5) all engines operating at the take-off power available at such altitude,

(6) the weight equal to maximum landing weight for that altitude.

4b.120 One-engine-inoperative climb

(a) Flaps in take-off position - landing gear extended. The steady rate of climb without ground effect shall not be less than 50 ft/min at any altitude within the range for which take-off weight is to be specified in the certificate, with:

(1) wing flaps in the take-off position (see §§ 4b.111 and 4b.323),

(2) cowl flaps in the position normally used during take-off,

(3) center of gravity in the most unfavorable position permitted for take-off,

(4) the critical engine inoperative, its propeller windmilling with the propeller control in a position normally used during take-off,

(5) all other engines operating at the take-off power available at such altitude,

(6) the speed equal to the minimum take-off safety speed V_2 (see § 4b.114 (b)),

(7) The weight equal to maximum take-off weight for that altitude,

(8) landing gear extended.

(b) Flaps in take-off position - landing gear retracted. With the landing gear retracted the steady rate of climb in feet per minute shall not be less than 0.035 $V_{s_1}{}^2$ with all other conditions as described in paragraph (a) of this section.

(c) Flaps in en route position. The steady rate of climb in feet per minute at any altitude at which the airplane is expected to operate, at any weight within the range of weights to be specified in the airworthiness certificate, shall be determined and shall, at a standard altitude of 5,000 feet and at the maximum take-off weight, be at least 0.02 $V_{s_o}^2$ for airplanes with a maximum take-off weight of 40,000 lbs or less, 0.04 $V_{s_o}^2$ for airplanes with a maximum take-off weight of 60,000 lbs or more, with a linear variation of the coefficient of $V_{s_o}^2$ between 40,000 lbs and 60,000 lbs with:

(1) the landing gear retracted,

(2) wing flaps in the most favorable position,

(3) cowl flaps or other means of controlling the engine cooling air supply in the position which provides adequate cooling in the hot-day condition,

(4) center of gravity in the most unfavorable position,

(5) the critical engine inoperative, its propeller stopped,

(6) all remaining engines operating at the maximum continuous power available at the altitude.

(d) Flaps in approach position. The steady rate of climb in feet per minute shall not be less than 0.04 $V_{s_o}^2$ at any altitude within the range for which landing weight is to be specified in the certificate, with:

(1) the landing gear retracted,

(2) wing flaps set in position such that V_{s_1} does not exceed 1.10 V_{s_o},

(3) cowl flaps in the position normally used during an approach to a landing,

(4) center of gravity in the most unfavorable position permitted for landing,

(5) the critical engine inoperative, its propeller stopped,

(6) all remaining engines operating at the take-off power available at such altitude,

(7) the weight equal to the maximum landing weight for that altitude.

4b.121 Two-engine-inoperative climb. For airplanes with four or more engines the steady rate of climb at any altitude at which the airplane is expected to operate, and at any weight within the range of weights to be specified in the Airplane Flight Manual, shall be determined with:

(a) the landing gear retracted,

(b) wing flaps in the most favorable position,

(c) cowl flaps or other means of controlling the engine cooling air supply in the position which will provide adequate cooling in the hot-day condition,

(d) center of gravity in the most unfavorable position,

(e) the two critical engines on one side of the airplane inoperative and their propellers stopped,

(f) all remaining engines operating at the maximum continuous power available at that altitude.

4b.122 Determination of the landing distance - general. The horizontal distance required to land and to come to a complete stop (to a speed of approximately 3 mph for seaplanes or float planes) from a point at a height of 50 feet above the landing surface shall be determined for a range of weights and altitudes selected by the applicant. In making this determination the following conditions shall apply:

(a) A steady gliding approach shall have been maintained down to the 50-foot altitude with a calibrated air speed of not less than $1.3\ V_{s_o}$.

(b) The nose of the airplane shall not be depressed nor the forward thrust increased by application of power after reaching the 50-foot altitude.

(c) At all times during and immediately prior to the landing the flaps shall be in the landing position, except that after the airplane is on the landing surface and the calibrated air speed has been reduced to not more than $0.9\ V_{s_o}$ the flap position may be changed.

(d) The landing shall be made in such manner that there is no excessive vertical acceleration, no tendency to bounce, nose over, ground loop, porpoise, or water loop, and in such manner that its reproduction shall not require any exceptional degree of skill on the part of the pilot or exceptionally favorable conditions.

4b.123 Landplanes. The landing distance referred to in § 4b.122 shall be determined on a dry, hard-surfaced runway in accordance with the following:

(a) the operating pressures on the braking system shall not be in excess of those approved by the manufacturer of the brakes,

(b) the brakes shall not be used in such manner as to produce excessive wear of brakes or tires,

(c) means other than wheel brakes may be used in determining the landing distance, provided that:

(1) exceptional skill is not required to control the airplane,

(2) the manner of their employment is such that consistent results could be expected under normal service, and

(3) they are regarded as reliable.

4b.124 Seaplanes or float planes. The landing distance referred to in § 4b.122 shall be determined on smooth water.

4b.125 Skiplanes. The landing distance referred to in § 4b.122 shall be determined on smooth, dry snow.

CONTROLLABILITY

4b.130 Controllability - general.

(a) The airplane shall be safely controllable and maneuverable during take-off, climb, level flight, descent, and landing.

(b) It shall be possible to make a smooth transition from one flight condition to another, including turns and slips, without requiring an exceptional degree of skill, alertness, or strength on the part of the pilot and without danger of exceeding the limit load factor under all conditions of operation probable for the type, including those conditions normally encountered in the event of sudden failure of any engine.

4b.131 Longitudinal control.

(a) It shall be possible at all speeds between 1.4 V_{s_1} and V_{s_1} to pitch the nose downward so that a prompt recovery to a speed equal to 1.4 V_{s_1} can be made with the following combinations of configuration:

(1) the airplane trimmed at 1.4 V_{s_1},

(2) the landing gear extended,

(3) the wing flaps in a retracted, and in an extended position,

(4) power off, and maximum continuous power on all engines.

(b) During each of the following controllability demonstrations a change in the trim control, or the exertion of more control force than can be readily applied with one hand for a short period, shall not be required. Each maneuver shall be performed with the landing gear extended.

(1) With power off, flaps retracted, and the airplane trimmed at 1.4 V_{s_1}, the flaps shall be extended as rapidly as possible while maintaining the air speed approximately 40 percent above the stalling speed prevailing at any instant throughout the maneuver.

(2) The maneuver of subparagraph (1) of this paragraph shall be repeated, except that it shall be started with flaps extended and the airplane trimmed at 1.4 V_{s_1}, after which the flaps shall be retracted as rapidly as possible.

(3) The maneuver of subparagraph (2) of this paragraph shall be repeated, except that maximum continuous power shall be used.

(4) With power off, flaps retracted, and the airplane

trimmed at 1.4 V_{s_1}, take-off power shall be applied quickly while maintaining the same air speed.

(5) The maneuver of subparagraph (4) of this paragraph shall be repeated, except that the flaps shall be extended.

(6) With power off, flaps extended, and the airplane trimmed at 1.4 V_{s_1}, air speeds within the range of 1.1 V_{s_1} to 1.7 V_{s_1} or to V_{FE}, whichever of the two is the lesser, shall be obtained and maintained.

(c) It shall be possible without the use of exceptional piloting skill to prevent loss of altitude when flap retraction from any position is initiated during steady horizontal flight at 1.1 V_{s_1} with simultaneous application of not more than maximum continuous power. (See also § 4b.323.)

4b.132 Directional and lateral control.

(a) Directional control – general. It shall be possible, while holding the wings approximately level, to execute reasonably sudden changes in heading in either direction without encountering dangerous characteristics. Heading changes up to 15° shall be demonstrated, except that the heading change at which the rudder pedal force is 180 pounds need not be exceeded. The control shall be demonstrated at a speed equal to 1.4 V_{s_1} under the following conditions:

(1) the critical engine inoperative and its propeller in the minimum drag position,

(2) power required for level flight at 1.4 V_{s_1}, but not greater than maximum continuous power,

(3) most unfavorable center of gravity position,

(4) landing gear retracted,

(5) wing flaps in the approach position,

(6) maximum landing weight.

(b) Directional control - four or more engines. Airplanes with four or more engines shall comply with paragraph (a) of this section, except that:

(1) the two critical engines shall be inoperative, their propellers in the minimum drag position,

(2) the center of gravity shall be in the most forward position,

(3) the wing flaps shall be in the most favorable climb position.

(c) Lateral control - general. It shall be possible to execute 20° banked turns with and against the inoperative engine from steady flight at a speed equal to 1.4 V_{s_1} with:

(1) the critical engine inoperative and its propeller in the minimum drag position,

(2) maximum continuous power on the operating engines,

(3) most unfavorable center of gravity position,

(4) landing gear retracted and extended,

(5) wing flaps in the most favorable climb position,

(6) maximum take-off weight.

(d) Lateral control - four or more engines. It shall be possible to execute 20° banked turns with and against the inoperative engines from steady flight at a speed equal to 1.4 V_{s_1} with maximum continuous power and with the airplane in the configuration prescribed by paragraph (b) of this section.

4b.133 Minimum control speed V_{MC}.

(a) A minimum speed shall be determined under the conditions specified in this paragraph, so that when the critical engine is suddenly made inoperative at that speed it shall be possible to recover control of the airplane, with the engine still inoperative, and maintain it in straight flight at that speed, either with zero yaw or, at the option of the applicant, with an angle of bank not in excess of 5°. Such speed shall not exceed 1.2 V_{S_1} with:

(1) take-off or maximum available power on all engines,

(2) rearmost center of gravity,

(3) flaps in take-off position,

(4) landing gear retracted.

(b) In demonstrating the minimum speed of paragraph (a) of this section, the rudder force required to maintain control shall not exceed 180 pounds, and it shall not be necessary to throttle the remaining engines.

(c) During recovery of the maneuver of paragraph (a) of this section the airplane shall not assume any dangerous attitude, nor shall it require exceptional skill, strength, or alertness on the part of the pilot to prevent a change of heading in excess of 20° before recovery is complete.

TRIM

4b.140 General. The means used for trimming the airplane shall be such that after being trimmed and without further pressure upon, or movement of, either the primary control or its corresponding trim control by the pilot or the automatic pilot the airplane shall comply with the trim requirements of §§ 4b.141 through 4b.144.

<u>4b.141</u> <u>Lateral and directional trim.</u> The airplane shall maintain lateral and directional trim under the most adverse lateral displacement of the center of gravity within the relevant operating limitations, under all normally expected conditions of operation, including operation at any speed from 1.4 V_{s_1} to 90 percent of the maximum speed in level flight obtained with maximum continuous power.

<u>4b.142</u> <u>Longitudinal trim.</u> The airplane shall maintain longitudinal trim under the following conditions:

(a) during a climb with maximum continuous power at a speed not in excess of 1.4 V_{s_1} with the landing gear retracted and the wing flaps both retracted and in the take-off position,

(b) during a glide with power off at a speed not in excess of 1.4 V_{s_1} with the landing gear extended and the wing flaps both retracted and extended, with the forward center of gravity position approved for landing with the maximum landing weight, and with the most forward center of gravity position approved for landing regardless of weight,

(c) during level flight at any speed from 1.4 V_{s_1} to 90 percent of the maximum speed in level flight obtained with maximum continuous power with the landing gear and wing flaps retracted, and from 1.4 V_{s_1} to V_{LE} with the landing gear extended.

<u>4b.143</u> <u>Longitudinal and directional trim.</u> The airplane shall maintain longitudinal and directional trim at a speed equal to 1.4 V_{s_1} during climbing flight with the critical engine inoperative, with:

(a) the other engine(s) at maximum continuous power,

(b) the landing gear retracted,

(c) wing flaps retracted.

4b.144 Trim for airplanes with four or more engines. The airplane shall maintain trim in rectilinear flight at the climb speed, configuration, and power used in establishing the rates of climb in § 4b.121, with the most unfavorable center of gravity position, and at the weight at which the two-engine-inoperative climb is equal to at least $.01 V_{S_0}^2$ at an altitude of 5,000 feet.

STABILITY

4b.150 General. The airplane shall be longitudinally, directionally, and laterally stable in accordance with §§ 4b.151 through 4b.157. Suitable stability and control "feel" (static stability) shall be required in other conditions normally encountered in service if flight tests show such stability to be necessary for safe operation.

4b.151 Static longitudinal stability. In the conditions outlined in §§ 4b.152 through 4b.155, the characteristics of the elevator control forces and friction shall comply with the following.

(a) A pull shall be required to obtain and maintain speeds below the specified trim speed, and a push shall be required to obtain and maintain speeds above the specified trim speed. This criterion shall apply at any speed which can be obtained without excessive control force, except that such speeds need not be greater than the appropriate operating limit speed or need not be less than the minimum speed in steady unstalled flight.

(b) The air speed shall return to within 10 percent of the original trim speed when the control force is slowly released from any speed within the limits defined in paragraph (a) of this section.

(c) The stable slope of stick force curve versus speed shall be such that any substantial change in speed is clearly perceptible to the pilot through a resulting change in stick force.

4b.152 Stability during landing. The stick force curve shall have a stable slope, and the stick force shall not exceed 80 pounds at any speed between 1.1 V_{s_1} and 1.8 V_{s_1} with:

(a) wing flaps in the landing position,

(b) the landing gear extended,

(c) maximum landing weight,

(d) throttles closed on all engines,

(e) the airplane trimmed at 1.4 V_{s_1} with throttles closed.

4b.153 Stability during approach. The stick force curve shall have a stable slope at all speeds between 1.1 V_{s_1} and 1.8 V_{s_1} with:

(a) wing flaps in sea level approach position,

(b) landing gear retracted,

(c) maximum landing weight,

(d) the airplane trimmed at 1.4 V_{s_1} and with power sufficient to maintain level flight at this speed.

4b.154 Stability during climb. The stick force curve shall have a stable slope at all speeds between 85 and 115 percent of the speed at which the airplane is trimmed with:

(a) wing flaps retracted,

(b) landing gear retracted,

(c) maximum take-off weight,

(d) 75 percent of maximum continuous power,

(e) the airplane trimmed at the best rate-of-climb speed, except that the speed need not be less than 1.4 V_{s_1}.

4b.155 Stability during cruising.

(a) Landing gear retracted. Between 1.3 V_{s_1} and V_{NE} the stick force curve shall have a stable slope at all speeds obtainable with a stick force not in excess of 50 pounds with:

(1) wing flaps retracted,

(2) maximum take-off weight,

(3) 75 percent of maximum continuous power,

(4) the airplane trimmed for level flight with 75 percent of the maximum continuous power.

(b) Landing gear extended. The stick force curve shall have a stable slope at all speeds between 1.3 V_{s_1} and the speed at which the airplane is trimmed, except that the range of speeds need not exceed that obtainable with a stick force of 50 pounds with:

(1) wing flaps retracted,

(2) maximum take-off weight,

(3) 75 percent maximum continuous power, or the power for level flight at the landing gear extended speed V_{LE}, whichever is the lesser,

(4) the airplane trimmed for level flight with the power specified in subparagraph (3) of this paragraph.

4b.156 Dynamic longitudinal stability. Any short period oscillation occurring between stalling speed and maximum permissible speed appropriate to the configuration of the airplane shall be heavily damped with the primary controls free and in a fixed position.

4b.157 Static directional and lateral stability.

(a) The static directional stability, as shown by the tendency to recover from a skid with rudder free, shall be positive with all landing gear and flap positions and symmetrical power conditions, at all speeds from 1.2 V_{S_1} up to the operating limit speed.

(b) The static lateral stability, as shown by the tendency to raise the low wing in a sideslip with all landing gear and flap positions and symmetrical power conditions shall:

(1) be positive at the operating limit speed,

(2) not be negative at a speed equal to 1.2 V_{S_1}.

(c) In straight steady sideslips (unaccelerated forward slips) the aileron and rudder control movements and forces shall be substantially proportional to the angle of sideslip, and the factor of proportionality shall lie between limits found necessary for safe operation throughout the range of sideslip angles appropriate to the operation of the airplane. At greater angles up to that at which the full rudder control is employed or a rudder pedal force of 180 pounds is obtained, the rudder pedal forces shall not reverse, and increased rudder deflection shall produce increased angles of sideslip. Sufficient bank shall accompany sideslipping to indicate clearly any departure from steady unyawed flight, unless a yaw indicator is provided.

4b.158 Dynamic directional and lateral stability. Any short period oscillation occurring between stalling speed and maximum permissible speed appropriate to the configuration of the airplane shall be heavily damped with the primary controls free and in a fixed position.

STALLING CHARACTERISTICS

4b.160 Stalling – symmetrical power.

(a) Stalls shall be demonstrated with the airplane in straight flight and in banked turns up to 30°, both with power off and with power on. In the power-on conditions the power shall be that necessary to maintain level flight at a speed of 1.6 V_{s_1}, where V_{s_1} corresponds with the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight.

(b) The stall demonstration shall be in the following configurations:

(1) wing flaps and landing gear in any likely combination of positions,

(2) all weights within the range for which certification is sought,

(3) the center of gravity in the most adverse position for recovery.

(c) The stall demonstration shall be conducted as follows: with trim controls adjusted for straight flight at a speed of 1.4 V_{s_1}, the speed shall be reduced by means of the elevator control until it is steady at slightly above stalling speed; after which the elevator control shall be pulled back at a rate such that the airplane speed reduction does not exceed one mile per hour per second until a stall is produced, as evidenced by an uncontrollable downward pitching motion of the airplane, or until the control reaches the stop. Normal use of the elevator control for recovery shall be permissible after the pitching motion is unmistakably developed.

(d) During stall demonstration it shall be possible to produce and to correct roll and yaw by unreversed use of the aileron and rudder controls up to the moment the pitching motion occurs.

(e) In straight flight stalls, the average roll occurring between the initiation of the pitching motion and the completion of the recovery shall not exceed 20°.

(f) In turning flight stalls, the roll following the stall shall not be so violent or extreme as to make it difficult with normal piloting skill to make a prompt recovery and to regain control of the airplane.

4b.161 Stalling - asymmetrical power.

(a) The airplane shall be safely recoverable without applying power to the inoperative engine when stalled with:

(1) the critical engine inoperative,

(2) flaps and landing gear retracted,

(3) the remaining engines operating up to 75 percent of maximum continuous power, except that the power need not be greater than that at which the wings can be held level laterally with the use of maximum control travel.

(b) It shall be acceptable to throttle back the operating engines during the recovery from the stall.

4b.162 Stall warning. Clear and distinctive stall warning shall be apparent to the pilot at a speed at least 5 percent above the stalling speed, with flaps and landing gear in all possible positions, both in straight and in turning flight. It shall be acceptable for the warning to be furnished either through the inherent aerodynamic qualities of the airplane, by a suitable instrument, or by other means which will give clearly distinguishable indications under all expected conditions of flight.

GROUND HANDLING CHARACTERISTICS

4b.170 Longitudinal stability and control.

(a) There shall be no uncontrollable tendency for landplanes to nose over in any reasonably expected operating condition or when rebound occurs during landing or take-off.

(b) Wheel brakes shall operate smoothly and shall exhibit no undue tendency to induce nosing over.

(c) When a tail-wheel landing gear is used it shall be possible during the take-off ground run on concrete to maintain any attitude up to thrust line level at 80 percent of V_{s_1}.

4b.171 Directional stability and control.

(a) There shall be no uncontrollable ground-looping tendency in 90° cross winds of velocity up to $0.2\ V_{s_0}$ at any ground speed at which the airplane is expected to operate.

(b) All landplanes shall be demonstrated to be satisfactorily controllable with no exceptional degree of skill or alertness on the part of the pilot in power-off landings at normal landing speed during which brakes or engine power are not used to maintain a straight path.

(c) Means shall be provided for directional control of the airplane during taxying.

4b.172 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.

4b.173 Demonstrated cross wind. There shall be established a cross component of wind velocity at which it has been demonstrated to be safe to take-off or land.

WATER HANDLING CHARACTERISTICS

4b.180 Stability and control.

(a) Seaplanes shall exhibit no uncontrollable porpoising at any speed at which the airplane is normally operated on water.

(b) There shall be no uncontrollable looping tendency in 90° cross winds of velocity up to 0.2 V_{s_o} at any speed at which the airplane is expected to operate on water.

(c) Means shall be provided for directional control of the airplane during taxying on water.

4b.181 Spray characteristics. Spray during taxying, take-off, or landing shall at no time dangerously obscure the vision of the pilots nor produce damage to the propeller or other parts of the airplane.

__4b.182__ __Demonstrated cross wind.__ There shall be established a cross component of wind velocity at which it has been demonstrated to be safe to take off and land.

MISCELLANEOUS FLIGHT REQUIREMENTS

__4b.190__ __Flutter and vibration.__

(a) All parts of the airplane shall be demonstrated in flight 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_D in § 4b.210 (b) (5). The maximum speeds so demonstrated shall be used in establishing the operating limitations of the airplane in accordance with § 4b.711.

(b) There shall be no buffeting condition in normal flight severe enough to interfere with the control of the airplane, to cause excessive fatigue to the crew, or to cause structural damage. 1/ (See also §§ 4b.308 and 4b.309.)

1/ It is not the intent of this requirement to discourage such stall warning buffeting as does not contradict these provisions.

SUBPART C – STRUCTURE

GENERAL

4b.200 Loads. Strength requirements of this subpart are specified in terms of limit and ultimate loads. Unless otherwise stated, the specified loads shall be considered as limit loads. In determining compliance with these requirements the following shall be applicable.

(a) The factor of safety shall be 1.5 unless otherwise specified.

(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.

(c) All loads shall be distributed in a manner closely approximating or conservatively representing actual conditions.

(d) If deflections under load significantly change the distribution of external or internal loads, the redistribution shall be taken into account.

4b.201 Strength and deformation.

(a) The structure shall be capable of supporting limit loads without suffering detrimental permanent deformations.

(b) At all loads up to limit loads the deformation shall be such as not to interfere with safe operation of the airplane.

(c) The structure shall be capable of supporting ultimate loads without failure. It shall support the load for at least 3 seconds, unless proof of strength is demonstrated by dynamic tests simulating actual conditions of load application.

4b.202 Proof of structure.

(a) Proof of compliance of the structure with the strength and deformation requirements of § 4b.201 shall be made for all critical loading conditions.

(b) Proof of compliance by means of structural analysis shall be acceptable only when the structure conforms to types for which experience has shown such methods to be reliable. In all other cases substantiating tests shall be required.

(c) In all cases certain portions of the structure shall be tested as specified in § 4b.300.

FLIGHT LOADS

4b.210 General. Flight load requirements shall be complied with at critical altitudes within the range for which certification is desired, at all weights from the design minimum weight to the design maximum weight, the latter not being less than the design take-off weight, with any practicable distribution of disposable load within prescribed operating limitations stated in the Airplane Flight Manual (see § 4b.740). At all speeds in excess of those corresponding with a Mach number of 0.65, compressibility effects shall be taken into account.

(a) Flight load factor. The flight load factors specified in this subpart shall represent the component of acceleration in terms of the gravitational constant. The flight load factor shall be assumed to act normal to the longitudinal axis of the airplane, shall be equal in magnitude, and shall be opposite in direction to the airplane inertia load factor at the center of gravity.

(b) Design air speeds. The design air speeds shall be equivalent air speeds (EAS) and shall be chosen by the applicant, except that they shall not be less than the speeds defined in subparagraphs (1) through (5) of this paragraph. Where estimated values of the speeds V_{s_o} and V_{s_1} are used, such estimates shall be conservative.

(1) Design flap speed V_F. The minimum value of the design flap speed shall be equal to 1.4 V_{s_1} or 1.8 V_{s_o}, whichever is the greater, where V_{s_1} is the stalling speed with flaps retracted at the design landing weight, and V_{s_o} is the stalling speed with flaps in the landing position at the design landing weight. (See § 4b.212 (d) regarding automatic flap operation.)

(2) Design maneuvering speed V_A. The design maneuvering speed V_A shall be equal to $V_{s_1}\sqrt{n}$ where n is the limit maneuvering load factor used (see § 4b.211 (a)) and V_{s_1} is the stalling speed with flaps retracted at the design take-off weight. (See Figure 4b-2.)

(3) Design speed for maximum gust intensity V_B. V_B shall be the speed at which the 40 fps gust line intersects the positive C_{Nmax} curve on the gust V-n envelope. (See § 4b.211 (b) and Figure 4b-3.)

(4) Design cruising speed V_C. The minimum design cruising speed V_C shall be sufficiently greater than V_B to provide for inadvertent speed increases likely to occur as a result of severe atmospheric turbulence. In the absence of a rational investigation substantiating the use of other values, V_C shall not be less than V_B + 50 (mph), except that it need not exceed the maximum speed in level flight at maximum continuous power for the corresponding altitude. At altitudes where V_D is limited

by Mach number, V_C need not exceed 0.8 V_D, as shown in Figure 4b-1, except that it shall not be less than 1.3 V_{S_1} with the flaps retracted at the maximum altitude for which certification is desired.

(5) Design dive speed V_D. The minimum design dive speed V_D shall be sufficiently greater than V_C to provide for safe recovery from inadvertent upsets occurring at V_C. In the absence of a rational investigation, the minimum value of V_D shall not be less than 1.25 V_C or V_C + 70 (mph), whichever is the greater, in the altitude range between sea level and an altitude selected by the applicant. At higher altitudes it shall be acceptable to limit V_D to a Mach number selected by the applicant. (See Figure 4b-1.)

4b.211 Flight envelopes. The strength requirements shall be met at all combinations of air speed and load factor on and within the boundaries of the V-n diagrams of Figures 4b-2 and 4b-3 which represent the maneuvering and gust envelopes. These envelopes shall also be used in determining the airplane structural operating limitations as specified in § 4b.710.

(a) Maneuvering load factors. (See Figure 4b-2.) The airplane shall be assumed to be subjected to symmetrical maneuvers resulting in the limit load factors prescribed in subparagraphs (1) and (2) of this paragraph, except where limited by maximum (static) lift coefficients. Lower values of maneuvering load factor shall be acceptable only if it is shown that the airplane embodies features of design which make it impossible to exceed such values in flight.

(1) The positive maneuvering load factor n for any flight speed up to V_D shall be selected by the applicant, except that it shall not be less than 2.5.

