CIVIL AERONAUTICS BOARD
WASHINGTON, D. C.

CIVIL AIR REGULATIONS AMENDMENT 04-0
Effective: November 9, 1945

PART 04

AIRPLANE AIRWORTHINESS

TRANSPORT CATEGORIES

04.0 Scope. An airplane shall be shown to comply with the airworthiness requirements set forth in this Part and shall have no characteristic which, according to the findings of the Administrator, makes the airplane unairworthy in order to become eligible for type and airworthiness certificates, provided that:

(a) If any of these requirements become inapplicable to a particular airplane because of increased knowledge of aeronautics or of the development of unforeseen design features, the Administrator shall accept designs shown to provide an equivalent standard of safety.

(b) Other requirements with respect to airworthiness found by the Administrator to provide an equivalent standard of safety shall be accepted in lieu of the requirements set forth in this Part.

04.00 Date of effectiveness. Aircraft certificated as a type on or after November 9, 1945, shall comply either with (1) the entire provisions of Part 04 of the CAR in effect immediately prior to that date, or (2) the entire provisions prescribed herein except that aircraft certificated under (1) may incorporate provisions of (2) when the Administrator finds the standard of safety to be equivalent to the particular and all related items of the latter.

Aircraft certificated as a type on or after January 1, 1948, shall comply with the provisions contained herein. If the prototype is not flown prior to January 1, 1948, and satisfactory evidence is presented indicating that the design work of the type was well advanced prior to November 9, 1945, and the delay of completion of the airplane was due to causes beyond the manufacturer's control, the Administrator may certificate the airplane as a type under the provisions of Part 04 which were in effect prior to November 9, 1945.

Unless otherwise specified, an amendment to this Part will apply only to airplanes for which application for a type certificate has been received subsequent to the effective date of such amendment.

04.01 Airplane categories. In this Part airplanes are divided upon the basis of their intended operation into the following categories for the purposes of certification:

Transport. Airplanes in this category must be multi-engine, are limited to non-acrobatic operation and intended for, but not limited to, scheduled passenger, cargo, or combined passenger and cargo carrying operation.

Restricted. Airplanes in this category are intended to be operated for restricted purposes not logically encompassed by the transport category. The requirements of this category shall consist of all the provisions for the transport category which are not rendered inapplicable by the nature of the special purpose involved, plus suitable operating restrictions which the Administrator finds will provide a level of safety equivalent to that contemplated for the transport category.

04.02 Airworthiness certificates. Airworthiness certificates are classified as follows:

(a) NC certificates. In order to become eligible for an NC certificate, the airplane must be shown to comply with all of the requirements contained in this Part for at least one category, but not the restricted purpose category.

(b) NR certificates. In order to become eligible for an NR certificate, an airplane must be shown to comply with all of the requirements of the restricted purpose category.

(c) NX certificates. An airplane will become eligible for an NX certificate when the applicant presents satisfactory evidence that the airplane is to be flown for experimental purposes and the Administrator finds it may, with appropriate restrictions, be operated for that purpose in a manner which does not endanger the general public. The applicant shall submit sufficient data such as photographs to identify the airplane satisfactorily and, upon inspection of the airplane, any pertinent information found necessary by the Administrator to safeguard the general public.

An airplane manufactured in accordance with a type certificate (See § 04.03) and conforming with the type design will become eligible for an airworthiness certificate when, upon inspection of the airplane, the Administrator determines it so to conform and that the airplane is in a condition for safe operation. For each newly manufactured airplane this determination shall include a flight check by the applicant.

04.03 Type certificates. A type certificate will be issued when the following requirements are met:

04.031 Data required for NC and NR certification. The applicant for a type certificate shall submit to the Administrator the following:

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.

04.032 Inspection and tests for NC and NR certification. The authorized representatives of the Administrator shall have access to the airplane and may witness or conduct such inspections and tests as are necessary to insure compliance with the airworthiness requirements.

04.0320 Inspection. Inspections and tests shall include all those found necessary by the Administrator to insure that the airplane conforms with the following:

(a) All materials and products are in accordance with the specification given in the type design.

(b) All parts of the airplane are constructed in accordance with the drawings contained 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.

04.0321 Flight tests. Upon satisfactory completion of all necessary inspection and testing on the ground, and upon receipt from the applicant of a report of flight tests conducted by him, and satisfactory proof of the conformity of the airplane with the type design, such official flight tests as the Administrator finds necessary to prove compliance with this Part shall be conducted.

04.04 Changes. Changes shall be substantiated to demonstrate continued compliance of the airplane with the appropriate airworthiness requirements in effect when the particular airplane was certificated as a type unless the applicant chooses to show compliance with the currently effective requirements subject to the approval of the Administrator or unless the Administrator finds it necessary to comply with current airworthiness requirements.

04.040 Minor changes. Minor changes to certificated airplanes which obviously do not impair the condition of the airplane for safe operation shall be approved by the authorized representatives of the Administrator prior to the submittal to the Administrator of any required revised drawings.

04.041 Major changes. A major change is any change not covered by minor changes as defined in § 04.040, Minor Changes.

04.042 Service experience changes. When the Administrator finds that service experience indicates the need for design changes, the applicant shall submit for the approval of the Administrator engineering data describing and substantiating the necessary changes. Upon approval by the Administrator, these changes shall be considered as a part of the type design, and descriptive data covering these changes shall be furnished by the applicant to all aircraft owners concerned.

04.0420 In the case of airplanes approved as a type under the terms of earlier airworthiness requirements, the Administrator may require that an airplane submitted for an original airworthiness certificate comply with such portions of the currently effective airworthiness requirements as may be necessary for safety.

04.07 Definitions.

04.070 General.

04.0701 Standard atmosphere. The standard atmosphere shall be based upon the following assumptions:

(a) The air is a dry perfect gas.

(b) The temperature at sea level is 59°F.

(c) The pressure at sea level is 29.92 inches Hg.

(d) The temperature gradient from sea level to the altitude at which the temperature becomes -67°F is -0.003566°F/Ft. and zero thereabove.

(e) The density, ρ_o, at sea level under the above conditions is 0.002378 lbs. Sec.^{2}/Ft.^{4}.

04.0702 Hot-day condition. See § 04.4400.

04.0703 Airplane configuration. This term refers to the position of the various elements affecting the aerodynamic characteristics of the airplane, such as landing gear, flaps, etc.

04.071 Weights.	Reference Sections
Empty weight. The actual weight used as a basis for determining operating weights.	§ 04.112
Maximum weight. The maximum weight at which the airplane may operate in accordance with the airworthiness requirements.	§ 04.113
Minimum weight. The minimum weight at which compliance with the airworthiness requirements is demonstrated.	§ 04.114
Design take-off weight. The maximum weight used in the structural design of the airplane for flight conditions, special landing conditions with reduced descent velocity (§ 04.241(b)), and taxiing conditions.	§ 04.210
Design landing weight. The maximum weight used in the structural design of the airplane for normal landing conditions.	§ 04.240
Minimum design weight. The minimum weight condition investigated in the structural flight load conditions not greater than the minimum weight specified in § 04.114, Minimum Weight.	§ 04.210

Unit weights for design purposes.

Gasoline	6 lbs. per U.S. gallon
Lubricating Oil	7.5 lbs. per U.S. gallon
Crew and Passengers	170 lbs. per person

04.072 Power.

One horsepower. 33,000 ft. lbs. per minute

Take-off power. The take-off rating of the engine established in accordance with Part 13, "Aircraft Engine Airworthiness".

Maximum continuous power. The maximum continuous rating of the engine established in accordance with Part 13, "Aircraft Engine Airworthiness."

04.073 Speeds.

		Reference Sections
V_t	True airspeed of the airplane relative to the undisturbed air	

In the following symbols having subscripts, V denotes

(a) "Equivalent" airspeed for structural design purposes equal to $V_t \sqrt{\rho/\rho_0} = V_t \sqrt{\sigma}$

(b) "True indicated" or "calibrated" airspeed for performance and operating purposes equal to indicator reading corrected for position and instrument errors.

		Reference Sections
V_{s_0}	stalling speed, in the landing configuration	§ 04.121
V_{s_1}	stalling speed in the configuration specified for particular conditions	§ 04.121
V_{mc}	minimum control speed	§ 04.1312
V_f	design speed for flight load conditions with flaps in the landing position	§ 04.2110
V_p	design maneuvering speed	§ 04.2110
V_b	design speed for 40 ft./sec. gust	§ 04.2110
V_c	design cruising speed	§ 04.2110
V_d	design dive speed	§ 04.2110
V_{ne}	never exceed speed	§ 04.6001
	Maximum structural cruising speed	§ 04.6002

04.074 Structural terms.

Structure. Those portions of the airplane the failure of which would seriously endanger the safety of the airplane.

Design wing area, S. The area enclosed by the wing outline (including ailerons, and flaps in the retracted position, but ignoring fillets and fairings) on a surface containing the wing chords. The outline is assumed to extend through the nacelles and fuselage to the plane of symmetry.

Aerodynamic coefficients, C_L, C_N, C_M, etc., used herein, are non-dimensional coefficients for the forces and moments acting on an airfoil, and correspond to those adopted by the U. S. National Advisory Committee for Aeronautics.

C_L = airfoil lift coefficient

C_N = airfoil normal force coefficient (normal to wing chord line)

C_{NA} = airplane normal force coefficient (based on lift of complete airplane and design wing area)

C_M = pitching moment coefficient

Loads.	Reference Sections
Limit load. The maximum load anticipated in service.	§ 04.200
Ultimate load. The maximum load which a part or structure must be capable of supporting.	§ 04.202
Factor of safety. The factor by which the limit load must be multiplied to establish the ultimate load.	§ 04.201

Load factor or acceleration factor, n The ratio of the force acting on a mass to the weight of the mass. When the force in question represents the net external load acting on the airplane in a given direction, n represents the acceleration in that direction in terms of the gravitational constant.

Limit load factor. The load factor corresponding to limit load.

Ultimate load factor. The load factor corresponding to ultimate load.

04.1 FLIGHT REQUIREMENTS

04.10 General.

04.100 Policy re proof of compliance. Compliance with the requirements specified in § 04.1 governing functional characteristics shall be demonstrated by suitable flight or other tests conducted upon an airplane of the type, or by calculations based upon the test data referred to above, provided that the results so obtained are substantially equal in accuracy to the results of direct testing. Compliance with each requirement must be provided at the critical combination of airplane weight and center of gravity position, within the range of either, for which certification is desired for each practicably separable operating condition to which the requirement is applicable. Such compliance must be demonstrated by systematic investigation of all probable weight and center of gravity combinations or must be reasonably inferable from such as are investigated.

04.101 The applicant shall provide a person holding an appropriate pilot certificate to make the flight tests, but a designated representative of the Administrator may pilot the airplane in so far as that may be necessary for the determination of compliance with the airworthiness requirements.

04.102 Official type tests will 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) Items of non-compliance with requirements are found which may render additional test data meaningless or are of such nature as to make further testing unduly hazardous.

04.103 Adequate provisions shall be made for emergency egress and use of parachutes by members of the crew during the flight tests.

04.104 The applicant shall submit to the representative of the Administrator 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 representative of the Administrator will conduct any flight tests which appear to him to be necessary in order to check the calibration and correction report.

04.11 Weight and balance. There shall be established, as a part of the type inspection, ranges of weight and center of gravity within which the airplane may be safely operated.

04.110 Use of ballast. Removable ballast may be used to enable airplanes to comply with the flight requirements in accordance with the following provisions:

04.1100 The place or places for carrying ballast shall be properly designed, installed, and plainly marked as specified in § 04.6120.

04.1101 The airplane operating manual shall include instructions regarding the proper disposition of the removable ballast under all loading conditions for which such ballast is necessary, as specified in § 04.620.

04.112 Empty weight. The empty weight and corresponding center of gravity location shall include all fixed ballast, the unusable fuel supply (see § 04.4221), undrainable oil, full engine coolant, and hydraulic fluid. The weight and location of items of equipment installed in the airplane when weighed shall be noted in the operating manual.

04.113 Maximum weight. The maximum landing and take-off weights shall not exceed any of the following:

(a) the weights selected by the applicant,
(b) the design weights for which the structure has been proven,
(c) the maximum weights at which compliance with all of the applicable requirements specified is demonstrated.

The maximum take-off weight and the maximum landing weight may be made variable with altitude.

04.114 Minimum weight. The minimum weight shall not be less than any of the following:

(a) the minimum weight selected by the applicant,
(b) the minimum design weight for which the structure has been proven,
(c) the minimum weight at which compliance with all the applicable requirements herein specified is demonstrated.

04.115 Center of gravity position. The fore and aft extremes of center of gravity position 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 applicable flight requirements is demonstrated.

04.12 Performance. The following items of performance shall be determined and the airplane shall comply with the corresponding requirements in the standard atmosphere and still air. The wing flap positions denoted respectively as the take-off, enroute, approach, and landing positions shall be selected by the applicant and may be made variable with weight and altitude (see § 04.353).

04.120 Minimum requirements for certification. An airplane may be certificated upon having established:

(a) a maximum take-off weight at sea level (see § 04.113),
(b) a maximum landing weight at sea level (see § 04.113),
(c) compliance with the climb requirement of § 04.1231 (b), Climb,
(d) take-off data at maximum sea level take-off weight, and landing data at maximum sea level landing weight, in accordance with § 04.122, Take-Off and § 04.124, Landing.
(e) compliance with the requirements of all other applicable parts of the regulations.

04.121 Definition of stalling speeds.

(a) V_{s_0} denotes the true indicated 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 set at a speed not greater than 110% of the stalling speed),
(2) propellers in 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) V_{s_1} denotes the true indicated stalling speed, or the minimum steady flight speed at which the airplane is controllable, in miles per hour, with:

(1) all engines idling, throttles closed (or not more than sufficient power for zero thrust set at a speed not greater than 110% of the stalling speed),
(2) propellers in 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.

These speeds shall be determined by flight tests using the procedure outlined in § 04.134(a) and (b).

04.122 Take-Off. The following take-off data shall be determined:

(a) at all weights and altitudes desired by the applicant,
(b) with a constant take-off flap position for a particular weight and altitude,
(c) with the operating engines not exceeding their approved limitations at the particular altitude.

These data, when corrected, shall assume a level take-off surface. All take-off data shall be determined on a smooth, dry, hard surfaced runway and in such a manner that reproduction of such data does not require exceptional skill or alertness on the part of the pilot.

04.1220 Speeds.

(a) The critical engine failure speed, V_1, is a true indicated airspeed, chosen by the applicant, which shall not be less than the minimum speed at which the controllability is demonstrated during 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. If V_1 is equal to or greater than V_2 below, no demonstration during take-off is required.
(b) The minimum take-off climb speed, V_2, is a true indicated airspeed chosen by the applicant which shall permit the rate of climb required in § 04.1231(a), Climb, but which shall not be less than:

(1) 1.20 V_{s1} for two-engine airplanes,
(2) 1.15 V_{s1} for airplanes having more than two engines,
(3) 1.10 times the minimum control speed, V_{mc}, established under § 04.1312, Minimum Control Speed.

04.1221 Accelerate-stop distance. The distance required to accelerate the airplane from a standing start to the speed, V_1, and, assuming an engine to fail at this point, to stop.

Means other than wheel brakes may be used in determining this distance providing that exceptional skill is not required to control the airplane, that the manner of their employment is such that consistent results could be expected under normal service, and that they are regarded as reliable.

04.1222 Take-off path.

(a) The distance required to accelerate the airplane to the speed, V_2, making the critical engine inoperative 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 windmilling with the propeller control in a position normally used during take-off,

(2) the landing gear extended.

(c) 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 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).

04.123 **Climb.** Compliance shall be shown with the following requirements:

04.1230 **All engines operating.**

(a) The steady rate of climb at 5,000 feet shall not be less in feet per minute than $8\ V_{s_0}$ with:

(1) landing gear fully retracted,

(2) wing flaps in the most favorable position,

(3) cowl flaps 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 at not more than maximum continuous power,

(6) maximum take-off weight.

The steady rate of climb shall also be determined at any altitude at which the airplane may be expected to operate at any weight within the range of weights to be specified in the airworthiness certificate.

(b) Flaps in landing position. - The steady rate of climb in feet per minute shall be at least $0.07\ V_{s_o}^2$ 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 § 04.12 and § 04.353),
(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.

04.1231 One-engine inoperative.

(a) Flaps in take-off position. - The steady rate of climb in feet per minute shall be at least $0.035\ V_{s_1}^2$ at any altitude within the range for which take-off weight is to be specified in the certificate, with:

(1) the landing gear retracted,
(2) wing flaps in the take-off position, (see § 04.12 and § 04.353),
(3) cowl flaps in the position normally used during take-off,
(4) center of gravity in the most unfavorable position permitted for take-off,
(5) the critical engine inoperative, its propeller windmilling with the propeller control in a position normally used during take-off,
(6) all other engines operating at the take-off power available at such altitude,
(7) the speed equal to the minimum take-off climb speed, V_2, used in § 04.122, Take-Off,
(8) the weight equal to maximum take-off weight for that altitude.

With the landing gear extended and all other conditions as described in the foregoing, the rate of climb shall be at least 50'/min.

(b) Flaps in enroute position. - The steady rate of climb in feet per minute at any altitude at which the airplane may be 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 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.

(c) Flaps in approach position. - The steady rate of climb in feet per minute shall not be less than $0.04 \, V_{s_0}^2$ 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 $1.06 \, V_{s_0}$,

(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.

04.1232 Two-engine inoperative. For airplanes with four or more engines, the steady rate of climb at any altitude at which the airplane may be expected to operate and at any weight within the range of weights to be specified in the operating 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.

04.124 Landing. 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 such range of weights and altitudes as the applicant may desire. In making this determination:

(a) Immediately prior to reaching the 50-foot altitude a steady gliding approach shall have been maintained, with a true indicated airspeed of at least 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. 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 true indicated airspeed has been reduced to not more than 0.9 V_{s_o} the flap position may be changed.

(c) 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.

04.1240 Landplanes. The landing distance as defined above shall be determined on a dry hard surfaced runway and:

(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 providing that exceptional skill is not required to control the airplane, that the manner of their employment is such that consistent results could be expected under normal service, and that they are regarded as reliable.

04.1241 Seaplanes or float planes. The landing distance as defined above shall be determined on smooth water.

04.1242 Skiplanes. The landing distance as defined above shall be determined on smooth, dry snow.

04.13 Flight characteristics. The airplane shall meet the following requirements at all normally expected operating altitudes under all critical loading conditions within the range of center of gravity appropriate thereto and, except as otherwise specified, at the maximum weight for which certification is sought, and there shall be no flight or operating characteristic which makes the airplane unairworthy.

04.131 Controllability. The airplane shall be safely controllable and maneuverable during take-off, climb, level flight, dive, and landing, and 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. The airplane shall be demonstrated to comply with the following:

04.1310 Longitudinal control.

04.13100 When a tail wheel landing gear is used it shall be possible during take-off ground run, to maintain any attitude up to thrust line level at 80% V_{s_1} when running on a concrete runway.

04.13101 It shall be possible at all speeds between 1.4 V_{s_1} and V_{s_1} to pitch the nose downward so that the rate of increase in airspeed is satisfactory for prompt acceleration to a speed equal to 1.4 V_{s_1} with:

(a) the airplane trimmed at 1.4 V_{s_1} with landing gear extended,
(b) the wing flaps in a retracted and extended position,
(c) power off and maximum continuous power on all engines.

04.13102 During each of the controllability demonstrations outlined below, it shall not require 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. Each maneuver shall be performed with the landing gear extended.

(a) (1) With power off, flaps retracted, and the airplane trimmed at 1.4 V_{s_1}, the flaps are to be extended as rapidly as possible while maintaining the airspeed at an adequate margin of approximately 40% above the stalling speed.

(2) Repeat (a)(1) except start with flaps extended and the airplane trimmed at 1.4 V_{s_1}, then retract the flaps as rapidly as possible.

(3) Repeat (a)(1) except using maximum continuous power.

(4) Repeat (a)(2) except using maximum continuous power.

(b) (1) With power off, the flaps retracted, and the airplane trimmed at 1.4 V_{s_1}, apply take-off power quickly while maintaining the same airspeed.

(2) Repeat (b)(1) except with the flaps extended.

(c) With power off, flaps extended, and the airplane trimmed at 1.4 V_{s_1}, obtain and maintain airspeeds within the range of 1.1 V_{s_1} to 1.7 V_{s_1} or to the flap placard speed, whichever is greater.

04.13103 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.

04.1311 Lateral and directional control.

04.13110 It shall be possible to execute 20° banked turns with or against the inoperative engine from steady climb at a speed equal to 1.4 V_{s_1}, with:

(a) the critical engine inoperative and its propeller in the minimum drag condition,
(b) maximum continuous power on the operating engines,
(c) most unfavorable center of gravity,
(d) landing gear retracted and extended,
(e) wing flaps in the most favorable climb position,
(f) maximum take-off weight.

04.13111 In the configuration outlined in § 04.13110 above, it shall be possible, while holding the wings level laterally, to execute sudden changes in heading in either direction without dangerous characteristics being encountered. This shall be demonstrated at a speed equal to 1.4 V_{s_1} at landing weight, approach flaps, one engine inoperative, gear retracted, and power for level flight at 1.4 V_{s_1}, up to heading changes of 15°, except that the heading change at which the rudder pedal force is 180 pounds need not be exceeded.

04.13112 Airplanes with four or more engines installed shall comply with § 04.13110 and § 04.13111 with the two critical engines inoperative, at an airplane weight at which the rate of climb is equal to at least .01 $V_{s_0}^2$ at an altitude of 5,000 feet with the landing gear retracted and the wing flaps in the most favorable position.

04.1312 Minimum control speed. (V_{mc}) The minimum speed after recovery at which the airplane can be maintained in straight flight with zero yaw (or, at the option of the applicant, with a bank not in excess of 5°) after any one engine is suddenly made inoperative during steady flight at that speed, shall be determined and shall not exceed 1.2 V_{s_1} with:

(a) Take-off or maximum available power in all engines,
(b) rearmost center of gravity,
(c) flaps in take-off position,
(d) landing gear retracted.

In demonstrating this minimum speed, the rudder force required to maintain it shall not exceed 180 pounds, nor shall it be necessary to throttle the remaining engines. During recovery 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.

04.132 Trim. 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 will maintain:

(a) Lateral and directional trim under all conditions of operation consistent with the intended use of the airplane including operation at any speed from 1.4 V_{s_1} to at least 90% of high speed and operation in which there is greatest lateral variation in the distribution of the useful load.

(b) Longitudinal trim under the following conditions:

(1) 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.

(2) 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 under the forward center of gravity position approved for landing with the maximum landing weight and under the most forward center of gravity position approved for landing, regardless of weight,

(3) during level flight at any speed from 1.4 V_{s_1} to 90% of the high speed with the landing gear both retracted and extended and wing flaps retracted.

(c) Longitudinal and directional trim at a speed equal to 1.4 V_{s_1}, during climbing flight with the critical engine inoperative, with:

(1) the other engine(s) at maximum continuous power,
(2) the landing gear retracted,
(3) wing flaps retracted.

(d) Rectilinear flight at the climb speed, configuration, and power used in establishing the rates of climb in § 04.1232, the most unfavorable center of gravity position, and the weight at which the two-engine inoperative climb is equal to at least .01 $V_{s_1}^2$ at an altitude of 5,000 feet.

<u>04.133 Stability</u>. The airplane shall be longitudinally, directionally, and laterally stable in accordance with the following subsections. Suitable stability and control "feel" (static stability) may be required in other conditions normally encountered in service if flight tests show such stability to be necessary for safe operation.

<u>04.1331 Static longitudinal stability</u>. In the configurations outlined in § 04.13310 below, and with the airplane trimmed as indicated, the characteristics of the elevator control forces and friction shall be as described below.

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

(b) The airspeed shall return to within 10% of the original trim speed when the control force is slowly released from any speed within the limits defined in (a) above.

04.13310 Specific conditions. In conditions (a), (b) and (c) below, within the speeds specified, 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.

(a) 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:

(1) wing flaps in the landing position,
(2) the landing gear extended,
(3) maximum sea level landing weight,
(4) throttles closed on all engines,
(5) the airplane trimmed at 1.4 V_{s_1} with throttles closed.

(b) 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:

(1) wing flaps in sea level approach position,
(2) landing gear retracted,
(3) maximum sea level landing weight,
(4) the airplane trimmed at 1.4 V_{s_1} and with power sufficient to maintain level flight at this speed.

(c) Climb. The stick force curve shall have a stable slope at all speeds between 1.2 V_{s_1} and 1.6 V_{s_1} with:

(1) wing flaps retracted,
(2) landing gear retracted,
(3) maximum sea level take-off weight,
(4) 75% of maximum continuous power,
(5) the airplane trimmed at 1.4 V_{s_1}.

