CIVIL AIR REGULATIONS

PART 3—AIRPLANE AIRWORTHINESS—NORMAL, UTILITY, AND ACROBATIC CATEGORIES

CIVIL AERONAUTICS BOARD
WASHINGTON, D.C.

SUBPART A—GENERAL

APPLICABILITY AND DEFINITIONS

Sec.
3.0 Applicability of this part.
3.1 Definitions.

CERTIFICATION

3.10 Eligibility for type certificate.
3.11 Designation of applicable regulations.
3.12 Amendment of part.
3.13 Type certificate.
3.14 Data required.
3.15 Inspections and tests.
3.16 Flight tests.
3.17 Airworthiness, experimental, and production certificates.
3.18 Approval of materials, parts, processes, and appliances.
3.19 Changes in type design.

AIRPLANE CATEGORIES

3.20 Airplane categories.
3.23 Changes.
3.24 Minor changes.
3.25 Major changes.
3.26 Service experience changes.
3.27 Application to earlier airworthiness requirements.

Approval of Materials, Parts, Processes, and Appliances

3.31 Specifications.

Definitions

3.41 Standard atmosphere.
3.42 Hot-day condition.

3.43 Airplane configuration.
3.44 Weights.
3.45 Power.
3.46 Speeds.
3.47 Structural terms.
3.48 Susceptibility of materials to fire.

Subpart B—Flight Requirements General

3.61 Policy re proof of compliance.
3.62 Flight test pilot.
3.61 Policy re proof of compliance.
3.63 Noncompliance with test requirements.
3.64 Emergency egress.
3.65 Report.

Weight Range and Center of Gravity

3.71 Weight and balance.
3.72 Use of ballast.
3.73 Empty weight.
3.74 Maximum weight.
3.75 Minimum weight.
3.76 Center of gravity position.

Performance Requirements General

3.81 Performance.
3.82 Definition of stalling speeds.
3.83 Stalling speed.

Take-off

3.84 Take-off.

Climb

3.85 Climb.

Landing

3.86 Landing.

Flight Characteristics

3.105 Requirements.

Controllability

3.106 General.
3.107-U Approved acrobatic maneuvers.
3.108-A Acrobatic maneuvers.
3.109 Longitudinal control.

3.110 Lateral and directional control.
3.111 Minimum control speed (Vmc).

Trim

3.112 Requirements.

Stability

3.113 General.
3.114 Static longitudinal stability.
3.115 Specific conditions.
3.116 Instrument stick force measurements.
3.117 Dynamic longitudinal stability.
3.118 Directional and lateral stability.

Stalls

3.120 Stalling demonstration.
3.121 Climbing stalls.
3.122 Turning flight stalls.
3.123 One-engine-inoperative stalls.

Spinning

3.124 Spinning.

Ground and Water Characteristics

3.143 Requirements.
3.144 Longitudinal stability and control.
3.145 Directional stability and control.
3.146 Shock absorption.
3.147 Spray characteristics.

Flutter and Vibration

3.159 Flutter and vibration.

Subpart C—Strength Requirements General

3.171 Loads.
3.172 Factor of safety.
3.173 Strength and deformations.
3.174 Proof of structure.

Flight Loads

3.181 General.
3.182 Definition of flight load factor.

Symmetrical Flight Conditions
(Flaps Retracted)

3.183 General.
3.184 Design air speeds.
3.185 Maneuvering envelope.
3.186 Maneuvering load factors.
3.187 Gust envelope.
3.188 Gust load factors.
3.189 Airplane equilibrium.

Flaps Extended Flight Conditions

3.190 Flaps extended flight conditions.

Unsymmetrical Flight Conditions

3.191 Unsymmetrical flight conditions.

Supplementary Conditions

3.194 Special condition for rear lift truss.
3.195 Engine torque effects.
3.196 Side load on engine mount.

Control Surface Loads

3.211 General.
3.212 Pilot effort.
3.213 Trim tab effects.

Horizontal Tail Surfaces

3.214 Horizontal tail surfaces.
3.215 Balancing loads.
3.216 Maneuvering loads.
3.214 Horizontal tail surfaces.
3.217 Gust loads.
3.218 Unsymmetrical loads.

Vertical Tail Surface

3.219 Maneuvering loads.
3.220 Gust loads.
3.221 Outboard fins.

Ailerons, Wing Flaps, Tabs, Etc.