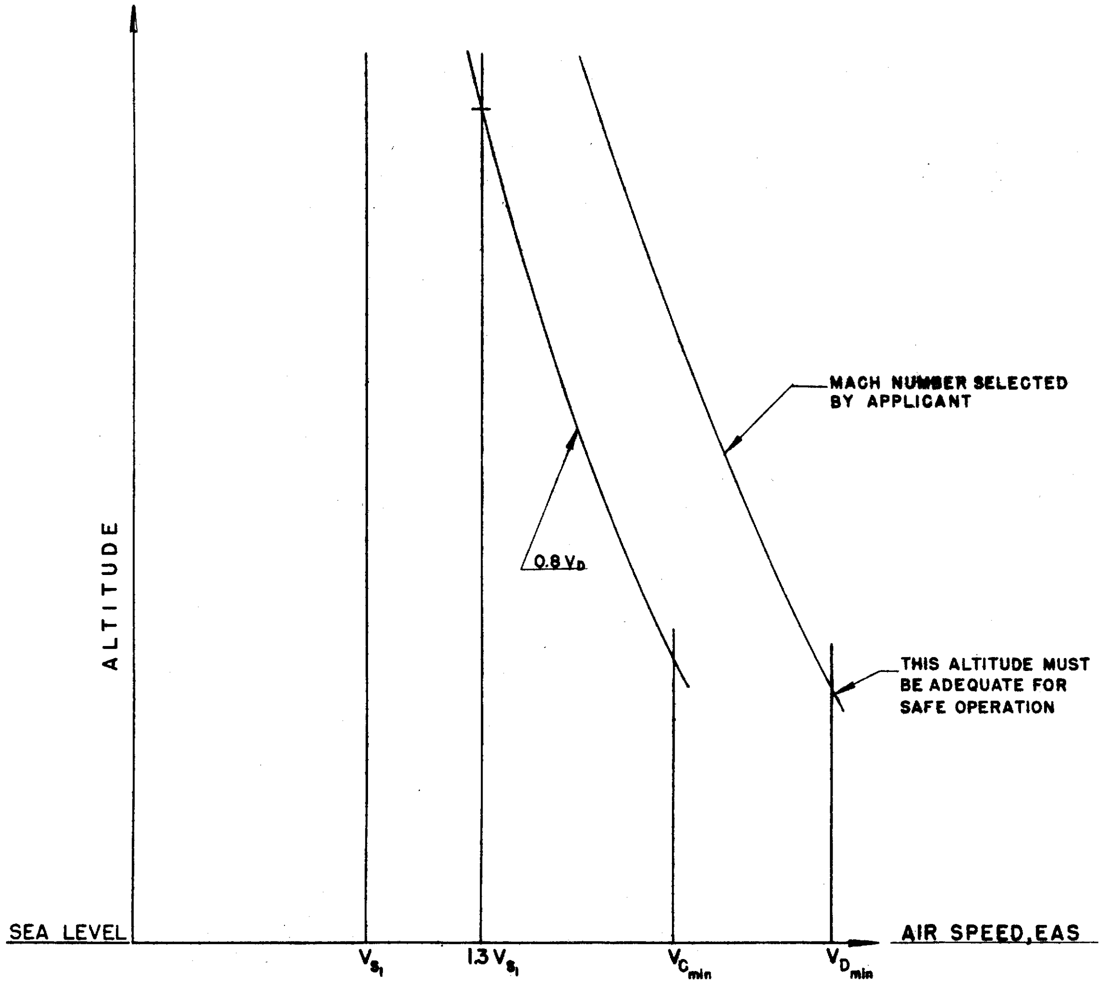

FIGURE 4b-1 MINIMUM DESIGN AIR SPEEDS VS. ALTITUDE

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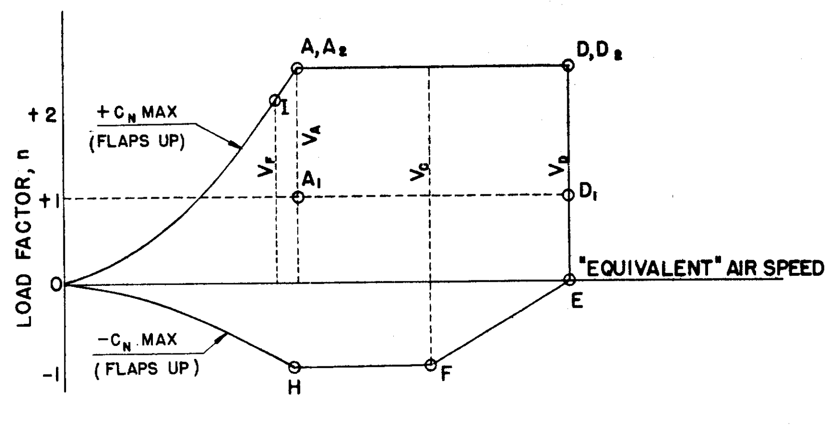


FIGURE 4b-2 MANEUVERING ENVELOPE
MANEUVERING LOAD FACTOR VS. SPEED, (V-n) DIAGRAM

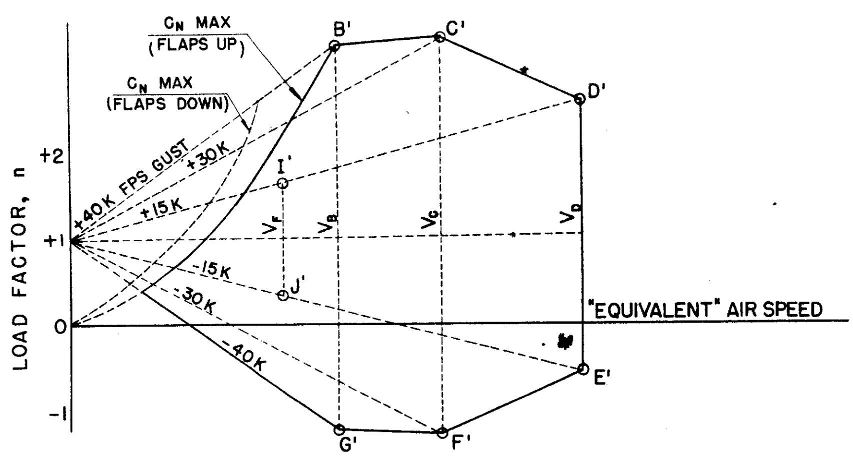


FIGURE 4b-3 GUST ENVELOPE
LOAD FACTOR VS. VELOCITY, (V-n) DIAGRAM

(2) The negative maneuvering load factor shall have a minimum value of -1.0 at all speeds up to V_C, and it shall vary linearly with speed from the value at V_C to zero at V_D.

(b) Gust load factors. The airplane shall be assumed to be subjected to symmetrical vertical gusts while in level flight. The resulting limit load factors shall correspond with the following conditions.

(1) Positive (up) and negative (down) gusts of 40 fps nominal intensity at a speed V_B shall be applicable where the positive 40 fps gust line intersects the positive $C_{N_{max}}$ curve. If this gust intensity produces load factors greater than those obtained in condition (2) of this paragraph, it shall be acceptable to modify it at altitudes above 20,000 ft in such a manner as to produce a load factor not less than that obtained in condition (2) of this paragraph.

(2) Positive and negative gusts of 30 fps shall be considered at V_C.

(3) Positive and negative gusts of 15 fps shall be considered at V_D.

(4) Gust load factors shall be assumed to vary linearly between the specified conditions as shown on the gust envelope of Figure 4b-3.

(5) In the absence of a more rational analysis the gust load factors shall be computed by the following formula:

$$n = 1 + \frac{KUVa}{575\ (W/S)}\ ; \text{ where:}$$

$$K = \frac{1}{2}\left(\frac{W}{S}\right)^{\frac{1}{4}} \text{ (for } W/S < 16 \text{ psf), or}$$

$$K = 1.33 - \frac{2.67}{(W/S)^{3/4}} \quad \text{(for } W/S > 16 \text{ psf),}$$

U = nominal gust velocity (fps), (Note that the "effective sharp-edged" gust equals KU.)

V = airplane speed (mph),

W/S = wing loading (psf),

a = slope of the airplane normal force coefficient curve C_{N_A} per radian if the gust loads are applied to the wings and horizontal tail surfaces simultaneously by a rational method. It shall be acceptable to use the wing lift curve slope C_L per radian when the gust load is applied to the wings only and the horizontal tail gust loads are treated as a separate condition.

4b.212 Effect of high lift devices. When flaps or similar high lift devices intended for use at the relatively low air speeds of approach, landing, and take-off are installed, the airplane shall be assumed to be subjected to symmetrical maneuvers and gusts with the flaps in landing position at the design flap speed V_F resulting in limit load factors within the range determined by the following conditions:

(a) maneuvering to a positive limit load factor of 2.0,

(b) positive and negative 15 fps nominal intensity gusts acting normal to the flight path in level flight,

(c) in designing the flaps and supporting structures, slipstream effects shall be taken into account as specified in § 4b.221,

(d) when automatic flap operation is provided, the airplane shall be designed for the speeds and the corresponding flap positions which the mechanism permits. (See § 4b.323.)

4b.213 Symmetrical flight conditions.

(a) Procedure of analysis. In the analysis of symmetrical flight conditions at least those specified in paragraphs (b), (c), and (d) of this section shall be considered. The following procedure of analysis shall be applicable.

(1) A sufficient number of points on the maneuvering and gust envelopes shall be investigated to insure that the maximum load for each part of the airplane structure is obtained. It shall be acceptable to use a conservative combined envelope for this purpose.

(2) All significant forces acting on the airplane shall be placed in equilibrium in a rational or a conservative manner. The linear inertia forces shall be considered in equilibrium with wing and horizontal tail surface loads, while the angular (pitching) inertia forces shall be considered in equilibrium with wing and fuselage aerodynamic moments and horizontal tail surface loads.

(3) Where sudden displacement of a control is specified, the assumed rate of displacement need not exceed that which actually could be applied by the pilot.

(4) In determining elevator angles and chordwise load distribution in the maneuvering conditions of paragraphs (b) and (c) of this section in turns and pull-ups, account shall be taken of the effect of corresponding pitching velocities.

(b) Maneuvering balanced conditions. The maneuvering conditions A through I on the maneuvering envelope (Figure 4b-2) shall be investigated, assuming the airplane to be in equilibrium with zero pitching acceleration.

(c) Maneuvering pitching conditions. The following conditions on Figure 4b-2 involving pitching acceleration shall be investigated.

(1) A_1 Unchecked pull-up at speed V_A. The airplane shall be assumed to be flying in steady level flight (point A_1 on Figure 4b-2) and the pitching control suddenly moved to obtain extreme positive pitching (nose up), except as limited by pilot effort, § 4b.220 (a).

(2) A_2 Checked maneuver at speed V_A.

(i) The airplane shall be assumed to be maneuvered to the positive maneuvering load factor by a checked maneuver from an initial condition of steady level flight (point A_1 on Figure 4b-2). The initial positive pitching portion of this maneuver may be considered to be covered by subparagraph (1) of this paragraph.

(ii) A negative pitching acceleration (nose down) of at least the following value shall be assumed to be attained concurrently with the airplane maneuvering load factor (point A_2 on Figure 4b-2), unless it is shown that a lesser value could not be exceeded:

$$-\frac{30}{V_A}\ n\ (n - 1.5)(\text{radians/sec}^2);$$ where n is equal to the value of the positive maneuvering load factor as defined by point A_2 on Figure 4b-2.

(3) D_1 and D_2 Checked maneuver at V_D. The airplane shall be assumed to be subjected to a checked maneuver from steady level flight (point D_1 on Figure 4b-2) to the positive maneuvering load factor (point D_2 on Figure 4b-2) as follows:

(i) A positive pitching acceleration (nose up) equal to at least the following value shall be assumed to be attained concurrently with the airplane load factor of unity, unless it is shown that lesser values could not be exceeded:

$$+\frac{45}{V_D} n\,(n - 1.5)\,(\text{radians/sec}^2)$$; where n is equal to the value of the positive maneuvering load factor as defined by point D_2 on Figure 4b-2.

(ii) A negative pitching acceleration (nose down) equal to at least the following value shall be assumed to be attained concurrently with the airplane positive maneuvering load factor (point D_2 on Figure 4b-2), unless it is shown that lesser values could not be exceeded:

$$-\frac{30}{V_D} n\,(n - 1.5)\,(\text{radians/sec}^2)$$; where n is equal to the value of the positive maneuvering load factor as defined by point D_2 on Figure 4b-2.

(d) <u>Gust conditions</u>. The gust conditions B' through J' on Figure 4b-3 shall be investigated. The following provisions shall apply.

(1) The air load increment due to a specified gust shall be added to the initial balancing tail load corresponding with steady level flight.

(2) It shall be acceptable to include the alleviating effect of wing down-wash and of the airplane's motion in response to the gust in computing the tail gust load increment.

(3) In lieu of a rational investigation of the airplane response it shall be acceptable to apply the gust factor K (see § 4b.211 (b)) to the specified gust intensity for the horizontal tail.

4b.214 Rolling conditions. The airplane shall be designed for rolling loads resulting from the conditions specified in paragraphs (a) and (b) of this section. Unbalanced aerodynamic moments about the center of gravity shall be reacted in a rational or a conservative manner considering the principal masses furnishing the reacting inertia forces.

(a) Maneuvering. The following conditions, aileron deflection, and speeds, except as the deflections may be limited by pilot effort (see § 4b.220 (a)), shall be considered in combination with an airplane load factor of at least 2/3 of the positive maneuvering factor used in the design of the airplane. In determining the required aileron deflections the torsional flexibility of the wing shall be taken into account in accordance with § 4b.200 (d).

(1) Conditions corresponding with steady rolling velocity shall be investigated. In addition, conditions corresponding with maximum angular acceleration shall be investigated for airplanes having engines or other weight concentrations outboard of the fuselage. For the angular acceleration conditions, it shall be acceptable to assume zero rolling velocity in the absence of a rational time history investigation of the maneuver.

(2) At speed V_A a sudden deflection of the aileron to the stop shall be assumed.

(3) At speed V_C the aileron deflection shall be that required to produce a rate of roll not less than that obtained in condition (2) of this paragraph.

(4) At speed V_D the aileron deflection shall be that required to produce a rate of roll not less than 1/3 of that in condition (2) of this paragraph.

(b) Unsymmetrical gusts. The condition of unsymmetrical gusts shall be considered by modifying the symmetrical flight conditions B' or C' of Figure 4b-3, whichever produces the greater load factor. It shall be assumed that 100 percent of the wing air load acts on one side of the airplane, and 80 percent acts on the other side.

4b.215 Yawing conditions. The airplane shall be designed for yawing loads resulting from the conditions specified in paragraphs (a) and (b) of this section. Unbalanced aerodynamic moments about the center of gravity shall be reacted in a rational or a conservative manner considering the principal masses furnishing the reacting inertia forces.

(a) Maneuvering. At all speeds from V_{MC} to V_A the vertical tail loads resulting from the following maneuvers shall be considered. In computing the tail loads it shall be acceptable to assume the yawing velocity to be zero.

(1) With the airplane in unaccelerated flight at zero yaw, it shall be assumed that the rudder control is suddenly displaced to the maximum deflection as limited by the control stops or by a 300 lb rudder pedal force, whichever is critical.

(2) With the rudder deflected as specified in subparagraph (1) of this paragraph, it shall be assumed that the airplane yaws to the resulting sideslip angle.

(3) With the airplane yawed to the static sideslip angle corresponding with the rudder deflection specified in subparagraph (1) of this paragraph, it shall be assumed that the rudder is returned to neutral.

(b) Lateral gusts. The airplane shall be assumed to encounter gusts of 30 fps nominal intensity normal to the plane of symmetry while in unaccelerated flight at speed V_C. In the absence of a rational investigation of the airplane's response to a true gust, it shall be acceptable to compute the gust loading on the vertical tail surfaces by the following formula:

$$\overline{W} = \frac{KUV_C a}{575}\text{; where:}$$

$\overline{W}$ = average limit unit pressure (psf),

$K = 1.33 - \frac{4.5}{\left(\frac{W}{S_V}\right)^{3/4}}$; except that K shall not be less than 1.0. A value of K obtained by rational determination shall be acceptable.

U = nominal gust intensity (fps),

V_C = design cruising speed (mph),

a = slope of lift curve of the vertical surface C_L per radian corrected for aspect ratio,

W = design take-off weight (lbs),

S_V = vertical surface area (sq ft).

<u>4b.216 Supplementary flight conditions.</u>

(a) <u>Engine torque effects.</u> Engine mounts and their supporting structures shall be designed for engine torque effects combined with basic flight conditions as described in subparagraphs (1) and (2) of this paragraph. The limit torque shall be obtained by multiplying the mean torque by a factor of 1.33 in the case of engines having 5 or more cylinders. For 4, 3, and 2-cylinder engines the factors shall be 2, 3, and 4, respectively.

(1) The limit torque corresponding with take-off power and propeller speed shall act simultaneously with 75 percent of the limit loads from flight condition A (see Figure 4b-2).

(2) The limit torque corresponding with maximum continuous power and propeller speed shall act simultaneously with the limit loads from flight condition A (see Figure 4b-2).

(b) Side load on engine mount. The limit load factor in a lateral direction for this condition shall be equal to the maximum obtained in the yawing conditions, but shall not be less than either 1.33 or 1/3 the limit load factor for flight condition A (see Figure 4b-2). Engine mounts and their supporting structure shall be designed for this condition which may be assumed independent of other flight conditions.

(c) Pressurized cabin loads. When pressurized compartments are provided for the occupants of the airplane, the following requirements shall be met. (See § 4b.373.)

(1) The airplane structure shall have sufficient strength to withstand the flight loads combined with pressure differential loads from zero up to the maximum relief valve setting. Account shall be taken of the external pressure distribution in flight.

(2) If landings are to be permitted with the cabin pressurized, landing loads shall be combined with pressure differential loads from zero up to the maximum to be permitted during landing.

(3) The airplane structure shall have sufficient strength to withstand the pressure differential loads corresponding with the maximum relief valve setting multiplied by a factor of 1.33 to provide for such effects as fatigue and stress concentration. It shall be acceptable to omit all other loads in this case.

(4) Where a pressurized cabin is separated into two or more

compartments by bulkheads or floor, the primary structure shall be designed for the effects of sudden release of pressure in any compartment having external doors or windows. This condition shall be investigated for the effects resulting from the failure of the largest opening in a compartment. Where intercompartment venting is provided, it shall be acceptable to take into account the effects of such venting.

CONTROL SURFACE AND SYSTEM LOADS

4b.220 Control surface loads - general. The control surfaces shall be designed for the limit loads resulting from the flight conditions prescribed in §§ 4b.213 through 4b.215, taking into account the following provisions.

(a) Effect of pilot effort.

(1) In the control surface flight loading conditions the air loads on the movable surfaces and the corresponding deflections need not exceed those which could be obtained in flight by employing the maximum pilot control forces specified in Figure 4b-5, except that 2/3 of the maximum values specified for the aileron and elevator shall be acceptable when control surface hinge moments are based on reliable data. In applying this criterion, proper consideration shall be given to the effects of servo mechanisms, tabs, and automatic pilot systems in assisting the pilot.

(b) Effect of trim tabs. The effects of trim tabs on the control surface design conditions need be taken into account only in cases where the surface loads are limited on the basis of maximum pilot effort in accordance with the provision of paragraph (a) of this section. In such cases the tabs shall be considered to be deflected in the direction which would assist the pilot and the deflections shall be those specified in § 4b.222.

(c) Unsymmetrical loads. The maximum horizontal tail surface loading (load per unit area) as determined by the provisions of this section shall be applied to the horizontal surface of one side of the plane of symmetry, and 80 percent of that loading shall be applied to the opposite side.

(d) Outboard fins.

(1) When outboard fins are carried on the horizontal tail surface, the tail surfaces shall be designed for the maximum horizontal surface load in combination with the corresponding loads induced on the vertical surfaces by end plate effects. Such induced effects need not be combined with other vertical surface loads.

(2) To provide for unsymmetrical loading when outboard fins extend above and below the horizontal surface, the critical vertical surface loading (load per unit area) as determined by the provisions of this section shall also be applied as follows:

(i) 100 percent to the area of the vertical surfaces above (or below) the horizontal surface, and

(ii) 80 percent to the area below (or above) the horizontal surface.

4b.221 Wing flaps.

(a) Wing flaps, their operating mechanism, and supporting structure shall be designed for critical loads prescribed by § 4b.212 with the flaps extended to any position from fully retracted to the landing position.

(b) The effects of propeller slipstream corresponding with take-off power shall be taken into account at an airplane speed of not less than 1.4 V_{s_1}, where V_{s_1} is the stalling speed with flaps as follows: (For automatic flaps see § 4b.212 (d).)

(1) landing and approach settings at the design landing weight,

(2) take-off and en route settings at the design take-off weight.

(c) It shall be acceptable to assume the airplane load factor to be equal to 1.0 for investigating the slipstream condition.

4b.222 Tabs.

(a) At all speeds up to V_D elevator trim tabs shall be designed for the deflections required to trim the airplane at any point within the positive portion of the maneuvering V-n diagram (Figure 4b-2), except as limited by the stops.

(b) Aileron and rudder trim tabs shall be designed for deflections required to trim the airplane in appropriate unsymmetrical lateral loading and rigging, and symmetrical and unsymmetrical power conditions.

(c) Balancing and servo tabs shall be designed for deflections consistent with the primary control surface loading conditions.

4b.223 Special devices. The loading for special devices employing aerodynamic surfaces, such as slots and spoilers, shall be based on test data.

4b.224 Primary flight control systems. Elevator, aileron, and rudder control systems and their supporting structures shall be designed for loads corresponding with 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in § 4b.220, subject to the following provisions.

(a) The system limit loads, except the loads resulting from ground gusts (§ 4b.226), need not exceed those which can be produced by the pilot or pilots and by automatic devices operating the controls. Acceptable maximum and minimum pilot loads for elevator, aileron, and rudder controls are shown in Figure 4b-5. These pilot loads shall be assumed to act at the appropriate control grips or pads in a manner simulating flight conditions and to be reacted at the attachment of the control system to the control surface horn.

(b) The loads shall in any case be sufficient to provide a rugged system for service use, including considerations of jamming, ground gusts, taxying tail to wind, control inertia, and friction.

<u>4b.225</u> <u>Dual primary flight control systems.</u>

(a) When dual controls are provided, the system shall be designed for the pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with § 4b.224, except that the individual pilot loads shall not be less than the minimum loads specified in Figure 4b-5.

(b) The control system shall be designed for the pilots acting in conjunction, using individual pilot loads equal to 75 percent of those obtained in accordance with § 4b.224.

<u>4b.226</u> <u>Ground gust conditions.</u> The following conditions intended to simulate the loadings on control surfaces due to ground gusts and when taxying downwind shall be investigated.

(a) The loads in the systems between the stops nearest the surfaces and the cockpit controls need not exceed those corresponding with the maxima of Figure 4b-5 for each pilot alone, or with 75 percent of these maxima for each pilot when the pilots act in conjunction.

(b) The control system stops nearest the surfaces, the control system locks, and the portions of the systems, if any, between such stops and locks and the control surface horns shall be designed for limit hinge moments H obtained from the following formula:

$H = KcSq$; where:

H = limit hinge moment (ft lbs),

c = mean chord of the control surface aft of the hinge line (ft),

S = area of the control surface aft of the hinge line (sq ft),

q = dynamic pressure (psf), based on a design speed not less than $10\sqrt{W/S} + 10$ (mph), except that the design speed need not exceed 60 mph,

K = factor as specified in Figure 4b-4.

<u>4b.227</u> <u>Secondary control systems</u>. Secondary controls, such as wheel brake, spoiler, and tab controls, shall be designed for the loads based on the maximum which a pilot is likely to apply to the control in question. The values of Figure 4b-6 are considered acceptable.

SURFACE		K	POSITION OF CONTROLS
(a)	Aileron	0.75	Control column locked or lashed in mid position
(b)	Aileron	± 0.50 *	Ailerons at full throw
(c) (d)	Elevator	± 0.75 *	(c) Elevator full down (d) Elevator full up
(e) (f)	Rudder	0.75	(e) Rudder in neutral (f) Rudder at full throw

Figure 4b-4

LIMIT HINGE MOMENT FACTOR FOR GROUND GUSTS

* A positive value of K indicates a moment tending to depress the surface, while a negative value of K indicates a moment tending to raise the surface.

LIMIT PILOT LOADS (ONE PILOT)		
CONTROL	MAXIMUM LOAD	MINIMUM LOAD
Aileron:		
Stick	100 lbs	40 lbs
Wheel *	80 D in. lbs **	40 D in. lbs
Elevator:		
Stick	250 lbs	100 lbs
Wheel	300 lbs	100 lbs
Rudder	300 lbs	130 lbs

Figure 4b-5

PILOT CONTROL FORCE LIMITS
(PRIMARY CONTROLS)

* The critical portions of the aileron control system shall be designed for a single tangential force having a limit value equal to 1.25 times the couple force determined from these criteria.

** D = wheel diameter.

CONTROL	LIMIT PILOT LOADS
Miscellaneous: * Crank wheel or lever	$\frac{1 + R}{3}$ x 50 lb, but not less than 50 lb nor more than 150 lb (R = radius) Applicable to any angle within 20° of plane of control
Twist	133 in. lbs
Push-pull	To be chosen by applicant

Figure 4b-6

PILOT CONTROL FORCE LIMITS
(SECONDARY CONTROLS)

* Limited to flap, tab, stabilizer, spoiler, and landing gear operating controls.

GROUND LOADS

4b.230 General. The limit loads obtained in the conditions specified in §§ 4b.231 through 4b.236 shall be considered as external forces applied to the airplane structure and shall be placed in equilibrium by linear and angular inertia forces in a rational or conservative manner. In applying the specified conditions the provisions of paragraph (a) of this section shall be complied with. In addition, for the landing conditions of §§ 4b.231 through 4b.234 the airplane shall be assumed to be subjected to forces and descent velocities prescribed in paragraph (b) of this section. (The basic landing gear dimensional data are given in Figure 4b-7.)

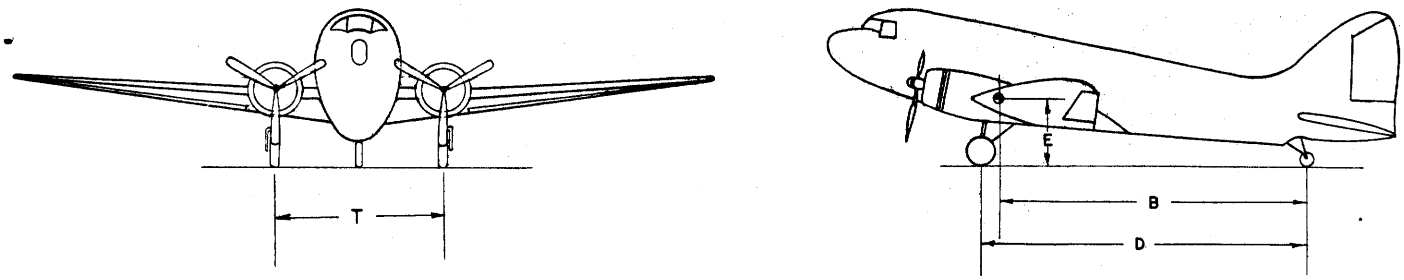
(a) Center of gravity positions. The critical center of gravity positions within the certification limits shall be selected so that the maximum design loads in each of the landing gear elements are obtained in the landing and the ground handling conditions.

(b) Load factors, descent velocities, and design weights for landing conditions.