(d) Cruising.

(1) Between 1.3 V_{s_1} and the maximum permissible speed, the stick force curve shall have a stable slope at all speeds obtainable with a stick force not in excess of 50 pounds, with:

(a) landing gear retracted,
(b) wing flaps retracted,
(c) maximum sea level take-off weight,
(d) 75% of maximum continuous power,
(e) the airplane trimmed for level flight with 75% of the maximum continuous power.

(2) Same as (1) above except that the landing gear shall be extended and the level flight trim speed need not be exceeded.

04.1332 Dynamic longitudinal stability. Any short period oscillation occurring between stalling speed and maximum permissible speed shall be heavily damped with the primary controls in (1) free, and (2) in a fixed position.

04.1333 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_{s1} up to the maximum permissible speed.

(b) The static lateral stability, as shown by the tendency to raise the low wing in a sideslip, shall be positive within the same limits.

(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 satisfactory limits up to sideslip angles considered appropriate to the operation of the type. 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 adequately any departure from steady unyawed flight unless a yaw indicator is provided.

(d) Any short period oscillation occurring between stalling speed and maximum permissible speed shall be heavily damped with the primary controls in (1) free, and (2) in a fixed position.

04.134 Stalling. Stalls shall be demonstrated under two conditions;

(a) with power off,

(b) with that power necessary to maintain level flight at a speed of 1.6 V_{s1} with flaps in approach position, landing gear retracted, maximum landing weight.

In either condition it shall be possible, with flaps and landing gear in any position, center of gravity in the most unfavorable position for recovery and with appropriate airplane weights and the airplane in straight flight and in turns up to 30° bank, to produce and to correct roll and yaw by unreversed use of the aileron and rudder controls in the maneuver described below up to the time when the airplane pitches. In straight flight stalls the average amount of roll occurring between the initiation of the pitching movement and the completion of the recovery shall not exceed 20°. The roll following the stall during turning flight must not be so violent or extreme as to make it difficult, with normal piloting skill, to make a prompt recovery and regain control of the airplane.

Clear and distinctive stall warning shall be apparent to the pilot at a speed at least 5% above the stalling speed, with flaps and landing gear in any position, both in straight and turning flight. The warning may be furnished either through the inherent aerodynamic qualities of the airplane, by a suitable instrument, or in any equivalent fashion which will give clearly distinguishable indications under all conditions of flight that are to be expected in airline operations.

In demonstrating these qualities, the order of events shall be:

(a) With trim controls adjusted for straight flight at a speed of 1.4 V_{s_1} reduce speed by means of the elevator control until the speed is steady at slightly above stalling speed; then,

(b) Pull elevator control 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 may be made after such pitching motion is unmistakably developed.

<u>04.1340 Stall test one-engine inoperative.</u> The airplane shall be safely recoverable without applying power to the inoperative engine when stalled with:

(a) the critical engine inoperative,
(b) flaps and landing gear retracted,
(c) the remaining engines operating at up to 75% of maximum continuous power, except that the power need not be greater than that at which the use of maximum control travel does not hold the wings laterally level. The operating engines may be throttled back during the recovery from the stall.

<u>04.14 Ground and water characteristics.</u> All airplanes shall comply with the following requirements.

<u>04.141 Longitudinal stability and control.</u> There shall be no uncontrollable tendency for landplanes to nose over in any operating condition reasonably expected for the type or when rebound occurs during landing or take-off. Wheel brakes shall operate smoothly and shall exhibit no undue tendency to induce nosing over.

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

<u>04.142 Directional stability and control.</u>

(a) There shall be no uncontrollable or dangerous looping tendency in 90° cross winds up to 0.2 V_{s_0} at any necessary speed upon the ground or water.

(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 adequate directional control during taxiing.

04.143 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.

04.144 Spray characteristics. For seaplanes, spray during taxiing, 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.

04.145 Critical cross wind. There shall be established a critical cross component of wind velocity at which it has been demonstrated to be safe to take-off or land.

04.15 Flutter and vibration. All parts of the airplane shall be demonstrated to be free from flutter and excessive vibration under all speed and power conditions appropriate to the operation of the airplane up to at least the minimum value permitted for V_d in § 04.2110. There shall also be no buffeting condition in any normal flight condition severe enough to interfere with the satisfactory control of the airplane, or to cause excessive fatigue to the crew or structural damage. However, buffeting as stall warning is considered desirable, and discouragement of this type of buffeting is not intended.

04.2 STRENGTH REQUIREMENTS

04.20 General.

04.200 Loads. Strength requirements are specified in terms of limit and ultimate loads. Limit loads are the maximum loads anticipated in service. Ultimate loads are equal to the limit loads multiplied by the factor of safety. When not otherwise described, loads specified are limit loads. Unless otherwise provided, the specified air, ground, and water loads shall be placed in equilibrium with inertia forces, considering all items of mass in the airplane. All such loads shall be distributed in a manner closely approximating or conservatively representing actual conditions. If deflections under load would significantly change the distribution of external or internal loads, such redistribution shall be taken into account.

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

04.202 Strength and deformations. The structure shall be capable of supporting limit loads without suffering detrimental permanent deformations. At all loads up to limit loads the deformation shall be such as not to interfere with safe operation of the airplane. The structure shall be capable of supporting ultimate loads without failure for at least 3 seconds.

04.203 Proof of structure. Proof of compliance of the structure with the strength and deformation requirements of § 04.202 shall be made for all critical loading conditions. Proof of compliance by means of structural analysis will be accepted only when the structure conforms with types for which experience has shown such methods to be reliable. In all other cases substantiating tests are required. In all cases certain portions of the structure must be tested as specified in § 04.3.

04.21 Flight loads.

04.210 General. Flight load requirements shall be complied with at critical altitudes within the range for which certification is desired, and at all weights between the minimum design weight and design take-off weight with any practicable distribution of disposable load within prescribed operating limitations stated in the airplane operating manual. (See § 04.6.)

04.2101 Definition of flight load factor. The flight load factors specified represent the acceleration (in terms of the gravitational constant) normal to the assumed longitudinal axis of the airplane equal in magnitude and opposite in direction to the airplane inertia load factor at the center of gravity.

04.211 Symmetrical flight conditions (flaps retracted). The strength requirements shall be met at all combinations of airspeed and load factor on and within the boundaries of the V-n diagrams of Figures 04-1 and 04-2 which represent the envelopes of the flight loading conditions specified by the maneuvering and gust criteria of § 04.2111, § 04.2112, and § 04.212. These diagrams will also be used in determining the airplane structural operating limitations as specified in § 04.6.

04.2110 Design airspeeds. The design airspeeds shall be chosen by the designer except that they shall not be less than the following values:

V_f (design flap speed)

= 1.4 V_{s_1} or 1.8 V_{s_0} whichever is greater, where

V_{s_1} = stalling speed, flaps retracted at design landing weight

V_{s_0} = stalling speed, flaps in landing position, design landing weight

(See § 04.212 for provision concerning automatic flap operation)

V_p (design maneuvering speed)

= $V_{s_1}\sqrt{n}$ where n = limit maneuvering load factor used in design (see § 04.2111)

V_{s_1} = stalling speed with flaps retracted at design take-off weight

V_b (design speed for 40 ft. per sec. gust)
The speed at which the effective 40 ft. per sec. gust line intersects the positive $C_{N_{max}}$ curve on the gust V-n envelope (see § 04.2112 and Figure 04-2)

V_c (design cruising speed)

V_c shall not be less than V_b plus 50 except that it need not exceed the speeds at altitude corresponding to a Mach number of 0.52 or the high speed of the airplane in level flight at maximum continuous power for the corresponding altitude. However, in no case shall V_c be less than 1.3 V_{s_1} with flaps retracted at design take-off weight.

V_d (design dive speed)

V_d shall be 1.25 times the value selected for V_c or the selected V_c plus 70 mph, whichever is greater; however V_d need not exceed the speed corresponding to a Mach number of 0.65. In any event, V_d need not exceed the terminal velocity in a dive at 30° to the horizontal. At all speeds in excess of those corresponding to a Mach number of 0.65, compressibility effects shall be taken into account.

04.2111 Maneuvering envelope. The airplane shall be assumed to be subjected to symmetrical maneuvers resulting in the following limit load factors except where limited by maximum (static) lift coefficients:

(a) The positive maneuvering load factor, n, at all speeds up to V_d. The value of n shall be selected by the designer except that it shall not be less than 2.5.

(b) The negative maneuvering load factor shall have a minimum value of -1.0 at all speeds up to V_c; and factors varying linearly with speed from the specified value at V_c to 0.0 at V_d.

Lower values of maneuvering load factor may be employed only if it be proven that the airplane embodies features of design which make it impossible to exceed such values in flight.

04.2112 Gust envelope. The airplane shall be assumed to encounter symmetrical vertical gusts as specified below while in level flight. The resulting loads shall be considered limit loads.

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

(b) Positive and negative gusts of 30 fps at V_c.

(c) Positive and negative 15 fps gusts at V_d. Gust load factors shall be assumed to vary linearly between the specified conditions as shown on the gust envelope of Figure 04-2.

04.21120 Gust load factors. In applying the gust requirements, the gust load factors shall be computed by the following formula:

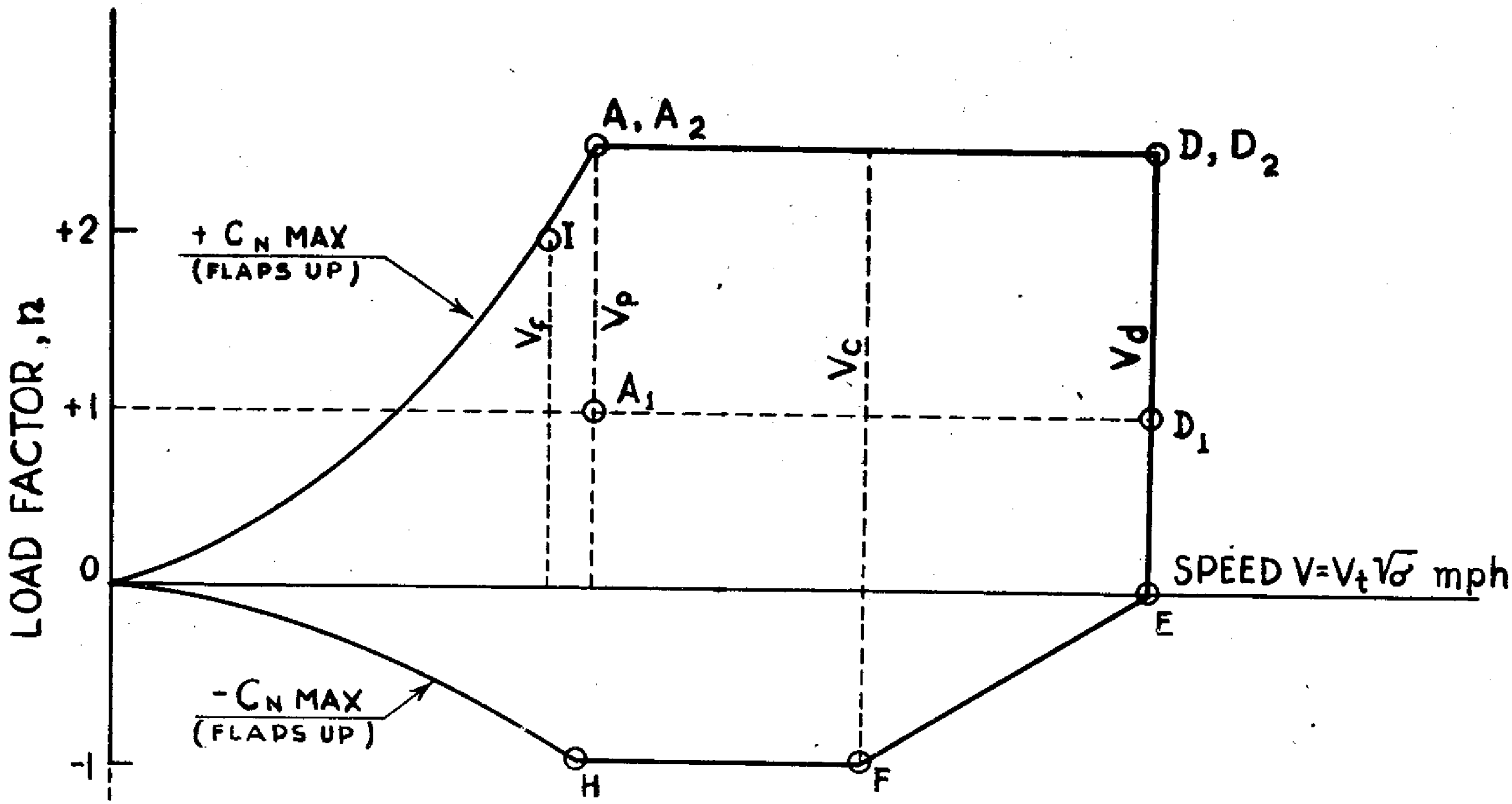
$$n = 1 + \frac{K\,U\,V\,a}{575\,(W/S)}$$

where

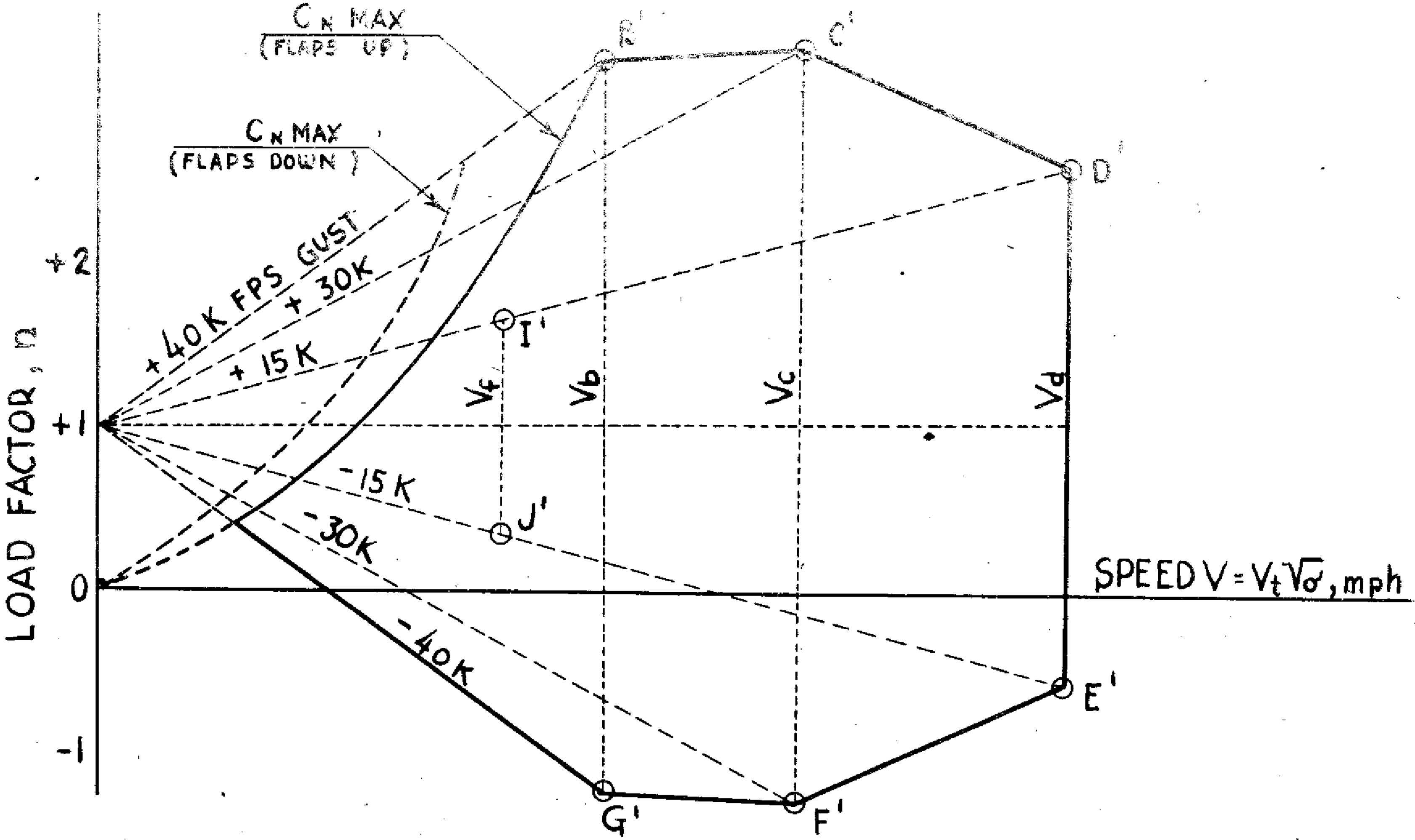
$$K = \frac{1}{2}\left(\frac{W}{S}\right)^{1/4} \quad \text{(for } W/S < 16 \text{ psf)}$$

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

U = nominal gust velocity, ft. per second.



MANEUVERING ENVELOPE (SEE 04.2111)
LOAD FACTOR VS VELOCITY (V-n) DIAGRAM
FIG. 04-1



GUST ENVELOPE (SEE 04.2112)
LOAD FACTOR VS VELOCITY (V-n) DIAGRAM
FIG. 04-2

(Note that the "effective sharp edged" gust equals K U)

V = airplane speed, miles per hour

a = slope of airplane normal force coefficient curve, C_{na} per radian, corrected for aspect ratio

W/S = wing loading, pounds per square foot

04.212 High lift devices extended conditions. 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. The gust load factors shall be computed by the formula of § 04.21120. In designing the flaps and supporting structures, slipstream effects must be taken into account as specified in § 04.225. When automatic flap operation is provided, the airplane may be designed for the speeds and corresponding flap positions which the mechanism permits. (See § 04.00 and § 04.353).

04.213 Investigation of specific conditions.

04.2130 General. A sufficient number of points on the maneuvering and gust envelopes shall be investigated to insure that the maximum load for each member of the airplane structure has been obtained. A conservative combined envelope may be used for this purpose if desired. At least the conditions specified in the following subsections shall be investigated unless shown to be non-critical.

All significant forces acting on the airplane shall be placed in equilibrium in a rational or conservative manner. At least the following forces shall be considered in establishing such equilibrium:

(a) Linear inertia forces in equilibrium with wing and horizontal tail surface loads.

(b) Pitching (angular) inertia forces in equilibrium with wing and fuselage aerodynamic moments and horizontal tail surface loads.

Terms used in the following subsections are defined as follows:

A "balancing tail load" is that necessary to place the airplane in equilibrium with zero pitching acceleration.

A "checked 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.

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

04.2131 Maneuvering conditions.

04.21310 Balanced conditions. The maneuvering conditions A through I on the maneuvering envelope (Figure 04-1) shall be investigated assuming the airplane in equilibrium with zero pitching acceleration.

04.21311 Pitching conditions. The following conditions on Figure 04-1 involving pitching acceleration shall be investigated.

(a) A_1, Unchecked pull-up at speed, V_p. The airplane shall be assumed to be flying in steady level flight and the pitching control suddenly moved to obtain extreme positive pitching, except as limited by pilot effort, § 04.221.

(b) A_2, Checked maneuver at speed, V_p. The airplane shall be assumed to be maneuvered to the limit positive maneuvering load factor by a checked maneuver from an initial condition of steady unaccelerated flight. The initial positive pitching portion of this maneuver may be considered covered by condition (a) above.

A negative pitching acceleration of at least the following value shall be assumed to be attained concurrently with the airplane limit maneuvering load factor, unless it is shown that a lesser value could not be exceeded:

$$-\frac{30}{V_p} n\ (n - 1.5) \quad (\text{radians / sec}^2)$$

(c) D_1 and D_2, Checked maneuver at V_d. The airplane shall be assumed to be maneuvered to the limit positive maneuvering load factor by a checked maneuver from steady unaccelerated flight.

Positive and negative pitching accelerations of at least the following values shall be assumed to be attained concurrently with the specified airplane load factors, unless it is shown that lesser values could not be exceeded:

Condition D_1: $+\frac{45}{V_d} n\ (n-1.5)$ (radians/sec^2) with the airplane at unity load factor.

Condition D_2: $-\frac{30}{V_d} n\ (n-1.5)$ (radians/sec^2) with the airplane at maneuvering load factor.

where n = limit maneuvering load factor in both equations.

04.2132 Gust conditions. The gust conditions B^1 through J^1 on Figure 04-2 shall be investigated. The airload increment due to a specified gust shall be added to the initial balancing tail load corresponding to steady unaccelerated flight. The alleviating effects of wing downwash may be included in computing the tail gust load increment.

04.214 Unsymmetrical flight conditions. The airplane shall be assumed to be subjected to rolling and yawing maneuvers as described in the following conditions. Unbalanced aerodynamic moments about the center of gravity shall be reacted in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces.

04.2140 Rolling conditions.

04.21400 The airplane shall be designed for the loads resulting from the following aileron deflections and speeds, (except as limited by pilot effort as specified in § 04.221) in combination with an airplane load factor of at least 2/3 of the positive maneuvering factor used in the design of the airplane.

(a) At speed, V_p, assume a sudden displacement of the aileron to the stop. A simplified condition of zero rolling velocity or the actual resulting dynamic condition may be used for design.

(b) When V_c is greater than V_p, the aileron deflection at V_c shall be that required to produce a rate of roll not less than that which would be obtained at the speed and aileron deflection specified in condition (a).

(c) At speed, V_d, the aileron deflection shall be that required to produce a rate of roll not less than 1/3 of that which would be obtained at the speed and aileron deflection specified in condition (a).

04.21401 To cover unsymmetrical gusts, the airplane shall be designed for loads obtained by modifying the symmetrical flight condition A shown on Figure 04-1 by assuming 100% of the wing airload acting on one side of the airplane and 80% on the other.

04.2141 Yawing conditions. The airplane shall be designed for the yawing loads resulting from the following conditions:

04.21410 Maneuvering loads. At all speeds from V_s to V_c, the following vertical tail loads shall be considered:

(a) With the airplane in unaccelerated flight at zero yaw, assume a sudden displacement of the rudder control to the maximum deflection as limited by the control stops or a 300 lb. rudder pedal force, whichever is critical.

In the following conditions it shall be assumed that the airplane yaws to a sideslip angle resulting from the application of the above rudder angle.

(b) Assume that the airplane yaws to the above sideslip angles while the rudder control is maintained at full deflection (except as limited by pilot effort) in the direction tending to increase the sideslip.

(c) Assume that the airplane yaws to the above sideslip angles with the rudder control in the neutral position, except as limited by the pilot effort.

Yawing velocity may be assumed zero in above conditions.

04.21411 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.

The gust loading on the vertical tail surfaces shall be computed by the following formula:

$$\bar{W} = \frac{K\,U\,V_c\,a}{575} \quad \text{where}$$

$\bar{W}$ = average limit unit pressure in pounds per square foot

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

U = nominal gust intensity in feet per second

V_c = design cruising speed in miles per hour

a = slope of lift curve of vertical surface in radians corrected for aspect ratio

S_v = vertical surface area sq. ft.

W = design take-off weight, pounds

04.215 Supplementary flight conditions.

04.2150 Engine torque effects. Engine mounts and their supporting structures shall be designed for engine torque effects combined with certain basic flight conditions as described in (a) and (b) below. Engine torque may be neglected in the other flight conditions.

(a) The limit torque corresponding to take-off power and propeller speed acting simultaneously with 75% of the limit loads from flight condition A (see Figure 04-1).

(b) The limit torque corresponding to maximum continuous power and propeller speed, acting simultaneously with the limit loads from flight condition A (see Figure 04-1).

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.

04.2151 Side load on engine mount. The limit load factor in a lateral direction for this condition shall be at least equal to the maximum obtained in the unsymmetrical flight (yawing) conditions but shall not be less than either 1/3 the limit load factor for flight condition A (see Figure 04-1) or 1.33. Engine mounts and their supporting structure shall be designed for this condition which may be assumed independent of other flight conditions.

04.2152 Pressure cabin loads.

(See § 04.38260).

04.22 Control surface loads.

04.220 General. The control surfaces shall be designed for the limit loads resulting from the symmetrical and unsymmetrical flight condition as described in § 04.213 and § 04.214 with the following provisions.

04.221 Pilot effort. In the control surface flight loading conditions, the airloads 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 04-3, except that 2/3 of the maximum values specified for the aileron and elevator may be used when reliable control surface hinge moment data are available. In applying this criterion, proper consideration shall be given to the effects of servo mechanisms, tabs, and automatic pilot systems in assisting the pilot.

04.222 Trim tab effects. 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 § 04.221. 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 § 04.226.

04.223 Unsymmetrical loads. The maximum horizontal tail surface loading (that is, load per unit area) as determined by the preceding subsections shall be applied to the horizontal surfaces on one side of the plane of symmetry and 80% of that loading shall be applied to the opposite side.