3.222 Ailerons.
3.223 Wing flaps.
3.224 Tabs.
3.225 Special devices.

Control System Loads

3.231 Primary flight controls and systems.
3.232 Dual controls.

3.233 Ground gust conditions.
3.234 Secondary controls and systems.

Ground Loads

3.241 Ground loads.
3.242 Design weight.
3.243 Load factor for landing conditions.

Landing Cases and Attitudes

3.244 Landing cases and attitudes.
3.245 Level landing.
3.246 Tail down.
3.247 One-wheel landing.

Ground Roll Conditions

3.248 Braked roll.
3.249 Side load.

Tail Wheels

3.250 Supplementary conditions for tail wheels.
3.251 Obstruction load.
3.252 Side load.

Nose Wheels

3.253 Supplementary conditions for nose wheels.
3.254 Aft load.
3.255 Forward load.
3.256 Side load.

Skiplanes

3.257 Supplementary conditions for skiplanes.

Water Loads

3.265 General.

Design Weight

3.266 Design weight.

Boat Seaplanes

3.267 Local bottom pressures.
3.268 Distributed bottom pressures.
3.267 Local bottom pressures.
3.269 Step loading condition.
3.270 Bow loading condition.
3.271 Stern loading condition.
3.272 Side loading condition.

Float Seaplanes
3.273 Landing with inclined reactions.
3.275 Landing with vertical reactions.
3.277 Landing with side load.
3.278 Supplementary load conditions.
3.279 Bottom loads.

Wing-Tip Float and Sea Wing Loads
3.280 Wing-tip float loads.
3.281 Wing structure.
3.282 Sea wing loads.

Subpart D—Design and Construction General

3.291 General.
3.292 Materials and workmanship.
3.293 Fabrication methods.
3.294 Standard fastenings.
3.295 Protection.
3.296 Inspection provisions.

Structural Parts
3.301 Material strength properties and design values.
3.302 Special factors.
3.303 Variability factor.
3.304 Castings.
3.305 Bearing factors.
3.306 Fitting factor.
3.307 Fatigue strength.

Flutter and Vibration
3.311 Flutter and vibration prevention measures.

Wings
3.317 Proof of strength.
3.318 Ribs.
3.319 External bracing.
3.320 Covering.

Control Surfaces (Fixed and Movable)
3.327 Proof of strength.
3.328 Installation.
3.329 Hinges.

Control Systems

3.335 General.
3.336 Primary flight controls.
3.337 Trimming controls.
3.338 Wing flap controls.
3.339 Flap interconnection.
3.340 Stops.
3.341 Control system locks.
3.342 Proof of strength.
3.343 Operation test.

Control System Details

3.344 General.
3.345 Cable systems.
3.346 Joints.
3.347 Spring devices.

Landing Gear
Shock Absorbers

3.351 Tests.
3.352 Shock absorption tests.
3.353 Limit drop tests.
3.354 Limit load factor determination.
3.355 Reserve energy absorption drop tests.

Retracting Mechanism

3.356 General.
3.357 Emergency operation.
3.358 Operation test.
3.359 Position indicator and warning device.
3.360 Control.

Wheels and Tires

3.361 Wheels.
3.362 Tires.

Brakes

3.363 Brakes.

Skis

3.364 Skis.
3.365 Installation
3.366 Tests.

Hulls and Floats

3.371 Buoyancy (main seaplane floats).
3.372 Buoyancy (boat seaplanes).

3.373 Water stability.

Fuselage
Pilot Compartment
3.381 General.
3.382 Vision.
3.383 Pilot windshield and windows.
3.384 Cockpit controls.
3.385 Instruments and markings.

Emergency Provisions
3.386 Protection.
3.387 Exits.
3.388 Fire precautions.

Personnel and Cargo Accommodations
3.389 Doors.
3.390 Seats and berths.
3.391 Safety belt or harness provisions.
3.392 Cargo compartments.
3.393 Ventilation.

Miscellaneous
3.401 Leveling marks.

SUBPART E —POWER-PLANT INSTALLATIONS; RECIPROCATING ENGINES

General
3.411 Components.

Engines and Propellers
3.415 Engines.
3.416 Propellers.
3.417 Propeller vibration.
3.418 Propeller pitch and speed limitations.
3.419 Speed limitations for fixed pitch propellers, ground adjustable pitch propellers, and automatically varying pitch propellers which cannot be controlled in flight.
3.420 Speed and pitch limitations for controllable pitch propellers without constant speed controls.
3.421 Variable pitch propellers with constant speed controls.
3.422 Propeller clearance.