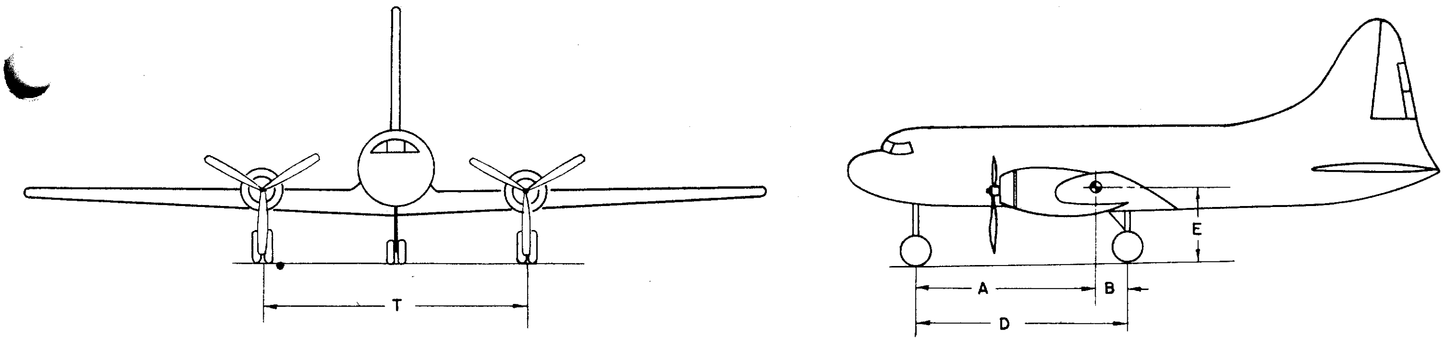
(1) In the landing conditions the limit vertical inertia load factors at the center of gravity of the airplane shall be chosen by the applicant, except that they shall not be less than the values which would be obtained when landing the airplane with the following limit descent velocities and weights:

(i) 10 fps at the design landing weight, and

(ii) 6 fps at the design take-off weight.



TAIL WHEEL TYPE



NOSE WHEEL TYPE

FIGURE 4b-7 BASIC LANDING GEAR DIMENSION DATA

(2) It shall be acceptable to assume a wing lift not exceeding 2/3 of the airplane weight to exist throughout the landing impact and to act through the center of gravity of the airplane.

(3) The provisions of subparagraphs (1) and (2) of this paragraph shall be predicated on conventional arrangements of main and nose gears, or main and tail gears, and on normal operating techniques. It shall be acceptable to modify the prescribed descent velocities if it is shown that the airplane embodies features of design which make it impossible to develope these velocities. (See § 4b.332 (a) for requirements on energy absorption tests which determine the minimum limit inertia load factors corresponding with the required limit descent velocities.)

4b.231 Level landing conditions.

(a) General. In the level attitude the airplane shall be assumed to contact the ground at a forward velocity component parallel to the ground equal to 1.2 V_{s_0} and shall be assumed to be subjected to the load factors prescribed in § 4b.230 (b) (1). The following two combinations of vertical and drag components shall be considered acting at the axle center line.

(1) Condition of maximum wheel spin-up load. Drag components simulating the forces required to accelerate the wheel rolling assembly up to the specified ground speed shall be combined with the vertical ground reactions existing at the instant of peak drag loads. A coefficient of friction between the tires and ground need not be assumed to be greater than 0.8. It shall be acceptable to apply this condition only to the landing gear and the directly affected attaching structure.

(2) Condition of maximum wheel vertical load. An aft acting drag component not less than 25 percent of the maximum vertical ground reaction

shall be combined with the maximum ground reaction of § 4b.230 (b).

(b) Level landing – tail wheel type. The airplane horizontal reference line shall be assumed to be horizontal. The conditions specified in subparagraphs (a) (1) and (a) (2) of this section shall be investigated. (See Figure 4b-8.)

(c) Level landing – nose wheel type. The following airplane attitudes shall be considered. (See Figure 4b-8.)

(1) Main wheels shall be assumed to contact the ground with the nose wheel just clear of the ground. The two conditions specified in subparagraphs (a) (1) and (a) (2) of this section shall be investigated.

(2) Nose and main wheels shall be assumed to contact the ground simultaneously. Conditions in this attitude need not be investigated if this attitude cannot reasonably be attained at the specified descent and forward velocities. The two conditions specified in subparagraphs (a) (1) and (a) (2) of this section shall be investigated, except that in condition (a) (1) it shall be acceptable to investigate the nose and main gear separately neglecting the pitching moments due to wheel spin-up loads, while in condition (a) (2) the pitching moment shall be assumed to be resisted by the nose gear.

4b.232 Tail-down landing conditions. The following conditions shall be investigated for the load factors obtained in § 4b.230 (b) (1) with the vertical ground reactions applied to the landing gear axles.

(a) Tail-wheel type. The main and tail wheels shall be assumed to contact the ground simultaneously. (See Figure 4b-9.) Two conditions of ground reaction on the tail wheel shall be assumed to act in the following directions:

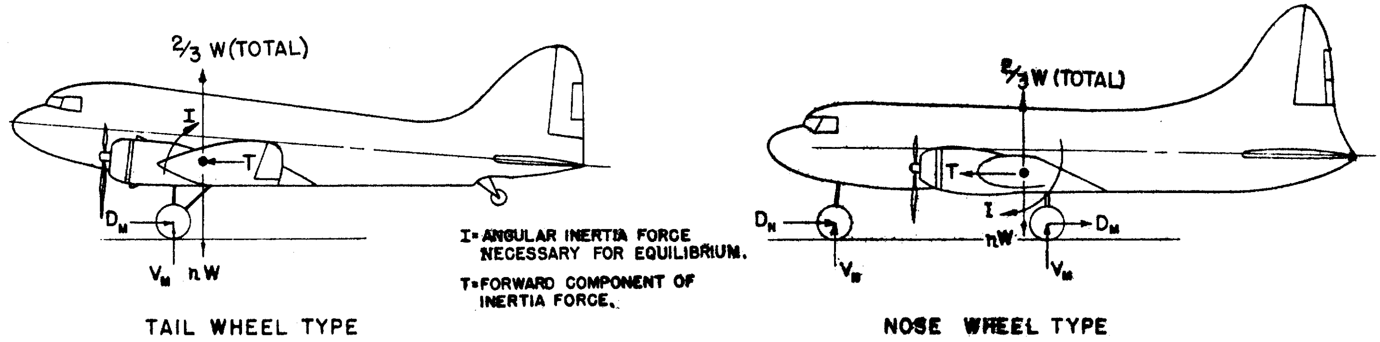


FIGURE 4b-8 LEVEL LANDING

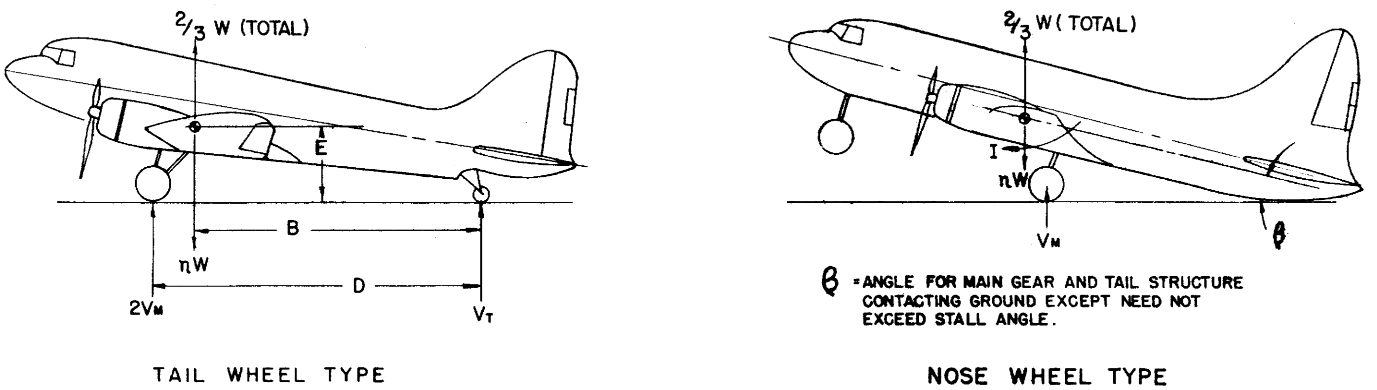
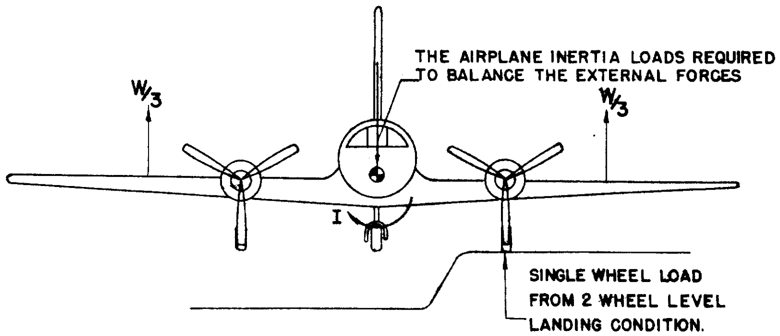
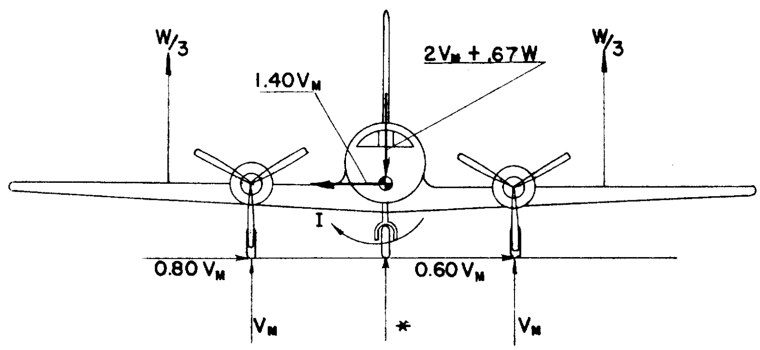


FIGURE 4b-9 TAIL DOWN LANDING



NOSE OR TAIL WHEEL TYPE

FIGURE 4b-10 ONE WHEEL LANDING



$V_M = 0.25(n - 0.67)\,W$

* NOSE GEAR GROUND REACTION = O

NOSE OR TAIL WHEEL TYPE AIRPLANE IN LEVEL ALTITUDE

FIGURE 4b-11 LATERAL DRIFT LANDING

(1) vertical,

(2) up and aft through the axle at 45° to the ground line.

(b) Nose-wheel type. The airplane shall be assumed to be at an attitude corresponding with either the stalling angle or the maximum angle permitting clearance with the ground by all parts of the airplane other than the main wheels, whichever is the lesser. (See Figure 4b-9.)

4b.233 One-wheel landing condition. The main landing gear on one side of the airplane center line shall be assumed to contact the ground in the level attitude. (See Figure 4b-10.) The ground reactions on this side shall be the same as those obtained in § 4b.231 (a) (2). The unbalanced external loads shall be reacted by inertia of the airplane in a rational or conservative manner.

4b.234 Lateral drift landing condition.

(a) The airplane shall be assumed to be in the level attitude with only the main wheels contacting the ground. (See Figure 4b-11.)

(b) Side loads of 0.8 of the vertical reaction (on one side) acting inward and 0.6 of the vertical reaction (on the other side) acting outward shall be combined with 1/2 of the maximum vertical ground reactions obtained in the level landing conditions. These loads shall be assumed to be applied at the ground contact point and to be resisted by the inertia of the airplane. It shall be acceptable to assume the drag loads to be zero.

4b.235 Ground handling conditions. The landing gear and airplane structure shall be investigated for the conditions of this section with the airplane at the design take-off weight, unless otherwise prescribed. No wing lift shall be considered. It shall be acceptable to assume the shock absorbers and tires to be deflected to their static position.

(a) Take-off run. The landing gear and the airplane structure shall be assumed to be subjected to loads not less than those encountered under conditions described in § 4b.172.

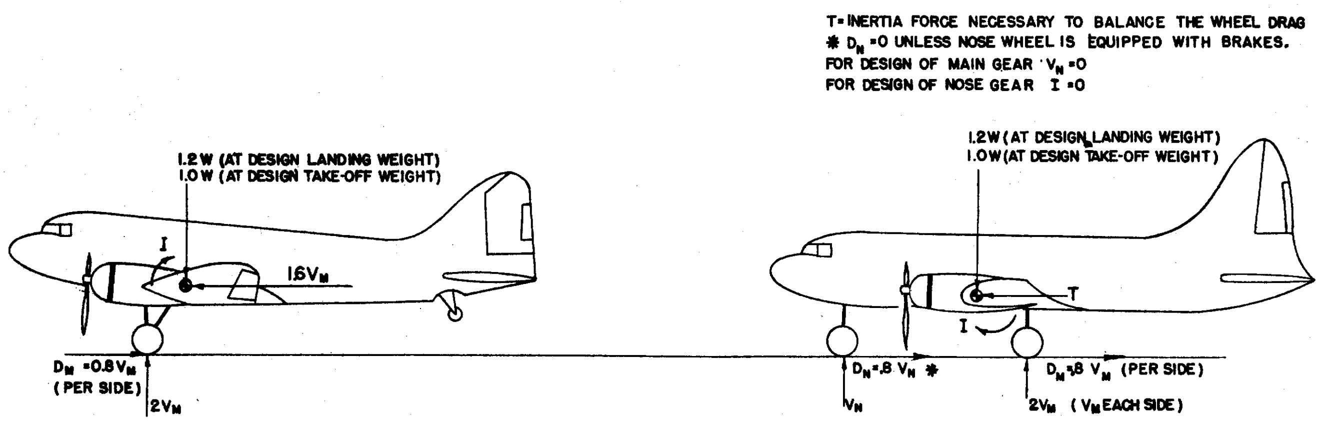
(b) Braked roll.

(1) Tail-wheel type. The airplane shall be assumed to be in the level attitude with all load on the main wheels. The limit vertical load factor shall be 1.2 for the airplane at the design landing weight, and 1.0 for the airplane at the design take-off weight. A drag reaction equal to the vertical reaction multiplied by a coefficient of friction of 0.8 shall be combined with the vertical ground reaction and applied at the ground contact point. (See Figure 4b-12.)

(2) Nose-wheel type. The limit vertical load factor shall be 1.2 for the airplane at the design landing weight, and 1.0 for the airplane at the design take-off weight. A drag reaction equal to the vertical reaction multiplied by a coefficient of friction of 0.8 shall be combined with the vertical reaction and applied at the ground contact point of each wheel having brakes. The following two airplane attitudes shall be considered. (See Figure 4b-12.)

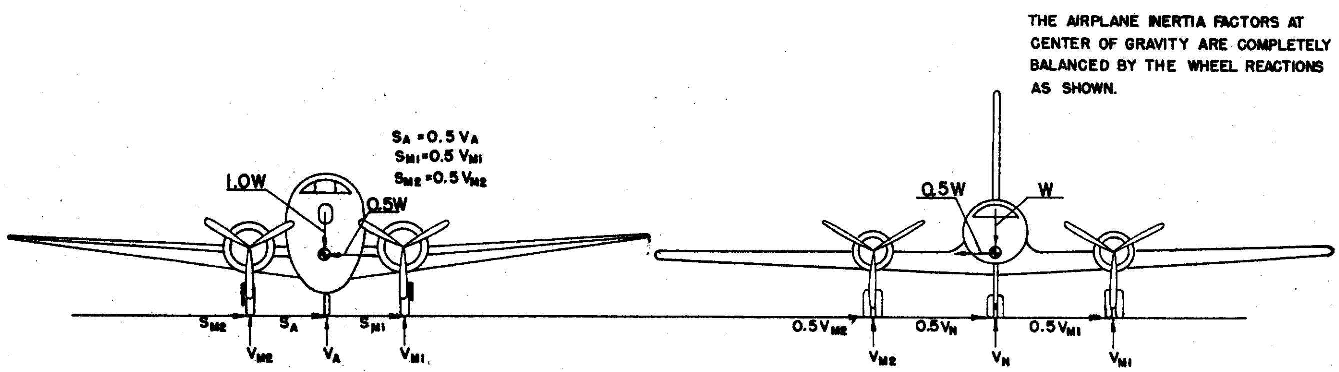
(i) The airplane shall be assumed to be in the level attitude with all wheels contacting the ground and the loads distributed between the main and nose gear. Zero pitching acceleration shall be assumed.

(ii) The airplane shall be assumed to be in the level attitude with only the main gear contacting the ground and the pitching moment resisted by angular acceleration.



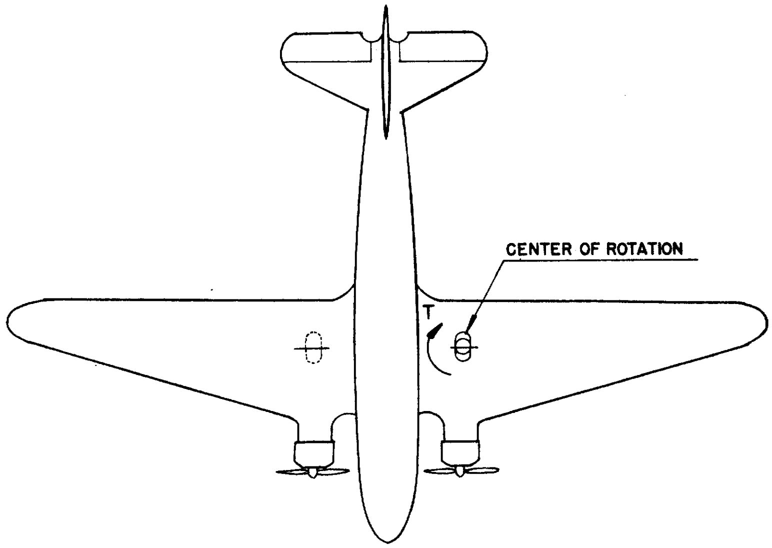
TAIL WHEEL TYPE NOSE WHEEL TYPE

FIGURE 4b-12 BRAKED ROLL



TAIL WHEEL TYPE NOSE WHEEL TYPE

FIGURE 4b-13 GROUND TURNING



V_N AND V_M ARE STATIC GROUND REACTIONS. FOR TAIL WHEEL TYPE THE AIRPLANE IS IN THE THREE POINT ATTITUDE. PIVOTING IS ASSUMED TO TAKE PLACE ABOUT ONE MAIN LANDING GEAR UNIT.

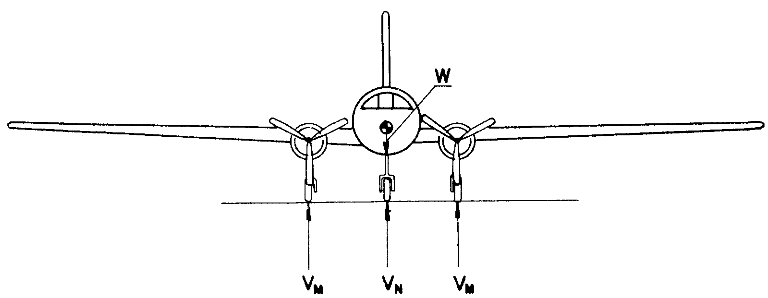


FIGURE 4b-14 PIVOTING, NOSE OR TAIL WHEEL TYPE

(c) Turning. The airplane in the static position shall be assumed to execute a steady turn by nose gear steering or by application of differential power such that the limit load factors applied at the center of gravity are 1.0 vertically and 0.5 laterally (see Figure 4b-13). The side ground reaction of each wheel shall be 0.5 of the vertical reaction.

(d) Pivoting. The airplane shall be assumed to pivot about one side of the main gear, the brakes on that side being locked. The limit vertical load factor shall be 1.0 and the coefficient of friction 0.8. The airplane shall be assumed to be in static equilibrium, the loads being applied at the ground contact points. (See Figure 4b-14.)

(e) Nose-wheel yawing.

(1) A vertical load factor of 1.0 at the airplane center of gravity and a side component at the nose wheel ground contact equal to 0.8 of the vertical ground reaction at that point shall be assumed.

(2) The airplane shall be assumed to be in static equilibrium with the loads resulting from the application of the brakes on one side of the main gear. The vertical load factor at the center of gravity shall be 1.0. The forward acting load at the airplane center of gravity shall be 0.8 times the vertical load on one main gear. The side and vertical loads at the ground contact point on the nose gear shall be those required for static equilibrium. The side load factor at the airplane center of gravity shall be assumed to be zero.

(f) Tail-wheel yawing.

(1) A vertical ground reaction equal to the static load on the tail wheel in combination with a side component of equal magnitude shall be assumed.

(2) When a swivel is provided, the tail wheel shall be assumed to be swiveled 90° to the airplane longitudinal axis with the resultant load passing through the axle. When a lock, steering device, or shimmy damper is provided, the tail wheel shall also be assumed to be in the trailing position with the side load acting at the ground contact point.

4b.236 Unsymmetrical loads on dual-wheel units. In dual-wheel units 60 percent of the total ground reaction for the unit shall be applied to one wheel and 40 percent to the other. To provide for the case of one flat tire, 60 percent of the load which would be assigned to the unit in the specified conditions shall be applied to either wheel, except that the vertical ground reaction shall not be less than the full static value.

WATER LOADS

4b.250 General. The water load requirements shall apply to the entire airplane.

4b.251 Design weight. The design weight used in the water landing conditions shall not be less than the design landing weight, except that local bottom pressure conditions shall be investigated at the design take-off weight.

4b.252 Boat seaplane bottom pressures.

(a) Maximum local pressure. The maximum value of the limit local pressure shall be determined from the following equation:

$p_{max} = 0.04\ V_s^{1.5}$; where:

p = pressure (psi),

V_s = stalling speed with flaps fully retracted at the design take-off weight (mph).

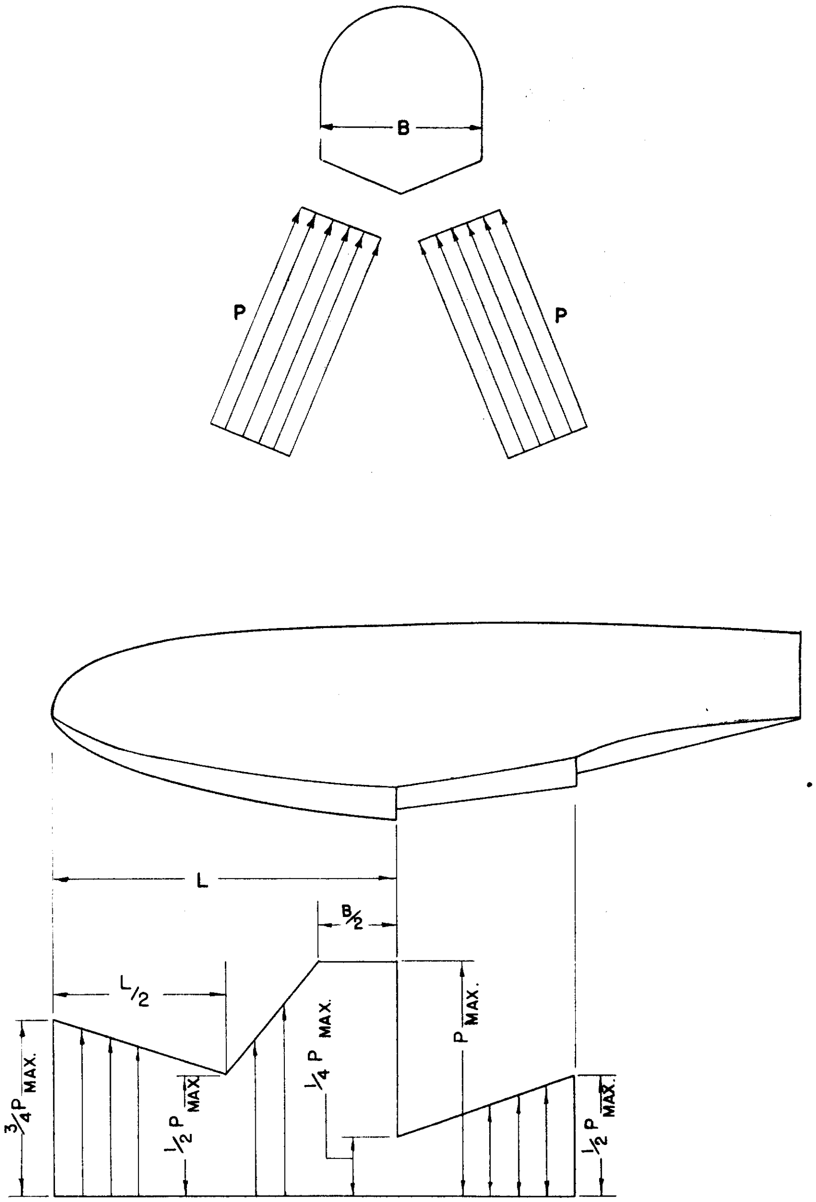


FIGURE 4b- 15 DISTRIBUTION OF LOCAL PRESSURES
BOAT SEAPLANES

(b) Variation in local pressure. The local pressures applied to the hull bottom shall vary in accordance with Figure 4b-15. No variation from keel to chine (beamwise) shall be assumed, except when the chine flare indicates the advisability of higher pressures at the chine.

(c) Application of local pressure. The local pressures determined in paragraphs (a) and (b) of this section shall be applied over a local area in such a manner as to cause the maximum local loads in the hull bottom structure.

(d) Distributed bottom symmetrical pressures. For the purpose of designing frames, keels, and chine structure, a maximum limit pressure shall be computed according to paragraph (a) of this section, except that the stalling speed used in the computation shall be based upon the design landing weight and the resulting pressure value shall be reduced to one-half. The pressure shall be applied simultaneously over the entire hull bottom according to the distribution of Figure 4b-15. The resulting loads shall be carried into the side-wall structure of the hull proper, but need not be transmitted in a fore-and-aft direction as shear and bending.

(e) Distributed bottom unsymmetrical pressures. Each floor member and frame shall be designed for a load on one side of the hull center line equal to the most critical symmetrical loading as obtained in paragraph (d) of this section, combined with a load on the other side of the hull center line equal to one-half the most critical symmetrical loading.

4b.253 Boat seaplane loading conditions.

(a) Step loading condition.

(1) Application of load. The resultant water load shall be applied vertically in the plane of symmetry to pass through the center of gravity of the airplane.

(2) Magnitude of load. The limit acceleration shall be 4.0, unless a lower value is shown by tests to be more applicable.

(3) Hull shear and bending loads. The hull shear and bending loads shall be computed from the inertia loads produced by the vertical water load. To avoid excessive local shear loads and bending moments near the point of water load application, it shall be acceptable to distribute the water load over the hull bottom using pressures not less than those specified in § 4b.252 (d).

(b) Bow loading condition.

(1) Application of load. The resultant water load shall be applied in the plane of symmetry at a point 1/10 of the distance from the bow to the step and shall be directed upward and rearward at an angle of 30° from the vertical.

(2) Magnitude of load. The magnitude of the limit resultant water load shall be determined from the following equation:

$P_b = 1/2\, n_s W_e$; where:

P_b = limit load (lbs),

n_s = the step landing load factor,

W_e = an effective weight (lbs), assumed to be equal to one-half the design landing weight of the airplane.

(3) Hull shear and bending loads. The hull shear and bending loads shall be determined by considering the inertia loads which resist the linear and angular accelerations involved. To avoid excessive local shear loads, it shall be acceptable to distribute the water reaction over the hull bottom using pressures not less than those specified in § 4b.252 (d).

(c) Stern loading condition.

(1) Application of load. The resultant water load shall be applied vertically in the plane of symmetry and shall be distributed over the hull bottom from the second step forward with an intensity equal to the pressures specified in § 4b.252 (d).