04.224 Outboard fins. 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. When outboard fins extend above and below the horizontal surface, the maximum vertical surface loading (load per unit area) as determined by § 04.220 shall be applied to the portion of the vertical surfaces above (or below) the horizontal surface, and 80% below (or above) the horizontal surface.

04.225 Wing flaps. Wing flaps, their operating mechanism and supporting structure shall be designed for critical loads occurring in the High lift devices extended conditions (§ 04.212) with the flaps extended to any position from fully retracted to landing position. The effects of propeller slipstream corresponding to take-off power shall be taken into account at an airplane speed of not less than 1.4 V_{s1} where V_{s1} is the stalling speed with flaps retracted at the appropriate weight, that is, landing weight for landing, and approach settings, and take-off for take-off setting. (For automatic flaps, see § 04.212).

04.226 Tabs. 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 V-n diagram, (Figure 04-1) except as limited by the stops. 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. Balancing and servo tabs shall be designed for deflections consistent with the primary control surface loading conditions.

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

04.23 Control system loads.

04.230 Primary flight controls and systems. Flight control systems and supporting structures shall be designed for loads corresponding to 125% of the computed hinge moments of the movable control surface in the conditions prescribed in § 04.22, subject to the following maxima and minima:

(a) The system limit loads, except the loads resulting from ground gusts, § 04.231, need not exceed those which can be produced by the pilot or pilots and automatic devices operating the controls.

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

Acceptable maximum and minimum pilot loads for elevator, aileron, and rudder controls are shown in Figure 04-3. 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.

04.2300 Dual controls. When dual controls are provided, the system shall be designed for the pilots operating in opposition, using individual pilot loads equal to 75% of those obtained in accordance with § 04.230, except that the individual pilot loads shall not be less than the minimum loads specified in Figure 04-3.

In addition the control system (but not the control surfaces) shall be designed for the pilots acting in conjunction, using individual pilot loads equal to 75% of those obtained in accordance with § 04.230.

04.231 Ground gust conditions. The following ground gust conditions, intended to simulate the loadings on control surfaces due to ground gusts and taxiing tail to wind, shall be investigated. The limit hinge moment, H, shall be obtained from the following formula:

$H = K\,c\,Sq$, where

H = limit hinge moment (ft. lb.)
c = Mean chord (aft) of the control surface aft of the hinge line

S = area of control surface (sq. ft.) <u>aft</u> of the hinge line

q = dynamic pressure (psf) to be 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 below:

Surface	K	Remarks
Aileron	+ 0.75	Control column locked or lashed in mid-position
	± 0.50	Ailerons at full throw, + moment on one aileron - moment on other
Elevator	± 0.75	Elevator (a) full up, and (b) full down
Rudder	± 0.75	Rudder (a) in neutral and (b) at full throw

As used above in connection with ailerons and elevators, 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.

FIGURE 04-3

PILOT CONTROL FORCE LIMITS

	LIMIT PILOT LOADS	
CONTROL	MAXIMUM LOAD	MINIMUM LOAD
Aileron: Stick Wheel (1)	 100 lbs. 80 D in. lbs. (2)	 40 lbs. 40 D in. lbs.
Elevator: Stick Wheel	 250 lbs. 300 lbs.	 100 lbs. 100 lbs.
Rudder	300 lbs.	130 lbs.

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

(2) D = wheel diameter.

04.232 Secondary controls and systems. Secondary controls, such as wheel brakes, spoilers, 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 04-4 may be used.

FIGURE 04-4

PILOT CONTROL FORCE LIMITS

SECONDARY CONTROLS

CONTROL	LIMIT PILOT LOADS
Miscellaneous:* Crank wheel or lever	$\frac{1 + R}{3} \times 50$ 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	No requirement - leave to discretion of designer

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

04.24 Ground loads. The limit loads specified in the following paragraphs shall be considered as the minimum acceptable structural requirements for landing and ground handling conditions. These limit loads 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.

04.240 Design weights. The critical center of gravity position within the limits for which certification is desired shall be selected such that the maximum design loads in each of the landing gear elements are obtained for both the design landing weight and the design take-off weight, as defined in § 04.071.

04.241 Load factor for landing conditions. In the following landing conditions the limit vertical inertia load factor at the center of gravity of the airplane shall be chosen by the designer, but shall not be less than the value which would be obtained when landing the airplane with a descent velocity as follows:

(a) Landing at the design landing weight with a limit descent velocity of 10 fps,

(b) Landing at the design take-off weight with a limit descent velocity of 6 fps.

Wing lift not exceeding 2/3 of the airplane weight may be assumed to exist throughout the landing impact and may, if desired, be assumed to act through the airplane c.g. The ground reaction load factor is then equal to the inertia load factor minus the ratio of the assumed wing lift to the airplane weight. (See § 04.3610 for requirements concerning the energy absorption tests which determine the minimum limit inertia load factors corresponding to the required limit descent velocities).

The above requirements are predicated on conventional arrangements of main and nose gears, or main and tail gears, and normal operating techniques. These velocities may be appropriately modified if it can be shown that the airplane embodies features of design which make it impossible to develop these velocities, in which case lower values may be used subject to the approval of the Administrator.

04.242 Landing cases and attitudes. The airplane shall be assumed to contact the ground with the specified vertical velocities in the following attitudes:

04.2420 Level landing. In the level attitude, the airplane shall be assumed to contact the ground with the rates of descent specified in § 04.241 at a forward velocity component parallel to the ground equal to 1.2 V_{sf}. The following two combinations of vertical and drag components shall be considered acting at the axle centerline:

(a) 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. This condition may be considered to apply only to the landing gear and the directly affected attaching structure.

(b) Condition of maximum wheel vertical load: An aft acting drag component not less than 25% of the maximum vertical ground reaction shall be combined with the maximum ground reaction of § 04.241.

<u>04.24201</u> <u>Tail wheel type</u>. The airplane horizontal reference line shall be assumed horizontal. Two conditions shall be investigated: (See Figure 04-5).

(a) Condition of maximum wheel spin-up load.
(b) Condition of maximum wheel vertical load.

<u>04.24202</u> <u>Nose wheel type</u>. Two airplane attitudes shall be considered. (See Figure 04-6).

(a) Main wheels contacting the ground with the nose wheel just clear of the ground. Two conditions shall be investigated:

(1) Condition of maximum wheel spin-up load.
(2) Condition of maximum wheel vertical load.

(b) Nose and main wheels contacting the ground simultaneously. (Unless such an attitude cannot reasonably be attained at the specified descent and forward velocities.) Two conditions shall be investigated:

(1) Condition of maximum wheel spin-up load. The nose and main gear may be investigated separately for this condition neglecting pitching moments due to wheel spin-up loads.

(2) Condition of maximum wheel vertical load. The pitching moment shall be assumed to be resisted by the nose gear.

<u>04.2421</u> <u>Tail down landing</u>. The following conditions shall be investigated for the <u>limit</u> vertical landing gear load factor obtained in § 04.241 with the vertical ground reactions applied to the landing gear axles.

(a) <u>Tail wheel type</u>. The main and tail wheels shall be assumed contacting the ground simultaneously. (See Figure 04-7). The ground reaction on the tail wheel, as determined from the above, shall be assumed to act in the following directions: (a) vertical, (b) up and aft through the axle at 45° to the ground line.

(b) <u>Nose wheel type</u>. The airplane shall be at the stalling attitude or the maximum angle permitting clearance of the ground by all parts of the airplane, whichever is the lesser. (See Figure 04-8.)

<u>04.2422</u> <u>One wheel landing</u>. The main landing gear on one side of the airplane centerline shall contact the ground in the level attitude. (See Figure 04-9.) The ground reaction on this side may be taken the same as those obtained in § 04.2420. The unbalanced external loads shall be rationally or conservatively reacted by inertia of the airplane.

04.2423 Lateral drift landing. The airplane shall be in the level attitude with only the main wheels contacting the ground. (See Figure 04-10.) 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. (§ 04.2420). These loads are applied at the ground contact point and may be assumed resisted by the inertia of the airplane. Drag loads may be assumed zero.

04.243 Taxi and ground handling cases. The landing gear and airplane structure shall be investigated for the following conditions in which the airplane shall be at the design take-off weight. No wing lift shall be considered.

04.2430 Take-off run. The landing gear and airplane structure shall be designed for loads not less than those resulting from the condition specified in § 04.143.

04.2431 Braked roll.

(a) Tail wheel type: The airplane shall be assumed in the level attitude with all load on the main wheels The limit vertical load factor shall be 1.2. A drag reaction equal to the vertical reaction multiplied by a coefficient of friction of 0.8 shall be applied at the ground contact point in combination with the vertical ground reaction. (See Figure 04-11.)

(b) Nose wheel type: The limit vertical load factor shall be 1.2. A drag reaction equal to 0.8 of the vertical reaction shall be combined with the vertical reaction and applied at the ground contact point of each wheel having brakes. Two airplane attitudes shall be considered. (See Figure 04-13.)

(1) The airplane in the level attitude with all wheels contacting the ground assuming zero pitching acceleration and the loads distributed between the main and nose gear by the principles of statics.

(2) The airplane in the level attitude with only the main gear contacting the ground and the pitching moment resisted by angular acceleration.

04.2432 Ground maneuvering.

04.24320 Turning. The airplane in the static position shall be assumed to execute a steady turn by nose gear steering or differential power such that the limit load factors applied at the center of gravity are 1.0 vertically and 0.5 laterally. The side ground reaction at each wheel shall be 0.5 of the vertical reaction. (See Figures 04-12 and 04-14.)

04.24321 Pivoting. The airplane shall be assumed to pivot about one main gear, the brakes on that gear 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 04-15).

04.24322 Nose wheel yawing.

(a) A vertical load factor of 1.0 at the airplane c.g. 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.

(b) The airplane shall be placed in static equilibrium with the loads resulting from the application of the brakes on one main gear. The vertical load factor at the c.g. shall be 1.0. The forward acting load at the airplane c.g. shall be 0.8 V_m where V_m is the vertical load on one main gear. The side and vertical loads at the ground contact point on the nose gear are those required for static equilibrium. The side load factor at the airplane c.g. shall be assumed zero.

04.24323 Tail wheel yawing. 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. When a swivel is provided, the tail wheel shall be assumed 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 in the trailing position with the side load acting at the ground contact point.

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

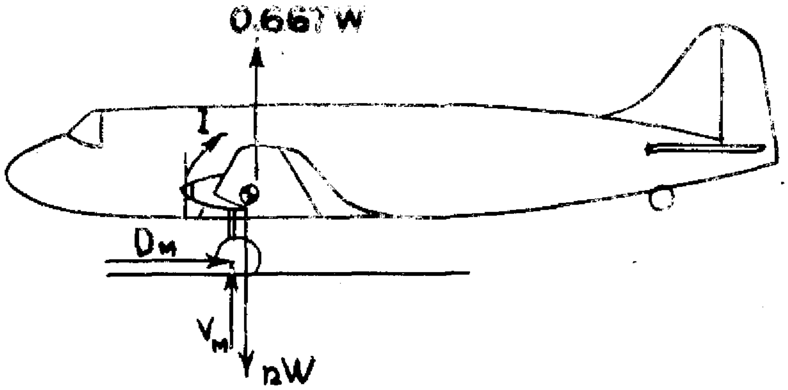
04.25 Water loads. The following requirements shall apply to the entire airplane, but have particular reference to hull structure, wing, nacelles, and float supporting structure.

04.250 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.

04.251 Boat seaplanes.

04.2510 Local bottom pressures.

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

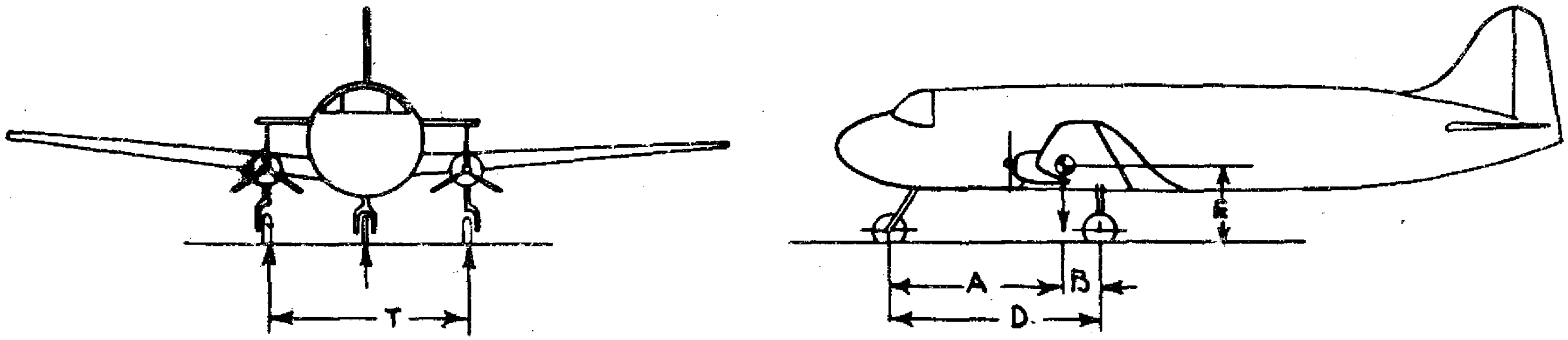


TWO CONDITIONS ARE USED:

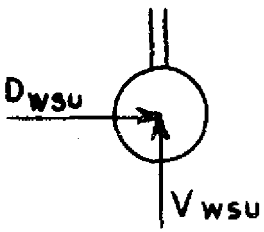
(1) $D_M = \mu V_M$ WHERE V_M IS VERTICAL WHEEL REACTION AT INSTANT WHEELS ARE UP TO SPEED AND μ IS COEFFICIENT OF FRICTION. μ MAY BE ASSUMED EQUAL TO 0.8. nW = VALUE NECESSARY FOR BALANCE.

(2) $D_M = 0.25\ V_M$ WHERE nW IS DETERMINED BY ENERGY ABSORPTION REQUIREMENTS FOR LANDING

FIG. 04-5 LEVEL LANDING
TAIL WHEEL TYPE

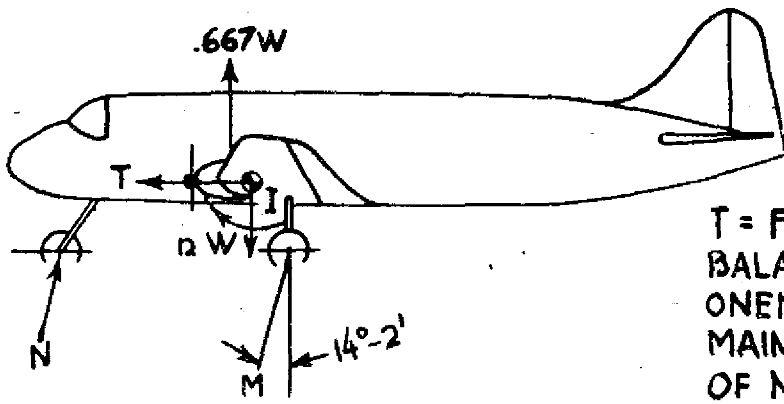


NOSE WHEEL TYPE LANDING GEAR
BASIC DIMENSIONS



CONDITION OF MAXIMUM WHEEL SPIN UP LOAD

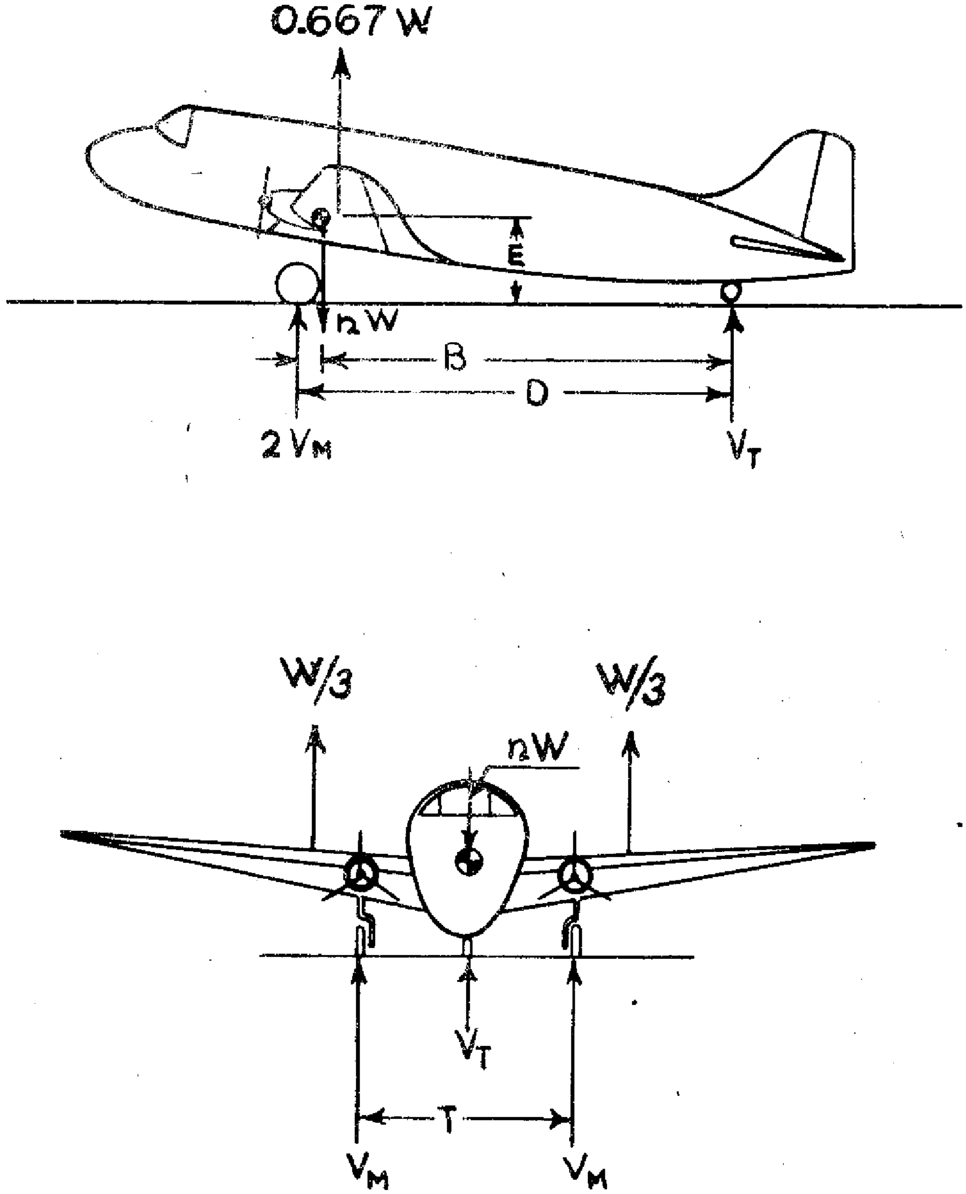
V_{wsu} = VERTICAL LOAD AT INSTANT WHEELS COME UP TO SPEED. $D_{wsu} = \mu V_{wsu}$
μ MAY BE ASSUMED EQUAL TO 0.8



T = FORCE NECESSARY TO BALANCE WHEEL DRAG COMPONENTS. FOR DESIGN OF MAIN GEAR N=0. FOR DESIGN OF NOSE GEAR I=0.

CONDITION OF MAXIMUM VERTICAL LOAD

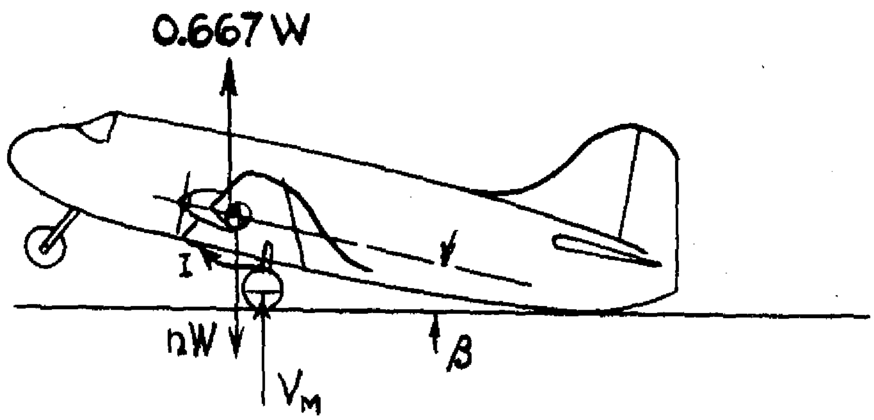
LEVEL LANDING - NOSE WHEEL TYPE
FIG. 04-6



BASIC DIMENSIONS AND TAIL DOWN LANDING

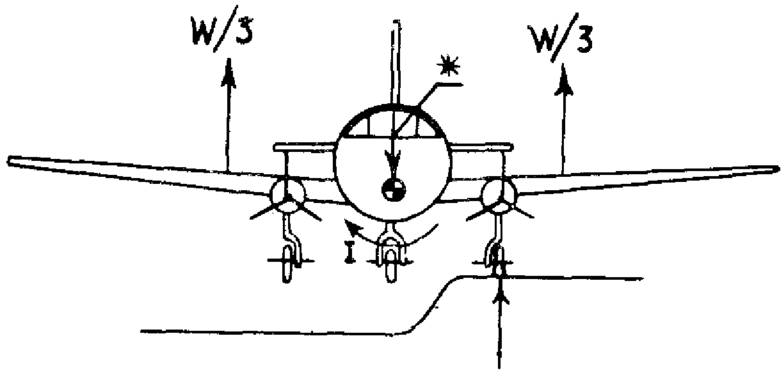
TAIL WHEEL TYPE

FIG. 04-7



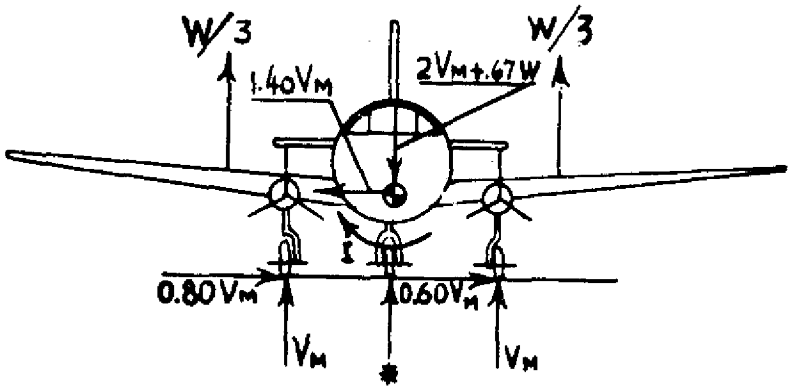
β = ANGLE FOR MAIN GEAR AND TAIL STRUCTURE CONTACTING GROUND EXCEPT NEED NOT EXCEED STALL ANGLE