Fuel System
3.429 General.

Arrangement
3.430 Fuel system arrangement.

3.431 Multiengine fuel system arrangement.
3.432 Pressure cross feed arrangements.

Operation

3.433 Fuel flow rate.
3.434 Fuel flow rate for gravity feed systems.
3.435 Fuel flow rate for pump systems.
3.436 Fuel flow rate for auxiliary fuel systems and fuel transfer systems.
3.437 Determination of unusable fuel supply and fuel system operation on low fuel.
3.438 Fuel system hot weather operation.
3.439 Flow between interconnected tanks.

Fuel Tanks

3.440 General.
3.441 Fuel tank tests.
3.442 Fuel tank installation.
3.443 Fuel tank expansion space.
3.444 Fuel tank sump.
3.445 Fuel tank filler connection.
3.446 Fuel tank vents and carburetor vapor vents.
3.447 A Fuel tank vents.
3.448 Fuel tank outlet.

Fuel Pumps

3.449 Fuel pump and pump installation.

Lines, Fittings, and Accessories

3.550 Fuel system lines, fittings, and accessories.
3.551 Fuel valves.
3.552 Fuel strainer.

Drains and Instruments

3.553 Fuel system drains.
3.554 Fuel system instruments.

Oil System

3.561 Oil system.
3.562 Oil cooling.

Oil Tanks

3.563 Oil tanks.
3.564 Oil tank tests.
3.565 Oil tank installation.
3.566 Oil tank expansion space.
3.567 Oil tank filler connection.
3.568 Oil tank vent.

3.569 Oil tank outlet.

Lines, Fittings, and Accessories

3.570 Oil system lines, fittings, and accessories.
3.571 Oil valves.
3.572 Oil radiators.
3.573 Oil filters.
3.574 Oil system drains.
3.575 Engine breather lines.
3.576 Oil system instruments.
3.577 Propeller feathering system.

Cooling

3.581 General.

Tests

3.582 Cooling tests.
3.583 Maximum anticipated summer air temperatures.
3.584 Correction factor for cylinder head, oil inlet, carburetor, air, and engine coolant inlet temperatures.
3.585 Correction factor for cylinder barrel temperatures.
3.586 Cooling test procedure for single-engine airplanes.
3.587 Cooling test procedure for multiengine airplanes.

Liquid Cooling Systems

3.588 Independent systems.
3.589 Coolant tank.
3.590 Coolant tank tests.
3.591 Coolant tank installation.
3.592 Coolant tank filler connection.
3.593 Coolant lines, fittings, and accessories.
3.594 Coolant radiators.
3.595 Cooling system drains.
3.596 Cooling system instruments.

Induction System

3.605 General.
3.606 Induction system de-icing and antiicing provisions.
3.607 Carburetor de-icing fluid flow rate.
3.608 Carburetor fluid de-icing system capacity.
3.609 Carburetor fluid de-icing system detail design.
3.610 Carburetor air preheater design.
3.611 Induction system ducts.
3.612 Induction system screens.

Exhaust System

3.615 General.

3.616 Exhaust manifold.
3.617 Exhaust heat exchangers.
3.618 Exhaust heat exchangers used in ventilating air heating systems.

Fire Wall and Cowling

3.623 Fire walls.
3.624 Fire wall construction.
3.625 Cowling.

Power-Plant Controls and Accessories Controls

3.627 Power-plant controls.
3.628 Throttle controls.
3.629 Ignition switches.
3.630 Mixture controls.
3.631 Propeller speed and pitch controls.
3.632 Propeller feathering controls.
3.633 Fuse system controls.
3.634 Carburetor air preheat controls.

Accessories

3.635 Power-plant accessories.
3.636 Engine battery ignition systems.

Power-Plant Fire Protection

3.637 Power-plant fire protection.

Subpart F- Equipment

3.651 General.
3.652 Functional and installational requirements.

Basic Equipment

3.655 Required basic equipment.

Instruments; Installation

General

3.661 Arrangement and visibility of instrument installations.
3.662 Instrument panel vibration characteristics.

Flight and Navigational Instruments

3.663 Air-speed indicating system.
3.664 Air-speed indicator marking.
3.665 Static air vent system.
3.666 Magnetic direction indicator.
3.667 Automatic pilot system.
3.668 Gyroscopic indicators (air-driven type).