(2) Magnitude of load. The limit resultant load shall equal 3/4 of the design landing weight of the airplane.

(3) Hull shear and bending loads. The hull shear and bending loads shall be determined by assuming the hull structure to be supported at the wing attachment fittings and by neglecting internal inertia loads. This condition need not be applied to the fittings or to the portion of the hull ahead of the wing rear attachment fittings.

(d) Side loading condition.

(1) Application of load. The resultant water load shall be applied in a vertical plane through the center of gravity. The vertical component shall be assumed to act in the plane of symmetry and the horizontal component at a point half-way between the bottom of the keel and the load water line at design landing weight (at rest).

(2) Magnitude of load. The limit vertical component of acceleration shall be 3.25, and the side component shall be 15 percent of the vertical component.

(3) Hull shear and bending loads. The hull shear and bending loads shall be determined by considering the inertia loads or by introducing couples at the wing attachment points. To avoid excessive local shear loads, it shall be acceptable to distribute the water reaction over the hull bottom using pressures not less than those specified by § 4b.252 (d).

4b.254 Float seaplane bottom pressures. The following provisions shall be applicable to the main float bottoms.

(a) Maximum local pressure. The maximum value of the limit local pressure shall be as determined by the equation in § 4b.252 (a).

(b) Variation in local pressure. The local pressures to be applied to the float bottom shall vary in accordance with the following.

(1) A pressure of the value prescribed in paragraph (a) of this section shall be applied over the portion of the bottom lying between the main step and a section at 25 percent of the distance from the step to the bow.

(2) A pressure equal to 1/2 the value prescribed in paragraph (a) of this section shall be applied over the portion of the bottom lying between the section at 25 percent of the distance from the main step to the bow and a section at 75 percent of the distance from the main step to the bow.

(3) A pressure equal to 0.3 times the value prescribed in paragraph (a) of this section shall be applied over the portion of the bottom aft of the main step.

(c) Application of local pressure. The local pressures determined in accordance with paragraphs (a) and (b) of this section shall be applied over a local area in a manner to cause maximum local loads in the float bottom structure.

(d) Distributed bottom pressures. For the purpose of designing frames, keels, and chine structure, distributed pressures equal to one-half the values specified in paragraphs (a) and (b) of this section shall be applied simultaneously over the entire affected float bottom.

4b.255 Float seaplane landing conditions.

(a) Landing with inclined reactions. The vertical component of the limit load factor shall be 4.0, unless a lower value is shown by tests to be more applicable. The propeller axis (or equivalent reference line) shall be assumed horizontal. The resultant water reaction shall be assumed to act in the plane of symmetry and to pass through the center of gravity of the airplane inclined so that its horizontal component is equal to 1/4 of its vertical component. Inertia forces shall be assumed to act in a direction parallel to the water reaction.

(b) Landing with vertical reactions. The limit load factor shall be 4.0 acting vertically, unless a lower value is shown by tests to be more applicable. The propeller axis (or equivalent reference line) shall be assumed horizontal. The resultant water reaction shall be assumed to act vertically and to pass through the center of gravity of the airplane.

(c) Landing with side load. The vertical component of the limit load factor shall be 4.0. The propeller axis (or equivalent reference line) shall be assumed horizontal. The resultant water reaction shall be assumed to act in a vertical plane which passes through the center of gravity of the airplane and which is perpendicular to the propeller axis. The vertical load shall be applied through the keel or keels of the float or floats and evenly divided between the floats if twin floats are used. A side load equal to 1/4 of the vertical load shall be applied along a line approximately halfway between the bottom of the keel and the level of the water line at rest. When twin floats are used the entire side load specified shall be applied to the float on the side from which the water reaction originates.

4b.256 Float seaplane loads. Each main float of a float seaplane shall be capable of carrying the following loads when supported at the attachment fittings as installed on the airplane:

(a) a limit load acting upward at the bow of the float equal to that portion of the airplane's weight which is normally supported by the float,

(b) a limit load acting upward at the stern of the float equal to 0.8 times that portion of the airplane's weight which is normally supported by the float,

(c) a limit load acting upward at the step of the float equal to 1.5 times that portion of the airplane's weight which is normally supported by the float.

4b.257 Wing tip float loads.

(a) Wing tip floats and their attachment, including the wing structure, shall be capable of carrying the following loads:

(1) a vertical limit up load acting through the completely submerged center of buoyancy of the float equal to three times the completely submerged displacement,

(2) a limit up load inclined to the rear at 45° to the vertical acting through the completely submerged center of buoyancy of the float equal to three times the completely submerged displacement,

(3) a limit lateral load acting parallel to the water surface applied at the center of area of the side view equal to 1.5 times the completely submerged displacement.

(b) The strength of the wing structure shall be sufficient to insure that failure of wing tip float attachment members occurs before the wing structure is damaged.

4b.258 Seawing loads. Seawing design loads shall be based on applicable test data.

EMERGENCY LANDING CONDITIONS

4b.260 General. The following requirements deal with emergency conditions of landing on land or water in which the safety of the occupants shall be considered, although it is accepted that parts of the airplane may be damaged.

(a) The structure shall be designed to give every reasonable probability that all of the occupants, if they make proper use of the seats, belts, and other provisions made in the design (see § 4b.358), will escape serious injury in the event of a minor crash landing (with wheels up if the airplane is equipped with retractable landing gear) in which the occupants experience the following ultimate inertia forces relative to the surrounding structure.

(1) Upward 2.0g (Downward 4.5g)

(2) Forward 6.0g

(3) Sideward 1.5g

(b) The use of a lesser value of the downward inertia force specified in paragraph (a) of this section shall be acceptable if it is shown that the airplane structure can absorb the landing loads corresponding with the design landing weight and an ultimate descent velocity of 5 fps without exceeding the value chosen.

(c) The inertia forces specified in paragraph (a) of this section shall be applied to all items of mass which would be apt to injure the passengers or crew if such items became loose in the event of a minor crash landing, and the supporting structure shall be designed to restrain these items.

<u>4b.261</u> <u>Ditching provisions</u>. Compliance with this section is optional. The requirements of this section are intended to safeguard the occupants in the event of an emergency landing during overwater flight. When compliance is shown with the following provisions and with the provisions of § 4b.361, the type certificate shall include certification to that effect. When an airplane is certificated to include ditching provisions, the recommended ditching procedures established on the basis of these requirements shall be set forth in the Airplane Flight Manual (see § 4b.742 (d)).

(a) Evidence shall be submitted that all practicable measures compatible with the general characteristics of the type airplane have been taken to minimize the chance of any behavior of the airplane in an emergency landing on water which would be likely to cause immediate injury to the occupants or to make it impossible for them to escape from the airplane.

(b) In demonstrating compliance with the provisions of this section, the probable behavior of the airplane in a water landing shall be investigated by model tests or by comparison with airplanes of similar configuration for which the ditching characteristics are known. The following provisions shall apply.

(1) Account shall be taken of scoops, flaps, projections,

and all other factors likely to affect the hydrodynamic characteristics of the actual airplane.

(2) External doors and windows shall be designed to withstand the probable maximum local pressures, unless the effects of the collapse of such parts are taken into account in the model tests or airplane comparison.

SUBPART D - DESIGN AND CONSTRUCTION

GENERAL

4b.300 Scope. The airplane shall not incorporate design features or details which experience has shown to be hazardous or unreliable. The suitability of all questionable design details or parts shall be established by tests.

4b.301 Materials. The suitability and durability of all materials used in the airplane structure shall be established on the basis of experience or tests. All materials used in the airplane structure shall conform to approved specifications which will insure their having the strength and other properties assumed in the design data.

4b.302 Fabrication methods. The methods of fabrication employed in constructing the airplane structure shall be such as to produce a consistently sound structure. When a fabrication process such as gluing, spot welding, or heat treating requires close control to attain this objective, the process shall be performed in accordance with an approved process specification.

4b.303 Standard fastenings. All bolts, pins, screws, and rivets used in the structure shall be of an approved type. The use of an approved locking device or method is required for all such bolts, pins, and screws. Self-locking nuts shall not be used on bolts which are subject to rotation in operation.

4b.304 Protection.

(a) All members of the structure shall be suitably protected against deterioration or loss of strength in service due to weathering, corrosion, abrasion, or other causes.

(b) Provision for ventilation and drainage of all parts of the structure shall be made where necessary for protection.

(c) In seaplanes, special precautions shall be taken against corrosion from salt water, particularly where parts made from different metals are in close proximity.

4b.305 Inspection provisions. Means shall be provided to permit the close examination of those parts of the airplane which require periodic inspection, adjustment for proper alignment and functioning, and lubrication of moving parts.

4b.306 Material strength properties and design values.

(a) Material strength properties shall be based on a sufficient number of tests of material conforming to specifications to establish design values on a statistical basis.

(b) The design values shall be so chosen that the probability of any structure being understrength because of material variations is extremely remote.

(c) ANC-5a and ANC-18 values shall be used unless shown to be inapplicable in a particular case.1/

(d) The structure shall be designed in so far as practicable to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service.

1/ ANC-5a, "Strength of Aircraft Elements," and ANC-18, "Design of Wood Aircraft Structures," are 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.

4b.307 Special factors. Where there is uncertainty concerning the actual strength of a particular part of the structure, or where the strength is likely to deteriorate in service prior to normal replacement of the part, or where the strength is subject to appreciable variability due to uncertainties in manufacturing processes and inspection methods, the factor of safety prescribed in § 4b.200 (a) shall be multiplied by a special factor of a value such as to make the probability of the part being understrength from these causes extremely remote. The following special factors shall be used.

(a) Casting factors.

(1) Where only visual inspection of a casting is to be employed, the casting factor shall be 2.0, except that it need not exceed 1.25 with respect to bearing stresses.

(2) It shall be acceptable to reduce the factor of 2.0 specified in subparagraph (1) of this paragraph to a value of 1.25 if such a reduction is substantiated by testing at least three sample castings and if the sample castings as well as all production castings are visually and radiographically inspected in accordance with an approved inspection specification. During these tests the samples shall withstand the ultimate load multiplied by the factor of 1.25 and in addition shall comply with the corresponding limit load multiplied by a factor of 1.15.

(3) Casting factors other than those contained in subparagraphs (1) and (2) of this paragraph shall be acceptable if they are found to be appropriately related to tests and to inspection procedures.

(4) A casting factor need not be employed with respect to the bearing surface of a part if the bearing factor used (see paragraph (b)

of this section) is of greater magnitude than the casting factor.

(b) Bearing factors.

(1) Bearing factors shall be used of sufficient magnitude to provide for the effects of normal relative motion between parts and in joints with clearance (free fit) which are subject to pounding or vibration. (Bearing factor values for control surface and system joints are specified in §§ 4b.313 (a), and 4b.329 (b).)

(2) A bearing factor need not be employed on a part if another special factor prescribed in this section is of greater magnitude than the bearing factor.

(c) Fitting factors.

(1) A fitting factor of at least 1.15 shall be used on all fittings the strength of which is not proven by limit and ultimate load tests in which the actual stress conditions are simulated in the fitting and the surrounding structure. This factor shall apply to all portions of the fitting, the means of attachment, and the bearing on the members joined.

(2) In the case of integral fittings the part shall be treated as a fitting up to the point where the section properties become typical of the member.

(3) The fitting factor need not be employed where a type of joint made in accordance with approved practices is based on comprehensive test data, e.g., continuous joints in metal plating, welded joints, and scarf joints in wood.

(4) A fitting factor need not be employed with respect to the bearing surface of a part if the bearing factor used (see paragraph (b) of this section) is of greater magnitude than the fitting factor.

4b.308 Flutter and vibration prevention measures. In all conditions of operation within the limit V-n envelope, the wings, control surfaces, control systems, and all other structural parts shall be free from flutter and dangerous vibration, including that resulting from gust impulses. In showing compliance with this requirement the following shall apply.

(a) Satisfactory analytical and/or experimental evidence shall be submitted to show that dangerous flutter conditions will not develop at any speed up to 1.2 V_D selected in accordance with § 4b.210 (b) (5), except that the speed need not exceed the terminal velocity in a 30° dive.

(b) The airplane shall comply with the flight demonstration requirements specified in § 4b.190.

(c) The natural frequencies of all main structural components, control surfaces, and control systems shall be determined by vibration tests or by other reliable methods, and shall be shown to be within the range of values appropriate for the prevention of flutter.

(d) The mass balance of movable control surfaces shall be shown to preclude flutter. The strength and stiffness of mass balance supports shall be sufficient for the accelerations likely to occur on mass balances.

(e) Control surface tabs not equipped with an irreversible actuating mechanism, as specified in § 4b.322, shall be properly mass balanced and shown by a rational flutter analysis or equivalent testing that they are free from flutter tendencies.

4b.309 Stiffness. Wings and tail surfaces shall be shown to be free from aero-elastic divergence, and control surfaces to be free from reversal of effect, at all speeds up to 1.2 V_D selected in accordance with

§ 4b.210 (b) (5), except that the speed need not exceed the terminal velocity in a 30° dive. In showing compliance with this requirement, the torsional rigidity of wings and tail surfaces shall be determined by tests or other reliable methods.

CONTROL SURFACES

4b.310 General. The requirements of §§ 4b.311 through 4b.313 shall apply to the design of fixed and movable control surfaces.

4b.311 Proof of strength.

(a) Control surface limit load tests shall be conducted to prove compliance with limit load requirements.

(b) Control surface tests shall include the horn or fitting to which the control system is attached.

(c) Analyses or individual load tests shall be conducted to demonstrate compliance with the special factor requirements for control surface hinges. (See §§ 4b.307 and 4b.313 (a).)

4b.312 Installation.

(a) Movable tail surfaces shall be so installed that there is no interference between any two surfaces when one is held in its extreme position and all the others are operated through their full angular movement.

(b) When an adjustable stabilizer is used, stops shall be provided which will limit its travel, in the event of failure of the adjusting mechanism, to a range equal to the maximum required to trim the airplane in accordance with § 4b.140.

4b.313 Hinges.

(a) Control surface hinges, except ball and roller bearings, shall incorporate a special factor of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing.

(b) For hinges incorporating ball or roller bearings, the approved rating of the bearing shall not be exceeded.

(c) Hinges shall provide sufficient strength and rigidity for loads parallel to the hinge line.

CONTROL SYSTEMS

4b.320 General. All controls and control systems shall operate with ease, smoothness, and positiveness appropriate to their function. (See also §§ 4b.350 and 4b.353.)

4b.321 Two-control airplanes. Two-control airplanes shall be capable of continuing safely in flight and landing in the event of failure of any one connecting element in the directional-lateral flight control system.

4b.322 Trim controls and systems.

(a) Trim controls shall be designed to safeguard against inadvertent or abrupt operation.

(b) Each trim control shall operate in the plane and with the sense of motion of the airplane. (See Figure 4b-16.)

(c) Means shall be provided adjacent to the trim control to indicate the direction of the control movement relative to the airplane motion.

(d) Means shall be provided to indicate the position of the trim device with respect to the range of adjustment. The indicating means shall be clearly visible.

(e) Trim devices shall be capable of continued normal operation in the event of failure of any one connecting or transmitting element of the primary flight control system.

(f) Trim tab controls shall be irreversible, unless the tab is appropriately balanced and shown to be free from flutter.

(g) Where an irreversible tab control system is employed, the portion from the tab to the attachment of the irreversible unit to the airplane structure shall consist of a rigid connection.

4b.323 Wing flap controls.

(a) The wing flap controls shall operate in a manner to permit the flight crew to place the flaps in all of the take-off, en route, approach, and landing positions established under § 4b.111 and to maintain these positions thereafter without further attention on the part of the crew, except for flap movement produced by an automatic flap positioning or load limiting device.

(b) The wing flap control shall be located and designed to render improbable its inadvertent operation.

(c) The rate of motion of the wing flap in response to the operation of the control and the characteristics of the automatic flap positioning or load limiting device shall be such as to obtain satisfactory flight and performance characteristics under steady or changing conditions of air speed, engine power, and airplane attitude.

(d) The wing flap control shall be designed to retract the flaps from the fully extended position during steady flight at maximum continuous engine power at all speeds below $V_F + 10$ (mph).

(e) Means shall be provided to indicate the take-off, en route, approach, and landing flap positions.

(f) If any extension of the flaps beyond the landing position is possible, the flap control shall be clearly marked to identify such range of extension.

4b.324 Wing flap interconnection.

(a) The motion of wing flaps on opposite sides of the plane of symmetry shall be synchronized by a mechanical interconnection unless the airplane is demonstrated to have safe flight characteristics while the flaps are retracted on one side and extended on the other.

(b) Where a wing flap interconnection is used, it shall be designed to account for the applicable unsymmetrical loads, including those resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at take-off power.

4b.325 Control system stops.

(a) All control systems shall be provided with stops which positively limit the range of motion of the control surfaces.

(b) Control system stops shall be so located in the system that wear, slackness, or take-up adjustments will not affect adversely the control characteristics of the airplane because of a change in the range of surface travel.

(c) Control system stops shall be capable of withstanding the loads corresponding with the design conditions for the control system.

4b.326 Control system locks. If a device is provided for locking a control surface while the airplane is on the ground or water, the following provisions shall apply.

(a) A means shall be provided to give unmistakable warning to the pilot when the locking device is engaged.

(b) Means shall be provided to preclude the possibility of the lock becoming engaged during flight.

(c) Locks shall be designed for the ground gust conditions prescribed in § 4b.226.

4b.327 Static tests. Tests shall be conducted on control systems to show compliance with limit load requirements in accordance with the following provisions.

(a) The direction of the test loads shall be such as to produce the most severe loading in the control system.

(b) The tests shall include all fittings, pulleys, and brackets used in attaching the control system to the main structure.

(c) Analyses or individual load tests shall be conducted to demonstrate compliance with the special factor requirements for control system joints subjected to angular motion. (See §§ 4b.307 and 4b.329 (b).)

4b.328 Operation tests. An operation test shall be conducted for each control system by operating the controls from the pilot compartment with the entire system loaded to correspond with 80 percent of the limit load specified for the control system. In this test there shall be no jamming, excessive friction, or excessive deflection.

4b.329 Control system details - general. All details of control systems shall be designed and installed to prevent jamming, chafing, and interference from cargo, passengers, and loose objects. Precautionary means shall be provided in the cockpit to prevent the entry of foreign objects into places where they would jam the control systems. Provisions shall be made to prevent the slapping of cables or tubes against other parts of the airplane. The following detail requirements shall be applicable with respect to cable systems and joints.

(a) Cable systems.

(1) Cables, cable fittings, turnbuckles, splices, and pulleys shall be of an approved type.

(2) Cables smaller than 1/8 inch diameter shall not be used in the aileron, elevator, or rudder systems.

(3) The design of cable systems shall be such that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations.

(4) Pulley types and sizes shall correspond with the cables used.

(5) All pulleys shall be provided with closely fitted guards to prevent the cables being displaced or fouled.

(6) Pulleys shall lie in the plane passing through the cable within such limits that the cable does not rub against the pulley flange.

(7) Fairleads shall be so installed that they do not cause a change in cable direction of more than 3°.

(8) Clevis pins (excluding those not subject to load or motion) retained only by cotter pins shall not be used in the control system.

(9) Turnbuckles attached to parts having angular motion shall be installed to prevent positively any binding throughout the range of travel.

(10) Provision for visual inspection shall be made at all fairleads, pulleys, terminals, and turnbuckles.

(b) Joints.

(1) Control system joints subjected to angular motion in push-pull systems, excepting ball and roller bearing systems, shall incorporate a special factor of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing.

(2) It shall be acceptable to reduce the factor specified in subparagraph (1) of this paragraph to a value of 2.0 for joints in cable control systems.

(3) The approved rating of ball and roller bearings shall not be exceeded.

LANDING GEAR

4b.330 General. The requirements of §§ 4b.331 through 4b.338 shall apply to the complete landing gear.

4b.331 Shock absorbers.

(a) The shock absorbing elements for the main, nose, and tail wheel units shall be substantiated by the tests specified in § 4b.332.

(b) The shock absorbing ability of the landing gear in taxying shall be demonstrated by the tests prescribed in § 4b.172.

4b.332 Landing gear tests. The landing gear shall withstand the following tests.

(a) Shock absorption tests.

(1) It shall be demonstrated by energy absorption tests that the limit load factors selected for design in accordance with § 4b.230 (b) for take-off and landing weights, respectively, will not be exceeded.

(2) In addition to the provisions of subparagraph (1) of this paragraph, a reserve of energy absorption shall be demonstrated by a test simulating an airplane descent velocity of 12 fps at design landing weight, assuming wing lift not greater than the airplane weight acting during the landing impact. In this test the landing gear shall not fail. (See paragraph (c) of this section.)

(b) Limit drop tests.

(1) If compliance with the limit landing conditions specified in subparagraph (a) (1) of this section is demonstrated by free drop tests, these shall be conducted on the complete airplane, or on units consisting of wheel, tire, and shock absorber in their proper relation. The free drop heights shall not be less than the following:

(i) 18.7 inches for the design landing weight conditions,

(ii) 6.7 inches for the design take-off weight conditions.

(2) If wing lift is simulated in free drop tests the landing gear shall be dropped with an effective mass equal to:

$$W_e = W\left(\frac{h + (1-L)d}{h + d}\right)$$; where:

W_e = the effective weight to be used in the drop test (lbs),

h = specified free drop height (inches),

d = deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (inches),

$W = W_M$ for main gear units (lbs), equal to the static weight on the particular unit with the airplane in the level attitude (with the nose wheel clear in the case of nose wheel type airplanes),

$W = W_T$ for tail gear units (lbs), equal to the static weight on the tail unit with the airplane in the tail-down attitude,

$W = W_N$ for nose wheel units (lbs), equal to the vertical component of the static reaction which would exist at the nose wheel, assuming the mass of the airplane acting at the center of gravity and exerting a force of 1.0g downward and 0.25g forward,

L = the ratio of the assumed wing lift to the airplane weight, not in excess of 0.667.

(3) The attitude in which a landing gear unit is drop tested shall simulate the airplane landing condition critical for the unit.

(4) The value of d used in the computation of W_e in subparagraph (2) of this paragraph shall not exceed the value actually obtained in the drop test.

(c) Reserve energy absorption drop tests.

(1) If compliance with the reserve energy absorption condition specified in § 4b.332 (a) (2) is demonstrated by free drop tests, the landing gear units shall be dropped from a free drop height of not less than 27 inches.

(2) If wing lift equal to the airplane weight is simulated, the units shall be dropped with an effective mass equal to:

$$W_e = W \left(\frac{h}{h + d}\right);$$

where the symbols and other details are the same as in paragraph (b) of this section.

4b.333 Limit load factor determination.

(a) In determining the airplane inertia limit load factor n from the free drop tests specified in § 4b.332, the following formula shall be used:

$$n = n_j \frac{W_e}{W} + L; \text{ where:}$$

n_j = the load factor during impact developed on the mass used in the drop test, (i.e. the acceleration dv/dt in g's recorded in the drop test plus 1.0). (See § 4b.332 (b) (2) for explanation of W_e, W, and L).

(b) The value of n determined in paragraph (a) of this section shall not be greater than the limit load factor used for the landing conditions. (See § 4b.230 (b).)

4b.334 Retracting mechanism.

(a) General.

(1) The landing gear retracting mechanism, wheel well doors, and supporting structure shall be designed for the loads occurring in the flight conditions when the gear is in the retracted position, and for the combination of friction, inertia, brake torque, and air loads occurring during retraction and extension at any air speed up to 1.6 V_{s_1}

(flaps in the approach position at design landing weight), and any load factor up to those specified in § 4b.212 for the flaps extended condition.

(2) The landing gear, the retracting mechanism, and the airplane structure including wheel well doors shall be designed to withstand the flight loads occurring with the landing gear in the extended position at any speed up to 0.67 V_C, unless other means are provided to decelerate the airplane in flight at this speed.

(b) Landing gear lock. A positive means shall be provided for the purpose of maintaining the landing gear in the extended position.

(c) Emergency operation. Emergency means of extending the landing gear shall be provided, so that the landing gear can be extended in the event of any reasonably probable failure in the normal retraction system. In any case the emergency system shall provide for the failure of any single source of hydraulic, electric, or equivalent energy supply.

(d) Operation test. Proper functioning of the landing gear retracting mechanism shall be demonstrated by operation tests.

(e) Position indicator and warning device.

(1) When a retractable landing gear is used, means shall be provided for indicating to the pilot when the gear is secured in the extended and in the retracted positions.

(2) In addition to the requirement of subparagraph (1) of this paragraph landplanes shall be provided with an aural warning device which will function continuously when all throttles are closed if the gear is not fully extended and locked.

(3) If a manual shutoff for the warning device prescribed

in subparagraph (2) of this paragraph is provided, it shall be installed so that reopening the throttles will reset the warning mechanism.

(f) Control. The location and operation of the landing gear retraction control shall be according to the provisions of § 4b.353.

4b.335 Wheels.

(a) Main landing gear wheels (i.e. those nearest the airplane center of gravity) shall be of a type approved in accordance with Part 15.

(b) The rated static load of each main wheel shall not be less than the design take-off weight of the airplane divided by the number of main wheels.

(c) Nose wheels shall be tested in accordance with Part 15 for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements and for the corresponding side loads.

4b.336 Tires.

(a) Landing gear tires shall be of a proper fit on the rim of the wheel, and their approved rating shall be such that it is not exceeded under the following conditions:

(1) airplane weight equal to the design take-off weight,

(2) load on main wheel tires equal to the airplane weight divided by the number of main wheels,

(3) load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane concentrated at the center of gravity and exerting a force of 1.0g downward and 0.31g forward, the

reactions being distributed to the nose and main wheels by the principles of statics with the drag reaction at the ground applied only at those wheels which have brakes.

4b.337 Brakes.

(a) General.

(1) All airplanes shall be equipped with approved brakes.

(2) The brake system shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system (excluding the operating pedal or handle), or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible to bring the airplane to rest under conditions specified in § 4b.122 with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section.

(3) In applying the requirement of subparagraph (2) of this paragraph to hydraulic brakes the brake drum, shoes, and actuators (or their equivalents) shall be considered as connecting or transmitting elements, unless it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in these units would not reduce the braking effectiveness below that specified in subparagraph (2) of this paragraph.

(b) Brake controls. Brake controls shall not require excessive control forces in their operation.

(c) Parking brake controls. A parking brake control shall be provided and installed so that it can be set by the pilot and, without further attention, will maintain sufficient braking to prevent the airplane from rolling on a paved, level runway while take-off power on the critical engine is being applied.

4b.338 Skis. Skis shall be of an approved type. The approved rating of the skis shall not be less than the maximum take-off weight of the airplane.

(a) Installation. In addition to any shock cords installed, front and rear check cables shall be provided on skis which are not equipped with special stabilizing devices.

(b) Tests. It shall be demonstrated that the airplane has safe landing and taxying characteristics, and that the airplane's flight characteristics are not impaired by the installation of the skis.

HULLS AND FLOATS

4b.340 General. The requirements of §§ 4b.341 and 4b.342 shall apply to the design of hulls and floats.

4b.341 Buoyancy (main seaplane floats).