FIG. 04-8 TAIL DOWN LANDING-NOSE WHEEL TYPE



* THE AIRPLANE INERTIA LOADS REQUIRED
TO BALANCE THE EXTERNAL FORCES

ONE WHEEL LANDING
NOSE OR TAIL WHEEL TYPE
FIG. 04-9



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

* NOSE GEAR GROUND REACTION = O

LATERAL DRIFT LANDING

NOSE OR TAIL WHEEL TYPE
AIRPLANE IN LEVEL ATTITUDE
FIG. 04-10

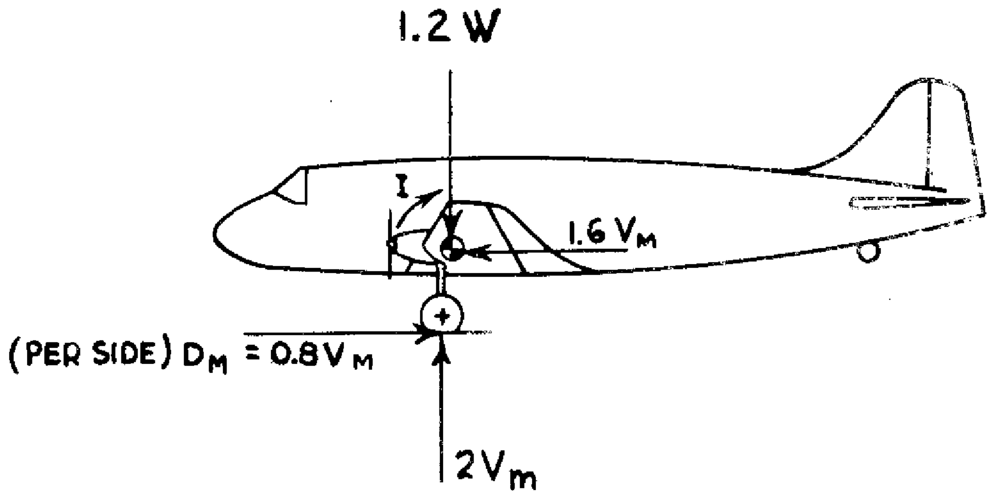


FIG. 04-11 BRAKED ROLL TAIL WHEEL TYPE

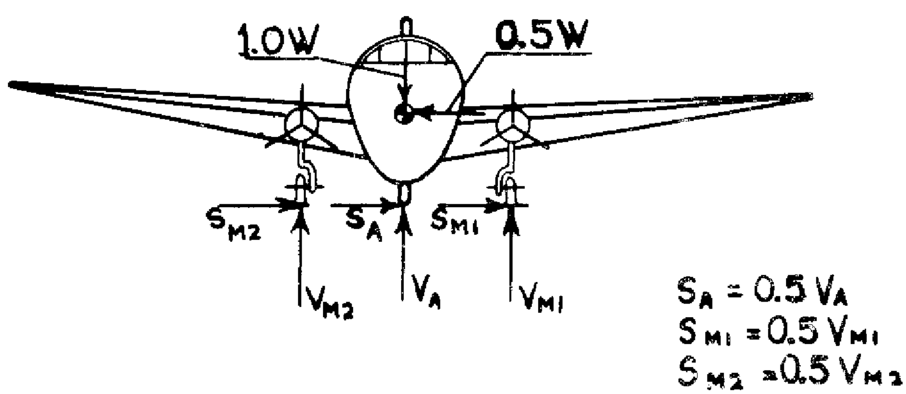
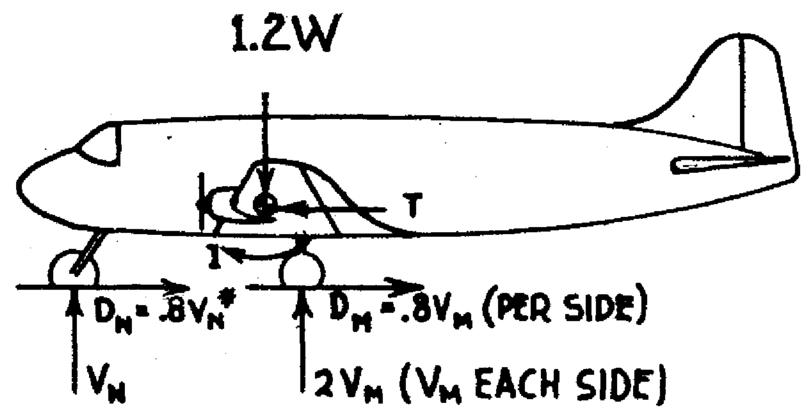


FIG. 04-12 GROUND TURNING TAIL WHEEL TYPE



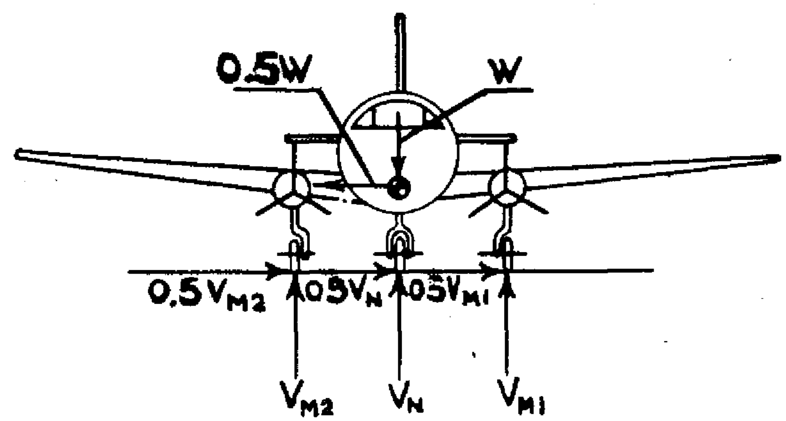
T= INERTIA FORCE NECESSARY TO BALANCE THE WHEEL DRAG FORCES.

* $D_N = 0$ UNLESS NOSE WHEEL IS EQUIPPED WITH BRAKES.

FOR DESIGN OF MAIN GEAR $V_N = 0$

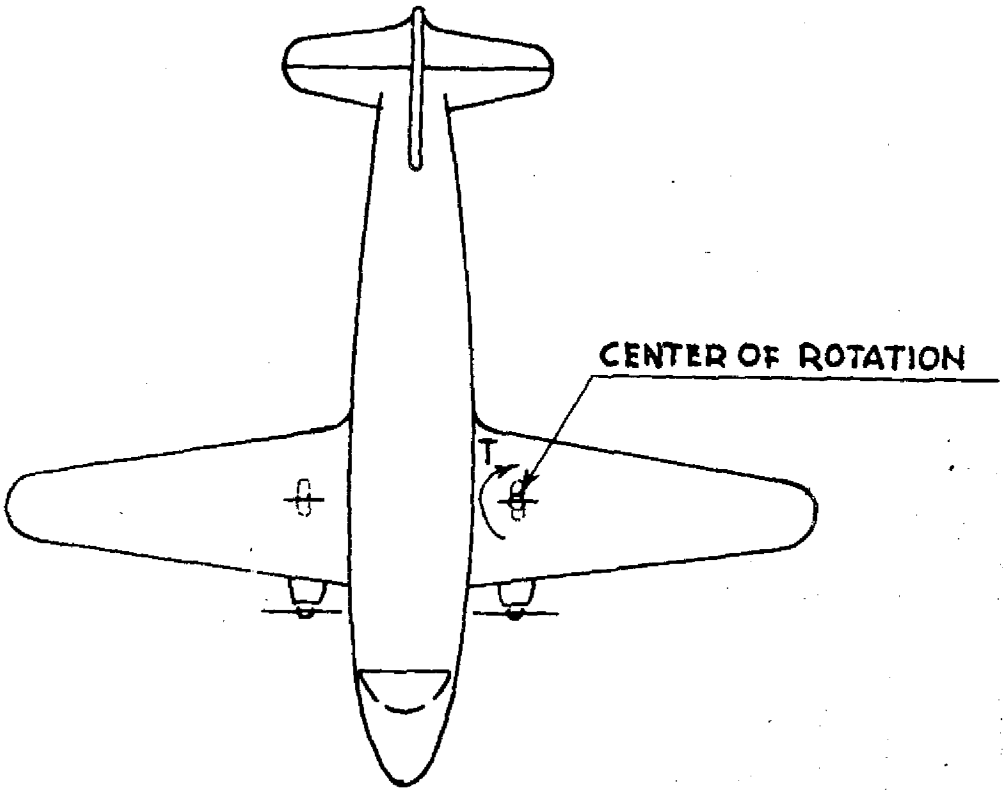
FOR DESIGN OF NOSE GEAR $I = 0$

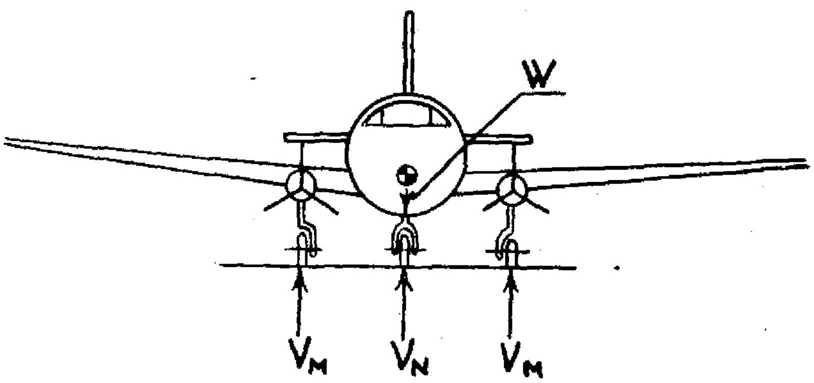
FIG.04-13 BRAKED ROLL - NOSE WHEEL TYPE



THE AIRPLANE INERTIA FACTORS AT THE CENTER OF GRAVITY ARE COMPLETELY BALANCED BY THE WHEEL REACTIONS AS SHOWN

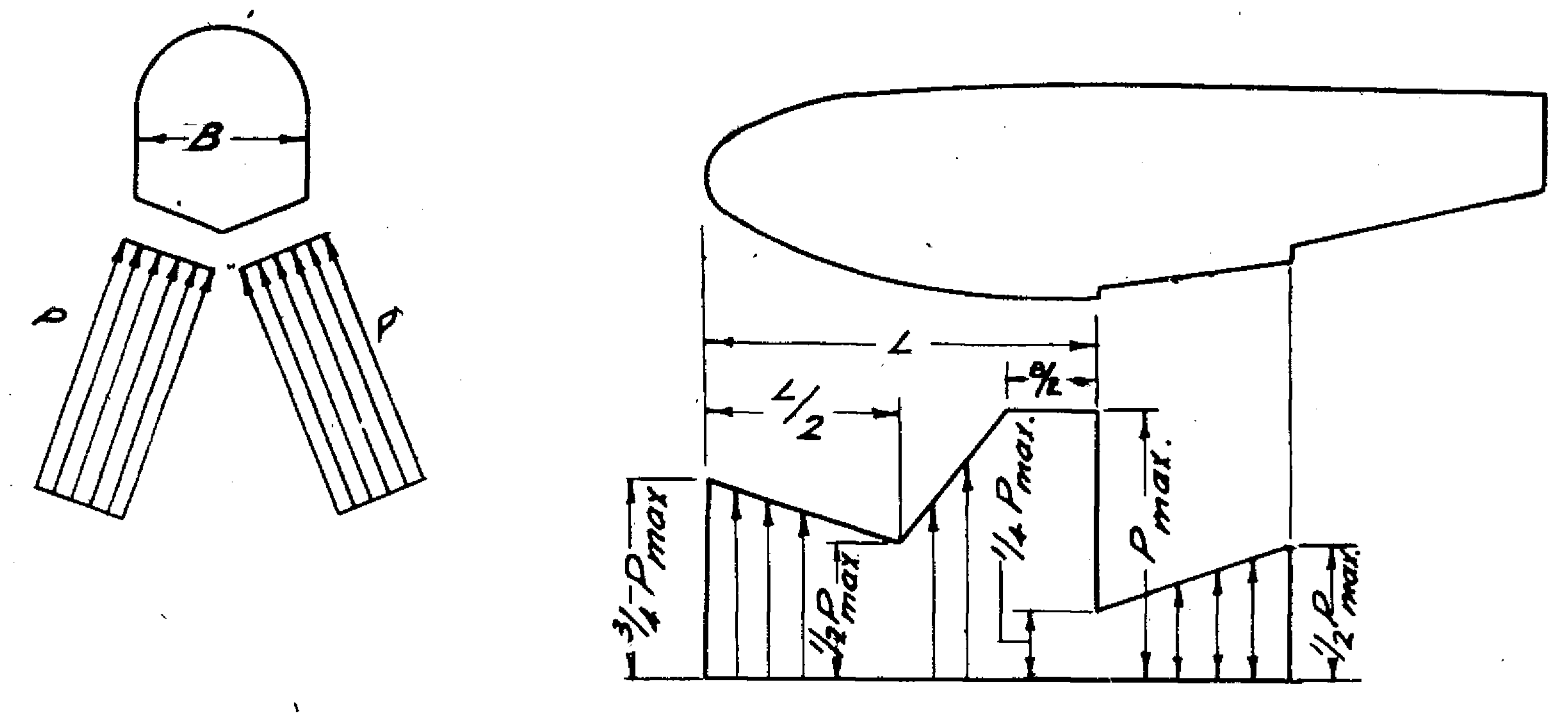
FIG.04-14 GROUND TURNING - NOSE WHEEL TYPE





V_N AND V_M ARE STATIC GROUND REACTIONS
FOR TAIL WHEEL TYPE THE AIRPLANE IS IN THE THREE POINT ATTITUDE WITH STATIC LANDING GEAR REACTIONS, PIVOTING ABOUT ONE MAIN LANDING GEAR UNIT

PIVOTING NOSE OR TAIL WHEEL TYPE
FIG. 04-15



DISTRIBUTION OF LOCAL PRESSURES
BOAT SEAPLANES

FIG. 04-16

$$p_{max} = 0.04 \ V_s^{1.5}$$

where

p = pressure, pounds per square inch

V_s = stalling speed with flaps fully retracted at design take-off weight

(b) Variation in local pressure. The local pressures to be applied to the hull bottom shall vary in accordance with Figure 04-16. 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 (a) and (b) shall be applied over a local area in such a manner as to cause the maximum local loads in the hull bottom structure.

04.2511 Distributed bottom pressures.

(a) For the purpose of designing frames, keels, and chine structure, the limit pressures obtained from § 04.2510, using a value of W not less than design landing weight, and Figure 04-16 shall be reduced to 1/2 the local values and simultaneously applied over the entire hull bottom. The loads so obtained 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 loads.

(b) Unsymmetrical loading. Each floor member or frame shall be designed for a load on one side of the hull centerline equal to the most critical symmetrical loading, combined with a load on the other side of the hull centerline equal to 1/2 of the most critical symmetrical loading.

04.2512 Step loading condition.

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

(b) Acceleration. The limit acceleration shall be 4.0, unless a lower value is substantiated by suitable tests such as impact basin tests.

(c) 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, the water load may be distributed over the hull bottom, using pressures not less than those specified in § 04.2511.

04.2513 Bow loading condition.

(a) 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.

(b) 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 = the load in pounds

n_s = the step landing load factor

W_e = an effective weight which is assumed equal to 1/2 the design landing weight of the airplane.

(c) Hull shear and bending loads. The hull shear and bending loads shall be determined by proper consideration of the inertia loads which resist the linear and angular accelerations involved. To avoid excessive local shear loads, the water reaction may be distributed over the hull bottom, using pressures not less than those specified in § 04.2511.

04.2514 Stern loading condition.

(a) 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 § 04.2511.

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

(c) 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 neglecting internal inertia loads. This condition need not be applied to the fittings or to the portion of the hull ahead of the rear attachment fittings.

04.2515 Side loading condition.

(a) 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 horizontal component at a point half-way between the bottom of the keel and the load waterline at design landing weight (at rest).

(b) Magnitude of load. The limit vertical component of acceleration shall be 3.25 and the side component shall be equal to 15% of the vertical component.

(c) Hull shear and bending loads. The hull shear and bending loads shall be determined by proper consideration of the inertia loads or by introducing couples at the wing attachment points. To avoid excessive local shear loads, the water reaction may be distributed over the hull bottom, using pressures not less than those specified by § 04.2511.

04.252 Float seaplanes.

04.2520 Landing with inclined reactions. The vertical component of the limit load factor shall be 4.0, unless a lower value is substantiated by suitable tests such as impact basin tests. The propeller axis (or equivalent reference line) shall be assumed to be horizontal and the resultant water reaction to be acting in the plane of symmetry and passing through the center of gravity of the airplane, but 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.

04.2521 Landing with vertical reactions (float seaplanes). The limit load factor shall be 4.0 acting vertically, unless a lower value is substantiated by suitable tests, such as impact basin tests. The propeller axis (or equivalent reference line) shall be assumed to be horizontal, and the resultant water reaction to be vertical and passing through the center of gravity of the airplane.

04.2522 Landing with side load (float sea planes). The vertical component of the limit load factor shall be 4.0. The propeller axis (or equivalent reference line) shall be assumed to be horizontal and the resultant water reaction shall be assumed to be in the vertical plane which passes through the center of gravity of the airplane and 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 when twin floats are used. A side load equal to one-fourth 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.

04.253 Seaplane float 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, applied at the bow end of the float and of magnitude equal to that portion of the airplane weight normally supported by the particular float.

(b) A limit load acting upward at the stern of magnitude equal to 0.8 times that portion of the airplane weight normally supported by the particular float.

(c) A limit load, acting upward, applied at the step and of magnitude equal to 1.5 times that portion of the airplane weight normally supported by the particular float.

04.2530 Seaplane float bottom loads. Main seaplane float bottoms shall be designed to withstand the following loads:

(a) A limit bottom pressure of at least the value specified in § 04.2510, applied over that portion of the bottom lying between the first step and a section at 25% of the distance from the step to the bow.

(b) A limit bottom pressure of at least one-half the value specified in (a) above, applied over that portion of the bottom lying between the section at 25% of the distance from the step to the bow and a section at 75% of the distance from the step to the bow.

(c) A limit bottom pressure of at least 0.3 of the values specified in (a) above, applied over that portion of the bottom aft of the step (aft of main step if more than one step is used).

04.254 Wing tip float loads. Wing tip floats and their attachment, including the wing structure, shall be analyzed for each of the following conditions:

(a) A limit load acting vertically up at the completely submerged center of buoyancy and equal to three times the completely submerged displacement.

(b) A limit load inclined upward at 45° to the rear and acting through the completely submerged center of buoyancy and equal to three times the completely submerged displacement.

(c) A limit load acting parallel to the water surface (laterally) applied at the center of area of the side view and equal to 1.5 times the completely submerged displacement.

04.2540 The primary wing structure shall incorporate sufficient extra strength to insure that failure of wing-tip float attachment members occurs before the wing structure is damaged.

04.255 Seawing loads. Seawing design loads shall be based on suitable test data.

04.26 Emergency landing conditions.

04.260 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.

The structure shall be designed to give every reasonable probability that all the occupants, if they make proper use of the seats, belts, and other provisions made in the design (see § 04.382) 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 all combinations of the following ultimate inertia forces relative to the surrounding structure.

Forward	0 to 6.0 g
Sideward	0 to 1.5 g
Vertical	0 to 4.5 g (down)
	0 to 2.0 g (up)

A lesser value of the downward inertia force may be used if it is shown that the airplane structure could absorb the landing shock corresponding to the design landing weight and an ultimate descent velocity of 5 fps without exceeding the value chosen. The specified inertia forces shall also be applied to all items of mass which would be liable to injure the passengers or crew if they came adrift under such conditions, and the supporting structure shall be designed to restrain these items.

04.261 Ditching provisions. At the request of the applicant, type certification may include certification that adequate provision has been made for emergency landings during over-water flights. In order that landplanes may qualify for such a certification, satisfactory evidence must be submitted that all practicable measures compatible with the general characteristics of the type 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. (Airplanes that are to receive this special certification must also comply with the terms of § 04.3811).

In demonstrating compliance with this requirement, the probable behavior of the airplane in a water landing shall be investigated by model tests or comparison with airplanes of similar configuration for which the ditching characteristics are known. In making such tests or comparisons proper consideration shall be given to scoops, flaps, projections, and all other factors likely to affect the hydrodynamic characteristics of the actual airplane. 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.

04.3 DESIGN AND CONSTRUCTION

04.30 General. 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. Minimum tests required to prove the strength and proper functioning of particular parts are specified.

04.300 Approved Specifications and Parts. Where the word "approved" or "acceptable" is used in this Part to describe specifications, materials, parts, methods and processes, such items shall be specifically approved by the Administrator upon a basis and in a manner found by him to be necessary to safety.

04.301 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.

04.302 Fabrication Methods. The methods of fabrication employed in constructing the airplane structure shall be such as to produce a uniformly 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.

04.3020 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.

04.303 Protection. 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. In seaplanes, special precaution shall be taken against corrosion from salt water, particularly where parts made from different metals are in close proximity. Adequate provisions for ventilation and drainage shall be made.

04.304 Inspection Provisions. Adequate means shall be provided to permit the close examination of such parts of the airplane as require periodic inspection, adjustments for proper alignment and functioning, and lubrication of moving parts.

04.31 Structural Parts.

04.310 Material Strength Properties and Design Values. 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. The design values shall be so chosen that the probability of any structure being understrength because of material variations is extremely remote. ANC-5* values and ANC-18* shall be used unless shown to be inapplicable in a particular case.

*Note: ANC-5, "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 Government Printing Office, Washington, D. C. for $.35 and $.25 respectively.

04.311 Special factors. Where there may be uncertainty concerning the actual strength of particular parts of the structure, or where the strength is likely to deteriorate in service prior to normal replacement, increased factors of safety shall be provided to insure that the reliability of such parts is not less than the rest of the structure as specified in the following subsections.

04.3110 Variability factor. For parts whose strength is subject to appreciable variability due to uncertainties in manufacturing processes and inspection methods, the factor of safety shall be increased sufficiently to make the probability of any part being understrength from this cause extremely remote. Minimum variability factors (only the highest pertinent variability factor need be considered) are as follows:

04.31100 Castings.

(a) Where visual inspection only is to be employed, the variability factor shall be 2.0.

(b) The variability factor may be reduced to 1.25 for ultimate loads and 1.15 for limit loads when at least three sample castings are tested to show compliance with these factors, and all sample and production castings are visually and radiographically inspected in accordance with an approved inspection specification.

(c) Other inspection procedures and variability factors may be used if approved by the Administrator.

04.3111 Bearing Factors. The factor of safety in bearing at bolted or pinned joints shall be suitably increased to provide for the following conditions: (Values in ANC-5 are acceptable)

(a) Relative motion in operation. (Control surface and system joints are covered in § 04.34 and § 04.35).

(b) Joints with clearance (free fit) subject to pounding or vibration.

Bearing factors need not be applied when covered by other special factors.

04.3112 Fitting factor. Fittings are defined as parts such as end terminals used to join one structural member to another. A multiplying factor of safety of at least 1.15 shall be used in the analysis of all fittings whose strength 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 applies to all portions of the fitting, the means of attachment, and bearing on the members joined. 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. The fitting factor need not be applied where a type of joint design based on comprehensive test data is used. The following are examples: Continuous joints in metal plating, welded joints, and scarf joints in wood, all made in accordance with approved practices.

04.313 Fatigue strength. 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.

04.32 Flutter, vibration, and stiffness.

04.320 Flutter and vibration prevention measures. Wings, tail surfaces, control surfaces, control systems, and other structural parts shall be free from flutter and all dangerous vibration, including that resulting from gust impulses, for all conditions of operation within the limit V-n envelope, (See § 04.15 for required flight demonstration). In addition to this flight demonstration, satisfactory analytical and/or experimental evidence shall be submitted to show that dangerous flutter conditions would not develop at any speed up to 1.2 V_d chosen in accordance with § 04.2110 except that the speed need not exceed the terminal velocity in a 30° dive.

In showing compliance with this requirement:

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

(b) The mass balance of movable control surfaces shall be shown to be such as to preclude flutter. If concentrated balance weights are used to balance control surfaces, their location and the stiffness of their supports shall be shown adequate to render them effective.

(c) Control surface tabs not equipped with a rugged irreversible actuating mechanism, as specified in § 04.352, shall be properly mass balanced and shown to be free from flutter tendencies by a rational flutter analysis or equivalent testing.

04.321 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 1.2V_d chosen in accordance with § 04.2110, 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 acceptable methods.

04.33 Wings.

04.330 External bracing. When wires are used for external lift bracing, they shall be double unless the design provides for a lift-wire-cut condition. Rigging loads shall be taken into account in a rational or conservative manner. The end connections of brace wires shall be such as to minimize restraint against bending or vibration. When brace struts of large fineness ratio are used, the aerodynamic forces on such struts shall be taken into account.

04.331 Covering. Strength tests of fabric covering are required unless approved grades of cloth, methods of support, attachment and finishing are employed. Special tests may be required when it appears necessary to account for the effects of unusually high design airspeeds, slipstream velocities, or other unusual conditions.

04.34 Control surfaces (fixed and movable)

04.341 Proof of strength. Limit load tests are required to prove compliance with limit load requirements. Control surface tests shall include the horn or fitting to which the control system is attached. Analysis or individual load tests shall be conducted to demonstrate compliance with the multiplying factor of safety requirements for control surface hinges. Rigging loads due to wire bracing shall be taken into account in a rational or conservative manner. The end connections of brace wires shall be such as to minimize restraint against bending or vibration.

04.342 Installation. Movable tail surfaces shall be so installed that there is no interference between the surfaces of their bracing when each is held in its extreme position and all others are operated through their full angular movement. 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 § 04.132.

04.343 Hinges. Control surface hinges, excepting ball and roller bearings, shall incorporate a multiplying factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing. For hinges incorporating ball or roller bearings, the approved rating of the bearing shall not be exceeded. Hinges shall provide sufficient strength and rigidity for loads parallel to the hinge line.

04.35 Control systems.

04.350 General. All controls shall operate with sufficient ease, smoothness, and positiveness to permit the proper performance of their function and shall be so arranged and identified as to provide satisfactory convenience in operation and prevent possibility of confusion and subsequent inadvertent operation.

04.351 Primary flight controls. Primary flight controls are defined as those used by the pilot for the immediate control of the pitching, rolling, and yawing of the airplane. Two control airplanes shall be capable of continuing safely in flight and landing in spite of the failure of any one connecting element in the primary directional-lateral flight control system.