3.669 Suction gauge.

Power-Plant Instruments

3.670 Operational markings.
3.671 Instrument lines.
3.672 Fuel quantity indicator.
3.673 Fuel flowmeter system.
3.674 Oil quantity indicator.
3.675 Cylinder head temperature indicating system for air-cooled engines.
3.676 Carburetor air temperature indicating system.

Electrical Systems and Equipment

3.681 Installation.

Batteries

3.682 Batteries.
3.683 Protection against acid.
3.684 Battery vents.

Generators

3.685 Generator.
3.686 Generator controls.
3.687 Reverse current cut-out.

Master Switch

3.688 Arrangement.
3.689 Master switch installation.

Protective Devices

3.690 Fuses or circuit breakers.
3.691 Protective devices installation.
3.692 Spare fuses.

Electric Cables

3.693 Electric cables.

Switches

3.694 Switches.
3.695 Switch installation.

Instrument Lights

3.696 Instrument lights.
3.697 Instrument light installation.

Landing Lights

3.698 Landing lights.

3.699 Landing light installation.

Position Lights
3.700 Type.
3.701 Forward position light installation.
3.702 Rear position light installation.
3.703 Flashing rear position lights.

Anchor Lights
3.704 Anchor light.
3.705 Anchor light installation.

Safety Equipment; Installation
3.711 Marking.
3.712 De-icers.
3.713 Flare requirements.
3.714 Flare installation.
3.715 Safety belts.

Emergency Flotation and Signaling Equipment
3.716 Rafts and life preservers.
3.717 Installation.
3.718 Signaling device.

Radio Equipment; Installation
3.721 General.

Miscellaneous Equipment; Installation
3.725 Accessories for multiengine airplanes.

Hydraulic Systems
3.726 General.
3.727 Tests.
3.728 Accumulators.

Subpart G - Operating Limitation and Information
3.735 General.

Limitations
3.737 Limitations.

Air Speed
3.738 Air speed.
3.739 Never exceed speed (Vne).
3.740 Maximum structural cruising speed (Vno).
3.741 Maneuvering speed (Vp).

3.742 Flaps-extended speed (Vfe).
3.743 Minimum control speed (Vmc).

Power Plant

3.744 Power plant.
3.745 Take-off operation.
3.746 Maximum continuous operation.
3.747 Fuel octane rating.

Airplane Weight

3.748 Airplane weight.

Minimum Flight Crew

3.749 Minimum flight crew.

Types of Operation

3.750 Types of operation.

Markings and Placards

3.755 Markings and placards.

Instrument Markings

3.756 Instrument markings.
3.757 Air-speed indicator.
3.758 Magnetic direction indicator.
3.759 Power-plant instruments.
3.760 Oil quantity indicators.
3.761 Fuel quantity indicator.

Control Markings

3.762 General.
3.763 Aerodynamic controls.
3.764 Power-plant fuel controls.
3.765 Accessory and auxiliary controls.

Miscellaneous

3.766 Baggage compartments, ballast location, and special seat loading limitations.
3.767 Fuel, oil, and coolant filler openings.
3.768 Emergency exit placards.
3.769 Approved flight maneuvers.
3.770 Airplane category placard.

Airplane Flight Manual

3.777 Airplane Flight Manual.
3.778 Operating limitations.
3.779 Operating procedures.

3.780 Performance information.

Subpart H - Identification Data

3.791 Name plate.
3.792 Airworthiness certificate number.

AUTHORITY: §§ 3.1 to 3.792 issued under sec. 205(a), 52 Stat. 984; 49 U. S. C. 425(a). Interpret or apply secs. 601; 52 Stat. 1007; 49 U.S.C. 551.

SOURCE: §§ 3.1 to 3.792 contained in Amendment 03-0, Civil Air Regulations, 11 F.R. 13368, except as noted following sections affected. Redesignated at 13 F.R. 5486.

SUBPART A — GENERAL
APPLICABILITY AND DEFINITIONS

§ 3.0 Applicability of this part . This part establishes standards with which compliance shall be demonstrated for the issuance of and changes to type certificates for normal, utility, and acrobatic category airplanes. This part, until superseded or rescinded, shall apply to all airplanes for which applications for type certification under this part were made between the effective date of this part (November 13, 1945) and March 31, 1953. For applications for a type certificate made after March 31, 1953, this part shall apply only to airplanes which have a maximum weight of 12,500 pounds or less.