(a) Main seaplane floats shall have the following excess buoyancy beyond that required to support the maximum weight of the airplane in fresh water:

(1) 80 percent in the case of single floats,

(2) 90 percent in the case of double floats.

(b) Each main seaplane float shall contain at least 5 watertight compartments of approximately equal volume.

4b.342 Buoyancy (boat seaplanes).

(a) The hulls of boat seaplanes and amphibians shall be divided into watertight compartments so that, with any 2 adjacent compartments flooded, the hull and auxiliary floats (and wheel tires, if used) will retain sufficient buoyancy to support the maximum weight of the aircraft in fresh water without capsizing.

(b) For the purpose of communication between compartments, bulkheads with watertight doors shall be allowed.

PERSONNEL AND CARGO ACCOMMODATIONS

4b.350 Pilot compartment - general.

(a) The arrangement of the pilot compartment and its appurtenances shall provide safety and assurance that the pilot will be able to perform all of his duties and operate the controls in the correct manner without unreasonable concentration and fatigue.

(b) The primary flight controls listed on Figure 4b-16, excluding cables and control rods, shall be so located with respect to the propellers that no portion of the pilot or the controls lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub and making an angle of 5° forward or aft of the plane of rotation of the propeller.

(c) When provision is made for a second pilot, the airplane shall be controllable with equal safety from both seats.

(d) The pilot compartment shall be constructed to prevent leakage likely to be distracting to the crew or harmful to the structure when flying in rain or snow.

(e) A door shall be provided between the pilot compartment and the passenger compartment.

CONTROLS	MOVEMENT AND ACTUATION
	Primary
Aileron	Right (clockwise) for right wing down
Elevator	Rearward for nose up
Rudder	Right pedal forward for nose right
	Secondary
Flaps (or auxiliary lift devices)	Down to extend
Trim tabs (or equivalent)	Rotate to produce similar rotation of the airplane about an axis parallel to the axis of the control.

Figure 4b-16

AERODYNAMIC CONTROLS

(f) The door prescribed in paragraph (e) of this section shall be equipped with a locking means to prevent passengers from opening the door without the pilot's permission.

(g) Vibration and noise characteristics of cockpit appurtenances shall not interfere with the safe operation of the airplane.

4b.351 Pilot compartment vision.

(a) Nonprecipitation conditions.

(1) The pilot compartment shall be arranged to afford the pilots a sufficiently extensive, clear, and undistorted view to perform safely all maneuvers within the operating limitations of the airplane, including taxying, take-off, approach, and landing.

(2) It shall be demonstrated by day and night flight tests that the pilot compartment is free of glare and reflections which would tend to interfere with the pilots' vision.

(b) Precipitation conditions.

(1) Means shall be provided for maintaining a sufficient portion of the windshield clear so that both pilots are afforded a sufficiently extensive view along the flight path in all normal flight attitudes of the airplane. Such means shall be designed to function under the following conditions without continuous attention on the part of the crew:

(i) in heavy rain at speeds up to 1.6 V_{S_1}, flaps retracted,

(ii) in the most severe icing conditions for which approval of the airplane is desired.

(2) In addition to the means prescribed in subparagraph (1) of this paragraph at least the first pilot shall be provided with a window which, when the cabin is not pressurized, is openable under the conditions prescribed in subparagraph (1) of this paragraph, and which provides the view specified in that subparagraph. The design shall be such that when the window is opened sufficient protection from the elements will be provided against the impairment of the pilot's vision.

4b.352 Pilot windshield and windows.

(a) All internal glass panes shall be of a nonsplintering safety type.

(b) The windshield, its supporting structure, and other structure in front of the pilots shall have sufficient strength to withstand without penetration the impact of a four-pound bird when the velocity of the airplane relative to the bird along the airplane's flight path is equal to the value of V_C at sea level selected in accordance with § 4b.210 (b) (4).

4b.353 Controls.

(a) All cockpit controls shall be located to provide convenience in operation and in a manner tending to prevent confusion and inadvertent operation. (See also § 4b.737.)

(b) The direction of movement of controls shall be according to Figures 4b-16 and 4b-17. Wherever practicable the sense of motion involved in the operation of other controls shall correspond with the sense of the effect of the operation upon the airplane or upon the part operated.

(c) The controls shall be so located and arranged with respect to the pilots' seats that there exists full and unrestricted movement of each control without interference from either the cockpit structure or the pilots' clothing when seated. This shall be demonstrated for individuals ranging from 5'2" to 6'0" in height.

(d) Identical powerplant controls for each engine shall be located to prevent any misleading impression as to the engine to which they relate.

CONTROLS	MOVEMENT AND ACTUATION
Powerplant	
Throttles	Forward to increase power
Propellers	Forward to increase rpm
Mixture	Forward for rich
Carburetor air heat	Forward for cold
Auxiliary	
Landing gear	Down to extend

Figure 4b-17

POWERPLANT AND AUXILIARY CONTROLS

(e) The wing flap (or auxiliary lift device) control and the landing gear control shall be separated sufficiently to prevent confusion and inadvertent operation.

4b.354 Instrument arrangement. (See § 4b.611.)

4b.355 Instrument marking. (The operational markings, instructions, and placards required for the instruments, controls, etc., are specified in §§ 4b.730 through 4b.738.)

4b.356 Doors.

(a) Airplane cabins shall be provided with at least one easily accessible external door.

(b) It shall be possible to open external doors from either inside or outside by the operation of only one handle inside or one handle outside even though persons may be crowding against the door from the inside. The means of opening shall be simple and obvious and shall be so arranged and marked that it can be readily located and operated even in darkness.

(c) Reasonable provisions shall be made to prevent the jamming of any external door as a result of fuselage deformation in a minor crash.

(d) External doors shall be so located that persons using them will not be endangered by the propellers when appropriate operating procedures are employed.

4b.357 Door louvres. Where internal doors are equipped with louvres or other ventilating means, provision convenient to the crew shall be made for stopping the flow of air through the door when such action is found necessary.

4b.358 Seats, berths, and safety belts.

(a) General. At all stations designated as occupiable during take-off and landing, the seats, berths, belts, harnesses, and adjacent parts of the airplane shall be such that a person making proper use of these facilities will not suffer serious injury in the emergency landing conditions as a result of inertia forces specified in § 4b.260.

(b) Arrangement.

(1) Passengers and crew shall be afforded protection from head injuries by one of the following means:

(i) safety belt and shoulder harness which will prevent the head from contacting any injurious object,

(ii) safety belt and the elimination of all injurious objects within striking radius of the head in the fore-n-aft direction,

(iii) safety belt and a cushioned rest which will support the arms, shoulders, head, and spine.

(2) For arrangements which do not provide a firm hand hold on seat backs, hand grips or rails shall be provided along aisles to enable passengers or crew members to steady themselves while using the aisles in moderately rough air.

(3) All projecting objects which would cause injury to persons seated or moving about the airplane in normal flight shall be padded.

(c) Strength.

(1) All seats, berths, and supporting structure shall be designed for an occupant weighing at least 170 lbs and for critical loads resulting from all specified flight load conditions.

(2) All seats and berths designated as occupiable during landing and take-off, and their supporting structure, shall be designed for the loads resulting from all specified ground load conditions including the emergency landing conditions of § 4b.260. Reactions from safety belts and harnesses shall be taken into account.

(3) Pilots' seats shall be designed for the reactions resulting from application of the pilot forces to the flight controls prescribed in § 4b.224.

4b.359 Cargo and baggage compartments. (See also §§ 4b.382-4b.384.)

(a) Each cargo and baggage compartment shall be designed for the placarded maximum weight of contents and the critical load distributions at the appropriate maximum load factors corresponding with all specified flight and ground load conditions, excluding the emergency landing conditions of § 4b.260.

(b) Provisions shall be made to prevent the contents in the compartments from becoming a hazard by shifting under the loads specified in paragraph (a) of this section.

(c) Provisions shall be made to protect the passengers and crew from injury by the contents of any compartment when the ultimate inertia force acting forward is 6g.

EMERGENCY PROVISIONS

4b.360 General. The requirements of §§ 4b.361 and 4b.362 shall apply to the emergency provisions.

4b.361 Flotation.

(a) For certification of ditching provisions prescribed by § 4b.261, evidence shall be required to show reasonable probability that the airplane after landing in the water will remain afloat to the following extent. (See also § 4b.362 (c) (2).)

(1) In the case of airplanes equipped with life rafts having capacity for all persons aboard the airplane, the flotation time and trim shall permit all occupants to leave their ditching stations and to occupy the rafts.

(2) In the case of airplanes not equipped with life rafts having capacity for all persons, the airplane shall float indefinitely with sufficient compartments remaining above the water line to accommodate all persons aboard the airplane.

(b) It shall be acceptable to demonstrate compliance with the requirements of paragraph (a) of this section by buoyancy and trim computations in which suitable allowances are made for probable structural damage and leakage. For airplanes equipped with fuel dump valves, it shall be acceptable to consider as buoyancy volume that volume of fuel which could be dumped.

4b.362 Emergency exits. Passenger and crew compartments designated as occupiable during take-off and landing shall be provided with emergency exits as prescribed in the following paragraphs. Individual compartments shall be considered as those closed spaces to which there is a normal access by a door, passageway, or stair, any of which might restrict rapid evacuation of the airplane.

(a) Evacuation. In case of question concerning the adequacy of emergency exits, it shall be demonstrated that the airplane can be completely evacuated in 30 seconds, or in a time equal to one second per occupant, whichever is the greater, under conditions simulating a forced landing. The following shall be observed during the demonstration:

(1) The maximum number of persons for whom seats are provided shall participate in the demonstration.

(2) The persons demonstrating the evacuation procedure shall not be briefed more than once prior to the official demonstration.

(b) Number of exits.

(1) The minimum number of exits per compartment shall be as follows:

Number of persons for whom seats are provided.	Minimum number of exits required.
5 or less	1
More than 5, but not more than 15	2
More than 15, but not more than 22	3
More than 22, but not more than 29	4
More than 29, but not more than 36	5
More than 36, but not more than 50	6

(2) The external door or doors specified in § 4b.356 shall be considered as emergency exits if they meet the requirements of paragraph (c) of this section.

(3) The number of exits in any one compartment need not exceed 4 if an adjacent compartment can be reached through a passageway without a door and if the total number of exits in the 2 compartments equals 1 exit per 8 passengers. Deviation from these numbers shall be allowed if it is demonstrated that the airplane can be evacuated within the time specified in paragraph (a) of this section.

(c) Exit arrangement.

(1) Emergency exits shall be located to give the maximum likelihood that they will be usable in an emergency landing with wheels up.

(2) For certification of ditching provisions prescribed by § 4b.261, it shall be shown that at least one emergency exit for every 16 passengers is located above the water line.

(3) In airplanes for which 2 or more emergency exits are required, the ratio of the number of exits on either side of the airplane to the total number required shall be not less than 1:3. At least one exit on the opposite side from the external main door shall be operable from the outside and shall be marked accordingly for the guidance of rescue personnel.

(4) The emergency exits shall be readily accessible, shall not require exceptional agility of a person using them, and shall be distributed to facilitate evacuation without crowding.

(5) Each emergency exit shall provide a clear and unobstructed opening to the outside, the minimum dimensions of which shall be such that a 19 by 26 inch ellipse can be inscribed therein.

(6) Reasonable provisions shall be made against the jamming of emergency exits as a result of fuselage deformation.

(7) The method of opening of emergency exits shall be simple and obvious. (See § 4b.738 (c).)

(8) The proper functioning of emergency exits shall be demonstrated by test.

(9) For all landplane emergency exits which are more than 10 feet from the ground with the airplane on the ground and wheels retracted, suitable means shall be provided by which the occupants can safely descend to the ground.

VENTILATION, HEATING, AND PRESSURIZATION

4b.370 General. The requirements of §§ 4b.371 through 4b.376 shall apply to the ventilation, heating, and pressurization of the aircraft.

4b.371 Ventilation. All passenger and crew compartments shall be ventilated. The following shall be specifically applicable.

(a) Provision shall be made to exclude fuel fumes and to prevent carbon monoxide concentration in excess of one part in 20,000 parts of air.

(b) Where partitions between compartments are equipped with louvres or other means allowing air to flow between such compartments, provision convenient to the crew shall be made for stopping the flow of air through the louvres or other means when such action is found necessary. (See also § 4b.357.)

4b.372 Combustion heaters. Gasoline combustion heater installations shall comply with all applicable provisions of the powerplant installation requirements pertaining to fire prevention including those concerning fuel tanks, lines, and exhaust systems.

4b.373 Pressurized cabins - general. The design of pressurized cabins shall comply with the requirements of §§ 4b.374 through 4b.376. (See § 4b.216 (c) for strength requirements.)

4b.374 Pressure supply. For cabin pressurization the pressure supply shall be sufficient to maintain a cabin pressure corresponding with an altitude of not more than 10,000 feet in standard atmosphere when the airplane's flight altitude is the maximum selected for certification.

4b.375 Pressure control. Pressurized cabins shall be provided with at least the following valves, controls, and indicators for controlling cabin pressure.

(a) Two pressure relief valves, at least one of which is the normal regulating valve, shall be installed to limit automatically the positive pressure differential to a predetermined value at the maximum rate of flow delivered by the pressure source. The combined capacity of the relief valves shall be such that the failure of any one valve would not cause an appreciable rise in the pressure differential. The pressure differential shall be considered positive when the internal pressure is greater than the external.

(b) Two reverse pressure differential relief valves (or equivalent) shall be installed to prevent automatically a negative pressure differential which would damage the structure, except that one such valve shall be considered sufficient if it is of a design which reasonably precludes its malfunctioning.

(c) Means shall be provided by which the pressure differential can be rapidly equalized.

(d) An automatic or manual regulator for controlling the intake and/or exhaust air flow shall be installed so that the required internal pressures and air flow rates can be maintained.

(e) Instruments shall be provided at the pilot or flight engineer station showing the pressure differential, the absolute pressure in the cabin, and the rate of change of the absolute pressure.

(f) Warning indication shall be provided at the pilot or flight engineer station to indicate when the safe or preset limits on pressure differential and on absolute cabin pressure are exceeded.

(g) If the structure is not designed for pressure differentials up to the maximum relief valve setting in combination with landing loads (see § 4b.216 (c)), a warning placard shall be placed at the pilot or flight engineer station.

<u>4b.376</u> <u>Tests.</u>

(a) <u>Strength test.</u> The complete pressurized cabin, including doors, windows, and all valves, shall be tested as a pressure vessel for the pressure differential specified in § 4b.216 (c) (3).

(b) <u>Functional tests.</u> The following functional tests shall be performed.

(1) To simulate the condition of regulator valves closed, the functioning and the capacity shall be tested of the positive and negative pressure differential valves and of the emergency release valve.

(2) All parts of the pressurization system shall be tested to show proper functioning under all possible conditions of pressure, temperature, and moisture up to the maximum altitude selected for certification.

(3) Flight tests shall be conducted to demonstrate the performance of the pressure supply, pressure and flow regulators, indicators, and warning signals in steady and stepped climbs and descents at rates corresponding with the maximum attainable without exceeding the operating limitations of the airplane up to the maximum altitude selected for certification.

(4) All doors and emergency exits shall be tested to ascertain that they operate properly after being subjected to the flight tests prescribed in subparagraph (3) of this paragraph.

FIRE PREVENTION

4b.380 General. Compliance shall be shown with the fire prevention requirements of §§ 4b.381 through 4b.384.

4b.381 Cabin interiors. All compartments occupied or used by the crew or passengers shall comply with the following provisions.

(a) The materials in no case shall be less than flash-resistant.

(b) The wall and ceiling linings, the covering of all upholstering, floors, and furnishings shall be flame-resistant.

(c) Compartments where smoking is to be permitted shall be equipped with ash trays of the self-contained type which are completely removable. All other compartments shall be placarded against smoking.

(d) All receptacles for used towels, papers, and waste shall be of fire-resistant material, and shall incorporate covers or other provisions for containing possible fires.

4b.382 Cargo and baggage compartments.

(a) Cargo and baggage compartments shall include no controls, wiring, lines, equipment, or accessories the damage or failure of which would affect the safe operation of the airplane, unless such items are shielded, isolated, or otherwise protected so that they cannot be damaged by movement of cargo in the compartment, and so that any breakage or failure of such item will not create a fire hazard.

(b) Provision shall be made to prevent cargo or baggage from interfering with the functioning of the fire-protective features of the compartment.

(c) All materials used in the construction of cargo or baggage compartments, including tie-down equipment, shall be flame-resistant.

4b.383 Cargo compartment classification. All cargo and baggage compartments shall include provisions for safeguarding against fires according to the following classification.

(a) "A" category. Cargo and baggage compartments shall be classified in the "A" category if the presence of a possible fire therein would be easily discernible to a member of the crew while at his station, and if all parts of the compartment are easily accessible in flight. A hand fire extinguisher shall be available for each compartment.

(b) "B" category. Cargo and baggage compartments shall be classified in the "B" category if sufficient access is provided while in flight to enable a member of the crew to move by hand all contents and to reach effectively all parts of the compartment with a hand fire extinguisher. Compliance shall be shown with the following.

(1) The design of the compartment shall be such that, when the access provisions are being used, no hazardous quantity of smoke, flames, or extinguishing agent will enter any compartment occupied by the crew or passengers.

(2) Each compartment shall be equipped with a separate system of an approved type smoke detector or fire detector other than a heat detector to give warning at the pilot or flight engineer station.

(3) Hand fire extinguishers shall be readily available for use in each compartment.

(4) The compartment shall be completely lined with fire-resistant material, except that additional service lining of flame-resistant material shall be acceptable.

(c) "C" category. Cargo and baggage compartments shall be classified in the "C" category if they do not conform to the prerequisites for the "A" or "B" categories. Compliance shall be shown with the following.

(1) Each compartment shall be equipped with:

(i) a separate system of an approved type smoke detector or fire detector other than heat detector to give warning at the pilot or flight engineer station, and

(ii) an approved built-in fire-extinguishing system controlled from the pilot or flight engineer station.

(2) Means shall be provided to exclude hazardous quantities

of smoke, flames, or extinguishing agent from entering into any compartment occupied by the crew or passengers.

(3) Ventilation and drafts shall be controlled within each compartment so that the extinguishing agent provided can control any fire which may start within the compartment.

(4) The compartment shall be completely lined with fire-resistant material, except that additional service lining of flame-resistant material shall be acceptable.

4b.384 Proof of compliance.

(a) Compliance with those provisions of § 4b.383 which refer to compartment accessibility, to the entry of hazardous quantities of smoke or extinguishing agent into compartments occupied by the crew or passengers, and to the dissipation of the extinguishing agent in category "C" compartments shall be demonstrated by tests in flight.

(b) It shall also be demonstrated during the tests prescribed in paragraph (a) of this section that no inadvertent operation of smoke or fire detectors in adjacent or other compartments within the airplane would occur as a result of fire contained in any one compartment, either during or after extinguishment, unless the extinguishing system floods such compartments simultaneously.

MISCELLANEOUS

4b.390 Reinforcement near propellers. Portions of the airplane near propeller tips shall have sufficient strength and stiffness to withstand the effects of the induced vibration and of ice thrown from the propeller. Windows shall not be located in such regions unless shown capable of withstanding the most severe ice impact likely to occur.

4b.391 Leveling marks. Reference marks shall be provided for use in leveling the airplane to facilitate weight and balance determinations on the ground.

SUBPART E - POWERPLANT INSTALLATION (RECIPROCATING ENGINES)

GENERAL

4b.400 Scope.

(a) The powerplant installation shall be considered to include all components of the airplane which are necessary for its propulsion. It shall also be considered to include all components which affect the control of the major propulsive units or which affect their safety of operation between normal inspections or overhaul periods. (See §§ 4b.604 and 4b.613 for instrument installation and marking.)

(b) All components of the powerplant installation shall be constructed, arranged, and installed in a manner which will assure their continued safe operation between normal inspections or overhaul periods.

(c) Accessibility shall be provided to permit such inspection and maintenance as is necessary to assure continued airworthiness.

(d) Electrical interconnections shall be provided to prevent the existence of differences of potential between major components of the powerplant installation and other portions of the airplane.

4b.401 Engines.

(a) Type certification. All engines shall be type certificated in accordance with the provisions of Part 13 of the Civil Air Regulations.

(b) Engine isolation. The engines shall be so isolated, each from the other, that the failure or malfunctioning of any one engine, or any part of the powerplant installation serving any one engine, will not prevent the safe operation of the remaining engine or engines.

(c) Control of engine rotation. Means shall be provided for stopping and restarting the rotation of any engine individually in flight. All components provided for this purpose which are located on the engine side of the fire wall and which might be exposed to fire shall be of fire-resistant construction. (See also § 4b.449.)

4b.402 Propellers. Propellers shall be type certificated in accordance with the provisions of Part 14 of the Civil Air Regulations. The maximum propeller shaft rotational speed and the engine power permissible for use in the airplane shall not exceed the corresponding limits for which the propeller has been certificated.

4b.403 Propeller vibration. The magnitude of the propeller blade vibration stresses under all normal conditions of operation shall be determined by actual measurement or by comparison with similar installations for which such measurements have been made. The vibration stresses thus determined shall not exceed values which have been demonstrated to be safe for continuous operation.

4b.404 Propeller pitch and speed limitations.

(a) The propeller pitch and speed shall be limited to values which will assure safe operation under all normal conditions and which will assure compliance with the performance requirements specified in §§ 4b.110 through 4b.125.

(b) A propeller speed limiting means shall be provided at the governor. Such means shall be set to limit the maximum possible governed engine speed to a value not exceeding the maximum permissible rpm.

(c) The low pitch blade stop in the propeller, or other means used to limit the low pitch position, shall be set so that the propeller speed does not exceed 103 percent of the maximum permissible engine rpm under the following conditions:

(1) propeller blades at the low pitch limit and governor inoperative, and

(2) engine operating at take-off manifold pressure with the airplane stationary under standard atmospheric conditions.

<u>4b.405</u> <u>Propeller clearance</u>. With the airplane loaded to the maximum weight and at the most adverse center of gravity position and the propellers in the most adverse pitch position, the propeller clearances shall not be less than the following, unless smaller clearances are substantiated for the particular design involved.

(a) <u>Ground</u>. Seven inches of ground clearance for airplanes equipped with nose-wheel type landing gears, or nine inches of ground clearance for airplanes equipped with tail-wheel type landing gears shall be provided with the landing gear statically deflected and the airplane in the level take-off or in the taxying attitude, whichever is most critical. In addition, there shall be positive clearance between the propeller and the ground when, with the airplane in the level take-off attitude, the critical tire is completely deflated and the corresponding landing gear strut is completely bottomed.

(b) <u>Water</u>. A water clearance of 18 inches shall be provided unless compliance with § 4b.181 is demonstrated with less clearance.

(c) <u>Structure</u>.

(1) One inch radial clearance shall be provided between the blade tips and the airplane structure, or whatever additional radial clearance is necessary to preclude harmful vibration of the propeller or airplane.

(2) One-half inch longitudinal clearance shall be provided between the propeller blades or cuffs and all stationary portions of the airplane.

(3) Positive clearance shall be provided between other rotating portions of the propeller or spinner and all stationary portions of the airplane.

4b.406 Propeller de-icing provisions.

(a) Airplanes intended for operation under atmospheric conditions conducive to the formation of ice shall be provided with means for the prevention and removal of propeller ice accumulations.

(b) If combustible fluid is used for propeller de-icing, the provisions of §§ 4b.430 through 4b.483, inclusive, shall be complied with.

FUEL SYSTEM OPERATION AND ARRANGEMENT

4b.410 General.

(a) The fuel system shall be constructed and arranged in such a manner as to assure a flow of fuel to each engine at a rate and pressure which have been established for proper engine functioning under all normal conditions, including all maneuvers for which the airplane is intended. (For fuel system instruments see § 4b.604.)

(b) The fuel system shall be so arranged that no one fuel pump can draw fuel from more than one tank at a time unless means are provided to prevent introducing air into the system.

4b.411 Fuel system independence. The fuel system shall be arranged to permit operation in such a manner that the failure of any one component will not result in the irrecoverable loss of power of more than one engine.

4b.412 Pressure cross-feed arrangements.

(a) Pressure cross-feed lines shall not pass through portions of the airplane intended to carry personnel or cargo, unless means are provided to permit the flight personnel to shut off the supply of fuel to these lines, or unless the lines are enclosed in a fuelproof and fumeproof shroud which is ventilated and drained to the exterior of the airplane.

(b) The shrouds specified in paragraph (a) of this section need not be used if the lines are routed or protected to safeguard against accidental damage and if they do not incorporate any fittings within the personnel or cargo areas.

(c) Lines which can be isolated from the remainder of the fuel system by means of valves at each end shall incorporate provisions for the relief of excessive pressures which might result from exposure of the isolated line to high ambient temperatures.

4b.413 Fuel flow rate.

(a) The ability of the fuel system to provide the required fuel flow rate shall be demonstrated when the airplane is in the attitude which represents the most adverse condition from the standpoint of fuel feed which the airplane is designed to attain. The following shall be considered in this respect:

(1) normal ground attitude,

(2) climb with take-off flaps, landing gear up, using take-off power, at speed V_2 as determined in § 4b.114 (b), at landing weight,

(3) level flight at maximum continuous power or at the power required for level flight at V_C, whichever is the lesser,

(4) glide at a speed of 1.3 V_{s_0}, at landing weight.

(b) During the demonstration prescribed in paragraph (a) of this section, fuel shall be delivered to the engine at a pressure not less than the minimum pressure established for proper engine operation. In addition the following shall be met.

(1) The quantity of fuel in the tank being considered shall not exceed the amount established as the unusable fuel supply for that tank, as determined by demonstrating compliance with the provisions of § 4b.416 (see also §§ 4b.420 and 4b.613 (b)), together with whatever minimum quantity of fuel it may be necessary to add for the purpose of conducting the flow test.

(2) If a fuel flowmeter is provided, the meter shall be blocked during the flow test and the fuel shall flow through the meter by-pass.

(3) It shall be acceptable to conduct the demonstration prescribed in paragraph (a) of this section by a ground test on the airplane or on a representative mock-up of the fuel system.

4b.414 Pump systems.

(a) The fuel flow rate for pump systems (main and reserve supply) shall be 0.9 pounds per hour for each take-off horsepower or 125 percent of the actual take-off fuel consumption of the engine, whichever is the greater.

(b) The fuel flow rate specified in paragraph (a) of this section shall be applicable to both the primary engine-driven pump and to emergency pumps. The fuel flow rate shall be available when the pump is running at the speed at which it would normally be operating during take-off. In the case of hand operated pumps, the speed required shall not be more than 60 complete cycles (120 single strokes) per minute.

4b.415 Transfer systems. The provisions of § 4b.414 shall apply to transfer systems, except that the required fuel flow rate for the engine or engines involved shall be established upon the basis of maximum continuous power and its corresponding speed instead of take-off power and its corresponding speed.

4b.416 Determination of unusable fuel supply and fuel system operation on low fuel.

(a) The quantity of fuel with which compliance with the provision of this paragraph is demonstrated shall be selected by the applicant who, in addition, shall indicate which of the conditions specified in paragraph (b) of this section are most likely to be critical from the standpoint of establishing the unusable fuel supply, and also indicate the order in which the other conditions may be critical.