04.352 Trimming controls. The trimming controls shall be conveniently located and each shall operate in the plane and with the sense of the motion of the airplane which its operation is intended to provide, as specified in § 04.3802. Proper precautions shall be taken against the possibility of inadvertent or abrupt tab operation. Means shall be provided, adjacent to the control to indicate to the pilot the direction of the control movement in relation to the airplane motion and the positions of the trim device with respect to the range of adjustment. Trimming devices shall be capable of continued normal operation in spite of the failure of any one connecting or transmitting element in the primary flight control system. Tab controls shall be irreversible unless the tab is properly balanced and investigated for flutter. Irreversible tab systems shall provide adequate rigidity and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the airplane structure.

04.353 Wing flap controls. The wing flap control shall provide means for bringing the flaps from any position within the operating range to any one of the take-off, enroute, approach, and landing positions specified in § 04.12. The control shall operate in such a manner as to permit the flight crew to place the flap in any of these positions readily and surely and to maintain these positions thereafter without further attention on the part of the crew. The flap control shall operate in the directions specified in § 04.3802 and shall be so located and designed as to render improbable its inadvertent operation. (See Figure 04-17.) The rate of motion of the flap in response to the operation of the control shall be such as to permit compliance with the requirements of § 04.13102 and § 04.13103. The control shall be so designed as to be capable of retracting the flaps from the fully extended position during steady flight drawing maximum continuous power at all speeds from V_{s_f} to V_f plus 10 mph. Means shall be provided to indicate the flap position to the pilot and the indicator shall show the take-off, enroute, approach, and landing positions. 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. Adequate instructions for the proper operation of the wing flaps shall be included in the airplane operating manual required by § 04.62.

04.3530 Flap interconnection. The motion of 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. Where an interconnection is used, it shall be designed to account for the unsymmetrical loads resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at take-off power. For single engined airplanes, it may be assumed that 100% of the critical airload acts on one side and 70% on the other.

04.354 Stops. All control systems shall be provided with stops which positively limit the range of motion of the control surfaces. Stops shall be so located in the system that wear, slackness or take-up adjustments will not appreciably affect the range of surface travel. Stops shall be capable of withstanding the loads corresponding to the design conditions for the control system.

04.355 Control system locks. When a device is provided for locking a control surface while the airplane is on the ground or water:

(a) The locking device shall be so installed as to provide unmistakeable warning to the pilot when it is engaged,

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

Such locks shall be designed for the ground gust conditions of § 04.231.

04.356 Proof of strength. Tests are required to prove compliance with limit load requirements. The direction of test loads shall be such as to produce the most severe loading of the control system structure. The tests shall include all fittings, pulleys, and brackets used to attach the control system to the primary structure. Analyses or individual load tests shall be conducted to demonstrate compliance with the multiplying factor of safety requirements specified for control system joints subjected to angular motion.

04.3560 Operation test. An operation test shall be conducted by operating the controls from the pilot's compartment with the entire system so loaded as to correspond to 80% of the limit load specified for the control system in question. In this test there shall be no jamming, excessive friction, or excessive deflection.

04.357 Control system details.

04.3570 General. All control systems and operating devices shall be so designed and installed as to prevent jamming, chafing, or interference from cargo, passengers, or loose objects as a result of inadequate clearances. Special precautions shall be provided in the cockpit to prevent the entry of foreign objects into places where they might jam the controls. Provisions shall be made to prevent the slapping of cables or tubes against parts of the airplane.

04.3571 Cable systems. Cables, cable fittings, turnbuckles, splices, and pulleys shall be in accordance with approved specifications. Cables smaller than 1/8 inch diameter shall not be used in the primary control system. The design of cable systems shall be such that there will not be a hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations. Pulley types and sizes shall correspond to the cables with which they are used, as specified on the pulley specification. All pulleys shall be provided with satisfactory guards which shall be closely fitted to prevent the cables becoming misplaced or fouled even when slack. The pulleys shall lie in the plane passing through the cable within such limits that the cable does not rub against the pulley flange. Fairleads shall be so installed that they are not required to cause a change in cable direction of more than 3°. Clevis pins (excluding those not subject to load or motion) retained only by cotter pins shall not be employed in the control system. Turnbuckles shall be attached to parts having angular motion in such a manner as to prevent positively any binding throughout the range of travel. Provisions for visual inspection shall be made at all fairleads, pulleys, terminals, and turnbuckles.

04.3572 Joints. Control system joints subjected to angular motion in push-pull systems, excepting ball and roller bearing systems, shall incorporate a multiplying factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for such joints in cable control systems. For ball or roller bearings the approved rating of the bearing shall not be exceeded.

04.36 Landing gear.

04.361 Shock absorbers. Main, nose, and tail wheel units shall incorporate shock absorbing elements which shall be substantiated by the tests specified in the following subsections. In addition, the shock absorbing ability of the landing gear in taxiing must be demonstrated in the operational tests of § 04.143.

04.3610 Shock absorption tests.

(a) It shall be demonstrated by energy absorption tests that the limit load factors selected for design in accordance with § 04.241 for take-off and landing weights respectively would not be exceeded under the critical landing conditions specified in that section.

(b) In addition, 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.

04.36100 Limit drop tests. If compliance with the specified limit landing conditions of § 04.3610(a) 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, from free drop heights not less than the following:

(a) 18.7 inches for the design landing weight conditions.

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

To simulate wing lift in free drop tests the landing gear shall be dropped with an effective mass equal to:

$$W_e = W \frac{h + (1-L)d}{h + d} \quad \text{where,}$$

W_e = the effective weight to be used in the drop test

h = specified height of drop in 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. The value of d used in the computation of W_e shall not exceed the value actually obtained in the drop test.

W = W_M for main gear units, 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, equal to the static weight on the tail unit with the airplane in the tail down attitude.

W = W_N for nose wheel units, equal to 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.

The attitude in which a landing gear unit is drop tested shall be such as to simulate the airplane landing condition which is critical from the standpoint of energy to be absorbed by the particular unit.

04.36101 Limit load factor determination. In determining the limit airplane inertia load factor, n, from the free drop tests described above, the following formula shall be used:

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

n_j = the load factor developed in the drop test, that is, the acceleration (dv/dt) in g's recorded in the drop test, plus 1.0.

The value of n so determined shall not be greater than the limit load factor used in the landing conditions, § 04.241.

04.36102 Reserve energy absorption drop tests. If compliance with the reserve energy absorption condition specified in § 04.3610(b) is demonstrated by free drop tests, the landing gear units shall be dropped from a free drop height of not less than 27 inches. If it is desired to simulate wing lift equal to the airplane weight, the units shall be dropped with an effective mass equal to

$$W_e = W \frac{h}{h + d}$$

where the symbols and other details are the same as in § 04.36100.

04.362 Retracting mechanism. The landing gear retracting mechanism and supporting structure shall be designed for the loads occurring in the flight conditions when the gear is in the retracted position. It shall also be designed for the combination of friction, inertia, brake torque, and air loads occurring during retraction and extension at any airspeed up to 1.6 V_{s_1}, (flaps in the approach position at design landing weight) and any load factors up to those specified for the flaps extended condition, § 04.212. The landing gear and retracting mechanism, including the wheel well doors, shall withstand flight loads with the landing gear extended at any speed up to V_c without permanent deformation. Positive means shall be provided for the purpose of maintaining the wheels in the extended position.

04.3620 Emergency operation. Emergency means of extending the landing gear shall be provided, so that the landing gear can be satisfactorily extended in the event of any reasonably probable failure in the normal retraction system. The emergency system shall provide for the failure of any single source of hydraulic, electric, or equivalent energy supply.

04.3621 Operation test. Proper functioning of the landing gear retracting mechanism shall be demonstrated by operation tests.

04.3622 Position indicator and warning device. When retractable landing wheels are used, means shall be provided for indicating to the pilot, when the wheels are secured in either extreme position. In addition, landplanes shall be provided with an aural warning device which shall function continuously after all throttles are closed until the gear is down and locked. If a manual shutoff for the warning device is provided, it shall be arranged so that reopening the throttles will render the warning device effective again, as specified above.

04.3623 Control. The landing gear retraction control shall be located and shall operate as described in § 04.3802.

04.363 Wheels. Main landing gear wheels (i.e. those nearest the airplane center of gravity) shall be of an approved type in accordance with Part 15. The rated static load of each main wheel shall not be less than the design take-off weight, divided by the number of main wheels. 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 and burst loads specified in Part 15.

04.364 Tires. A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the approved tire rating is not exceeded under the following conditions:

(a) Airplane weight equal to the design take-off weight.

(b) Load on main wheel tires equal to the airplane weight divided by the number of wheels.

(c) 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 having brakes. When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies, and identification marking of the proper tire.

Approved ratings are those assigned by the Tire and Rim Association or by the Administrator.

04.365 Brakes. All airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 for the maximum certificated landing weight at sea level and the power-off stalling speed, V_{s_0}, as defined in § 04.121. 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, as shown by suitable test or other data, to bring the airplane to rest under conditions specified in § 04.124 with a mean negative acceleration during the landing roll of at least 50% of that obtained in determining the landing distance under that section. In applying this requirement 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 above.

04.3650 Parking brake. A parking brake control shall also be provided which may be set by the pilot, and without further attention, maintain braking sufficient to prevent the airplane from rolling on a paved runway while applying take-off power on the most critical engine.

04.3651 Brake controls. Brake controls shall not require excessive control forces in their operation.

04.366 Skis. Skis shall be certificated in accordance with the ski requirements of Part 15. The approved rating of the skis shall not be less than the maximum take-off weight of the airplane on which they are installed.

04.3660 Installation. The ski installation shall be made in accordance with the ski or airplane manufacturer's recommendations which shall have been approved by the Administrator.

In addition to such shock cord(s) as may be provided, front and rear check cables shall be used on skis not equipped with special stabilizing devices.

04.3661 Tests. It shall be demonstrated that the airplane has satisfactory landing and taxiing characteristics and that the airplane's flight characteristics are not impaired by the installation of the skis.

04.37 Hulls and floats.

04.370 Buoyancy (main seaplane floats). Main seaplane floats shall have a buoyancy in excess of that required to support the gross weight of the airplane in fresh water as follows:

(a) 80% in the case of single floats.
(b) 90% in the case of double floats.

Main seaplane floats shall contain at least 5 water-tight compartments of approximately equal volume.

04.371 Buoyancy (boat seaplanes). The hulls of boat seaplanes and amphibians shall be divided into water tight compartments such that with any 2 adjacent compartments flooded, the hull and auxiliary floats (and tires, if used) will retain sufficient buoyancy to support the gross weight of the aircraft in fresh water without capsizing. Bulkheads may have water-tight doors for the purpose of communication between compartments.

04.38 Fuselage.

04.380 Pilot compartment.

04.3800 General. The arrangement of the pilot compartment and its appurtenances shall provide a satisfactory degree of safety and assurance that the pilot will be able to perform all his duties and operate the controls in the correct manner without unreasonable concentration and fatigue.

The primary flight control units listed on Figure 04-17, excluding cables and control rods, shall be so located with respect to the propellers that no portion of the pilot or controls lie 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.

When a second pilot is required for particular operations by Parts 40, 41, and 61, the airplane shall be fully and readily controllable from each seat.

The pilot compartment shall be so constructed as to prevent leakage likely to be distracting to the crew or harmful to the structure when flying in rain or snow. A door or an adequate openable window shall be provided between the pilot compartment and the passenger compartment. When a door is provided, it shall be equipped with a locking means which will prevent passengers from opening such door without the pilot's permission.

04.3801 Vision.

04.38010 Non-precipitation conditions. 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 taxiing, take-off, approach, and landing. It shall be demonstrated by day and night flight tests that the pilot compartment is free of glare and reflections that would interfere with the pilots' vision.

04.38011 Precipitation conditions. At least the first pilot shall be afforded an adequate view along the flight path in normal flight, approach, and landing, by the provisional means for maintaining appropriate areas of the windshield clear without continuous attention by the crew during the following conditions of precipitation:

(a) In heavy rain at all speeds up to $1.6V_{S1}$, flaps retracted.
(b) In severe icing conditions, whenever de-icing provisions are required for the particular operations by Parts 40, 41, and 61.

In all cases, at least the first pilot shall be provided with a window which is openable under the above conditions and is so arranged as to afford, through the opening, a view as specified above, with sufficient protection from the elements that his vision is not impaired. The window need not be opened under pressurized conditions.

04.38012 Pilot windshield and windows. All internal glass panes shall be of a non-splintering safety type.

04.38013 Bird impact. 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 relative velocity of the bird to the airplane along the flight path of the latter is equal to the value of V_C at sea level chosen in accordance with § 04.2110.

04.3802 Cockpit arrangement. All cockpit controls shall be so located and except for the primary controls, identified as to provide satisfactory convenience in operation including adequate provisions to prevent the possibility of confusion and consequent inadvertent operation. See Figures 04-17 and 04-18 for direction of movement of aerodynamic, and certain powerplant, accessories, and auxiliary controls. 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 the part operated.

The controls shall be so located and arranged with respect to the pilot's seat that it will be readily possible for the operator to obtain full and unrestricted movement of each control without interference from either the cockpit structure or the operator's clothing when seated. This shall be demonstrated for individuals ranging from 5'2" to 6'0" in height.

Identical power plant controls for the several engines shall be so located as to prevent any misleading impression as to the engines to which they relate.

04.38020 Instruments and markings. See § 04.5200 relative to instrument arrangement. The operational markings, instructions, and placards required for the instruments, controls, etc., are specified in § 04.61.

AERODYNAMIC CONTROLS

FIGURE 04-17

CONTROLS	TYPE OF CONTROL	MOVEMENT AND ACTUATION
PRIMARY: —		
Aileron	Stick or Column with grip or wheel	RIGHT (clockwise) for RIGHT WING DOWN
Elevator		REARWARD TO pitch NOSE UP
Rudder	Foot pedals or rudder bar	RIGHT pedal forward for NOSE RIGHT
SECONDARY:— Flaps or Aux Lift Devices	X X X X	DOWN TO EXTEND
TRIMMING Tabs or Equivalent	Wheel (or Segment when actuation suggests rotary movement)	ROTATE to produce similar rotation of the airplane about the axis which is parallel to the axis of the control being operated.

Wing flap or auxiliary lift device controls and the landing gear control shall be adequately separated to prevent confusion and subsequent inadvertent operation.

POWERPLANT AND AUXILIARY CONTROLS

Figure 04-18

CONTROLS	MOVEMENT AND ACTUATION
POWERPLANT:	
Throttles	FORWARD TO INCREASE POWER
Propeller	FORWARD TO INCREASE RPM
Mixture	FORWARD FOR RICH
Carburetor Air Heat	FORWARD FOR COLD
AUXILIARY:	
Landing Gear	DOWN TO EXTEND

Wing flap or auxiliary lift device controls and the landing gear control shall be adequately separated to prevent confusion and subsequent inadvertent operation.

04.3803 Noise and vibration. Vibration and noise characteristics of cockpit appurtenances shall be such as not to interfere with the safe operation of the airplane.

04.381 Emergency provisions.

04.3811 Flotation. When certification of ditching provisions is desired under the provisions of § 04.261, satisfactory evidence shall be submitted that there is every reasonable probability that the airplane, after landing in the water as specified in § 04.261, would remain afloat, as follows:

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

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

Compliance with these requirements may be demonstrated by buoyancy and trim computations in which suitable allowances are made for probable structural damage and leakage. For airplanes equipped with fuel dump valves, the volume of fuel which could be dumped may be considered as buoyancy volume.

04.3812 Emergency exits. Passenger and crew compartments designated as occupiable during take-off and landing shall be provided with emergency exits as specified in the following subsections. For the purposes of this requirement, a compartment is defined as a closed space to which normal access is by a door, passageway, or stair that is likely to become a bottleneck in evacuating the airplane. In case of question concerning the adequacy and suitability 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 greater, under conditions simulating a forced landing. The maximum number of persons for which seats are provided shall be used in this demonstration. The persons demonstrating the evacuation procedure may be briefed once prior to the official demonstration.

04.38120 Number of exits. The minimum number of exits per compartment is as follows:

Number of persons for which seats are provided.	Minimum number of exits required
5 or less	1
Exceeding 5, not exceeding 15	2
Exceeding 15, not exceeding 22	3
Exceeding 22, not exceeding 29	4
Exceeding 29, not exceeding 36	5
Exceeding 36, not exceeding 50	6

The external door specified in § 04.3821 may be counted as one emergency exit if it meets the detail requirements of § 04.38121.

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 exits in the 2 compartments exceeds at least 1 exit per 8 passengers. Other numbers of exits may be used if it can be demonstrated that the airplane can be evacuated in the time specified in § 04.3812.

04.38121 Exit arrangement. At least the minimum number of exits specified in § 04.38120 shall be located so as to give the maximum likelihood of their being usable in the emergency landing with wheels up. When certification of ditching provisions is desired, it shall be shown that at least one emergency exit for every 16 passengers is located above the water line as determined in § 04.3811.

In airplanes for which 2 or more exits are required, the ratio of the number of exits on either side to the total number required shall be not less than one-third. In such cases at least one exit on the opposite side from the main door shall be operatable from the outside and shall be marked accordingly for the guidance of rescue personnel.

The exits shall be readily accessible, shall not require exceptional agility of a person using them and shall be distributed so as to facilitate egress without crowding. Each exit shall provide a clear and unobstructed opening to the outside, the minimum dimensions of the opening shall be such that a 19 by 26 inch ellipse may be inscribed therein. Reasonable provisions shall be made against the jamming of exits as a result of fuselage deformation.

The method of opening shall be simple and obvious and the exits shall be so arranged that they may be readily operated. (See § 04.6122) The proper functioning of exits shall be demonstrated by test. At landplane 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 descent to the ground.

04.382 Passenger and crew accommodations.

04.3821 Doors. Airplanes having closed cabins shall be provided with at least one adequate and easily accessible external main door. It shall be possible to open such door from either inside or outside by the operation of only one handle inside or one handle outside even though the persons using the exit may be crowded near it. 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. Reasonable provisions shall be made to prevent the jamming of such door as a result of fuselage deformation in a minor crash.

No door for regular use shall be so located that persons using it would be endangered by the propellers.

04.3822 Seats, berths, and safety belts.

04.38220 Arrangement. At all stations designated as occupiable during take-off and landing, the seats, berths, belts or harness and surrounding parts of the airplane shall be so arranged that a person making proper use of the facilities provided would not suffer serious injury in the emergency landing conditions of § 04.26 as a result of contact of a vulnerable part of his body with any penetrating or relatively solid object. Passengers and crew shall be afforded protection from head injuries by one of the following or equivalent means:

(a) Safety belt and shoulder harness which will prevent the head from contacting any injurious object,
(b) Safety belt and the elimination of all injurious objects within radius of the head in a fore and aft direction,
(c) Safety belt and a cushioned rest which will properly support the arms, shoulders, head, and spine. This method may be applied to forward, sideward, and rearward facing seats.

Suitable hand grips or rails shall be provided along aisles to enable passengers or crew members to steady themselves while using the aisles during moderately rough air flights. Any projecting objects likely to cause injury to persons seated or moving about the airplane in normal flight shall be suitably padded.

04.38221 Strength. All seats, berths, and supporting structure shall be designed for an occupant weighing at least 170 lbs. and the critical loads resulting from all specified flight load conditions.

All seats and berths designated as occupiable during landing and take-off, and their supporting structure, shall also be designed for the loads resulting from the specified ground loads and the emergency landing conditions of § 04.26, including appropriate reactions from the safety belts or harness.

Pilots' seats shall be designed for the reactions resulting from application of the pilot forces to the flight controls as specified in § 04.23.

04.3823 Ventilation and heating.

04.38230 Ventilation. All passenger and crew compartments shall be suitably ventilated. Carbon monoxide concentration shall not exceed one part in 20,000 parts of air, and fuel fumes shall not be present.

04.38231 Combustion heaters. Gasoline operated combustion heater installations shall comply with applicable parts of the power plant installation requirements covering fire hazards and precautions. All applicable requirements concerning fuel tanks, lines, and exhaust systems shall be considered.

04.3824 Fire precautions.

04.38240 Cabin interiors. In compartments where smoking is to be permitted, the materials of the cabin lining, floors, upholstery, and furnishings shall be sufficiently flame resistant to preclude ignition by cigarettes or matches, and suitable ash containers shall be provided. All other compartments shall be placarded against smoking.

04.3825 Cargo compartments. Each cargo compartment shall be designed for the placarded maximum weight of contents and critical load distributions at the appropriate maximum load factors corresponding to all specified flight and ground load conditions, excluding the emergency landing conditions of § 04.26. Suitable provisions shall be made to prevent the contents of cargo compartments from becoming a hazard by shifting under these loads. Such provisions shall also be adequate to protect the passengers and crew from injury by the contents of any cargo compartment when the ultimate forward acting inertia force is 6 g.

04.3826 Pressure cabins. When pressurized compartments are provided for the occupants of the airplane, the following requirements shall be met.

04.38260 Strength.

(a) All parts of the airplane subjected to loads from both pressure differential and flight strength conditions shall be designed for limit loads corresponding to the flight limit loads combined with pressure differential loads from zero up to the maximum relief valve setting. The external pressure distribution on the cabin in flight shall be taken into account.

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

(c) As a separate condition, all parts of the airplane affected by pressure differential loads shall be designed for limit pressure differential loads corresponding to 1.33 times the maximum relief valve setting. All other loads shall be omitted in this case.

(d) When a pressurized cabin is separated into two or more compartments by bulkheads or floors, the primary structure shall be designed to withstand the effects of sudden release of pressure in any compartment having external doors or windows. This condition shall be investigated for the failure of the largest opening in a compartment and intercompartment venting may be accounted for when provided.

04.38261 Pressure supply. If cabin pressurization is to be used in lieu of the regular use of oxygen at altitude in complying with the operating requirements of Parts 40, 41, and 61, the pressure supply shall be capable of maintaining a cabin pressure corresponding to an altitude of not more than 10,000 feet in standard atmosphere when the airplane altitude is any value up to the maximum for which certification is desired.

04.38262 Pressure control. Pressure cabins shall be provided with at least the following valves, controls, and indicators for controlling cabin pressure:

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

(b) At least two reversed pressure differential relief valves (or equivalent) which will automatically prevent a negative pressure differential greater than that which would damage the structure. One negative pressure relief valve may be used if it is of simple design.

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

(d) A suitable automatic or manual regulator for controlling the intake and/or exhaust airflow by means of which required internal pressures and airflow rates can be maintained.

(e) Instruments at an appropriate crew station showing the pressure differential, the absolute pressure in the cabin, and the rate of change of the absolute pressure.

(f) Suitable warning indications shall be provided at the appropriate crew station, which will indicate when the safe or pre-set limits on pressure differential and absolute cabin pressure are exceeded.

(g) If the structure has not been designed for pressure differentials up to the maximum relief valve setting in combination with landing loads (see § 04.38260-b) a suitable warning placard shall be provided at the appropriate crew station.

04.38263 Tests. The complete pressure cabin, including doors and windows and valves, shall be tested as a pressure vessel for the pressure differential specified in § 04.38260(c).

The following functional tests shall be performed up to the working pressures:

(a) Functional and capacity tests of the positive and negative pressure differential relief valves and the emergency release valve, simulating the condition of regulator valves closed.

(b) Tests showing that all parts of the pressurization system would function properly under all possible conditions of pressure, temperature, and moisture up to the maximum altitude for which certification is desired.

(c) Flight tests demonstrating the performance of the pressure supply pressure and flow regulators, indicators, and warning signals in steady and stepped climbs and descents at rates corresponding to the maximum attainable without exceeding the operating limitations of the airplane, up to the maximum altitude for which certification is desired.

(d) Tests showing that all doors and emergency exits operate properly after flights listed in (c) above.

04.3827 Reinforcement near propellers. Surfaces 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 this area unless shown capable of withstanding the most severe ice impact likely to occur.

04.39 Miscellaneous.

04.390 Leveling marks. Suitable reference marks shall be provided for use in leveling the airplane when making weight and balance determinations on the ground.

04.4 POWER PLANT INSTALLATION - RECIPROCATING ENGINES

04.40 General.

(a) The power plant 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.

(b) All components of the power plant installation shall be constructed, arranged, and installed in a manner that will assure their continued safe operation between normal inspections or overhaul periods. Accessibility shall be provided to permit such inspection and maintenance as is necessary to assure continued airworthiness.

(c) Electrical inter-connections shall be provided to prevent the existence of differences of potential between major components of the power plant installation and other portions of the airplane.

04.41 Engines and propellers.

04.410 Engines. Engines installed in certificated airplanes shall be of a type that has been certificated in accordance with the provisions of Part 13 of the Civil Air Regulations.

04.41000 Engine isolation. The engines shall be so isolated, each from the other, that the failure or malfunctioning of any engine, or any part of the power plant installation serving any engine, will not prevent the safe operation of the remaining engine or engines.