§ 3.1 *Definitions.* As used in this part terms are defined as follows:

(a) *Administration* —

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

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

(3) *Approved.* Approved, when used alone or as modifying terms such as means, devices, specifications, etc., shall mean approved by the Administrator.(See Sec. 3.18.)

(b) *General design* —

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

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

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

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

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

(v) The density *po* at sea level under the above conditions is 0.002378 lb. sec. 2 /ft. 4

(2) *Maximum anticipated air temperature* . The maximum anticipated air temperature is a temperature specified for the purpose of compliance with the powerplant cooling standards. (See § 3.583.)

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

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

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

(c) *Weights* —

(1) *Maximum weight* . The maximum weight of the airplane is that maximum at which compliance with the requirements of this part of the Civil Air Regulations is demonstrated. (See § 3.74.)

(2) *Minimum weight.* The minimum weight of the airplane is that minimum at which compliance with the requirements of this part of the Civil Air Regulations is demonstrated. (See § 3.75.)

(3) *Empty weight* . The empty weight of the airplane is a readily reproducible weight which is used in the determination of the operating weights. (See § 3.73.)

(4) *Design maximum weight.* The design maximum weight is the maximum weight of the airplane at which compliance is shown with the structural loading conditions. (See § 3.181.)

(5) *Design minimum weight.* The design minimum weight is the minimum weight of the airplane at which compliance is shown with the structural loading conditions. (See § 3.181.)

(6) *Design landing weight.* The design landing weight is the maximum airplane weight used in structural design for landing conditions at the maximum velocity of descent. (See § 3.242.)

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

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

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

(iii) Crew and passengers 170 pounds per person.

(d) *Speeds* —

(1) *IAS* . Indicated air speed is equal to the pitot static airspeed indicator reading as installed in the airplane without correction for airspeed indicator system errors but including the sea level standard adiabatic compressible flow correction. (This latter correction is included in the calibration of the air-speed instrument dials.)

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

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

(4) *TAS* . True air speed of the airplane relative to undisturbed air. (TAS=EAS(r 0/r) «).

(5) V_c. The design cruising speed. (See § 3.184.)

(6) V_d . The design diving speed. (See § 3.184.)

(7) V_f . The design flap speed for flight loading conditions with wing flaps in the landing position. (See § 3.190.)

(8) V_{fe}. The flap extended speed is a maximum speed with wing flaps in a prescribed extended position. (See § 3.742.)

(9) V_h . The maximum speed obtainable in level flight with rated rpm and power.

(10) V_{mc} . The minimum control speed with the critical engine inoperative. (See § 3.111.)

(11) V_{ne} . The never-exceed speed. (See § 3.739.)

(12) V_{no} . The maximum structural cruising speed. (See § 3.740.)

(13) V_p . The design maneuvering speed. (See § 3.184.)

(14) V_{sf} . The stalling speed computed at the design landing weight with the flaps fully extended. (See § 3.190.)

(15) V_{s0}. The stalling speed or the minimum steady flight speed with wing flaps in the landing position. (See § 3.82.)

(16) V_{s1} . The stalling speed or the minimum steady flight speed obtained in a specified configuration. (See § 3.82.)

(17) V*x.* The speed for best angle of climb.

(18) V*y* = The speed for best rate of climb.

(e) *Structural* —

(1) *Limit load* . A limit load is the maximum load anticipated in normal conditions of operation. (See § 3.171.)

(2) *Ultimate load* . An ultimate load is a limit load multiplied by the appropriate factor of safety. (See § 3.173.)

(3) *Factor of safety* . The factor of safety is a design factor used to provide for the possibility of loads greater than those anticipated in normal conditions of operation and for uncertainties in design. (See § 3.172.)

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

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

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

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

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

(9) *Fitting* . A fitting is a part or terminal used to join one structural member to another. (See § 3.306.)

(f) *Power installation*[1] —

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

[1] For engine airworthiness requirements see Part 13 of the Civil Air Regulations. For propeller airworthiness requirements see Part 14 of the Civil Air Regulations.

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

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

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

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

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

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

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

(7) *Feathered pitch* . Feathered pitch is the pitch setting, which in flight, with the engines stopped, gives approximately the minimum drag and corresponds with a windmilling torque of approximately zero.