(b) The unusable fuel supply for each tank used for take-off and landing shall be established as not less than the quantity at which the first evidence of malfunctioning occurs under the following conditions: (See § 4b.420.)

(1) level flight at maximum continuous power or at the power required for level flight at V_C, whichever is the lesser,

(2) climb with take-off flaps and landing gear up, at take-off power, at landing weight, and at speed V_2 determined in accordance with § 4b.114 (b),

(3) rapid application of maximum continuous power and

subsequent transition to a climb at speed V_2 determined in accordance with § 4b.114 (b), with retraction of flaps and landing gear, from a power-off glide at 1.3 V_{s_0}, with flaps and landing gear down, at landing weight.

(c) If an engine can be supplied with fuel from more than one tank, it shall be possible to regain the full fuel pressure of that engine in not more than 20 seconds after switching to any fuel tank after engine malfunctioning becomes apparent due to the depletion of the fuel supply in any tank from which the engine can be fed. Compliance with this provision shall be demonstrated in level flight.

(d) The unusable fuel supply for all tanks other than those used for take-off and landing shall be established as not less than the quantity at which the first evidence of malfunctioning occurs under the conditions specified in subparagraph (b) (1) of this section. It shall be acceptable to demonstrate compliance with this requirement by a ground test.

<u>4b.417</u> <u>Fuel system hot weather operation.</u>

(a) To prove satisfactory hot weather operation the airplane shall be climbed from the altitude of the airport chosen by the applicant to the altitude corresponding with that at which the one-engine-inoperative best rate of climb is not greater than the en route climb with the configuration and at the weight specified in § 4b.120 (c). There shall be no evidence of vapor lock or other malfunctioning. The climb test shall be conducted under the following conditions.

(1) All engines shall operate at maximum continuous power, except that take-off power shall be used for the altitude range extending from 1,000 feet below the critical altitude through the critical altitude. The time interval during which take-off power is used shall not exceed the take-off time limitation.

(2) The weight shall be with full fuel tanks, minimum crew, and such ballast as is required to maintain the center of gravity within allowable limits.

(3) The speed of climb shall not exceed that which will permit compliance with the minimum climb requirement specified in § 4b.119 (a).

(4) The fuel temperature shall be not less than 110° F.

(b) The test prescribed in paragraph (a) of this section shall be performed either in flight or on the ground closely simulating flight conditions. If a flight test is performed in weather sufficiently cold to interfere with the proper conduct of the test, the fuel tank surfaces, fuel lines, and other fuel system parts subjected to cooling action from cold air shall be insulated to simulate, in so far as practicable, flight in hot weather.

4b.418 Flow between interconnected tanks. In fuel systems where the tanks outlets are interconnected, it shall not be possible for fuel to flow between tanks in quantities sufficient to cause an overflow of fuel from the tank vent when the airplane is operated as specified in § 4b.416 (b) and the tanks are full.

FUEL SYSTEM CONSTRUCTION AND INSTALLATION

4b.420 General.

(a) Fuel tanks shall be capable of withstanding without failure all vibration, inertia, fluid, and structural loads to which they may be subjected in operation.

(b) Flexible fuel tank liners shall be of an approved type or shall be shown to be suitable for the particular application.

(c) The fuel tanks, as installed, shall be designed to withstand a minimum internal pressure of 3.5 psi.

(d) Integral type fuel tanks shall be provided with facilities for inspection and repair of the tank interior.

(e) The total usable capacity of the fuel tanks shall not be less than 0.15 gallons for each maximum continuous horsepower for which the airplane is certificated.

(f) The unusable fuel capacity shall be the minimum quantity of fuel which will permit compliance with the provisions of § 4b.416.

4b.421 Fuel tank tests.

(a) Fuel tanks shall be capable of withstanding the following pressure tests without failure or leakage. It shall be acceptable to apply the pressures in a manner simulating the actual pressure distribution in service.

(1) Conventional metal tanks and nonmetallic tanks the walls of which are not supported by the airplane structure shall be submitted to a pressure of 3.5 psi, or the pressure developed during the maximum ultimate acceleration of the airplane with a full tank, whichever is the greater.

(2) Integral tanks shall be submitted to a pressure of 3.5 psi unless the pressure developed during the maximum limit acceleration of the airplane with a full tank exceeds this value, in which case a hydrostatic head, or equivalent test, shall be applied to duplicate the acceleration loads in so far as possible, except that the pressure need not exceed

3.5 psi on surfaces not exposed to the acceleration loading.

(3) Nonmetallic tanks the walls of which are supported by the airplane structure shall be submitted to a pressure of 3.5 psi when mounted in the airplane structure.

(b) Tanks with large unsupported or unstiffened flat areas shall be capable of withstanding the following test, or other equivalent test, without leakage or failure.

(1) The complete tank assembly together with its supports shall be subjected to a vibration test when mounted in a manner simulating the actual installation.

(2) The tank assembly shall be vibrated for 25 hours at an amplitude of not less than 1/32 of an inch while filled two-thirds full of water.

(3) The frequency of vibration shall be 90 percent of the maximum continuous rated speed of the engine unless some other frequency within the normal operating range of speeds of the engine is more critical, in which case the latter speed shall be employed and the time of test shall be adjusted to accomplish the same number of vibration cycles.

(4) In conjunction with the vibration test the tank assembly shall be rocked through an angle of 15° on either side of the horizontal (30° total) about an axis parallel to the axis of the fuselage.

(5) The assembly shall be rocked at the rate of 16 to 20 complete cycles per minute.

(c) In the case of nonmetallic tanks a specimen tank of the same basic construction as that to be used in the airplane, when installed in a representative test tank, shall withstand the test as specified in paragraph (b) of this section with fuel at a temperature of 110° F.

4b.422 Fuel tank installation.

(a) The method of support for fuel tanks shall not permit concentration of loads, resulting from the weight of the fuel in the tank, on unsupported tank surfaces. The following shall be applicable.

(1) Pads shall be provided to prevent chafing between the tank and its supports.

(2) Materials employed for padding shall be nonabsorbent or shall be treated to prevent the absorption of fluids.

(3) If flexible tank liners are employed they shall be so supported that the liner is not required to withstand fluid loads.

(4) Interior surfaces of tank compartments shall be smooth and free of projections which could cause wear of the liner, unless provisions are made for protection of the liner at such points or unless the construction of the liner itself provides such protection.

(b) Spaces adjacent to the surfaces of the tank shall be ventilated consistent with the size of the compartment to avoid fume accumulation in the case of minor leakage. If the tank is in a sealed compartment it shall be acceptable to limit the ventilation to that provided by drain holes of sufficient size to prevent excessive pressure resulting from altitude changes.

(c) Location of fuel tanks shall comply with the provisions of § 4b.481 (a).

(d) No portion of engine nacelle skin which lies immediately behind a major air egress opening from the engine compartment shall act as the wall of an integral tank.

(e) Fuel tanks shall be isolated from personnel compartments by means of fumeproof and fuelproof enclosures.

4b.423 Fuel tank expansion space.

(a) Fuel tanks shall be provided with an expansion space of not less than 2 percent of the tank capacity.

(b) It shall not be possible to fill the fuel tank expansion space inadvertently when the airplane is in the normal ground attitude.

4b.424 Fuel tank sump.

(a) Each fuel tank shall be provided with a sump having a capacity of not less than either 0.25 percent of the tank capacity or 1/16 of a gallon, whichever is the greater.

(b) The fuel tank sump capacity specified in paragraph (a) of this section shall be effective with the airplane in the normal ground attitude. The fuel tank shall be constructed to permit drainage of any hazardous quantity of water from all portions of the tank to the sump when the airplane is in the ground attitude.

(c) Fuel tank sumps shall be provided with an accessible drain to permit complete drainage of the sump on the ground. The drain shall discharge clear of all portions of the airplane and shall be provided with means for positive locking of the drain in the closed position, either manually or automatically.

4b.425 Fuel tank filler connection.

(a) The design of fuel tank filler connections shall be such as to prevent the entrance of fuel into the fuel tank compartment or any other portion of the airplane other than the tank itself.

(b) Recessed fuel tank filler connections which retain any appreciable quantity of fuel shall incorporate a drain, and the drain shall discharge clear of all portions of the airplane.

(c) The fuel tank filler cap shall provide a fuel-tight seal.

(d) The fuel tank filler connections shall be marked as prescribed in § 4b.738 (b).

<u>4b.426</u> <u>Fuel tank vents and carburetor vapor vents.</u>

(a) Fuel tanks shall be vented from the top portion of the expansion space in such a manner that venting of the tank is effective under all normal flight conditions. The following shall be applicable.

(1) Vent outlets shall be located and contructed to prevent the possibility of being obstructed by ice or other foreign matter.

(2) The vent shall be constructed to preclude the possibility of siphoning fuel during normal operation.

(3) The vent shall be of sufficient size to permit the rapid relief of excessive differences of pressure between the interior and exterior of the tank.

(4) Air spaces of tanks with interconnected outlets shall also be interconnected.

(5) There shall be no points in the vent line where moisture could accumulate with the airplane in either the ground or the level flight attitudes unless drainage is provided.

(6) Vents and drainage shall not terminate at points where the discharge of fuel from the vent outlet would constitute a fire hazard or from which fumes could enter personnel compartments.

(b) Carburetors which are provided with vapor elimination connections shall be provided with a vent line to lead vapors back to one of the fuel tanks. The vents shall comply with the following.

(1) Provisions shall be incorporated in the vent system to avoid stoppage by ice.

(2) If more than one fuel tank is provided and it is necessary to use the tanks in a definite sequence, the vapor vent return line shall lead back to the fuel tank used for take-off and landing.

4b.427 Fuel tank outlet. A fuel strainer of 8 to 16 meshes per inch shall be provided either for the fuel tank outlet or for the booster pump. Strainers shall comply with the following.

(a) The clear area of the fuel tank outlet strainer shall not be less than 5 times the area of the fuel tank outlet line.

(b) The diameter of the strainer shall not be less than the diameter of the fuel tank outlet.

(c) Finger strainers shall be accessible for inspection and cleaning.

FUEL SYSTEM COMPONENTS

4b.430 Fuel pumps.

(a) If the engine fuel supply is maintained by means of pumps, one fuel pump for each engine shall be engine driven.

(b) Fuel pumps shall meet the pertinent flow requirements of § 4b.413.

(c) All positive displacement fuel system pumps shall incorporate an integral by-pass unless equivalent provisions are available for the continuous supply of fuel to all engines in case of the failure of any one pump. Engine fuel injection pumps which are certificated as an integral part of the engine need not incorporate a by-pass.

(d) Emergency fuel pumps shall be provided to permit supplying all engines with fuel in case of the failure of any one fuel system pump, unless the engine-driven pump has been approved with the engine and precautions are taken to avoid vapor lock and pump cavitation. If the only pump used in the system is an engine fuel-injection pump which has been certificated as an integral part of the engine, an emergency pump need not be provided.

(e) Emergency pumps shall comply with the same flow requirements as are prescribed for the main pumps.

(f) Hand emergency pumps shall not require excessive effort for their continued operation at the rate of 60 complete cycles (120 single strokes) per minute.

(g) Emergency pumps shall be available for immediate use in case of failure of any other pump.

(h) If engine-driven pumps are capable of maintaining flight up to a 10,000-foot altitude and with 110° F fuel without the aid of auxiliary pumps, it shall be acceptable to consider the auxiliary pumps as emergency pumps.

<u>4b.431</u> <u>Fuel pump installation.</u>

(a) Provision shall be made to maintain the fuel pressure at the inlet to the carburetor within the range of limits established for proper engine operation.

(b) When necessary for the maintenance of the proper fuel delivery pressure, a connection shall be provided to transmit the carburetor air intake static pressure to the proper fuel pump relief valve connection. In such cases, to avoid erroneous fuel pressure reading, the gauge balance lines shall be independently connected to the carburetor inlet pressure.

4b.432 Fuel system lines and fittings.

(a) Fuel lines shall be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure and due to accelerated flight conditions.

(b) Fuel lines which are connected to components of the airplane between which relative motion could exist shall incorporate provisions for flexibility.

(c) Flexible connections in fuel lines which may be under pressure and subjected to axial loading shall employ flexible hose assemblies rather than hose clamp connections.

(d) Flexible hose shall be of an approved type or shall be shown to be suitable for the particular application.

4b.433 Fuel lines and fittings in designated fire zones. Fuel lines and fittings in all designated fire zones (see § 4b.480) shall comply with the provisions of § 4b.483.

4b.434 Fuel valves. In addition to the requirements of § 4b.482 for shut-off means, all fuel valves shall be provided with positive stops or suitable index provisions in the "on" and "off" positions and shall be supported so that loads resulting from their operation or from accelerated flight conditions are not transmitted to the lines attached to the valve.

4b.435 Fuel strainer. A fuel strainer shall be provided between the fuel tank outlet and the carburetor inlet and shall comply with the following.

(a) If an engine-driven fuel pump is provided, the strainer shall be located between the tank outlet and the engine-driven pump inlet.

(b) The fuel strainer shall be accessible for drainage and cleaning, and the strainer screen shall be easily removable.

(c) The strainer shall be mounted in a manner not to cause its weight to be supported by the connecting lines or by the inlet or outlet connections of the strainer itself.

4b.436 Fuel system drains. Drainage of the system shall be accomplished by fuel strainer drains and other drains as provided in § 4b.424. The following shall apply.

(a) Drains shall discharge clear of all portions of the airplane and shall incorporate means for positive locking of the drain in the closed position, either manually or automatically.

(b) All fuel system drains shall be accessible.

(c) If drainage of the fuel strainer permits compliance with paragraphs (a) and (b) of this section, no additional drains need be provided unless it is possible for a hazardous quantity of water or sediment to be trapped therein. (See also § 4b.483 (c).).

4b.437 Fuel jettisoning system. If the maximum take-off weight for which the airplane is certificated exceeds 105 percent of the certificated maximum landing weight, provision shall be made for the jettisoning of fuel from the maximum take-off to the maximum landing weight.

(a) The average rate of fuel jettisoning shall be 1 percent of the maximum take-off weight per minute, except that the time required to jettison the fuel need not be less than 10 minutes. Compliance with these provisions shall be shown at maximum take-off weight, with flaps and landing gear up, and in the following flight conditions:

(1) power-off glide at a speed of 1.4 V_{s_1},

(2) climb at the one-engine-inoperative speed with the critical engine inoperative, the other engines at maximum continuous power,

(3) level flight at a speed of 1.4 V_{s_1}, if the results of tests in conditions specified in subparagraphs (1) and (2) of this paragraph indicate that this condition could be critical.

(b) During the flight tests prescribed in paragraph (a) of this section it shall be demonstrated that the fuel jettisoning system complies with the following provisions.

(1) The fuel jettisoning system and its operation shall be free of fire hazard.

(2) The fuel shall discharge clear of all portions of the airplane.

(3) Fuel or fumes shall not enter any portion of the airplane.

(4) The jettisoning operation shall not affect adversely the controllability of the airplane.

(c) The design of the jettisoning system shall be such that it would not be possible to jettison fuel in the tanks used for take-off and landing below the level providing 45 minutes flight at 75 percent maximum continuous power, except that it shall be permissible to jettison all fuel where an auxiliary control is provided independent of the main jettisoning control.

(d) The fuel jettisoning valve shall permit the flight personnel to close the valve during any portion of the jettisoning operation. (See § 4b.475 for fuel jettisoning system controls.)

(e) Unless it is demonstrated that lowering of the flaps does not adversely affect fuel jettisoning, a placard shall be provided adjacent to the jettisoning control to warn flight personnel against jettisoning fuel while the flaps are lowered. A notation to this effect shall also be included in the Airplane Flight Manual. (See § 4b.740.)

OIL SYSTEM

4b.440 General.

(a) Each engine shall be provided with an independent oil system capable of supplying the engine with an appropriate quantity of oil at a temperature not exceeding the maximum which has been established as safe for continuous operation. (For oil system instruments see §§ 4b.604 and 4b.735.)

(b) The oil capacity of the system shall not be less than one gallon for every 30 gallons of fuel capacity, unless provisions are made for transferring oil between tanks in flight or unless there is provided a reserve oil supply which can be fed to any tank during flight.

(c) If either an oil transfer system or a reserve oil system is provided, the total oil capacity need not exceed one gallon for each 40 gallons of fuel capacity.

(d) Oil-fuel ratios lower than those prescribed in paragraphs (b) and (c) of this section shall be acceptable if substantiated by data on the actual oil consumption of the engine.

(e) The ability of the oil cooling provisions to maintain the oil inlet temperature to the engine at or below the maximum established value shall be demonstrated in accordance with pertinent provisions of §§ 4b.450 through 4b.454.

4b.441 Oil tank construction. The following requirements shall apply to the construction of the oil tank.

(a) Oil tank expansion space.

(1) Oil tanks shall have an expansion space of not less than either 10 percent of the tank capacity or 0.5 gallon, whichever is the greater.

(2) Reserve oil tanks which have no direct connection to any engine shall have an expansion space which is not less than 2 percent of the tank capacity.

(3) It shall not be possible to fill the oil tank expansion space inadvertently when the airplane is in the normal ground attitude.

(b) Oil tank filler connection.

(1) Recessed oil tank filler connections which retain any appreciable quantity of oil shall incorporate a drain, and the drain shall discharge clear of all portions of the airplane.

(2) The oil tank filler cap shall provide an oil-tight seal.

(3) Oil tank filler connections shall be marked as prescribed in § 4b.738 (b).

(c) Oil tank vent.

(1) Oil tanks shall be vented from the top portion of the expansion space in such a manner that venting of the tank is effective under all normal flight conditions.

(2) Oil tank vents shall be arranged so that condensation of water vapor which might freeze and obstruct the line cannot accumulate at any point. (See also § 4b.483 (c).)

(d) Oil tank outlet. The oil tank outlet shall not be enclosed or covered by any screen or other guard which could impede the flow of oil. (See also § 4b.449.)

(e) Flexible oil tank liners. Flexible oil tank liners shall be of an approved type or shall be shown to be suitable for the particular application.

4b.442 Oil tank tests.

(a) Oil tanks shall be capable of withstanding without failure all vibration, inertia, and fluid loads to which they would be subjected in operation.

(b) The provisions of § 4b.421 shall be applicable to oil tanks, except as follows.

(1) The test pressure specified in § 4b.421 (a) shall be 5 psi.

(2) The test fluid specified in § 4b.421 (c) shall be oil at a temperature of 250° F.

4b.443 Oil tank installation. The provisions of § 4b.422 shall be applicable to the oil tank installation, except that it shall be acceptable to locate oil tanks on the engine side of the fire wall.

4b.444 Oil lines and fittings.

(a) General. The provisions of § 4b.432 shall be applicable to oil lines.

(b) Lines and fittings in designated fire zones. Oil lines and fittings in all designated fire zones (see § 4b.480) shall comply with the provisions of § 4b.483.

(c) Engine breather lines.

(1) Engine breather lines shall be arranged so that condensation of water vapor which might freeze and obstruct the line cannot accumulate at any point.

(2) Breathers shall discharge in a location which will not constitute a fire hazard in case foaming occurs and in a manner so that the emitted oil will not impinge upon the pilot windshield.

(3) The breather shall not discharge into the engine air induction system. (See also § 4b.483 (c).)

4b.445 Oil valves.

(a) The requirements of § 4b.482 for shut-off means shall be complied with. Closing of oil shut-off means shall not prevent feathering the propeller.

(b) All oil valves shall be provided with positive stops or suitable index provisions in the "on" and "off" positions, and they shall be supported so that loads resulting from their operation or from accelerated flight conditions are not transmitted to the lines attached to the valve.

4b.446 Oil radiators.

(a) Oil radiators shall be capable of withstanding without failure all vibration, inertia, and oil pressure loads to which they would be subjected in operation.

(b) Oil radiator air ducts shall be located so that in case of fire flames issuing from normal openings of the engine nacelle cannot impinge directly upon the radiator.

<u>4b.447</u> <u>Oil filters.</u> If the airplane is equipped with an oil filter, the filter shall be constructed or installed in such a manner that complete blocking of the flow through the filter element will not prevent the safe operation of the engine oil supply system.

<u>4b.448</u> <u>Oil system drains.</u> Accessible drains shall be provided to permit safe drainage of the entire oil system and shall incorporate means for the positive locking of the drain in the closed position, either manually or automatically. (See also § 4b.483 (c).)

<u>4b.449</u> <u>Propeller feathering system.</u>

(a) If the propeller feathering system is dependent upon the use of the engine oil supply, provision shall be made to trap a quantity of oil in the tank in case the supply becomes depleted due to failure of any portion of the lubricating system other than the tank itself.

(b) The quantity of trapped oil shall be sufficient to accomplish the feathering operation and shall be available only to the feathering pump.

(c) The ability of the system to accomplish feathering with the trapped supply of oil shall be demonstrated. It shall be acceptable to make this demonstration on the ground.

COOLING SYSTEM

4b.450 General. The powerplant cooling provisions shall be capable of maintaining the temperatures of major powerplant components, engine fluids, and the carburetor intake air within the established safe values under all conditions of ground and flight operation. (For cooling system instruments see §§ 4b.604 and 4b.734.)

4b.451 Cooling tests.

(a) General. Compliance with the provisions of § 4b.450 shall be demonstrated under critical ground, water, and flight operating conditions. If the tests are conducted under conditions which deviate from the maximum anticipated air temperature (see paragraph (b) of this section), the recorded powerplant temperatures shall be corrected in accordance with the provisions of paragraphs (c) and (d) of this section. The corrected temperatures determined in this manner shall not exceed the maximum established safe values. The fuel used during the cooling tests shall be of the minimum octane number approved for the engines involved, and the mixture settings shall be those used in normal operation. The test procedures shall be as outlined in §§ 4b.452 through 4b.454.

(b) Maximum anticipated air temperature. The maximum anticipated air temperature (hot day condition) shall be 100° F at sea level, decreasing from this value at the rate of 3.6° F per thousand feet of altitude above sea level until a temperature of -67° F is reached above which altitude the temperature shall be constant at -67° F.

(c) Correction factor for cylinder head, oil inlet, carburetor air, and engine coolant outlet temperatures. The cylinder head, oil inlet, carburetor air, and engine coolant outlet temperatures shall be corrected by adding the difference between the maximum anticipated air temperature and the temperature of the ambient air at the time of the first occurrence of maximum head, air, oil, or coolant temperature recorded during the cooling test, unless a more rational correction is shown to be applicable.

(d) Correction factor for cylinder barrel temperatures. Cylinder barrel temperatures shall be corrected by adding 0.7 of the difference between the maximum anticipated air temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test, unless a more rational correction is shown to be applicable.

4b.452 Climb cooling test procedure.

(a) The climb cooling test shall be conducted with the critical engine inoperative and its propeller feathered.

(b) All remaining engines shall be operated at their maximum continuous power or at full throttle when above the critical altitude.

(c) After stabilizing temperatures in flight, the climb shall be started at or below the lower of the two following altitudes and shall be continued until at least 5 minutes after the occurrence of the highest temperature recorded, or until the maximum altitude is reached for which certification is desired:

(1) 1,000 feet below the engine critical altitude,

(2) 1,000 feet below the maximum altitude at which the rate of climb is equal to that established in accordance with § 4b.120 (c).

(d) The climb shall be conducted at an air speed which does not exceed the speed used in establishing the rate of climb required in

§ 4b.120 (c). It shall be acceptable to conduct the climb cooling test in conjunction with the take-off cooling test of § 4b.453.

4b.453 Take-off cooling test procedure. If the time for which take-off power is used in establishing the take-off path of the airplane exceeds two minutes, a take-off cooling test shall be conducted to demonstrate cooling during take-off and during subsequent climb with one engine inoperative. The following procedure shall be applicable.

(a) The take-off cooling test shall be commenced by stabilizing temperatures during level flight with all engines operating at 75 percent of maximum continuous power with the appropriate cowl flap and shutter settings.

(b) After all temperatures have stabilized, the climb shall be started at the lowest practicable altitude and shall be conducted with one engine inoperative and its propeller feathered.

(c) The remaining engines shall be operated at take-off rpm and power (or at full throttle when above the take-off critical altitude) for the same time interval as take-off power is used during determination of the take-off flight path (see § 4b.116).

(d) At the end of the time interval prescribed in paragraph (c) of this section the power shall be reduced to the maximum continuous power and the climb continued until at least 5 minutes after the occurrence of the highest temperature recorded.

(e) The speed used during take-off power operation (paragraph (c) of this section) shall not exceed the speed used during determination of the take-off flight path (see § 4b.116).

4b.454 Cooling test procedure for flying boat operation. In the case of flying boats, cooling shall be demonstrated during taxying down wind for 10 minutes at 5 mph above the step speed.

4b.455 Liquid cooling systems. Each liquid-cooled engine shall be provided with an independent coolant system. The coolant system shall be so arranged that no air or vapor can be trapped in any portion of the system other than the expansion tank, either during filling or during operation. No flammable coolant shall be used.

4b.456 Coolant tank.

(a) General. The tank shall have a usable coolant capacity of not less than one gallon and shall be capable of withstanding without failure all vibration, inertia, and fluid loads to which it would be subjected in operation. Coolant tanks shall be provided with an expansion space of not less than 10 percent of the total coolant system capacity. It shall not be possible inadvertently to fill the expansion space with the airplane in the normal ground attitude.

(b) Coolant tank tests. The provisions of § 4b.421 shall be applicable to coolant tanks, except as follows.

(1) The test pressure specified in § 4b.421 (a) shall be either the sum of the pressure developed during the maximum ultimate acceleration with a full tank plus the maximum working pressure of the system, or 1.25 times the maximum working pressure of the system, whichever is the greater.

(2) The test fluid specified in § 4b.421 (c) shall be coolant at operating temperature.

(c) Coolant tank installation.

(1) Coolant tanks shall be supported so that the tank loads will be distributed over a large portion of the tank surface.

(2) Pads shall be provided to prevent chafing between the tank and its supports.

(3) Materials employed for padding shall be nonabsorbent or shall be treated to prevent the absorption of fluids.

(d) Coolant tank filler connection.

(1) Recessed coolant tank filler connections which retain any appreciable quantity of coolant shall incorporate a drain, and the drain shall discharge clear of all portions of the airplane.

(2) Coolant tank filler connections shall be marked as prescribed in § 4b.738 (b).

4b.457 Coolant system installation. The following requirements shall apply to the installation of the coolant system components.

(a) Coolant lines. The provisions of § 4b.432 shall be applicable to coolant lines.

(b) Fire-resistant coolant lines and fittings. If the coolant used will ignite and burn under the conditions of powerplant fires, all lines and fittings located within designated fire zones shall comply with the provisions of § 4b.483.

(c) Coolant radiators.

(1) Coolant radiators shall be capable of withstanding without failure all vibration, inertia, and coolant pressure loads to which they would be subjected in operation.

(2) Coolant radiators shall be supported in a manner which will permit expansion due to operating temperatures and which will prevent the transmittal of harmful vibration to the radiator.

(3) The air intake duct to the coolant radiator shall be located so that in case of fire flames issuing from normal openings of the engine nacelle cannot impinge directly upon the radiator.

(d) Coolant system drains.