04.4101 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 firewall and might be exposed to fire, shall be of fire resistant construction (See also § 04.436).

04.411 Propellers. Propellers installed in certificated airplanes shall be of a type that has been certificated in accordance with the provisions of Part 14 of the Civil Air Regulations.

04.4110 Propeller vibration. The magnitude of the propeller blade vibration stresses under all normal conditions of operations 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 that have been demonstrated to be safe for continuous operation.

04.4111 Propeller pitch and speed limitations.

(a) The propeller pitch and speed shall be limited to values that will assure safe operation under all normal conditions of operation and will assure compliance with the performance requirements specified in § 04.12 and its related sub-sections.

(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 shall be set or other means used to limit the low pitch position, so as not to exceed 103% of the maximum permissible propeller shaft RPM under the following conditions:

(1) Propeller blades at the low pitch limit and governor inoperative.

(2) Engine operating at take-off manifold pressure with the airplane stationary under standard atmospheric conditions.

04.4112 Propeller clearance.

(a) Ground clearance:

(1) Seven inches (for airplanes equipped with nose wheel type landing gears) or nine inches (for airplanes equipped with tail wheel type landing gears) with the landing gear statically deflected and the airplane in the level, normal take-off, or taxiing attitude, whichever is most critical.

(2) In addition to (1) above, 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) Water clearance: A minimum clearance of 18 inches shall be provided unless compliance with § 04.144 can be demonstrated.

(c) Structural clearance:

(1) One inch radial clearance 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 between the propeller blades or cuffs and stationary portions of the airplane. Adequate positive clearance shall be provided between other rotating portions of the propeller or spinner and stationary portions of the airplane.

04.4113 Propeller de-icing provisions. Airplanes intended for operation under atmospheric conditions conducive to the formation of propeller ice shall be provided with means for the prevention and removal of such ice accumulations.

04.42 Fuel system. The fuel system shall be constructed and arranged in a manner to assure the provision of fuel to each engine at a flow rate and pressure which have been established for proper engine functioning under all normal conditions of operation including all maneuvers for which the airplane is intended.

04.421 Fuel system arrangement. Fuel systems shall be so arranged that any one fuel pump cannot draw fuel from more than one tank at a time unless means are provided to prevent introducing air into the system.

04.4210 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 the power of more than one engine. A separate fuel tank need not be provided for each engine to show compliance with this requirement if the Administrator finds that the fuel system incorporates features which provide equivalent safety.

04.4211 Pressure cross feed arrangements. Pressure cross feed lines shall not pass through portions of the airplane devoted to carrying 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 fuel and fume proof enclosure that is ventilated and drained to the exterior of the airplane. Such enclosures need not be used if these lines incorporate no fittings on or within the personnel or cargo areas and are suitably routed or protected to safeguard against accidental damage. 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 that may result from exposure of the isolated line to high ambient temperatures.

04.422 Fuel system operation.

04.4220 Fuel flow rate. 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. At least the following shall be considered in this regard:

(a) The normal ground attitude.

(b) Climb with take-off flaps (landing weight) and gear up, using take-off power, at speed V_2, as determined in § 04.1220(b), at landing weight.

(c) Level flight at maximum continuous power or the power required for level flight at V_c, whichever is less.

(d) The attitude of glide at a speed of $1.3V_{so}$.

During this test, fuel shall be delivered to the engine at a pressure not less than the minimum established for proper engine operation. The quantity of fuel in the tank being tested shall not exceed the amount established as the unusable fuel supply for that tank (as determined by demonstration of compliance with the provisions of § 04.4221, (See also § 04.423 and 04.5222) plus whatever minimum quantity of fuel it may be necessary to add for the purpose of conducting the flow test. 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.

04.42200 Fuel flow rate for pump systems. 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% of the actual take-off fuel consumption of the engine, whichever is greater. This flow rate shall be applicable to both the primary engine-driven pump and to emergency pumps and 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, this speed shall be considered to be not more than 60 complete cycles (120 single strokes) per minute.

04.42201 Fuel flow rate for transfer systems. The provisions of § 04.42200 shall also apply to transfer systems with the exception that the required fuel flow rate for the engine or engines involved shall be established upon the basis of maximum continuous power and speed instead of take-off power and speed.

04.4221 Determination of unusable fuel supply and fuel system operation on low fuel.

(a) 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 conditions specified below. (See § 04.423). Upon presentation of the airplane for test, the applicant shall stipulate the quantity of fuel with which he wishes to demonstrate compliance with this provision and shall also indicate which of the following conditions is most likely to be critical from the standpoint of establishing the unusable fuel supply. He shall also indicate the order in which the other conditions may be critical from this standpoint.

(1) Level flight at maximum continuous power or the power required for level flight at V_c, whichever is less.

(2) Climb with take-off flaps (landing weight) and gear up, using take-off power at speed V_2, as determined in § 04.1220(b), at landing weight.

(3) Rapid application of maximum continuous power and subsequent transition to climb at speed V_2 as in (2), with retraction of flaps and gear from a power-off glide at $1.3V_{so}$ with flaps and gear down, at minimum weight with sufficient fuel for demonstration.

(b) 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 full 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.

(c) 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 § 04.4221(a)(1). This may be a ground test.

04.4222 Fuel system hot weather operation. There shall be no evidence of vapor lock or other malfunctioning when the airplane is operated with fuel at a temperature of not less than 110°F and is climbed, at a climb speed not to exceed that which will permit compliance with the climb requirement specified in § 04.1230, to the altitude at which the one-engine inoperative best rate of climb, expressed in feet per minute, is not more than $0.02\ V_{s_0}^2$ for airplanes with a maximum take-off weight of 40,000 lbs. or less, $0.04\ V_{s_0}^2$ for airplanes with a maximum take-off weight of 60,000 lbs. or more with a linear variation between 40,000 lbs. and 60,000 lbs. when climbing at the weight corresponding to operation with full fuel tanks, minimum crew, and only that ballast which may be necessary to maintain the center of gravity limits for which the airplane is to be certificated. Demonstration of compliance with this provision shall be accomplished either in flight or by means of a ground installation which closely simulates conditions in flight. In case of a flight demonstration conducted in cold weather, the Administrator may request that fuel tank surfaces, fuel lines, and other fuel system parts which may be subjected to cooling action from cold air, be suitably insulated to simulate, in so far as practicable, flight in hot weather.

04.4223 Flow between interconnected tanks. In the case of systems with tanks whose 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 § 04.4221(a) and the tanks are full.

04.423 Fuel Tanks. Fuel tanks shall be capable of withstanding without failure any vibration, inertia, fluid, and structural loads to which they may be subjected in operation. Flexible fuel tank liners shall be of an acceptable type or proven suitable for the particular application. The fuel tanks, as installed, shall be designed to withstand a minimum internal pressure of 3.5 psi. Integral type fuel tanks shall be provided with adequite facilities for the inspection and repair of the tank interior. The total usuable capacity of the fuel tanks shall not be less than 0.15 gallons for each maximum continuous horsepower for which the airplane is certificated. The unusable capacity shall be considered to be the minimum quantity of fuel that will permit compliance with the provisions of § 04.4221. The fuel quantity guage shall be adjusted to account for the unusable fuel supply as specified in § 04.5222. The weight of the unusable fuel supply shall be included in the empty weight of the airplane.

04.4230 Fuel tank tests.

(a) Fuel tanks shall be capable of withstanding the following pressure tests without failure or leakage. These pressures may be applied in a manner simulating the actual pressure distribution in service.

(1) Conventional metal tanks and non-metallic tanks whose walls are not supported by the airplane structure: A pressure of 3.5 psi. or the pressure developed during the maximum ultimate acceleration of the airplane with a full tank, whichever is greater.

(2) Integral tanks: A minimum pressure of 3.5 psi shall be used unless the pressure developed during the maximum limit acceleration of the airplane with a full tank exceeds this amount, in which case a hydrostatic head, or equivalent test, shall be applied to duplicate the acceleration loads in so far as possible, but need not exceed 3.5 psi on surfaces not exposed to the acceleration loading.

(3) Non-metallic tanks whose walls are supported by airplane structure shall be tested 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 tests, or other suitable tests, without leakage or failure. The complete tank assembly, together with its supports, shall be subjected to a vibration test when mounted in a manner simulating the actual installation. 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. The frequency of vibration shall be 90% 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. 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. The assembly shall be rocked at the rate of 16 to 20 complete cycles per minute.

(c) In case of tanks with non-metallic liners, a specimen liner of the same basic construction as that to be used in the airplane shall, when installed in a suitable representative test tank, satisfactorily withstand the slosh test in (b) with fuel at a temperature of 110°F.

<u>04.4231</u> <u>Fuel tank installation</u>.

(a) The method of support for fuel tanks shall not be such as to concentrate loads on unsupported tank surfaces resulting from the weight of the fuel in the tank. Pads shall be provided to prevent chafing between the tank and its supports. Materials employed for padding shall be non-absorbent or shall be treated to prevent the absorption of fluids. If flexible tank liners are employed, they shall be so supported that the liner is not required to withstand fluid loads. Interior surfaces of compartments for such liners shall be smooth and free of projections which may 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, or if the tank is in a sealed compartment the ventilation may be limited to that provided by drain holes of sufficient size to prevent excessive pressure resulting from altitude changes.

(c) Fuel tanks shall not be located on the engine side of the firewall. Not less than [illegible] an inch of clear air space shall be provided between the fuel tank and the firewall. 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.. Fuel tanks shall be isolated from personnel compartments by means of fume and fuel proof enclosures.

04.4232 Fuel tank construction.

04.42320 Fuel tank expansion space. Fuel tanks shall be provided with an expansion space of not less than 2% of the tank capacity. It shall not be possible inadvertently to fill the fuel tank expansion space when the airplane is in the normal ground attitude.

04.42321 Fuel tank sump.

(a) Each tank shall be provided with a sump having a capacity of not less than either 0.25% of the tank capacity or 1/16 of a gallon, whichever is greater.

(b) The fuel tank sump capacity specified above 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 a 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 positively or automatically locking the drain in the closed position. The drain shall be readily accessible.

(d) An additional drain may be provided, if necessary, for tank drainage.

04.42322 Fuel tank filler connection. The fuel tank filler connections shall be marked as specified in § 04.6121. Provision shall be made to prevent the entrance of fuel into the fuel tank compartment or any portions of the airplane other than the tank itself. Recessed fuel filler connections which retain any appreciable quantity of fuel shall be drained and the drain shall discharge clear of all portions of the airplane. The filler cap shall provide a fuel tight seal.

04.42323 Fuel Tank vents and carburetor vapor vents.

(a) Fuel tanks shall be vented from the top portion of the expansion space in such a manner that the tank is adequately vented under all normal flight conditions. Vent outlets shall be so located and constructed as to prevent the possibility of their being obstructed by ice or other foreign matter. The vent shall be so constructed as to preclude the possibility of syphoning fuel during normal operation. 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. Air spaces of tanks whose outlets are interconnected shall also be interconnected. There shall be no points in the vent line where moisture may accumulate with the airplane in either the ground or level flight attitude unless proper drainage is provided. Vents and drainage shall not terminate at points where the discharge of fuel from the vent outlet will constitute a fire hazard or from which fumes may enter personnel compartments.

(b) Carburetors which are provided with vapor elimination connections shall be provided with a vent line which will lead vapors back to one of the fuel tanks. Satisfactory provisions shall be incorporated in the vent system to avoid stoppage by ice. If more than one fuel tank is provided and it is necessary to use the tanks in a definite sequence for any reason, the vapor vent return line shall lead back to the fuel tank used for take-off and landing.

04.42324 Fuel tank outlet. The fuel tank outlet shall be provided with a strainer of from 8 to 12 meshes per inch, or a suitable strainer on the booster pump. The clear area of the fuel tank outlet strainer shall not be less than 5 times the area of the fuel tank outlet line. The diameter of the strainer shall not be less than the diameter of the fuel tank outlet. Finger strainers shall be installed in a manner to be accessible for inspection and cleaning.

04.424 Fuel pump and pump installation.

(a) If fuel pumps are provided to maintain a supply of fuel to the engine, at least one pump for engine engine shall be driven by the engine. Fuel pumps shall be adequate to meet the flow requirements of the applicable portions of § 04.4220 and its related sub-sections. 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. 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 should be independently connected to the carburetor inlet pressure.

(b) Unless equivalent provisions are made to permit the system to continue to supply fuel to all engines in case of the failure of any positive displacement fuel system pump, the pump itself shall incorporate in integral by-pass. Engine fuel injection pumps which are certificated as an integral part of the engine need not incorporate a by-pass.

(c) 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 suitable 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. Emergency pumps shall be capable of complying with the same flow requirements as are prescribed for the main pumps. Hand emergency pumps shall not require excessive effort for their continued operation at the rate of 60 complete cycles (120 single strokes) per minute. Emergency pumps shall be available for immediate use in case of the failure of any other pump.

If the engine-driven pumps are capable of maintaining flight up to 10,000 feet altitude and with 110°F fuel without the aid of auxiliary pumps, the auxiliary pumps may be considered as emergency pumps.

04.425 Fuel system lines and fittings. Fuel lines shall be installed and supported in a manner that will prevent excessive vibration and will be adequate to withstand loads due to fuel pressure and accelerated flight conditions. Lines which are connected to components of the airplane between which relative motion may exist shall incorporate provisions for flexibility. Flexible connections in lines which may be under pressure and subjected to axial loading shall employ flexible hose assemblies rather than hose clamp connections. Flexible hose shall be of an acceptable type or proven suitable for the particular application.

04.4250 Fire resistant fuel lines and fittings. Metal fuel lines, except for flexible portions thereof, located on the engine side of the firewall shall be constructed of corrosion resistant steel or material of equivalent fire resistance. Flexible connections in such lines shall employ fire-resistant hose with factory fixed ends, detachable ends, or heat and corrosion resistant hose clamps. Fire resistant hose may be used in lieu of metal lines. Aluminum alloy fittings and accessories may be used if adequately fire resistant.

04.4251 Fuel valves.

(a) Means shall be provided to permit the flight personnel to shut off rapidly the flow of fuel to any engine individually in flight. Valves provided for this purpose shall be located not closer to the engine than the remote side of the firewall. It shall be demonstrated that no appreciable amount of fuel will drain into the engine compartment after the valve has been closed.

(b) Shut-off valves shall be so constructed that is is possible for the flight personnel to reopen the valves after they have once been closed. (See § 04.4804 for fuel valve controls.)

(c) Valves shall be provided with positive stops or suitable index provisions in the on and off positions and shall be supported in such a manner that loads resulting from their operation or from accelerated flight conditions are not transmitted to the lines connected to the valve.

04.4252 Fuel strainer.- A fuel strainer shall be provided between the fuel tank outlet and the carburetor inlet. If an engine driven fuel pump is provided, the strainer shall be located between the tank outlet and the engine driven pump inlet. The strainer shall be accessible for drainage and cleaning, and the strainer screen shall be easily removable. The strainer shall be mounted in a manner that does not cause its weight to be supported by the connecting lines or by the inlet or outlet connections of the strainer itself.

04.426 Fuel system drains. Drainage of the system shall be accomplished by fuel strainer drains and other drains as provided in § 04.42321. Drains shall discharge clear of all portions of the airplane and shall be provided with means for positively or automatically locking the drain in the closed position. All fuel system drains shall be accessible. If drainage of the strainer permits compliance with the foregoing, no additional drains need be provided unless a hazardous quantity of water or sediment may be trapped.

04.427 Fuel system instruments. (See § 04.51(b) and § 04.522 through § 04.5223.)

04.428 Fuel jettisoning system.

(a) If the maximum take-off weight for which the airplane is certificated exceeds 105% of its maximum landing weight, provision shall be made to permit the jettisoning of fuel from the maximum take-off to the maximum landing weight at a rate per minute of 1% of the maximum take-off weight, when the airplane is flown in the configurations specified below, except that the time required to jettison the fuel need not in any case be less than 10 minutes. The fuel jettisoning system shall permit the safe discharge of fuel clear of all portions of the airplane under the following conditions of flight at the maximum take-off weight and with flaps and gear up:

(1) Power-off glide at a speed of $1.4V_{s1}$.

(2) Climb at the one-engine inoperative speed with the critical engines on one side of the airplane inoperative, the other engines at maximum continuous power.

(3) Level flight at a speed of $1.4V_{s1}$, if found necessary from tests (1) and (2).

Unless it is demonstrated that flap position 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 operating manual.

No fire hazard shall exist during, or as the result of, the jettisoning operation. Neither fumes nor fuel shall enter any portion of the airplane and the jettisoning operation shall not adversely affect control. Compliance with these provisions shall be demonstrated in flight. It shall not be possible to jettison fuel in the tanks used for take-off and landing below the level providing 45 minutes flight at 75% maximum continuous power, except that all fuel may be jettisoned where an auxiliary control is provided independent of the main jettisoning control.

(b) The fuel jettisoning valve shall be so constructed as to permit the flight personnel to close the valve during any portion of the jettisoning operation. (See § 04.4804(b) for fuel jettisoning system controls.)

04.43 Oil system. Each engine shall be provided with an independent oil system capable of supplying the engine with an ample quantity of oil at a temperature not exceeding the maximum which has been established as safe for continuous operation. 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 a reserve oil supply, which can be fed to any tank during flight, is provided. If either a reserve oil system or an oil transfer system is provided, the total oil capacity need not exceed one gallon for each 40 gallons of fuel capacity. Lower oil fuel ratios may be used providing they can be substantiated by oil consumption data.

04.430 Oil cooling. Demonstration of 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 accomplished in accordance with § 04.440 and its related sub-sections.

04.431 Oil tanks. Oil tanks shall be capable of withstanding without failure all vibration, inertia, and fluid loads to which they may be subjected in operation. Flexible oil tank liners shall be of an acceptable type or proven suitable for the particular application.

04.4310 Oil tank tests. Oil tank tests shall be the same as fuel tank tests (See § 04.4230) except as follows:

(a) The $3\frac{1}{2}$ psi pressure specified in § 04.4230 shall be 5 psi.

(b) In the case of tanks with non-metallic liners, the test fluid shall be oil at a temperature of 250°F rather than fuel as specified in § 04.4230(c).

04.4311 Oil tank installation. Oil tank installations shall comply with the provisions of § 04.4231 except that oil tanks may be located on the engine side of the firewall.

04.4312 Oil tank construction.

04.43120 Oil tank expansion space. Oil tanks shall be provided with an expansion space of not less than either 10% of the tank capacity or 0.5 gallon, whichever is greater. Reserve oil tanks which have no direct connection to any engine shall be provided with an expansion space which need not exceed, but shall not be less than, 2% of the tank capacity. It shall not be possible inadvertently to fill the oil tank expansion space when the airplane is in the normal ground attitude.

04.43121 Oil tank filler connection. Oil tank filler connections shall be marked as specified in § 04.6121. Recessed oil filler openings which retain any appreciable quantity of oil shall be drained and the drain shall discharge clear of all portions of the airplane. The filler cap shall provide an oil tight seal.

04.43122 Oil tank vent. Oil tanks shall be vented from the top portion of the expansion space in such a manner that the tank is adequately vented under all normal flight conditions. Oil tank vents shall be so arranged that condensed water vapor that may freeze and obstruct the line cannot accumulate at any point.

04.43123 Oil tank outlet. The oil tank outlet shall not be enclosed or covered by any screen or other guard that may impede the flow of oil. (See also § 04.436.)

04.432 Oil system lines and fittings. Oil lines shall comply with the provisions of § 04.425.

04.4320 Fire resistant oil lines and fittings. Metal oil lines, except for flexible portions thereof, located on the engine side of the firewall shall be constructed of corrosion resistant steel or material of equivalent fire resistance. Flexible connections in such lines shall employ fire resistant hose with factory fixed ends, detachable ends, or heat and corrosion resistant hose clamps. Fire resistant hose may be used in lieu of metal lines. Aluminum alloy fittings and accessories may be used if fire resistant.

04.4321 Oil valves. Means shall be provided by which the flow of oil to each engine can be shut off individually in flight. If the oil tank is located outside the engine compartment, the valve shall also be located on the same side of the firewall and as close to this bulkhead as possible. If the oil tank is located on the engine side of the firewall, the valve shall be mounted on the tank or connected to the tank with a solid steel line. Shut-off valves shall be so constructed that it is possible for the flight personnel to reopen the valves after they have once been closed. The controls for shut-off valves located forward of the firewall shall be of fire resistant construction.

Valves shall be provided with positive stops in the on and off positions and shall be supported in such a manner that loads resulting from their operation or from accelerated flight conditions are not transmitted to the tubing attached to the valve. Closing of the oil shut-off valve shall not prevent feathering the propeller.

04.4322 Oil radiator. Oil radiators shall be capable of withstanding without failure any vibration, inertia, and oil pressure loads to which they may normally be subjected.

Oil radiator air ducts shall be so located that flames issuing from normal openings of the engine nacelle in case of fire shall not impinge directly upon the radiator.

04.4323 Oil filters. 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.

04.433 Oil system drains. Accessible drains shall be provided to permit safe drainage of the entire oil system and shall incorporate means for positive or automatic locking in the closed position.

04.434 Engine breather line. Engine breather lines shall be so arranged that condensed water vapor which may freeze and obstruct the line cannot accumulate at any point. Breathers shall discharge in a location which will not constitute a fire hazard in case foaming occurs and so that oil emitted from the line will not impinge upon the pilots' windshield. The breather shall not discharge into the engine air indiction system.

04.435 Oil system instruments. See § 04.51, § 04.522 through § 04.5221 and § 04.5224.

04.436 Propeller feathering system. 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. The quantity of oil so trapped shall be sufficient to accomplish the feathering operation and shall be available only to the feathering pump. The ability of the system to accomplish feathering when the supply of oil has fallen to the above level shall be demonstrated. This propeller feathering demonstration may be made on the ground if desired.

04.44 Cooling. The power plant cooling provisions shall be capable of maintaining the temperatures of major power plant components, engine fluids, and the carburetor intake air within the established safe values under all conditions of ground and flight operation.

04.440 Cooling tests. Compliance with the provisions of § 04.44 shall be demonstrated under critical ground, water, and flight operating conditions. If the tests are conducted under conditions that deviate from the highest anticipated summer air temperature (See § 04.400), the recorded power plant temperatures shall be corrected in accordance with the provisions of § 04.4401 and § 04.4402. 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 § 04.4403 through § 04.4405.

04.4400 Maximum anticipated summer air temperatures. The maximum anticipated summer air temperature (hot day condition) shall be considered to be 100°F at sea level and to decrease from this value at the rate of 3.6°F per thousand feet of altitude above sea level until a temperature of -67° is reached above which altitude the temperature will be held constant at -67°F.

04.4401 Correction factor for cylinder head, oil inlet, carburetor air, and engine coolant outlet temperatures. These temperatures shall be corrected by adding the difference between the maximum anticipated summer 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. A correction factor other than 1.0 may be employed if it can be demonstrated to be applicable.

04.4402 Correction factors for cylinder barrel temperatures. Cylinder barrel temperatures shall be corrected by adding 0.7 of the difference between the maximum anticipated summer 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. A correction factor other than 0.7 may be employed if it can be demonstrated to be applicable.

04.4403 Climb cooling test procedure. The climb cooling test shall be conducted with the critical engine inoperative and its corresponding propeller feathered. All remaining engines shall be operated at their maximum continuous power or at full throttle when above the critical altitude. 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:

(a) 1000 feet below the engine critical altitude.

(b) 1000 feet below the altitude at which the rate of climb, as established in § 04.1231(b), at the maximum take-off weight, is equal to at least $0.02\ Vs_o^2$ for airplanes with a maximum take-off weight of 40,000 lbs. or less, $0.04\ Vs_o^2$ for airplanes with a maximum take-off weight of 60,000 lbs. or more, with a linear variation between 40,000 lbs. and 60,000 lbs.

The climb shall be conducted at an airspeed which does not exceed the speed used in establishing the rate of climb required in § 04.1231(b). The climb cooling test may be conducted as a continuation of the take-off cooling test of § 04.4404.

04.4404 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, the test of § 04.4403 shall be supplemented by demonstration of adequate cooling during take-off and subsequent climb with one engine inoperative. The take-off cooling test shall be conducted by stabilizing temperatures during level flight at 75% of maximum continuous power (all engines operating) with normal cowl flap and shutter settings for the conditions. After all temperatures have stabilized, the climb shall be started at the lowest practicable altitude and shall be conducted with one engine inoperative and the corresponding propeller feathered. The remaining engines shall be operated at take-off RPM and power (or 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 § 04.1222). The power shall then be reduced to the maximum continuous power and the climb continued until at least 5 minutes after the occurrence of the highest temperature recorded. The speed used during take-off power operation shall not exceed the speed used during determination of the take-off flight path.

04.4405 Cooling test procedure for flying boat water operation. In the case of flying boats, adequate cooling shall be demonstrated during taxiing down wind for 10 minutes at 5 MPH above the step speed.