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

(g) *Fire protection* —

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

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

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

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

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

CERTIFICATION

§ 3.10 *Eligibility for type certificate.* An airplane shall be eligible for type certification under the provisions of this part if it complies with the airworthiness provisions hereinafter established or if the Administrator finds that the provision or provisions not complied with are compensated for by factors which provide an equivalent level of safety: *Provided* , That the Administrator finds no feature or characteristic of the airplane which renders it unsafe for the category in which it is certificated.

§ 3.11 Designation of applicable regulations . The provisions of this section shall apply to all airplane types certificated under this part irrespective of the date of application for type certificate.

(a) Unless otherwise established by the Board, the airplane shall comply with the provisions of this part together with all amendments thereto effective on the date of application for type certificate, except that compliance with later effective amendments may be elected or required pursuant to paragraphs (c), (d), and (e) of this section.

(b) If the interval between the date of application for a type certificate and the issuance of the corresponding type certificate exceeds three years, a new application for type certificate shall be required, except that for applications pending on May 1, 1954, such three-year period shall commence on that date. At the option of the applicant, a new application may be filed prior to the expiration of the three-year period. In either instance the applicable regulations shall be those effective on the date of the new application in accordance with paragraph (a) of this section.

(c) During the interval between filing the application and the issuance of a type certificate, the applicant may elect to show compliance with any amendment to this part which becomes effective during that interval, in which case all other amendments found by the Administrator to be directly related shall be complied with.

(d) Except as otherwise provided by the Board, or by the Administrator pursuant to § 1.24 of this subchapter, a change to a type certificate (see § 3.13 (b)) may be accomplished, at the option of the holder of the type certificate, either in accordance with the regulations incorporated by reference in the type certificate pursuant to § 3.13(c), or in accordance with subsequent amendments to such regulations in effect on the date of application for approval of the change, subject to the following provisions:

(1) When the applicant elects to show compliance with an amendment to the regulations in effect on the date of application for approval of a change, he shall show compliance with all amendments which the Administrator finds are directly related to the particular amendment selected by the applicant.

(2) When the change consists of a new design or a substantially complete redesign of a component, equipment installation, or system installation of the airplane, and the Administrator finds that the regulations incorporated by reference in the type certificate pursuant to § 3.13(c) do not provide complete standards with

respect to such change, he shall require compliance with such provisions of the regulations in effect on the date of application for approval of the change as he finds will provide a level of safety equal to that established by the regulations incorporated by reference at the time of issuance of the type certificate.

NOTE: Examples of new or redesigned components and installations which might require compliance with regulations in effect on the date of application for approval, are: New powerplant installation which is likely to introduce additional fire or operational hazards unless additional protective measures are incorporated; the installation of an auto-pilot or a new electric power system.

(e) If changes listed in subparagraphs (1) through (3) of this paragraph are made, the airplane shall be considered as a new type, in which case a new application for type certificate shall be required and the regulations together with all amendments thereto effective on the date of the new application shall be made applicable in accordance with paragraphs (a), (b), (c), and (d) of this section.

(1) A change in the number of engines;

(2) A change in engines employing different principles of operation or propulsion;

(3) A change in design, configuration, power, or weight which the Administrator finds is so extensive as to require a substantially complete investigation of compliance with the regulations.

§ 3.12 *Recording of applicable regulations.* The Administrator, upon the issuance of a type certificate, shall record the applicable regulations with which compliance was demonstrated. Thereafter, the Administrator shall record the applicable regulations for each change in the type certificate which is accomplished in accordance with regulations other than those recorded at the time of issuance of the type certificate. (See § 3.11.)

§ 3.13 *Type certificate.*

(a) An applicant shall be issued a type certificate when he demonstrates the eligibility of the airplane by complying with the requirements of this part in addition to the applicable requirements in Part 1 of the Civil Air Regulations.

(b) The type certificate shall be deemed to include the type design (see § 3.14 (b)), the operating limitations for the airplane (see § 3.737), and any other conditions or limitations prescribed by the Civil Air Regulations.

(c) The applicable provisions of this part recorded by the Administrator in accordance with § 3.12 shall be considered as incorporated in the type certificate as though set forth in full.