(1) One or more accessible drains shall be provided to permit drainage of the coolant system, including the coolant tank, radiator, and the engine, when the airplane is in the normal ground attitude.

(2) Drains shall discharge clear of all portions of the airplane and shall incorporate means for positive locking of the drain in the closed position.

INDUCTION AND EXHAUST SYSTEMS

4b.460 General.

(a) The engine air induction system shall permit supplying the proper quantity of air to the engine under all conditions of operation.

(b) The induction system shall provide air for proper fuel metering and mixture distribution with the induction system valves in any position.

(c) Each engine shall be provided with an alternate air source.

(d) Air intakes shall not open within the cowling, unless that portion of the cowling is isolated from the engine accessory section by means of a fireproof diaphragm, or unless provision is made to prevent the emergence of backfire flames.

(e) Alternate air intakes shall be so located as to preclude the entrance of rain, ice, or any other foreign matter.

4b.461 Induction system de-icing and anti-icing provisions.

(a) General. The engine air induction system shall incorporate means for the prevention and elimination of ice accumulations.

(b) Heat rise. Unless it is demonstrated that other means will accomplish the intent of paragraph (a) of this section, compliance with the following heat-rise provisions shall be demonstrated in air free of visible moisture at a temperature of 30° F.

(1) Airplanes equipped with altitude engines employing conventional venturi carburetors shall have a preheater capable of providing a heat rise of 120° F when the engine is operating at 60 percent of its maximum continuous power.

(2) Airplanes equipped with altitude engines employing carburetors which embody features tending to reduce the possibility of ice formation shall have a preheater capable of providing a heat rise of 100° F when the engine is operating at 60 percent of its maximum continuous power.

4b.462 Carburetor air preheater design. Carburetor air preheaters shall incorporate the following provisions.

(a) Means shall be provided to assure ventilation of the preheater when the engine is being operated with cold air.

(b) The preheater shall be constructed to permit inspection of exhaust manifold parts which it surrounds and also to permit inspection of critical portions of the preheater itself.

4b.463 Induction system ducts. Induction system ducts shall incorporate the following provisions.

(a) Induction system ducts ahead of the first stage of the supercharger shall be provided with drains to prevent hazardous accumulations of fuel and moisture in the ground attitude. The drains shall not discharge in locations which might cause a fire hazard.

(b) Sufficient strength shall be incorporated in the ducts to prevent induction system failures resulting from normal backfire conditions.

(c) Ducts which are connected to components of the airplane between which relative motion could exist shall incorporate provisions for flexibility.

4b.464 Induction system screens. If induction system screens are employed, they shall comply with the following provisions.

(a) Screens shall be located upstream from the carburetor.

(b) Screens shall not be located in portions of the induction system which constitute the only passage through which air can reach the engine, unless the screen is so located that it can be de-iced by heated air.

(c) De-icing of induction system screens by means of alcohol alone shall not be acceptable.

(d) It shall not be possible for fuel to impinge upon the screens.

4b.465 Carburetor air cooling. Installations employing two-stage superchargers shall be provided with means to maintain the air temperature at the inlet to the carburetor at or below the maximum established value. The demonstration of this provision shall be accomplished in accordance with § 4b.451.

4b.466 Inter-coolers and after-coolers. Inter-coolers and after-coolers shall be capable of withstanding without failure all vibration, inertia, and air pressure loads to which they would be subjected in operation.

4b.467 Exhaust system and installation components.

(a) General.

(1) The exhaust system shall be constructed and arranged to assure the safe disposal of exhuast gases without the existence of a fire hazard or carbon monoxide contamination of air in personnel compartments.

(2) Unless appropriate precautions are taken, exhaust system parts shall not be located in hazardous proximity to portions of any system carrying flammable fluids or vapors nor shall they be located under portions of such systems where the latter could be subject to leakage.

(3) All airplane components upon which hot exhaust gases might impinge, or which could be subjected to high temperatures due to proximity to exhaust system parts, shall be constructed of fireproof material. All exhaust system components shall be separated by means of fireproof shields from adjacent portions of the airplane which are outside the engine compartment.

(4) Exhaust gases shall not discharge within dangerous proximity of any fuel or oil system drains.

(5) Exhaust gases shall not discharge at a location which will cause a glare seriously affecting pilot visibility at night.

(6) All exhaust system components shall be ventilated to prevent the existence of points of excessively high temperature.

(b) Exhaust piping.

(1) Exhaust piping shall be constructed of material

resistant to heat and corrosion, and shall incorporate provisions to prevent failure due to expansion when heated to operating temperatures.

(2) Exhaust pipes shall be supported to withstand all vibration and inertia loads to which they would be subjected in operation.

(3) Portions of the exhaust piping which are connected to components between which relative motion could exist shall incorporate provisions for flexibility.

(c) Exhaust heat exchangers.

(1) Exhaust heat exchangers shall be constructed and installed to assure their ability to withstand without failure all vibration, inertia, and other loads to which they would be subjected in operation.

(2) Heat exchangers shall be constructed of materials which are suitable for continued operation at high temperatures and which are resistant to corrosion due to elements contained in exhaust gases.

(3) Provision shall be made for the inspection of all critical portions of exhaust heat exchangers.

(4) Heat exchangers shall incorporate cooling provisions wherever they are subject to contact with exhaust gases.

(d) Exhaust heating of ventilating air. If an exhaust heat exchanger is used for heating ventilating air, a secondary heat exchanger shall be provided between the primary exhaust gas heat exchanger and the ventilating air system, unless it is demonstrated that other means used preclude harmful contamination of the ventilating air.

(e) Exhaust driven turbo-superchargers.

(1) Exhaust driven turbines shall be of an approved type or

shall be shown to be suitable for the particular application. They shall be installed and supported to assure their safe operation between normal inspection and overhautl periods.

(2) Provision for expansion and flexibility shall be made between exhaust conduits and the turbine.

(3) Provision shall be made for lubrication of the turbine and for cooling of those turbine parts where the temperatures are critical.

(4) Automatic means shall be provided for limiting the turbine speed to its maximum allowable overspeed value.

POWERPLANT CONTROLS AND ACCESSORIES

4b.470 Powerplant controls - general. The provisions of § 4b.353 shall be applicable to all powerplant controls with respect to location, grouping, and direction of motion, and the provisions of § 4b.737 shall be applicable to all powerplant controls with respect to marking. In addition all powerplant controls shall comply with the following.

(a) Controls shall be so located that they cannot be inadvertently operated by personnel entering, leaving, or making normal movements in the cockpit.

(b) Controls shall maintain any set position without constant attention by flight personnel. They shall not tend to creep due to control loads or vibration.

(c) Flexible controls shall be of an approved type or shall be shown to be suitable for the particular application.

(d) Controls shall have strength and rigidity to withstand operating loads without failure and without excessive deflection.

4b.471 Throttle controls.

(a) A separate throttle control shall be provided for each engine. Throttle controls shall be grouped and arranged to permit separate control of each engine and also simultaneous control of all engines.

(b) Throttle controls shall afford a positive and immediately responsive means of controlling the engines.

4b.472 Ignition switches.

(a) Ignition switches shall provide control for each ignition circuit on each engine.

(b) Means shall be provided for quickly shutting off all ignition by the grouping of switches or by providing a master ignition control.

(c) If a master ignition control is provided, a guard shall be incorporated to prevent inadvertent operation of the control.

4b.473 Mixture controls. If mixture controls are provided, a separate control shall be provided for each engine. The mixture controls shall be grouped and arranged to permit separate control of each engine and also simultaneous control of all engines.

4b.474 Propeller controls.

(a) Propeller speed and pitch controls.

(1) A separate propeller speed and pitch control shall be provided for each propeller. The propeller speed and pitch controls shall be grouped and arranged to permit separate control of each propeller and also simultaneous control of all propellers.

(2) The propeller speed and pitch controls shall provide for synchronization of all propellers. (See also § 4b.404.)

(b) Propeller feathering controls.

(1) A separate propeller feathering control shall be provided for each propeller.

(2) Propeller feathering controls shall be provided with means to prevent inadvertent operation.

(3) If feathering is accomplished by movement of the propeller pitch or speed control lever, provision shall be made to prevent the movement of this control to the feathering position during normal operation.

(c) Propeller reversing controls. If the propeller blades can be placed in a pitch position which produces negative thrust, propeller reversing controls shall be arranged to prevent inadvertent operation.

4b.475 Fuel system controls. (See also § 4b.434.)

(a) Fuel jettisoning system controls shall be provided with guards to prevent their inadvertent operation.

(b) Fuel jettisoning system controls shall not be located in close proximity to fire extinguisher controls nor to any other controls intended to combat fire.

4b.476 Carburetor air preheat controls. Separate carburetor air preheat controls shall be provided to regulate the temperature of the carburetor air for each engine.

4b.477 Powerplant accessories.

(a) Engine mounted accessories shall be of a type approved for installation on the engine involved, and shall utilize the provisions made on the engine for mounting.

(b) Items of electrical equipment subject to arcing or sparking shall be installed to minimize the possibility of their contact with any flammable fluids or vapors which might be present in a free state.

4b.478 Engine ignition systems.

(a) Battery ignition systems shall be supplemented with a generator which is automatically made available as an alternate source of electrical energy to permit continued engine operation in the event of the depletion of any battery.

(b) The capacity of batteries and generators shall be sufficient to meet the simultaneous demands of the engine ignition system and the greatest demands of any airplane electrical system components which would draw electrical energy from the same source.

(1) The design of the engine ignition system shall take into consideration the condition of an inoperative generator and the condition of a completely depleted battery when the generator is running at its normal operating speed.

(2) If only one battery is provided the design of the engine ignition system shall take into consideration the condition in which the battery is completely depleted and the generator is operating at idling speed.

(c) Means shall be provided to warn flight personnel if malfunctioning of any part of the electrical system is causing the continuous discharging of a battery which is necessary for engine ignition. (See § 4b.472 for ignition switches.)

POWERPLANT FIRE PROTECTION

4b.480 Designated fire zones.

(a) Designated fire zones shall comprise the following regions:

(1) engine power section,

(2) engine accessory section,

(3) complete powerplant compartments in which no isolation is provided between the engine power section and the engine accessory section,

(4) auxiliary power unit compartments,

(5) fuel-burning heaters and other combustion equipment installations.

(b) Designated fire zones shall be protected from fire by compliance with §§ 4b.481 through 4b.489.

4b.481 Flammable fluids.

(a) No tanks or reservoirs which are a part of a system containing flammable fluids or gasses shall be located in designated fire zones, except where the fluid contained, the design of the system, the materials used in the tank, the shut-off means, all connections, lines, and controls are such as to provide an equally high degree of safety.

(b) Not less than 1/2 inch of clear air space shall be provided between any tank or reservoir and a fire wall or shroud isolating a designated fire zone.

4b.482 Shut-off means.

(a) Means for each individual engine and for each individual fire zone specified in § 4b.480 (a) (4) and (5) shall be provided for shutting off or otherwise preventing hazardous quantities of fuel, oil, de-icer, and other flammable fluids from flowing into, within, or through any designated fire zone, except that means need not be provided to shut off flow in lines forming an integral part of an engine.

(b) In order to facilitate rapid and effective control of fires, the shut-off means shall permit an emergency operating sequence which is compatible with the emergency operation of other equipment, such as feathering the propeller.

(c) The shut-off means shall be located outside of designated fire zones, unless an equally high degree of safety is otherwise provided (see § 4b.481). It shall be shown that no hazardous quantity of flammable fluid could drain into any designated fire zone after shutting-off has been accomplished.

(d) Provisions shall be made to guard against inadvertent operation of the shut-off means and to make it possible for the crew to reopen the shut-off means after it has once been closed.

4b.483 Lines and fittings.

(a) All lines and fittings located in designated fire zones which carry flammable fluids or gases and which are under pressure, or which attach directly to the engine, or are subject to relative motion between components, exclusive of those lines and fittings forming an integral part of the engine, shall be flexible, fire-resistant lines with fire-resistant end fittings of the permanently attached, detachable, or other approved types.

(b) Lines and fittings which are not subject to pressure or to relative motion between components shall be of fire-resistant materials.

(c) Vent and drain lines and fittings located in designated fire zones and which carry flammable fluids or gases shall be subject to the provisions of paragraph (a) of this section if it is found that rupture or breakage of a particular drain or vent line might result in a fire hazard.

4b.484 Fire extinguisher systems.

(a) General.

(1) Unless it is demonstrated that equivalent protection against destruction of the airplane in case of fire is provided by the use of fireproof materials in the nacelle and other components which would be subjected to flame, fire extinguishing systems shall be provided to serve all designated fire zones, except in the case of an engine power section which is completely isolated from the engine accessory section by a fire-proof diaphragm complying with the provisions of § 4b.486.

(2) The fire extinguishing system, the quantity of extinguishing agent, and the rate of discharge shall be such as to provide two adequate discharges. It shall be possible to direct both discharges to any main engine installation. Individual "one-shot" systems shall be acceptable in the case of auxiliary power units, fuel-burning heaters, and other combustion equipment.

(3) Materials in the fire extinguishing system shall not react chemically with the extinguishing agent so as to constitute a hazard.

(b) Fire extinguishing agents.

(1) Extinguishing agents employed shall be methyl bromide,

carbon dioxide, or any other agent which has been shown to provide equivalent extinguishing action.

(2) If methyl bromide, carbon dioxide, or any other toxic extinguishing agent is employed, provision shall be made to prevent the entrance of harmful concentration of fluid or fluid vapors into any personnel compartments either due to leakage during normal operation of the airplane or as a result of discharging the fire extinguisher on the ground or in flight even though a defect may exist in the extinguishing system. Compliance with this requirement shall be demonstrated by appropriate tests.

(3) If a methyl bromide system is provided, the containers shall be charged with a dry agent and shall be sealed by the fire extinguisher manufacturer or by any other party employing appropriate recharging equipment.

(c) Extinguishing agent container pressure relief. Extinguisher agent containers shall be provided with a pressure relief to prevent bursting of the container due to excessive internal pressures. The following provisions shall apply.

(1) The discharge line from the relief connection shall terminate outside the airplane in a location convenient for inspection on the ground.

(2) An indicator shall be provided at the discharge end of the line to provide a visual indication when the container has discharged.

(d) Extinguishing agent container compartment temperature. Precautions shall be taken to assure that the extinguishing agent containers are installed in a location where reasonable temperatures can be maintained for effective use of the extinguisher system.

(e) Fire extinguishing system materials. All components of fire extinguishing systems located in designated fire zones shall be constructed of fireproof materials, except for connections which are subject to relative motion between components of the airplane, in which case they shall be of flexible fire-resistant construction and so located as to minimize the possibility of failure.

4b.485 Fire detector systems. Quick acting fire detectors shall be provided in all designated fire zones and shall be sufficient in number and location to assure the detection of fire in such zones. Fire detectors shall comply with the following provisions.

(a) Fire detectors shall be constructed and installed to assure their ability to resist without failure all vibration, inertia, and other loads to which they would be subjected in operation.

(b) Fire detectors shall be unaffected by exposure to oil, water, or other fluids or fumes which might be present.

4b.486 Fire walls. All engines, auxiliary power units, fuel-burning heaters, and other combustion equipment which are intended for operation in flight shall be isolated from the remainder of the airplane by means of fire walls, shrouds, or other equivalent means. The following shall apply.

(a) Fire walls and shrouds shall be constructed in such a manner that no hazardous quantity of air, fluids, or flame can pass from the engine compartment to other portions of the airplane.

(b) All openings in the fire wall or shroud shall be sealed with close-fitting fireproof grommets, bushings, or fire-wall fittings.

(c) Fire walls and shrouds shall be constructed of fireproof material and shall be protected against corrosion.

4b.487 Cowling.

(a) Cowling shall be constructed and supported so as to make it capable of resisting all vibration, inertia, and air loads to which it would be subjected in operation.

(b) Provision shall be made to permit rapid and complete drainage of all portions of the cowling in all normal ground and flight attitudes. Drains shall not discharge in locations which might cause a fire hazard.

(c) Cowling, unless otherwise specified by these regulations, shall be constructed of fire-resistant material.

(d) Those portions of the cowling which would be subjected to high temperatures due to their proximity to exhaust system parts or exhaust gas impingement shall be constructed of fireproof material.

4b.488 Engine accessory section diaphragm. Unless equivalent protection can be shown by other means, a diaphragm shall be provided on air-cooled engines to isolate the engine power section and all portions of the exhaust system from the engine accessory compartment. This diaphragm shall comply with the provisions of § 4b.486.

4b.489 Protection of other airplane components against fire. All airplane surfaces aft of the nacelles, in the region of one nacelle diameter on both sides of the nacelle center line, shall be constructed of fire-resistant material. This provision need not be applied to tail surfaces lying behind nacelles, unless the dimensional configuration of the aircraft is such that the tail surfaces could be affected readily by heat, flames, or sparks emanating from a designated fire zone or engine compartment of any nacelle.

SUBPART F – EQUIPMENT

GENERAL

4b.600 Scope. The required basic equipment as prescribed in this subpart is the minimum which shall be installed in the airplane for certification. Such additional equipment as is necessary for a specific type of operation is prescribed in the operating rules of the Civil Air Regulations.

4b.601 Functional and installational requirements. Each item of equipment shall be:

(a) of a type and design appropriate to perform its intended function,

(b) labeled as to its identification, function, or operational limitations, or any combination of these, whichever is applicable,

(c) installed in accordance with specified limitations of the equipment,

(d) demonstrated to function properly in the airplane.

4b.602 Required basic equipment. The equipment listed in §§ 4b.603 through 4b.605 shall be the required basic equipment. (See § 4b.600.)

4b.603 Flight and navigational instruments. (See § 4b.612 for installation requirements.)

(a) Air-speed indicating system,

(b) Altimeter (sensitive),

(c) Clock (sweep-second),

(d) Free air temperature indicator,

(e) Gyroscopic bank and pitch indicator,

(f) Gyroscopic rate-of-turn indicator (with bank indicator),

(g) Gyroscopic direction indicator,

(h) Magnetic direction indicator,

(i) Rate-of-climb indicator (vertical speed).

4b.604 Powerplant instruments. (See § 4b.613 for installation requirements.)

(a) Carburetor air temperature indicator for each engine,

(b) Coolant temperature indicator for each liquid-cooled engine,

(c) Cylinder head temperature indicator for each air-cooled engine,

(d) Fuel pressure indicator for each pump-fed engine,

(e) Fuel flowmeter indicator or fuel mixture indicator for each engine not equipped with an automatic altitude mixture control,

(f) Fuel quantity indicator for each fuel tank,

(g) Manifold pressure indicator for each engine,

(h) Oil pressure indicator for each engine,

(i) Oil quantity indicator for each oil tank when a transfer or oil reserve supply system is used,

(j) Oil temperature indicator for each engine,

(k) Tachometer for each engine,

(l) Fire warning indicators (see § 4b.485).

4b.605 Miscellaneous equipment.

(a) Approved seats for all occupants (see § 4b.358),

(b) Approved safety belts for all occupants (see § 4b.643),

(c) Master switch arrangement for electrical circuits other than ignition (see §§ 4b.623 and 4b.624),

(d) Source(s) of electrical energy (see §§ 4b.620),

(e) Electrical protective devices (see §§ 4b.625 and 4b.626),

(f) Radio communication system (two-way),

(g) Radio navigation system,

(h) Windshield wiper or equivalent for each pilot,

(i) Ignition switch for each and all engines (see § 4b.472),

(j) Approved portable fire extinguisher (see § 4b.641).

INSTRUMENTS - INSTALLATION

4b.610 General. The provisions of §§ 4b.611 through 4b.613 shall apply to the installation of instruments.

4b.611 Arrangement and visibility of instrument installations.

(a) Flight, navigation, and powerplant instruments for use by each pilot shall be plainly visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking out and forward along the flight path.

(b) All of the required flight instruments shall be conveniently grouped and as nearly as practicable centered about the vertical plane of the pilot's forward vision.

(c) All the required powerplant instruments shall be closely grouped on the instrument panel.

(d) Identical powerplant instruments for the several engines shall be located to prevent any misleading impression as to the engines to which they relate.

(e) Powerplant instruments vital to the safe operation of the airplane shall be plainly visible to the appropriate crew members.

(f) The vibration characteristics of the instrument panel shall be such as not to impair seriously the accuracy of the instruments or to damage them.

4b.612 Flight and navigational instruments.

(a) Air-speed indicating systems.

(1) Air-speed indicating instruments shall be calibrated to indicate true air speed at sea level in the standard atmosphere with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied to the instrument.

(2) The air-speed indicating system shall be calibrated in flight to determine the system error, i.e. the relation between IAS and CAS.

(3) The air-speed error of the installation, excluding the air-speed indicator instrument calibration error, shall not exceed 3 percent or 5 mph, whichever is the greater, throughout the speed range from V_{NO} to 1.3 V_{S_1} with flaps retracted, and from 1.3 V_{S_O} to V_{FE} with flaps in the landing position.

(4) The air-speed indicating system shall be arranged in so far as practicable to preclude malfunctioning or serious error due to the entry of moisture, dirt, or other substances.

(5) The air-speed indicating system shall be provided with a heated pitot tube or equivalent means of preventing malfunctioning due to icing.

(b) Static air vent system.

(1) All instruments provided with static air case connections shall be vented to the outside atmosphere through an appropriate piping system.

(2) The vent(s) shall be so located on the airplane that its orifices will be least affected by air flow variation, moisture, or other foreign matter.

(3) The installation shall be such that the system will be air-tight, except for the vent into the atmosphere.

(c) <u>Magnetic direction indicator.</u>

(1) The magnetic direction indicator shall be installed so that its accuracy will not be excessively affected by the airplane's vibration or magnetic fields of a permanent or transient nature.

(2) After the magnetic direction indicator has been compensated, the calibration shall be such that the deviation in level flight does not exceed $\pm 10^\circ$ on any heading.

(3) A calibration placard shall be provided as specified in § 4b.733.

(d) <u>Automatic pilot system.</u> If an automatic pilot system is installed, the following shall be applicable.

(1) The actuating (servo) devices shall be of such design that they can, when necessary, either be disengaged positively or be overpowered by the pilot to enable him to maintain control of the airplane.

(2) A means shall be provided to indicate readily to the pilot the alignment of the actuating device in relation to the control system which it operates, except when automatic synchronization is provided.

(3) The manually operated control(s) for the system's operation shall be readily accessible to the pilot.

(4) The automatic pilot system shall be of such design and

so adjusted that, within the range of adjustment available to the human pilot, it cannot produce loads in the control system and surfaces greater than those for which the system and surfaces were designed.

(e) Gyroscopic indicators (air-driven type). All air-driven gyroscopic instruments shall derive their energy from a suction air pump driven either by an engine or by an auxiliary power unit. The following shall be applicable.

(1) Two suction air pumps actuated by separate power means shall be provided, either one of which shall be of sufficient capacity to operate all of the air-driven gyroscopic instruments at the service ceiling of the airplane in normal cruising condition.

(2) A means shall be provided in the suction air pump installation, where the lines from the individual pumps connect into a common line, to select either pump in case of failure of one pump source.

(3) When an automatic means to permit simultaneous air flow is provided in the system, a method for indicating any interrupted air flow in the suction air pump lines shall be incorporated in the system. In order to indicate which source has failed, a visual means shall be provided to indicate this condition to the flight crew.

(4) A suction gauge shall be installed to indicate readily to the flight crew while in flight the suction in inches of mercury which is being applied to the air-driven types of gyroscopic instruments.

4b.613 Powerplant instruments.

(a) Instrument lines.

(1) Powerplant instrument lines carrying flammable fluids

or gases under pressure shall be provided with restricted orifices or equivalent safety devices at the source of the pressure to prevent the escape of excessive fluid or gas in case of line failure.

(2) The provisions of §§ 4b.432 and 4b.433 shall be made applicable to powerplant instrument lines.

(b) Fuel quantity indicator. Means shall be provided to indicate to the flight crew the quantity in gallons or equivalent units of usable fuel in each tank during flight. The following shall apply.

(1) Tanks the outlets and air spaces of which are interconnected shall be considered as one tank for the purpose of providing separate indicators.

(2) Exposed sight gauges shall be protected against damage.

(3) Fuel quantity indicators shall be calibrated to read zero during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply as defined by § 4b.416 (see § 4b.736).

(c) Fuel flowmeter system. When a flowmeter system is installed, the metering component shall include a means for by-passing the fuel supply in the event that malfunctioning of the metering component results in a severe restriction to fuel flow.

(d) Oil quantity indicator.

(1) A stick gauge or other equivalent means shall be provided to indicate the quantity of oil in each tank. (See § 4b.735.)

(2) If an oil transfer system or a reserve oil supply system is installed, means shall be provided to indicate to the crew during flight the quantity of oil in each tank.

(e) Cylinder head temperature indicating system for air-cooled engines. A cylinder head temperature indicator shall be provided for each air-cooled engine on airplanes equipped with cowl flaps. In the case of airplanes without cowl flaps, an indicator shall be provided if compliance with the provisions of § 4b.450 is demonstrated at a speed in excess of the speed of best rate of climb.

ELECTRICAL SYSTEMS AND EQUIPMENT

4b.620 Installation.

(a) Electrical systems and equipment shall be free from hazards in themselves, in their method of operation, and in their effects on other parts of the airplane. They shall be protected from fuel, oil, water, other detrimental substances, and from mechanical damage.

(b) For substantiation of the electrical system the data required under § 4b.13 shall include:

(1) wiring diagrams, including a schematic power supply diagram,

(2) installation data, including the manufacturer's name, type of all electrical items, and reference to pertinent specifications,

(3) an electrical load analysis.

4b.621 Batteries.

(a) The battery capacity shall be that determined necessary from an electrical load analysis.

(b) Means shall be provided to prevent corrosive battery substance from coming in contact with other parts of the airplane during servicing or in flight.

(c) Batteries shall be completely enclosed in a container or compartment and shall be accessible for servicing and inspection on the ground.

(d) The battery container or compartment shall be vented so that gases released by the battery are carried outside the airplane.

(e) Battery cooling shall be provided, if found necessary to keep the battery temperature within the limits specified by the battery manufacturer.

4b.622 Generator system.

(a) Generator. The generator capacity necessary shall be determined initially from an electrical load analysis, and its adequacy shall be demonstrated during flight test. A switch shall be provided for each generator to permit its output to be interrupted. Individual generators shall be capable of delivering their continuous rated power.

(b) Generator controls. Generator voltage control equipment shall be capable of regulating the generator output within rated limits.

(c) Reverse current cutout. A generator reverse current cutout shall disconnect the generator from the battery and from other generators when the generator is developing a voltage of such value that current sufficient to cause malfunctioning can flow into the generator.

4b.623 Master switch. A master switch arrangement shall be provided which will disconnect all sources of electrical power from the main distribution system at a point adjacent to the power sources.

4b.624 Master switch installation. The master switch or its controls shall be so installed that it is easily discernible and accessible to a member of the crew in flight.

4b.625 Protective devices. Protective devices (fuses or circuit breakers) shall be installed in the circuits to all electrical equipment, except that such items need not be installed in the main circuits of starter motors or in other circuits where no hazard is presented by their omission. If fuses are used, one spare of each rating or 50 percent spare fuses of each rating, whichever is the greater, shall be provided.