04.441 Liquid cooling systems. Each liquid cooled engine shall be provided with an independent cooling 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.

04.4410 Coolant tank. A coolant tank shall be provided. The tank shall have a usable coolant capacity of not less than one gallon. Coolant tanks shall be capable of withstanding without failure all vibration, inertia, and fluid loads to which they may be subjected in operation. Coolant tanks shall be provided with an expansion space of not less than 10% 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.

04.44100 Coolant tank tests. Coolant tank tests shall be the same as fuel tank tests (See § 04.4230) except as follows:

(a) The 3.5 psi pressure test of § 04.4230(a) shall be replaced by 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 greater.

(b) In the case of tanks with non-metallic liners, the test fluid shall be coolant at operation temperature rather than fuel as specified in § 04.4230(c).

04.44101 Coolant tank installation. Coolant tanks shall be supported in such a manner that the tank loads will be distributed over a large portion of the tank surface. Pads shall be provided to prevent chafing between the tank and the support. Material used for padding shall be non-absorbent or shall be treated to prevent the absorption of inflammable fluids.

04.44102 Coolant tank filler connection. Coolant tank filler connections shall be marked as specified in § 04.6121. Recessed coolant filler connections which retain any appreciable quantity of coolant shall be drained and the drain shall discharge clear of all portions of the airplane.

04.4411 Coolant lines and fittings. Coolant lines shall comply with the provisions of § 04.425.

04.44110 Fire resistant coolant lines and fittings. If the coolant employed is inflammable, coolant lines located on the engine side of the firewall shall be constructed of corrosion resistant steel or material of equivalent fire resistance. Flexible connections in such lines shall employ fire resistant hose with factory fixed ends, detachable ends, or heat and corrosion resistant hose clamps. Fire resistant hose may be used in lieu of metal lines. Aluminum alloy fittings and accessories may be used if adequately fire resistant.

04.44111 Coolant radiators. Coolant radiators shall be capable of withstanding without failure any vibration, inertia, and coolant pressure loads to which they may be normally subjected. Radiators shall be supported in a manner that will permit expansion due to operating temperatures and that will prevent the transmittal of harmful vibration to the radiator. If the coolant employed is inflammable the air intake duct to the coolant radiator shall be so located that flames issuing from normal openings of the engine nacelle, in case of fire, shall not impinge directly upon the radiator.

04.4412 Coolant system drains. One or more drains shall be provided to permit drainage of the entire coolant system, including the coolant tank, radiator, and the engine, when the airplane is in the normal ground attitude. Drains shall discharge clear of all portions of the airplane and shall be provided with means for positively locking the drain in the closed position. Coolant system drains shall be accessible.

04.4413 Coolant system instruments. See § 04.51, § 04.522 through § 04.5221 and § 04.5224.

04.45 Induction system. The engine air indiction system shall permit supplying an adequate quantity of air to the engine under all conditions of operation. The induction system shall provide air in such a manner as to permit acceptable fuel metering and mixture distribution with the induction system valves in any position. Each engine shall be provided with an alternate air source unless equivalent safety can be demonstrated by other means. Air intakes may open within the cowling only if that portion of the cowling is isolated from the engine accessory section by means of a fire resistant diaphragm, or if provision is made to prevent the emergence of backfire flames. Alternate air intakes shall be located in a sheltered position.

04.450 Induction system de-icing and anti-icing provisions. The engine air induction system shall incorporate means for the prevention and elimination of ice accumulations in accordance with the following provisions unless it can be demonstrated that equivalent safety can be obtained by a lower heat rise or by other means. It shall be demonstrated that compliance with the provisions outlined in the following paragraphs can be accomplished when the airplane is operating in air at a temperature of 30°F when the air is free of visible moisture.

(a) Airplanes equipped with altitude engines employing conventional venturi carburetors shall be provided with a preheater capable of providing a heat rise of 120°F when the engine is operating at 60% of its maximum continuous power.

(b) Airplanes equipped with altitude engines employing carburetors which embody features tending to reduce the possibility of ice formation shall be provided with a preheater capable of providing a heat rise of 100°F when the engine is operating at 60% of its maximum continuous power.

04.451 Carburetor air preheater design. Means shall be provided to assure adequate ventilation of the carburetor air preheater when the engine is being operated on cold air. The preheater shall be constructed in such a manner as to permit inspection of exhaust manifold parts which it surrounds and also to permit inspection of critical portions of the preheater itself.

04.452 Induction system ducts. Induction system ducts ahead of the first stage of the supercharger shall be provided with drains which will prevent the hazardous accumulation of fuel or moisture in the ground attitude. Sufficient strength shall be incorporated in the ducts to prevent induction system failures resulting from normal backfire conditions. Drains shall not discharge in a location that will constitute a fire hazard. Ducts which are connected to components of the airplane between which relative motion may exist shall incorporate provisions for flexibility.

04.453 Induction system screens. If induction system screens are employed, they shall be located upstream from the carburetor. It shall not be possible for fuel to impinge upon the screen. Screens shall not be located in portions of the induction system which constitute the only passage through which air may reach the engine unless the screen is so located that it can be de-iced. De-icing of screens by means of alcohol shall not be considered acceptable.

04.454 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. Demonstration of compliance with this provision shall be accomplished in accordance with § 04.440 and its related sub-sections.

04.4540 Inter-coolers and after-coolers. Inter-coolers and after-coolers shall be capable of withstanding without failure any vibration, inertia, and air pressure loads to which they may be subjected in operation.

04.46 Exhaust system. The exhaust system shall be constructed and arranged in such a manner as to assure the safe disposal of exhaust gases without the existence of a hazard of fire or carbon monoxide contamination of air in personnel compartments.

Unless suitable precautions are taken, exhaust system parts shall not be located in hazardous proximity to portions of any systems carrying inflammable fluids or vapors nor shall they be located under portions of such systems which may be subject to leakage. All airplane components upon which hot exhaust gases may impinge, or which may be subjected to high temperatures due to proximity to exhaust system parts, shall be constructed of heat resistant materials. All exhaust system components shall be separated from adjacent portions of the airplane, which are outside the engine compartment, by means of fire resistant shields.

Exhaust gases shall not be discharged at a location that will cause a glare seriously affecting pilot visibility at night, nor shall they discharge within dangerous proximity of any fuel or oil system drains.

All exhaust system components shall be ventilated to prevent the existence of points of excessively high temperature.

04.460 Exhaust piping. Exhaust piping shall be constructed of material suitably resistant to heat and corrosion and shall incorporate provisions to prevent failure due to expansion when heated to operating temperatures.

Exhaust pipes shall be supported in a manner adequate to withstand all vibration and inertia loads to which they may be subjected in operation. Portions of the exhaust piping, which are connected to components between which relative motion may exist, shall incorporate provisions for flexibility.

04.461 Exhaust heat exchangers. Exhaust heat exchangers shall be constructed and installed in such a manner as to assure their ability to withstand without failure all vibration, inertia, and other loads to which they may normally be subjected. Heat exchangers shall be constructed of materials that are suitable for continued operation at high temperatures and that are resistant to corrosion due to products contained in exhaust gases.

Provision shall be made for the inspection of all critical portions of exhaust heat exchangers, particularly if a welded construction is employed. Heat exchangers shall be adequately cooled whenever they are subject to contact with exhaust gases.

04.4610 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 can be demonstrated that sufficient safety can be obtained by other means.

04.462 Exhaust driven turbo-superchargers. Exhaust driven turbines shall be of an acceptable type or proven suitable for the particular application and shall be installed and supported in a manner to assure their safe operation between normal inspection or overhaul periods. Provisions for expansion and flexibility shall be made between exhaust conduits and the turbine. Provision shall also be made for cooling of turbine parts whose temperature is critical and for lubrication of the turbine. Means shall be provided for automatically limiting the turbine speed to its maximum allowable overspeed value.

04.47 Firewall and cowling.

04.470 Firewalls. All engines and auxiliary power plants which are intended for operation in flight shall be isolated from the remainder of the airplane by means of fire resistant bulkheads unless they are located in a nacelle that is remote from the remainder of the airplane and contains no fuel tanks.

04.4700 Firewall construction. The firewall 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. All openings in the firewall shall be sealed with close fitting fire resistant grommets, bushings, or firewall fittings.

Firewalls shall be constructed of material capable of withstanding a flame temperature of 2000°F for 15 minutes without flame penetration and shall be protected against corrosion. The following materials have been found to comply with this requirement:

<u>04.4803 Propeller speed and pitch controls.</u> (See also § 04.4111(a).) It shall be possible to control the propellers separately. The controls shall be grouped and arranged in such a manner as to permit control of the propellers separately and together. The controls shall permit ready synchronization of all propellers.

<u>04.48030 Propeller feathering controls.</u> A separate control shall be provided for each propeller. Propeller feathering controls shall be provided with means to prevent inadvertent operation. If feathering is accomplished by movement of the normal pitch or speed control lever, provision shall be made to prevent the movement of this control to the feathering position during normal operation.

<u>04.48031 Propeller reversing controls.</u> If the propeller blades can be placed in a pitch position which will produce negative thrust, reversing controls shall be so arranged as to prevent inadvertent operation.

<u>04.4804 Fuel system controls.</u> (See § 04.4251(c).) Fuel jettisoning system controls shall be provided with guards to prevent their inadvertent operation. Such controls shall not be located in close proximity to fire extinguisher controls or any other controls intended for operation in order to combat a fire.

<u>04.4805 Carburetor air reheat controls.</u> Separate controls shall be provided to regulate the temperature of the carburetor air for each engine.

<u>04.481 Power plant accessories.</u> Engine mounted accessories shall be of a type satisfactory for installation on the engine involved and shall utilize the provisions made on the engine for the mounting of such units.

Items of electrical equipment subject to arcing or sparking shall be installed so as to minimize the possibility of their contact with any inflammable fluids or vapors which may be present in a free state.

<u>04.4810 Engine ignition systems.</u>

(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 may draw electrical energy from the same source. Consideration shall be given to the condition of an inoperative generator and to the condition of a completely depleted battery when the generator is running at its normal operating speed. If only one battery is provided, consideration shall also be given to the condition in which the battery is completely depleted and the generator is operating at idling speed.

(c) Means shall be provided to warn the appropriate flight personnel if malfunctioning of any part of the electrical system is causing the continuous discharging of a battery that is necessary for engine ignition. (See § 04.4801 for ignition switches.)

04.49 Power plant fire protection. Unless it can be demonstrated that equivalent protection against destruction of the airplane in case of fire is provided by the use of fire resistant materials in the nacelle and other components that would be subjected to flame, fire extinguishers shall be provided. These shall be provided for the accessory sections, installations where no isolation is provided between the engine and accessory compartments, auxiliary power plants, fuel burning heaters, and other combustion equipment. Such regions shall be referred to as designated fire zones.

04.490 Fire resistant fluid lines. All lines not heretofore specified which carry inflammable fluids or gases into designated fire zones shall be constructed of corrosion resistant steel or material of equivalent fire resistance. Flexible connections in such lines shall employ fire resistant hose with factory fixed ends, detachable ends, or heat and corrosion resistant hose clamps. Fire resistant hose may be used in lieu of metal lines. Aluminum alloy fittings and accessories may be used if adequately fire resistant. All such lines shall be provided with suitable means to shut off or otherwise prevent the flow of hazardous quantities of inflammable fluids or gases into the designated fire zones. Unless equivalent safety is provided, such means shall not be located within the designated fire zone. Operation of the shut-off means shall not prevent the operation of emergency equipment such as propeller feathering systems and the like.

04.491 Fire extinguisher systems.

(a) The fire extinguishing system and quantity of agent shall be such as to provide two adequate discharges, each or both of which may be directed to any main engine installation. Individual "one shot" systems may be provided for items such as auxiliary power plants, fuel burning heaters, and other combustion equipment.

(b) If a methyl bromide system is employed, it shall be so arranged that after discharge to any designated fire zone it shall not be possible to trap extinguishing agent in any portion of the system which is not open to the atmosphere through open lines, unless equivalent safety can be demonstrated by other means.

04.4910 Fire extinguishing agents. Extinguishing agents employed shall be methyl bromide, carbon dioxide, or any other agent which has been demonstrated to provide equivalent extinguishing action. If methyl bromide or any other toxic extinguishing agent is employed, provisions 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 when a defect exists in the extinguisher system. If a methyl bromide system is provided, the containers shall be charged with dry agent and shall be sealed by the fire extinguisher manufacturer or any other party employing satisfactory recharging equipment. If carbon dioxide is used, it shall not be possible to discharge sufficient gas into personnel compartments to constitute a hazard from the standpoint of suffocation of the occupants.

04.4911 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 discharge line from the relief connection shall terminate outside the airplane in a location convenient for inspection on the ground. An indicator shall be provided at the discharge end of the line to provide a visual indication when the container has discharged.

04.4912 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.

04.4913 Fire extinguisher system materials. Fire extinguisher system components located in designated fire zones shall be constructed of stainless steel or materials of equivalent fire resistance, except for such flexible connections as may be required between fixed and moving portions of the airplane. Such flexible connections shall be of fire resistant construction and located so as to minimize the possibility of failure.

04.492 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 which may occur in such zones.

04.4920 Fire detectors. Fire detectors shall be constructed and installed in such a manner as to assure their ability to resist without failure, all vibration, inertia, and other loads to which they may normally be subjected. Detectors shall be unaffected by exposure to oil, water, or other fluids or fumes which may be present in potential fire zones.

04.493 Protection of other airplane components against fire. All airplane surfaces aft of the nacalle, in the region of one nacelle diameter on either side of the nacelle centerline, shall be constructed of material at least equivalent to present aluminum alloy construction and fire resistance. This provision need not be applied to tail surfaces lying behind nacelles unless the distance between the nacelle and such surfaces is small.

04.5 EQUIPMENT

04.50 General. The equipment specified in § 04.51 below is the minimum which shall be installed in the airplane. (See also § 04.300) Such additional equipment as is necessary for a specific type of operation is specified in Part 40 entitled "Air Carrier Operating Certification," Part 41 entitled "Certification and Operation Rules for Scheduled Air Carrier Operations Outside the Continental Limits of the United States," and Part 61 entitled "Scheduled Air Carrier Rules." All equipment essential to the safe operation of the airplane shall comply with the following subsections.

04.500 Functional and installational requirements. Each item of equipment shall be: (1) of a type and design satisfactory to perform its intended function, (2) adequately labeled as to its identification, function, or operational limitations, or any combination of these, whichever is applicable, (3) properly installed, in accordance with specified limitations of the equipment, and (4) demonstrated to function satisfactorily in the airplane. Items of equipment for which type certification is required are outlined in Part 15. Such items, when used in the airplane, shall have been certificated in accordance with the provisions of Part 15 (or previous regulations) and such other Parts as may be applicable.

04.51 Required basic equipment. The following table shows the required basic equipment items necessary for type and airworthiness certification of the airplane:

(a) Flight and navigation instruments (See § 04.52)

1. Airspeed indicating system with heated pitot tube or equivalent means of preventing malfunctioning due to icing. (See § 04.5210 and § 04.5212)
2. Altimeter (sensitive) (See § 04.5212)
3. Clock (sweep-second)
4. Free air temperature indicator
5. Gyroscopic bank & pitch indicator (non-upsetting type) (See § 04.5215)
6. Gyroscopic rate-of-turn indicator (with bank indicator) (See § 04.5215)
7. Gyroscopic direction indicator (See § 04.5215)
8. Magnetic direction indicator (See § 04.5213)
9. Rate-of-climb indicator (vertical speed) (See § 04.5212)

(b) Power plant instruments (See § 04.52)

1. Carburetor air temperature indicator for each engine (See § 04.5226)
2. Coolant temperature indicator for each liquid-cooled engine
3. Cylinder head temperature indicator for each air cooled engine (See § 04.5225)

4. Fuel pressure indicator for each pump-fed engine
5. For each engine not equipped with an automatic altitude mixture control:
   (a) Fuel flowmeter indicator (See § 04.5223) or,
   (b) Fuel mixture indicator
6. Fuel quantity indicator for each fuel tank (See § 04.5222)
7. Manifold pressure indicator for each engine
8. Oil pressure indicator for each engine
9. Oil quantity indicator for each oil tank when a transfer or oil reserve supply system is used (See § 04.5224)
10. Oil temperature indicator for each engine
11. Tachometer for each engine
12. Fire warning indicators (See § 04.492)

(c) Miscellaneous equipment

1. Approved seats for all occupants (See § 04.3822)
2. Certificated safety belts for all occupants
3. A master switch arrangement for electrical circuits other than ignition
4. Adequate source(s) of electrical energy
5. Electrical protective devices
6. Radio communication system (two-way)
7. Radio navigation system
8. Windshield wiper or equivalent for each pilot
9. Ignition switch for each and all engines (See § 04.4801)
10. Portable fire extinguisher (See § 04.552)

04.52 Instruments - installation.

04.520 General.

04.5200 Arrangement and visibility of instrument installations.

(a) Flight, navigation, and powerplant instruments for use by each pilot shall be easily 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 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. Identical powerplant instruments for the several engines shall be so located as to prevent any misleading impression as to the engines to which they relate. Important powerplant instruments shall be easily visible to the appropriate personnel.

04.5201 Instrument panel vibration characteristics. The vibration characteristics of the instrument panel shall not be such as to seriously impair the accuracy of the instruments or to damage them.

04.521 Flight and navigation instruments.

04.5210 Airspeed indicating system. This system shall be so installed that the airspeed indicator shall indicate true airspeed at sea level under standard conditions to within an allowable installational error of not more than plus or minus 3% or 5 mph, whichever is greater, throughout the operating range of the airplane from $1.3V_{s_1}$ (flaps up and down) to V_c. The calibration shall be made while in flight and the method used shall be subject to the approval of the Administrator.

04.5211 Airspeed indicator marking. The airspeed indicator shall be marked as specified in § 04.6000.

04.5212 Static air vent system. All instruments provided with static air case connections shall be vented to the outside atmosphere through a suitable piping system. This 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. The installation shall be such that the system will be air-tight, except for the vent into the atmosphere.

04.5213 Magnetic direction indicator. The magnetic direction indicator shall be so installed that its accuracy shall not be excessively affected by the airplane's vibration or magnetic fields of a permanent or transient nature. After the magnetic direction indicator has been compensated, the calibration shall be such that the deviation in level flight does not exceed plus or minus 10° on any heading. A suitable calibration placard shall be provided as specified in § 04.6101.

04.5214 Automatic pilot system. If an automatic pilot system is installed, the following shall be applicable:

(a) The actuating (servo) devices shall be of such design that they can, when necessary, be either positively disengaged from operating the control system or be overpowered by the human pilot so as to enable him to maintain satisfactory control of the airplane,

(b) A satisfactory means shall be provided to readily indicate to the pilot the alignment of the actuating device in relation to the control system to which it operates, except when automatic synchronisation is provided,

(c) The manually operated control(s) for the system's operation shall be readily accessible to the pilot,

(d) 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 they were designed.

04.5215 Gyroscopic indicators (Air-driven type). All air-driven gyroscopic instruments installed shall derive their energy from a suction air pump driven either by an engine or an auxiliary power unit. The following detail requirements shall be applicable:

(a) Two suction air pumps actuated by separate power means shall be provided, either one of which shall be of sufficient capacity to operate, at the service ceiling of the airplane in normal cruising condition, all of the air-driven gyroscopic instruments with which the airplane is equipped.

(b) A suitable means shall be provided in the attendant installation, where the pump lines connect into a common line, to select either suction air pump for the proper functioning of the instruments should failure of one source or a breakage of one pump line occur. When an automatic means to permit simultaneous air flow is provided in the system, a suitable method for indicating any interrupted air flow in the pump lines shall be incorporated in the system. In order to indicate which source of energy has failed, a visual means shall be provided to indicate this condition to the flight crew.

(c) A suction gauge shall be provided and so installed as 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. This gauge(s) shall be connected to the instruments by a suitable system.

04.522 Power plant instruments.

04.5220 Operational markings. Instruments shall be marked as specified in § 04.6102.

04.5221 Instrument lines. Power plant instrument lines shall comply with the provisions of § 04.425. In addition, instrument lines carrying inflammable fluids or gases under pressure shall be provided with restricted orifices or equivalent safety devices at the source of the pressure to prevent escape of excessive fluid or gas in case of line failure. (For fire resistant power plant instrument lines see § 04.49.)

04.5222 Fuel quantity indicator. Means shall be provided to indicate to the flight personnel the quantity in gallons or equivalent units of usable fuel in each tank during flight. Tanks whose outlets and air spaces are interconnected may be considered as one tank and need not be provided with separate indicators. Exposed sight gauges shall be so installed and guarded as to prevent breakage or damage. 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 § 04.422 (See § 04.6104).

04.5223 Fuel flowmeter system. When a fuel flowmeter system is installed in the fuel line(s), the metering component shall be of such design as to include a suitable means for by-passing the fuel supply in the event that malfunctioning of the metering component offers a severe restriction to fuel flow.

04.5224 Oil quantity indicator. Ground means, such as a stick gauge, shall be provided to indicate the quantity of oil in each tank. (See § 04.6103) If an oil transfer system or a reserve oil supply system is installed, means shall be provided to indicate to the flight personnel the quantity of oil in each tank during flight.

04.5225 Cylinder head temperature indicating system for aircooled engines. A cylinder head temperature indicator shall be provided for each engine on airplanes equipped with cowl flaps. In the case of airplanes which do not have cowl flaps, an indicator shall be provided if compliance with the provisions of § 04.44 and its related sub-sections is demonstrated at a speed in excess of the speed of best rate of climb.

04.53 Electrical systems and equipment - installation. Electrical systems and equipment shall: (1) be free from hazards in themselves, in their method of operation, and in their effects on other parts of the airplane; (2) be installed in such a manner that they are suitably protected from fuel, oil, water, other detrimental substances and mechanical damage.

In addition to the requirements specified, all electrical equipment shall be of a type and design adequate for the use intended. For substantiation of the electrical system the data required under § 04.031 is considered to include:

(a) Wiring diagrams, including a schematic power supply diagram.

(b) Installation data which includes the manufacturer's name and type of all electrical items and reference to pertinent specifications.

(c) A load analysis.

Items of electrical equipment for specific types of airplane operations are listed in Part 41 entitled "Certification and Operation Rules for Scheduled Operations Outside the Continental Limits of the United States" and Part 61 entitled "Scheduled Air Carrier Rules."

04.530 Batteries. The capacity shall be that determined necessary from an electrical load analysis.

04.5300 Protection against acid. Means shall be provided to prevent corrosive battery substance from coming in contact with other parts of the airplane during servicing or flight.

04.5301 Battery containers. Batteries shall be completely enclosed in a container or compartment and shall be easily accessible for servicing and inspection on the ground.

04.5302 Battery vents. The battery container or compartment shall be vented in such a manner that gases released by the battery are carried outside the airplane.

04.5303 Battery cooling. Battery cooling shall be provided, if necessary, to keep the battery temperature within the limits specified by the battery manufacturer.

04.531 Generators. The 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.

04.5310 Generator rating. Individual generators shall be capable of delivering their continuous rated power.

04.5311 Generator controls. Generator voltage control equipment shall be capable of dependably regulating the generator output within rated limits.

04.5312 Reverse current cut-out. A generator reverse current cut-out shall disconnect the generator from the battery and other generators when the generator is developing a voltage of such value that current sufficient to cause malfunctioning can flow into the generator.

04.532 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.

04.5320 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.

04.533 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.

04.5330 Protective devices installation. Protective devices in circuits used in flight shall be so located and identified that fuses may be replaced or circuit breakers reset readily in flight.

04.5331 Spare fuses. If fuses are used, one spare of each rating or 50% spare fuses of each rating, whichever is greater, shall be provided.

04.534 Electric cables. The electrical cable used shall be in accordance with approved standards for aircraft electric cable of a slow burning type and shall have adequate current carrying capacity to deliver the necessary power to the items of equipment to which it is connected.

04.535 Switches. Switches shall be capable of carrying their rated current.

04.5350 Switch installation. Switches shall be so installed as to be readily accessible to a member of the crew and shall be suitably labeled as to operation and the circuit controlled.

04.536 Instrument lights. Instrument lights shall provide sufficient illumination to make all instruments, switches, etc., easily readable and discernible.

04.5360 Instrument light installation. Instrument lights shall be installed in such a manner that their direct rays are shielded from the pilot's eyes and that no objectional reflections are visible to him.

04.5361 Light dimming. A suitable means of controlling the intensity of illumination shall be provided unless it can be shown that non-dimmed instrument lights are satisfactory.

04.537 Landing lights. Landing lights shall be of a type acceptable to the Administrator.

04.5370 Landing light installation. Landing lights shall be so installed that there is no objectionable glare visible to the pilot and also that the pilot is not seriously affected by halation. They shall be installed at such a location that they provide adequate illumination for night landing.