§ 3.14 *Data required.*

(a) The applicant for a type certificate shall submit to the Administrator such descriptive data, test reports, and computations as are necessary to demonstrate that the airplane complies with the requirements of this part.

(b) The descriptive data required in paragraph (a) of this section shall be known as the type design and shall consist of such drawings and specifications as are necessary to disclose the configuration of the airplane and all the design features covered in the requirements of this part, such information on dimensions, materials, and processing as is necessary to define the structural strength of the airplane, and such other data as are necessary to permit by comparison the determination of the airworthiness of subsequent airplanes of the same type.

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

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

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

(c) All manufacturing processes, construction, and assembly are as specified in the type design.

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

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

(b) After the conclusion of flight tests specified in paragraph (a) of this section, such additional flight tests, on airplanes having a maximum certificated take-off weight of more than 6,000 pounds, as the Administrator finds necessary to ascertain whether there is reasonable assurance that the airplane, its components, and equipment are reliable and function properly. The extent of such additional flight tests shall depend upon the complexity of the airplane, the number and nature of new design features, and the record of previous tests and experience for the particular airplane type, its components, and equipment. If practicable, these flight tests shall be conducted on the same airplane used in the flight tests specified in paragraph (a) of this section.

§ 3.17 *Airworthiness experimental, and production certificates.* (For requirements with regard to these certificates see Part 1 of this chapter.)

§ 3.18 *Approval of materials, parts, processes, and appliances.*

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

NOTE: The provisions of this paragraph are intended to allow approval of materials, parts, processes, and appliances under the system of Technical Standard Orders, or in conjunction with type certification procedures for an airplane, or by any other form of approval by the Administrator.

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

§ 3.19 *Changes in type design.* (For requirements with regard to changes in type design and the designation of applicable regulations therefor, see Sec. 3.11(d) and (e), and Part 1 of this subchapter.)

AIRPLANE CATEGORIES

§ 3.20 *Airplane categories* .

(a) For the purpose of certification under this part, airplanes are divided upon the basis of their intended operation into the following categories:

(1) *Normal suffix N* . Airplanes in this category are intended for nonacrobatic, nonscheduled passenger, and nonscheduled cargo operation.

(2) *Utility suffix U* . Airplanes in this category are intended for normal operations and limited acrobatic maneuvers. These airplanes are not suited for use in snap or inverted maneuvers.

NOTE: The following interpretation of paragraph (a) (2) was issued May 15, 1947, 12 F.R. 3434: The phrase "limited acrobatic maneuvers" as used in § 3.6 (now § 3.20) is interpreted to include steep turns, spins, stalls (except whip stalls), lazy eights, and chandelles.

(3) *Acrobatic suffix A* . Airplanes in this category will have no specific restrictions as to type of maneuver permitted unless the necessity therefor is disclosed by the required flight tests.

(b) An airplane may be certificated under the requirements of a particular category, or in more than one category, provided that all of the requirements of each such category are met. Sections of this part which apply to only one or more, but not all, categories are identified in this part by the appropriate suffixes added to the section number, as indicated in paragraph (a) of this section. All sections not identified by a suffix are applicable to all categories except as otherwise specified.

CHANGES

§ 3.23 *Changes.* Changes shall be substantiated to demonstrate compliance of the airplane with the appropriate airworthiness requirements in effect when the particular airplane was certificated as a type, unless the holder of the type certificate chooses to show compliance with the currently effective requirements subject to the approval of the Administrator, or unless the Administrator finds it necessary to require compliance with current airworthiness requirements.

§ 3.24 *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.

§ 3.25 *Major changes.* A major change is any change not covered by minor changes as defined in § 3.24.

§ 3.26 *Service experience changes.* When experience shows that any particular part of characteristic of an airplane is unsafe, the holder of the type certificate for such airplane shall submit for approval of the Administrator the design changes which are necessary to correct the unsafe condition after the unsafe condition becomes known the Administrator shall withhold the issuance of airworthiness certificates for additional airplanes of the type involved until he has approved the design changes and until the additional airplanes are modified to include such changes. Upon approval by the Administrator the design changes shall be considered as a part of the type design, and descriptive data covering these changes shall be made available by the holder of the type certificate to all owners of airplanes previously certificated under such type certificate.

§ 3.27 *Application to earlier airworthiness requirements.* 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.

APPROVAL OF MATERIALS, PARTS, PROCESSES, AND APPLIANCES

§ 3.31 Specifications.