4b.626 Protective devices installation. Protective devices in circuits used in flight shall be conveniently located and properly identified to facilitate replacement of fuses or resetting of circuit breakers in flight.

4b.627 Electric cables. The electric cables used shall be in accordance with approved standards for aircraft electric cable of a slow-burning type. They shall have current-carrying capacity sufficient to deliver the necessary power to the items of equipment to which they are connected.

4b.628 Switches. Switches shall be capable of carrying their rated current. They shall be accessible to the crew and shall be labeled as to operation and the circuit controlled.

LIGHTS

4b.630 Instrument lights.

(a) Instrument lights shall provide sufficient illumination to make all instruments, switches, etc., easily readable.

(b) Instrument lights shall be so installed that their direct rays are shielded from the pilot's eyes and so that no objectionable reflections are visible to him.

(c) A means of controlling the intensity of illumination shall be provided, unless it is shown that non-dimmed instrument lights are satisfactory under all expected conditions of flight.

4b.631 Landing lights.

(a) Landing lights shall be of an approved type.

(b) Landing lights shall be installed so that there is no objectionable glare visible to the pilot and so that the pilot is not adversely affected by halation.

(c) Landing lights shall be installed in a location where they provide the necessary illumination for night landing.

(d) A switch for each light shall be provided, except that where multiple lights are installed at one location a single switch for the multiple lights shall be acceptable.

4b.632 Position lights.

(a) General. Forward and rear position lights shall be of a type certificated in accordance with Part 15.

(b) Forward position light installation.

(1) Forward position lights shall be installed so that, with the airplane in normal flying position, the red light is displayed on the left side and the green light is displayed on the right side, each showing unbroken light between two vertical planes the dihedral angle of which is 110° when measured respectively to the left and to the right of the airplane from dead ahead.

(2) The lights shall be spaced laterally as far apart as practicable.

(c) Rear position light installation.

(1) The red and white position lights shall be mounted as far aft as practicable and installed so that unbroken light is directed symmetrically aft from each light with the axis of the maximum cone of illumination parallel to the flight path.

(2) The intersection of the two planes forming the dihedral angle A prescribed in Part 15 shall be vertical.

(3) If separate red and white lights are used, they shall be located as closely together as practicable.

(d) Top and bottom fuselage lights.

(1) The top and bottom fuselage lights shall each furnish illumination of an intensity equivalent to a 32-candlepower lamp installed in a reflector of high reflective properties and shall have a clear cover glass.

(2) The top and bottom fuselage lights shall show through approximately a hemisphere.

(3) The top fuselage light shall be installed approximately in line with the forward position lights.

(4) The bottom fuselage light on landplanes shall be installed approximately in line with the forward position lights. In the case of seaplanes the location of the bottom light will be subject to specific approval on each model airplane.

(e) Position light flasher.

(1) The position light flasher shall incorporate two flashing circuits which are energized alternately to provide flashing of the position and fuselage lights in the manner indicated in paragraph (f) of this section.

(2) The flasher shall be of an approved type.

(f) Flashing light sequence.

(1) The forward position lights and the rear white position light shall be on one of the flasher circuits, and the top and bottom fuselage lights and the rear red position light shall be on the other circuit.

(2) The flashing sequence shall be repeated automatically when the position light switch is in the "flash" position.

(g) Flashing light cutout switch. A switch shall be provided to eliminate the flasher from the position light circuit so that continuous light may be provided by the forward position lights and the rear white position light, while the top and bottom fuselage lights are not lighted.

4b.633 Riding light.

(a) When a riding (anchor) light is required for a seaplane, flying boat, or amphibian, it shall be capable of showing a white light for at least two miles at night under clear atmospheric conditions.

(b) The riding light shall be installed to show the maximum unbroken light practicable when the airplane is moored or drifting on the water. Externally hung lights shall be acceptable.

SAFETY EQUIPMENT

4b.640 Ice protection. When an ice protection system is installed, it shall be of an approved type. If pneumatic boots are used, at least two independent sources of power and a positive means for the deflation of the boots shall be provided.

4b.641 Hand fire extinguishers - number and installation.

(a) The approved portable fire extinguisher required by

§ 4b.605 (j) shall be installed primarily for the use of the pilot and copilot.

(b) When the operating rules of the Civil Air Regulations require additional fire-extinguishing equipment, the installation of such equipment shall depend upon the size and compartmentation of the airplane and on the number and distribution of the crew and passengers. Such fire extinguishers shall be placed in approved locations.

(c) Hand fire extinguishers prescribed by §§ 4b.383 shall be of an approved type, and their number, capacity, and installation shall be appropriate to the size and location of the compartments which they are intended to safeguard.

4b.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 airplane and its occupants.

(c) If recoil loads are involved in the ejection of the flares, the structure of the airplane shall withstand such loads.

4b.643 Safety belts. Airplanes manufactured on or after January 1, 1951, shall be equipped with safety belts approved in accordance with § 4b.18. In no case shall the rated strength of the safety belt be less than that corresponding with the ultimate load factors specified in § 4b.260 (a), 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 in § 4b.260 (a).

4b.644 Safety belt signal. When means are provided to indicate to the passengers when seat belts should be fastened, the device shall be so installed that it can be operated from the seat of either pilot or copilot.

4b.645 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 following provisions.

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

(b) Rafts released automatically or released by the pilot shall be attached to the airplane by means of a line to keep them alongside the airplane.

(c) Signaling devices shall be free from hazard in their operation and shall be installed in an accessible location.

MISCELLANEOUS EQUIPMENT

4b.650 Radio installation. Radio equipment installations in the airplane shall be free from hazards in themselves, in their method of operation, and in their effects on other components of the airplane.

4b.651 Oxygen equipment and supply. When required by the operating rules of the Civil Air Regulations, the supplemental and protective breathing equipment and its installation shall meet the following requirements.

(a) General. The oxygen system installed shall be free from hazards in itself, in its method of operation, and in its effect on other components of the airplane. Means shall be provided to enable the crew to determine the quantity of oxygen available in each source of supply.

(b) Required minimum mass flow of supplemental oxygen. The minimum mass flow of supplemental oxygen required per person at various cabin pressure altitudes shall be at least that indicated on Figure 4b-18.

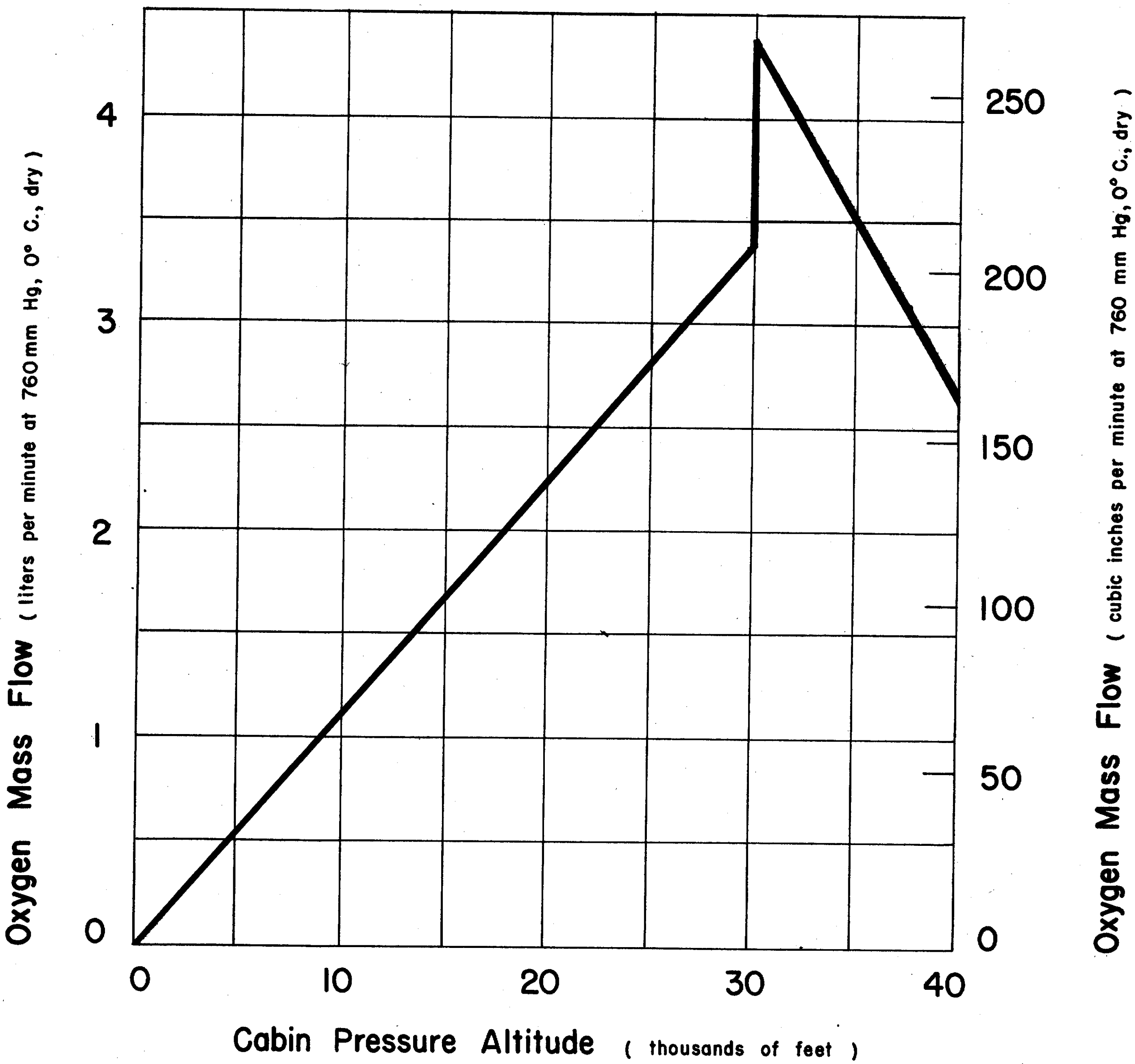
(c) Equipment standards for distribution system. Where oxygen is to be supplied to both crew and passengers, the distribution system shall be designed to provide either:

(1) a source of supply for the flight crew on duty and a separate source for the passengers and other crew members, or

(2) a common source of supply with means provided so that the minimum supply required by the flight crew on duty can be separately reserved.

(d) Equipment standards for dispensing units. An individual dispensing unit shall be provided for each crew member and passenger for whom supplemental oxygen is required to be furnished. All units shall be designed to cover the nose, and at least 25 percent of the units required to be furnished shall, in addition, cover the mouth. (For crew masks to be used for protective breathing purposes see the pertinent air carrier operating rules.)

(e) Means for determining use of oxygen. Means shall be provided to enable the crew to determine whether oxygen is being delivered to each user.



NOTE: 1. Data based on:
- a. System 100% efficient.
- b. Respiratory minute volume equals 15 liters (915 cubic inches) per minute.
- c. 100% oxygen above 30,000 feet.

2. For dilutor-demand regulators use flow characteristics supplied by manufacturer to calculate required supply. Such flows must not be less than those indicated on this graph at delivery rate of 15 liters per minute.

FIGURE 4b-18 MINIMUM FLOW OF OXYGEN FOR OPERATION AT VARIOUS ALTITUDES

4b.652 Engine-driven accessories. Engine-driven accessories essential to safe operation of the airplane shall be so distributed among two or more engines that the failure of any one engine will not impair the safe operation of the airplane.

4b.653 Hydraulic systems.

(a) Design. Hydraulic systems and elements shall withstand, without exceeding the yield point, all structural loads which are expected to be imposed in addition to the hydraulic loads.

(b) Tests. Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of a hydraulic system shall fail, malfunction, or experience a permanent set. The proof load of any system shall be 1.5 times the maximum operating pressure of that system.

(c) Lines and fittings. Hydraulic lines and fittings in all designated fire zones (see § 4b.480) shall comply with the provisions of § 4b.483.

(d) Reservoirs and accumulators. Location of hydraulic reservoirs and accumulators shall comply with the provisions of § 4b.481, except when they are an integral part of the engine or propeller.

SUBPART G - OPERATING LIMITATIONS AND INFORMATION

GENERAL

4b.700 Scope.

(a) The operating limitations listed in §§ 4b.710 through 4b.723 shall be established as prescribed in this part.

(b) The operating limitations, together with any other information concerning the airplane found necessary for safety during operation, shall be included in the Airplane Flight Manual (§ 4b.740), shall be expressed as markings and placards (§ 4b.730), and shall be made available by such other means as will convey the information to the crew members.

OPERATING LIMITATIONS

4b.710. Air-speed limitations - general. When air-speed limitations are a function of weight, weight distribution, altitude, or Mach number, the values corresponding with all critical combinations of these values shall be established.

4b.711 Never-exceed speed V_{NE}.

(a) To allow for possible variations in the airplane characteristics and to minimize the possibility of inadvertently exceeding safe speeds, the never-exceed speed V_{NE} shall be a speed established sufficiently below the lesser of:

(1) the design dive speed V_D chosen in accordance with § 4b.210 (b) (5), or

(2) the maximum speed demonstrated in flight in accordance with § 4b.190.

(b) In the absence of a rational investigation, the value of V_{NE} shall not exceed 0.9 times the lesser of the two speeds referred to in paragraph (a) of this section.

<u>4b.712</u> <u>Normal operating limit speed V_{NO}</u>.

(a) The normal operating limit speed V_{NO} shall be established not to exceed the design cruising speed V_C chosen in accordance with § 4b.210 (b) (4) and sufficiently below the never-exceed speed V_{NE} to make it unlikely that V_{NE} would be exceeded in a moderate upset occurring at V_{NO}.

(b) In the absence of a rational investigation, the value of V_{NO} shall not exceed 0.9 times V_{NE}.

<u>4b.713</u> <u>Maneuvering speed</u>. The maneuvering speed shall not exceed the design maneuvering speed V_A determined in accordance with § 4b.210 (b) (2).

<u>4b.714</u> <u>Flap extended speed V_{FE}</u>.

(a) The flap extended speed V_{FE} shall be established not to exceed the lesser of:

(1) the design flap speed V_F chosen in accordance with § 4b.210 (b) (1), or

(2) the design speed for slipstream effects with flaps in the landing position, chosen in accordance with § 4b.221.

(b) The value of V_{FE} established in accordance with paragraph (a) of this section shall not be less than a value which provides a safe speed margin above the stall during approach and landing.

(c) It shall be acceptable to establish supplementary values of V_{FE} for other combinations of flap setting, air speed, and engine power, if the structure and the flight characteristics of the airplane have been shown to be satisfactory for such combinations.

4b.715 Landing gear operating speed V_{LO}. The landing gear operating speed V_{LO} shall be established not to exceed a speed at which it is safe to extend or retract the landing gear as limited by design in accordance with § 4b.334 or by flight characteristics.

4b.716 Landing gear extended speed V_{LE}. The landing gear extended speed V_{LE} shall be established not to exceed a speed at which it has been shown that the airplane can be safely flown with the landing gear secured in the fully extended position, and for which the structure has been proven in accordance with § 4b.334.

4b.717 Minimum control speed V_{MC}. (See § 4b.133.)

4b.718 Powerplant limitations. The following powerplant limitations shall be established for the airplane. They shall not exceed the corresponding limits established as a part of the type certification of the engine and propeller installed in the airplane.

(a) Take-off operation.

(1) Maximum rotational speed (rpm),

(2) Maximum permissible manifold pressure,

(3) The time limit for use of the power which corresponds with the values established in subparagraphs (1) and (2) of this paragraph,

(4) Where the time limit established in subparagraph (3) of this paragraph exceeds two minutes, the maximum allowable cylinder head or coolant outlet, and oil temperatures.

(b) Maximum continuous operation.

(1) Maximum rotational speed (rpm),

(2) Maximum permissible manifold pressure,

(3) Maximum allowable cylinder head or coolant outlet, and oil temperatures.

(c) Fuel octane rating. The minimum octane rating of fuel required for satisfactory operation of the powerplant at the limits specified in paragraphs (a) and (b) of this section.

4b.719 Airplane weight and center of gravity limitations. The airplane weight and center of gravity limitations shall be those determined in accordance with §§ 4b.101 and 4b.102. Where the airplane is certificated for more than one center of gravity range, the appropriate limitations with regard to weight and loading procedures shall be set forth in the Airplane Flight Manual for each separate center of gravity range.

4b.720 Minimum flight crew. The minimum flight crew shall be established by the Administrator as that number of persons which he finds necessary for safety in the operations authorized under § 4b.721. This finding shall be based upon the work load imposed upon individual crew members with due consideration given to the accessibility and the ease of operation of all necessary controls by the appropriate crew members.

4b.721 Types of operation. The types of operation to which the airplane is limited shall be established by the category in which it has been found eligible for certification and by the equipment installed. (See the operating rules of the Civil Air Regulations.)

4b.722 Maximum operating altitude. A maximum altitude shall be established up to which operation is permitted, as limited by flight, structural, powerplant, functional, or equipment characteristics.

4b.723 Maneuvering flight load factors. Load factor limitations shall be established not to exceed the positive limit load factors determined from the maneuvering diagram, Figure 4b-2. (See § 4b.211 (a).)

MARKINGS AND PLACARDS

4b.730 General.

(a) Markings and placards shall be displayed in conspicuous places and shall be such that they cannot be easily erased, disfigured, or obscured.

(b) Additional information, placards, and instrument markings having a direct and important bearing on safe operation of the airplane shall be required when unusual design, operating, or handling characteristics so warrant.

4b.731 Instrument markings – general.

(a) When markings are placed on the cover glass of the instrument, provision shall be made to maintain the correct alignment of the glass cover with the face of the dial.

(b) All arcs and lines shall be of sufficient width and so located that they are clearly visible to the pilot.

4b.732 Air-speed indicator. The following markings shall be placed on the air-speed indicator. If speeds vary with altitude, means shall be provided to indicate the appropriate limitation to the pilot throughout the operating altitude range.

(a) A radial red line shall indicate the never-exceed speed V_{NE} (see § 4b.711).

(b) A yellow arc extending from the red line specified in paragraph (a) of this section to the upper limit of the green arc specified in paragraph (c) of this section shall indicate the caution range.

(c) A green arc with the lower limit at V_{S_1} as determined in accordance with § 4b.112 (b) with maximum take-off weight, landing gear and wing flaps retracted, and the upper limit at the normal operating limit speed V_{NO} established in accordance with § 4b.712 shall indicate the normal operating range.

(d) A white arc with the lower limit at V_{S_O} as determined in accordance with § 4b.112 (a) at the maximum landing weight, and the upper limit at the flaps-extended speed V_{FE} as established in accordance with § 4b.714 shall indicate the flap operating range.

4b.733 Magnetic direction indicator. A placard shall be installed on or in close proximity to the magnetic direction indicator which shall comply with the following.

(a) The placard shall contain the calibration of the instrument in a level flight attitude with engine(s) operating.

(b) The placard shall state whether the calibration was made with radio receiver(s) on or off.

(c) The calibration readings shall be in terms of magnetic headings in not greater than 45° increments.

4b.734 Powerplant instruments - general. All required powerplant instruments shall be marked as follows.

(a) The maximum and the minimum (if applicable) safe operational limits shall be marked with red radial lines.

(b) The normal operating ranges shall be marked with a green arc not extending beyond the maximum and minimum safe operational limits.

(c) The take-off and precautionary ranges shall be marked with a yellow arc.

4b.735 Oil quantity indicators. Oil quantity indicators shall be marked in sufficient increments to indicate readily and accurately the quantity of oil.

4b.736 Fuel quantity indicator. When the unusable fuel supply for any tank exceeds 1 gallon or 5 percent of the tank capacity, whichever is the greater, a red arc shall be marked on the indicator extending from the calibrated zero reading to the lowest reading obtainable in the level flight attitude. A notation in the Airplane Flight Manual shall be made to indicate that the fuel remaining in the tank when the quantity indicator reaches zero is not usable in flight. (See § 4b.613 (b).)

4b.737 Control markings - general. All cockpit controls, with the exception of the primary flight controls and other controls the function of which is obvious, shall be plainly marked and/or identified as to their function and method of operation. The markings shall include the following.

(a) Aerodynamic controls. The secondary aerodynamic controls shall be marked to comply with §§ 4b.322 and 4b.323.

(b) Powerplant fuel controls.

(1) Controls for fuel tank selector valves shall be marked to indicate the position corresponding with each tank and with all possible cross-feed positions.

(2) When more than one fuel tank is provided, and if safe

operation depends upon the use of tanks in a specific sequence, the fuel tank selector controls shall be marked adjacent to or on the control itself to indicate the order in which the tanks should be used.

(3) Controls for engine selector valves shall be marked to indicate the position corresponding with each engine.

(c) Accessory and auxiliary controls.

(1) When a retractable landing gear is used, the visual indicator required in § 4b.334 (e) shall be marked so that the pilot can ascertain at all times when the wheels are locked in either extreme position.

(2) Emergency controls shall be colored red and shall be marked to indicate their method of operation.

4b.738 Miscellaneous markings and placards.

(a) Baggage compartments and ballast location. Each baggage and cargo compartment as well as the ballast location shall bear a placard stating the maximum allowable weight of contents and, if applicable, any other limitation on contents found necessary due to loading requirements.

(b) Fuel, oil, and coolant filler openings. The following information shall be marked on or adjacent to the appropriate filler cover:

(1) the word "fuel", the minimum permissible fuel octane number for the engines installed, and the usable fuel tank capacity (see § 4b.416),

(2) the word "oil" and the oil tank capacity,

(3) the name of the proper coolant fluid and the capacity of the coolant system.

(c) Emergency exit placards.

(1) Emergency exits shall be marked as such with luminous

paint in letters not less than 3/4 inch high. The markings shall be located either on or immediately adjacent to the exit and shall be conspicuous to the passengers.

(2) The location and method of operation of the emergency exit handles shall be marked with luminous paint. (See § 4b.362 (c).)

(d) Operating limitation placard. A placard shall be provided in front of and in clear view of the pilots stating: "This airplane must be operated in compliance with the operating limitations specified in the CAA approved Airplane Flight Manual."

(e) Safety equipment.

(1) Safety equipment controls which the crew is expected to operate in time of emergency, such as flares, automatic life raft releases, etc., shall be readily accessible and plainly marked as to their method of operation.

(2) When fire extinguishers and signaling and other life-saving equipment are carried in lockers, compartments, etc., these locations shall be marked accordingly.

AIRPLANE FLIGHT MANUAL

4b.740 General.

(a) An Airplane Flight Manual shall be furnished with each airplane.

(b) The portions of the manual listed in §§ 4b.741 through 4b.743 as are appropriate to the airplane shall be verified and approved and shall be segregated, identified, and clearly distinguished from portions not so approved.

(c) Additional items of information having a direct and important bearing on safe operation shall be required when unusual design, operating, or handling characteristics so warrant.

4b.741 Operating limitations.

(a) Air-speed limitations. The following air-speed limitations shall be included together with sufficient information to permit marking the air-speed indicator in accordance with § 4b.732:

(1) the never-exceed speed (see § 4b.711);

(2) the normal operating limit speed (see § 4b.712), together with a statement to the effect that normal flight operations should be confined to speeds below this value, and a further statement to the effect that the range of speeds between the normal operating limit speed and the never-exceed speed should be entered with caution and with due regard to the prevailing flight and atmospheric conditions;

(3) when an air-speed limitation is based upon compressibility effects, a statement to this effect, together with information as to any symptoms, the probable behavior of the airplane, and the recommended recovery procedures;

(4) the maneuvering speed (see § 4b.210 (b) (2)), together with a statement to the effect that full application of rudder and aileron controls as well as those maneuvers which involve angles of attack near the stall should be confined to speeds below this value;

(5) the flap extended speed (see § 4b.714), together with a description of the pertinent flap positions and engine powers;

(6) the landing gear operating speed (see § 4b.715), together

with a statement to the effect that this is the maximum speed at which it is safe to extend or retract the landing gear;

(7) the landing gear extended speed (see § 4b.716), if greater than the landing gear operating speed, together with a statement to the effect that this is the maximum speed at which the airplane can be flown safely with the landing gear in the extended position.

(b) Powerplant limitations. Information shall be included to outline and to explain all powerplant limitations (see § 4b.718) and to permit marking the instruments as required by §§ 4b.734 through 4b.736.

(c) Weight and loading distribution. The airplane weights and center of gravity limits required by §§ 4b.101 and 4b.102 shall be included, together with the items of equipment on which the empty weight is based. Where the variety of possible loading conditions warrants, instructions shall be included to facilitate observance of the limitations.

(d) Flight load acceleration limits. The positive maneuvering limit load factors for which the airplane structure has been proven shall be described in terms of accelerations, together with a statement to the effect that these accelerations limit the angle of bank in turns and limit the severity of pull-up maneuvers.

(e) Flight crew. The number and functions of the minimum flight crew determined in accordance with § 4b.720 shall be described.

(f) Type of operation. The type(s) of operating(s) shall be listed for which the airplane and its equipment installations have been approved. (See § 4b.721.)

(g) Maximum operating altitude. The altitude established in accordance with § 4b.722 shall be included, together with an explanation of the limiting factors.

4b.742 Operating procedures.

(a) Normal. Information and instructions shall be included regarding peculiarities of starting and warming the engines, taxying, operation of wing flaps, landing gear, automatic pilot, etc.

(b) One engine inoperative. The recommended procedure shall be described to be followed in the event of engine failure, including minimum speeds, trim, operation of remaining engine(s), operation of flaps, etc.

(c) Propeller feathering. The recommended procedure shall be described to be followed in stopping the rotation of propellers in flight.

(d) Emergency procedures. Recommended emergency procedures shall be described to be followed in the event of fire, decompression, ditching, etc.

4b.743 Performance information.

(a) Performance data. A summary of all pertinent performance data shall be given, including the performance data necessary for the application of the operating rules of the Civil Air Regulations, together with descriptions of the conditions, air speeds, etc. under which these data were determined.

(b) Flap controls. Instructions shall be included describing the use and adjustment of the flap controls necessary to obtain the performance referred to in paragraph (a) of this section.

(c) Air speeds. The indicated air speeds corresponding with those determined for take-off shall be listed together with the procedures to be followed in the event the critical engine becomes inoperative during take-off (see § 4b.742 (b)).

(d) Miscellaneous. An explanation shall be included of any significant or unusual flight or ground handling characteristics.

AIRPLANE IDENTIFICATION DATA

4b.750 Identification plate. A fireproof identification plate shall be securely attached to the structure in an accessible location where it will not likely be defaced during normal service. The identification plate shall not be placed in a location where it might be expected to be destroyed or lost in the event of an accident. The identification plate shall contain the identification data required by § 2.36 of the Civil Air Regulations.

4b.751 Identification marks. The nationality and registration marks shall be permanently affixed in accordance with the operating rules of the Civil Air Regulations.

(Sec. 205 (a), 52 Stat. 984, 49 U.S.C. 425. Interpret or apply secs. 601, 603, 52 Stat. 1007, 1009, 49 U.S.C. 551, 553; 62 Stat. 1216, Act of July 1, 1948)

By the Civil Aeronautics Board:

/s/ M. C. Mulligan

M. C. Mulligan
Secretary

(SEAL)