04.5371 Landing light switch. 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 is satisfactory.

04.538 Position lights. Forward and rear position lights shall be of a type certificated in accordance with Part 15.

04.5380 Forward position light installation. Forward position lights shall be so installed that, with the airplane in normal flying position, the red light is displayed on the left side and the green light on the right side, each showing unbroken light between two vertical planes whose dihedral angle is 110 degrees when measured to the left and right, respectively, of the airplane from dead ahead. The lights shall be spaced laterally as far apart as practicable.

04.5381 Rear position light installation. The red and white position lights shall be mounted as far aft as practicable and so installed that unbroken light is directed symmetrically aft from each light in such a manner that the axis of the maximum cone of illumination is parallel to the flight path. In addition, the intersection of the two planes forming dihedral angle A given in Part 15 shall be vertical. If separate red and white lights are used, they shall be located as close together as practicable.

04.5382 Top and bottom fuselage lights. The top and bottom fuselage lights shall each furnish illumination of an intensity equivalent to that of a 32-candlepower lamp installed in a reflector of relatively high reflective properties and shall have a clear cover glass. They shall show light through approximately a hemisphere.

04.53821 Top and bottom fuselage lights - installation. The top fuselage light shall be installed in the top of the fuselage approximately in line with the forward position lights. The bottom fuselage light on landplanes shall be installed in the bottom of the fuselage 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.

04.5383 Position light flasher. 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 below. The flasher shall be of a type acceptable to the Administrator.

04.5384 Flashing light sequence. 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. The flashing sequence shall be repeated automatically when the position light switch is in the "flash" position.

04.5385 Flashing light cut-out 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. The top and bottom fuselage lights shall not be lighted under this condition.

04.539 Riding light. When a riding light is required, seaplanes, flying boats, and amphibians shall have at least one riding (anchor) light, which is capable of showing a white light for at least two miles at night under clear atmospheric conditions.

04.5390 Riding light - installation. The riding light shall be so installed that it shows the maximum unbroken light practicable when the airplane is moored or drifting on the water. Externally hung light(s) are permitted.

04.54 Safety equipment - installation.

04.540 Marking. Safety equipment controls which the crew is expected to operate at the time of an emergency such as flares, automatic life raft releases, etc., shall be readily accessible and plainly marked as to the method of operation. When fire extinguishing, life enduring, and signaling equipment is carried in lockers, compartments, etc., such storage places shall be marked for the benefit of passengers and crew.

04.541 De-icers. When pneumatic de-icers are installed, the installation shall be in accordance with approved data. Positive means shall be provided for the deflation of the pneumatic boots.

04.542 Fire extinguishers - number and installation. The approved hand-type fire extinguisher required in § 04.51(c) shall be installed primarily for the use of the pilot and copilot. The installation of the additional fire extinguishing equipment required in Parts 41 and 61 will depend upon the size and type of the aircraft and the disposition and size of the crew and passengers and location of such fire extinguishers used will be subject to the approval of the Administrator.

An approved fire extinguisher is one approved by the Underwriters Laboratories or by any other agency deemed qualified by the Administrator.

04.543 Flares.

04.5430 Flare requirements. When parachute flares are required, they shall be of a type certificated in accordance with Part 15.

04.5431 Flare installation. Parachute flares shall be releasable from the pilot's compartment and so installed that danger from accidental discharge is reduced to a minimum. It shall be demonstrated in flight that the installation in each model of airplane is such that ejection is accomplished without any hazard to the airplane or its occupants. If the flares are ejected so that recoil loads are involved, structural provision for such loads shall be made.

04.544 Safety belts. Safety belts shall be of a type certificated in accordance with Part 15. They shall be so attached that no part of the attachment will fail at a lower load than that specified in § 04.38221.

04.545 Safety belt signal. When a means is provided to indicate to the passengers when the seat belt should be fastened, the device shall be so installed that it can be operated from the seat of either pilot or co-pilot.

04.546 Emergency flotation and signaling equipment.

04.5460 General. When required by Parts 40, 41, and 61, an approved life raft or approved life preserver is one approved by either the Administrator, the Bureau of Marine Inspection and Navigation, the U. S. Army Air Forces, or the Bureau of Aeronautics, Navy Department.

04.5461 Installation of rafts and life preservers. When such emergency equipment is required, it shall be so installed as to be readily available to the crew and passengers. Rafts released automatically or by the pilot shall be attached to the airplane by means of a line to keep them adjacent to the airplane.

04.5462 Signaling device. Signaling devices, when required by Parts 40, 41, and 61, shall be accessible, shall function satisfactorily, and be free from any hazard in their operation.

04.5463 First aid equipment. The amount of first aid equipment will vary with the number and distribution of passengers and the type of operation involved and the location(s) of such equipment shall be subject to the approval of the Administrator.

04.55 Radio equipment - installation.

04.550 General. 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.

04.56 Miscellaneous equipment - installation.

04.560 Accessories. Engine-driven accessories essential to the safe operation of the airplane shall be distributed among two or more engines.

04.561 Hydraulic systems.

04.5610 General. Hydraulic systems and elements shall be so designed as to withstand, without exceeding the yield point, any structural loads which may be imposed in addition to the hydraulic loads.

04.5611 Tests. Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of the hydraulic systems 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.

04.5612 Lines. All hydraulic lines carrying inflammable fluids into a designated fire zone shall be constructed in accordance with § 04.490.

04.5613 Accumulators. Hydraulic accumulators or pressurized reservoirs shall not be installed on the engine side of the firewall except when they form an integral part of the powerplant.

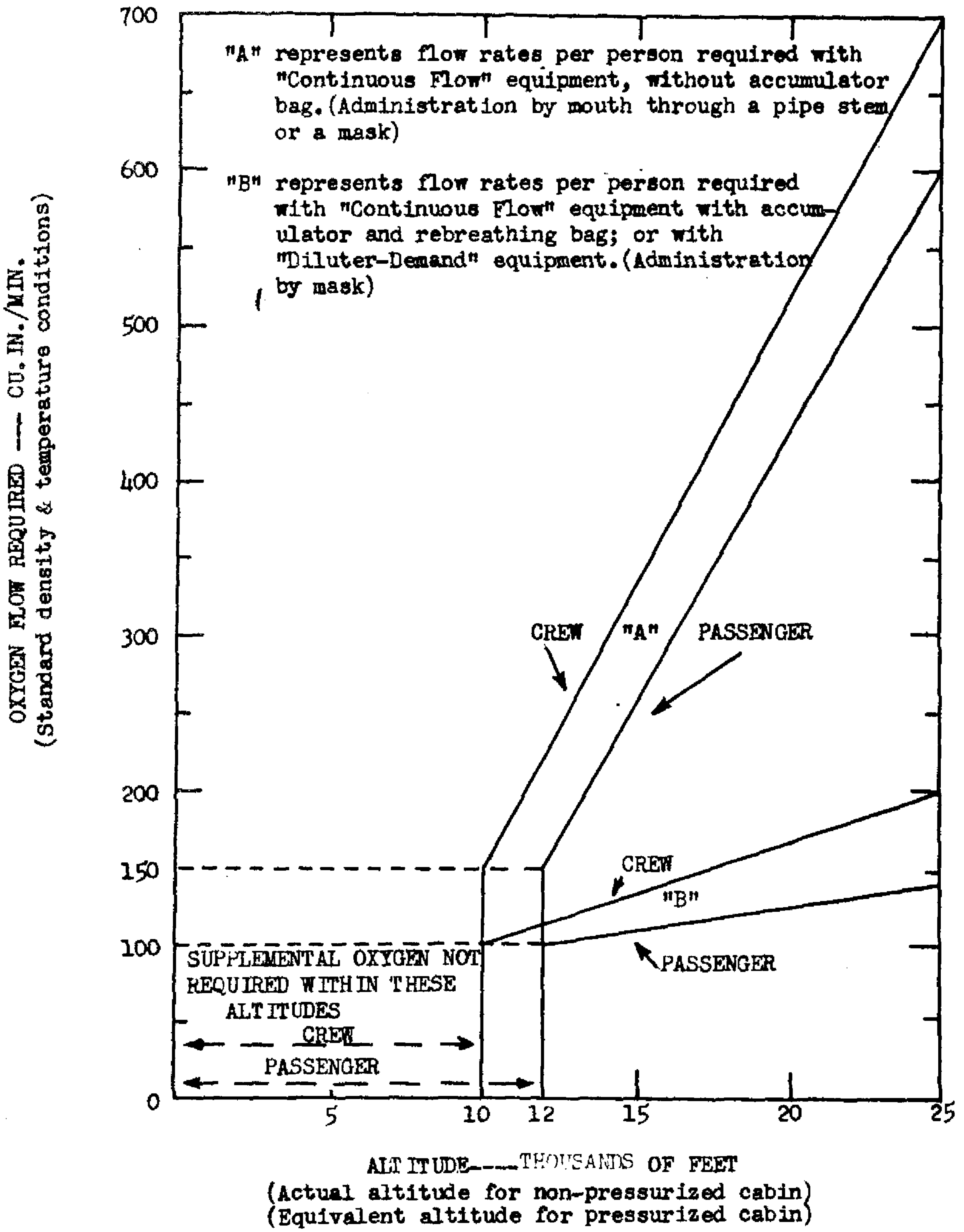
04.562 Oxygen system. When oxygen is provided to comply with the requirements of Parts 41 and 61, the oxygen system installation shall be free from hazards in itself, in its method of operation, and in its effects on other components of the airplane. The oxygen equipment shall be of a type and design which experience or conclusive tests have shown to be adequate for the use intended. The minimum amount of supplemental oxygen required per person for continuous operation is indicated in Figure 04-19.

MINIMUM FLOW OF SUPPLEMENTAL

OXYGEN FOR CONTINUOUS OPERATION AT

VARIOUS ALTITUDES

Figure 04-19



04.6 OPERATING LIMITATIONS AND INFORMATION

04.6 Operating limitations and information. Means shall be provided by which the pilot and other appropriate crew members are adequately informed of all operating limitations upon which the type design is based. Any other information concerning the airplane found by the Administrator to be necessary for safety during its operation shall also be made available to the crew.

04.60 Limitations. The operating limitations specified in the following subsections and any similar limitations shall be established for any airplane and made available to the operator as further described in § 04.61 and § 04.62, unless its design is such that they are unnecessary.

04.600 Airspeed. The following airspeed limitations shall be established:

04.6001 Never exceed speed. This speed shall not exceed the lesser of the following:

(a) $0.9V_d$ chosen in accordance with § 04.2110, or
(b) 0.9 times the maximum speed demonstrated in accordance with § 04.15, but shall not be less than 0.9 times the minimum value of V_d permitted by § 04.2110.

The 0.9 factor may be suitably modified to take into account the increase of drag coefficient at high Mach numbers. The factor used shall be substantiated by flight tests.

04.6002 Maximum structural cruising speed. This operating limitation shall be:

(a) Not greater than V_c chosen in accordance with § 04.2110.
(b) Not greater than 0.89 times the "Never Exceed" speed established under § 04.6001.
(c) Not less than the minimum V_c permitted in § 04.2110.

The 0.89 factor may be suitably modified to take into account the increase in drag coefficient at high Mach numbers. The factor used shall be substantiated by flight tests.

04.6003 Maneuvering speed. (See § 04.2110).

04.6004 Flaps extended speed. This speed shall not exceed the lesser of the following:

(a) The design flap speed, V_f, chosen in accordance with § 04.2110 or
(b) the flap design speed chosen in accordance with § 04.225, but shall not be less than the minimum value of flap design speed permitted in § 04.2110 and § 04.225.

04.6005 Minimum control speed. (See § 04.312).

04.601 Power plant. The following power plant limitations shall be established and shall not exceed the corresponding limits established as a part of the type certification of the engine and propeller installed in the airplane.

04.6011 Take-off operation.

(a) Maximum rotational speed (RPM).
(b) Maximum permissible manifold pressure.
(c) The time limit upon the use of the corresponding power.
(d) Where the time limit of Item (c) exceeds two minutes, the maximum allowable cylinder head, or coolant outlet and oil temperatures.

04.6012 Maximum continuous operation.

(a) Maximum rotational speed (RPM).
(b) Maximum permissible manifold pressure.
(c) Maximum allowable cylinder head, or coolant outlet and oil termperatures.

04.6013 Fuel octane rating. The minimum octane rating of fuel required for satisfactory operation of the power plant at the limits of § 04.6011 and § 04.6012.

04.602 Airplane weight. The airplane weight and c.g. limitations are those required to be determined by § 04.11.

04.603 Minimum flight crew. The minimum flight crew shall be established as that number of persons required for the safe operation of the airplane during day contact flight as determined by the availability and satisfactory operation of all necessary controls by each operator concerned.

04.604 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 Parts 41 and 61).

04.61 Markings and placards. The markings and placards specified are required for all airplanes. Placards shall be displayed in a conspicuous place and both shall be such that they may not be easily erased, disfigured, or obscured. Additional information, placards, and instrument markings having a direct and important bearing on safe operation may be required when unusual design, operating or handling characteristics so warrant.

04.610 Instrument markings. The instruments listed below shall have the following limitations marked thereon. When these markings are placed on the cover glass of the instrument, adequate provisions shall be made to maintain the correct alignment of the glass cover with the face dial. All arcs and lines shall be of sufficient width and so located as to be clearly and easily visible to the pilot.

04.6100 Airspeed indicator. True indicated airspeed shall be used:

(a) The never exceed speed, V_{ne},-a radial red line (See § 04.6001).

(b) The caution range - a yellow arc extending from the red line in (a) above to the upper limit of the green arc specified in (c) below.

(c) The normal operating range - a green arc with the lower limit at V_s, as determined in § 04.121 with maximum take-off weight, landing gear and wing flaps retracted, and the upper limit at the maximum structural cruising speed established in § 04.6002.

(d) The flap operating range - a white arc with the lower limit at V_{so} as determined in § 04.121 at the maximum landing weight, and the upper limit at the flaps extended speed in § 04.6004.

When the Never Exceed speed and Maximum Structural Cruising speed vary with altitude, means shall be provided which will indicate the appropriate limitation to the pilot throughout the operating altitude range.

04.6101 Magnetic direction indicator. A placard shall be installed on or in close proximity to the magnetic direction indicator which contains the calibration of the instrument in a level flight attitude with engine(s) operating and radio receiver(s) on or off (which shall be stated). The calibration readings shall be those to known magnetic headings in not less than 45° increments.

04.6102 Power plant instruments. All required power plant instruments shall be marked with a red radial line at the maximum, and minimum (if applicable) indications for safe operation. The normal operating ranges shall be marked with a green arc which shall not extend beyond the maximum and minimum limits for continuous operation. Take-off and precautionary ranges shall be marked with a yellow arc.

04.6103 Oil quantity indicators. Indicators shall be suitably marked in sufficient increments so that they will readily and accurately indicate the quantity of oil.

04.6104 Fuel quantity indicator. When the unusable fuel supply for any tank exceeds 1 gallon or 5% of the tank capacity, whichever is greater, a red band shall be placed on the indicator which extends from the calibrated zero reading to the lowest reading obtainable in the level flight attitude, and a suitable notation in the airplane's operating manual shall be provided to indicate to the flight personnel that the fuel remaining in the tank when the quantity indicator reaches zero cannot be used safely in flight (See § 04.5222).

04.611 Control markings. All cockpit controls, with the exception of the primary flight controls, shall be plainly marked and/or identified as to their function and method of operation.

04.6110 Aerodynamic controls. The secondary controls shall be suitably marked to comply with § 04.352 and § 04.353.

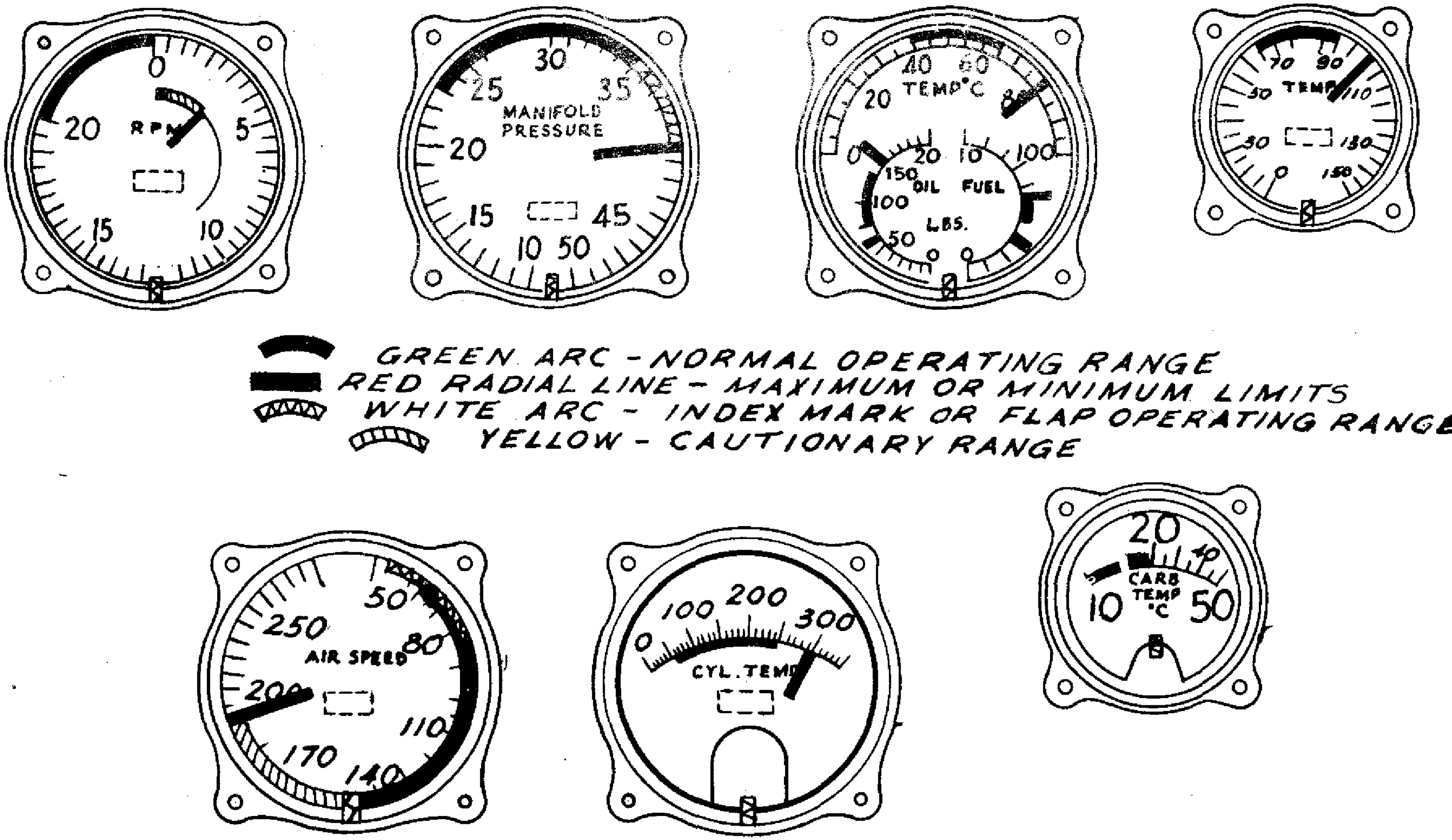


FIG 04-20
REPRESENTATIVE INSTRUMENT MARKINGS

04.6111 Power plant fuel controls.

(a) Controls for fuel tank selector valves shall be marked to indicate the position corresponding to each tank and any cross feed positions that may exist.

(b) 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 to indicate to the flight personnel the order in which the tanks should be used.

(c) Controls for engine selector valves shall be marked to indicate the position corresponding to each engine.

04.6112 Accessory and auxiliary controls.

(a) When a retractable landing gear is used, the visual indicator required in § 04.3622 shall be marked in such a manner that the pilot, at all times, can ascertain when the wheels are secured in either extreme position.

(b) Emergency controls shall be colored red and clearly marked as to their method of operation.

04.612 Miscellaneous markings and placards.

04.6120 Baggage compartments and ballast location. Each baggage or cargo compartment and ballast location shall bear a placard which states the maximum allowable weight of contents and, if applicable, any special limitation of contents due to loading requirements, etc.

04.6121 Fuel, oil, and coolant filler openings. The following information shall be marked on or adjacent to the filler cover in each case:

(a) The word "fuel", the minimum permissible fuel octane number for the engines installed, and the usable fuel tank capacity. (See § 04.4221).

(b) The word "oil" and the oil tank capacity.

(c) The name of the proper coolant fluid and the capacity of the coolant system.

04.6122 Emergency exit placards. Emergency exists shall be clearly marked as such in letters not less than 3/4 inch high with luminous paint, such markings to be located either on or immediately adjacent to the pertinent exit and readily visible to passengers. Location and method of operation of the handles shall be marked with luminous paint. (See § 04.38121).

04.6124 Operating limitation placard. A placard shall be provided in front of and in clear view of the pilot(s) stating: "This airplane must be operated in compliance with the operating limitations specified in C.A.A. approved Airplane Operating Manual."

04.62 Airplane operating manual. An airplane operating manual shall be furnished with each airplane. (See Parts 41 and 61). The portions of the manual listed below shall be verified and approved by the Administrator. Additional items of information having a direct and important bearing on safe operation may be required when unusual design, operating or handling characteristics so warrant. The manual shall contain, as a minimum, the following:

04.620 Operating limitations. This part of the manual shall contain the operating limitation information listed below:

(a) Airspeed limitation - Sufficient information shall be included in this section of the manual to permit proper marking of the airspeed limitations on the indicator as required in § 04.6100. It shall also include the design maneuvering speed and the maximum safe airspeed at which the landing gear can be safely lowered. In addition to the above information, the manual shall explain the significance of the airspeed limitations, and the color coding used.

(b) Power plant limitations - Sufficient information shall be included in this section of the manual to outline and explain all power plant limitations (see § 04.601) and to permit marking the instruments as required in § 04.6102.

(c) Weight and loading distribution - The airplane weights and c.g. limits required to be determined by § 04.11, together with the items of equipment on which the weight empty is based, shall be entered in this section of the manual. Where the variety of possible loadings warrants, instructions adequate to insure observance of those limitations shall be included in this section of the manual. (See also § 04.1101).

(d) Flight load acceleration limits - The positive limit load factors made good by the airplane structure shall be described here in the manual in terms of accelerations.

(e) Flight crew - The number and functions of the minimum flight crew required to operate the airplane safely, which has been determined by the requirements of § 04.603, shall be entered in this section of the manual.

(f) Type of airplane operation - This section of the manual shall state the type(s) of operation(s) for which the airplane and its necessary equipment installations have been certificated.

04.621 Operating Procedures. This part of the manual shall contain information indicated below which is peculiar to the airplane, and which concerns the normal and emergency procedures necessary to their safe performance by the crew.

(a) Normal - This section shall contain information and instructions regarding peculiarities of: starting and warming engines, taxiing, operation of wing flaps, landing gear, automatic pilot, etc.

(b) One-engine inoperative - This section of the manual shall outline the procedure to be used in the event of engine failure, including recommended minimum speeds, trim, operation of remaining engine(s), etc.

(c) <u>Propeller feathering</u> - The desirable procedure to be followed in stopping the rotation of propellers in flight shall be included in this section of the manual.

<u>04.622</u> <u>Performance information</u>. This part of the manual shall contain the performance information listed below:

(a) <u>Performance data</u> - A summary of all performance data secured in accordance with § 04.12 - Performance, § 04.122 - Take-off, § 04.123 - Climb, and § 04.124 - Landing, inclusive, as well as all data derived therefrom, required for the application of the operating rules of § 61.712. Also, any pertinent descriptions of the conditions, airspeeds, etc., under which the above data were determined.

(b) <u>Flap controls</u> - Adequate instructions for the use and adjustment of the flap controls necessary to obtain the desired performance.

(c) <u>Airspeeds</u> - The indicated airspeeds corresponding to those determined in § 04.122 - Take-off, together with pertinent discussion of procedures to be followed if the critical engine becomes inoperative during take-off.

(d) <u>Miscellaneous</u> - Include a discussion of any significant or unusual flying or ground handling characteristics, knowledge of which would be useful to a pilot who has not previously flown the airplane and which would thereby enable him more readily to obtain maximum performance.

04.7 AIRPLANE IDENTIFICATION DATA

<u>04.70</u> <u>Nameplate</u>. A nameplate shall be securely attached and shall contain:

(a) The manufacturer's name and address,
(b) Model and serial numbers,
(c) Date of manufacture,
(d) Type certification number.

<u>04.71</u> <u>Airworthiness certificate number</u>. The identifying symbols and registration numbers shall be permanently affixed to the airplane structure in compliance with § 43.102.