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

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

DEFINITIONS

§ 3.41 *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. per foot and zero there above.

(e) The density ρ_0 at sea level under the above conditions is 0.002378 lbs. sec.2/ft4.

§ 3.42 *Hot-day condition.* See § 3.583.

§ 3.43 *Airplane configuration.* This term refers to the position of the various elements affecting the aerodynamic characteristics of the airplane, such as landing gear and flaps.

§ 3.44 Weights.

	Reference sections
Empty weight: The actual weight used as a basis for determining operating weights	3.73
Maximum weight: The maximum weight at which the airplane may operate in accordance with the airworthiness requirements	3.74
Minimum weight: The minimum weight at which compliance with the airworthiness requirements is demonstrated.	3.75
Maximum design weight: The maximum weight used for the structural design of the airplane.	3.181
Minimum design weight: The minimum weight condition investigated in the structural flight load conditions, not greater than the minimum weight specified in §3.75.	3.181
Design landing weight: The weight used in the structural investigation of the airplane for normal landing conditions. Under the provisions of §3.242, this weight may be equal to or less than the maximum design weight.	3.242

Unit weights for design purposes:
Gasoline...................... 6 pounds per United States gallon.
Lubricating oil............. 7.5 pounds per United States gallon.
Crew and passengers.... 170 pounds per person.

§ 3.45 Power.
One horsepower: 33,000 foot-pounds 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.

§ 3.46 Speeds.

Vt True air speed of the airplane relative to the undisturbed air.

In the following symbols having subscripts, V denotes:

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

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

	Reference sections
Vs0 stalling speed, in the land configuration.	3.82
Vs1 stalling speed in the configurations specified for particular conditions.	3.82
Vsf computed stalling speed at design landing weight with flaps fully defected.	3.190
Vx speed for best angle of climb.	3.111
Vy speed for best rate of climb.	
Vmc minimum control speed.	
Vf design speed for flight load conditions with flaps in landing position.	3.190
Vfe flaps-extended speed.	3.742
Vp design maneuvering speed.	3.184
Vc design cruising speed.	3.184
Vd design dive speed	3.184
Vne never-exceed speed.	3.739
Vno maximum structural cruising speed.	3.740

Vh maximum speed in level flight at maximum continuous power.

§ 3.47 *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 centerline of symmetry.

Aerodynamic coefficients: CL, CN, CM, etc., used in this part, are nondimensional coefficients for the forces and moments acting on an airfoil, and correspond to those adopted by the United States National Advisory Committee for Aeronautics.

CL = airfoil lift coefficient.
CN = airfoil normal force coefficient (normal to wing chord line).
CNA = airplane normal force coefficient (based on lift of complete airplane and design wing area).
CM = pitching moment coefficient.

Loads	Reference Sections
Limit load: The maximum load anticipated in service.	8.171
Ultimate load: The maximum load which a part of structure must be capable of supporting.	8.173
Factor of safety: The factor by which the limit load must be multiplied to establish the ultimate load.	8.172

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.

§ 3.48 *Susceptibility of materials to fire.* Where necessary for the purpose of determining compliance with any of the definitions in this section, the Administrator shall prescribe the heat conditions and testing procedures which any specific material or individual part must meet.

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

(b) *Fire-resistant.* When applied to sheet or structural members, "fire-resistant" material shall mean a material which will withstand heat equally well or better than aluminum alloy in dimensions appropriate for the purpose for which it is to be used. When applied to fluid-carrying lines, this term refers to a line and fitting assembly which will perform its intended protective functions under the heat and other conditions likely to occur at the particular location.

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

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

(e) Inflammable. "Inflammable" fluids or gases means those which will ignite readily or explode.

SUBPART B—FLIGHT REQUIREMENTS
GENERAL

§ 3.61 *Policy re proof of compliance.* Compliance with the requirements specified in this subpart 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. 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.

§ 3.62 *Flight test pilot.* 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 insofar as that may be necessary for the determination of compliance with the airworthiness requirements.

§ 3.63 *Noncompliance with test requirements.* Official type tests will be discontinued until corrective measures have been taken by the applicant when either:

(a) The applicant's test pilot is unable or unwilling to conduct any of the required flight tests; or

(b) Items of noncompliance with requirements are found which may render additional test data meaningless or are of such nature as to make further testing unduly hazardous.

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

§ 3.65 *Report.* 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 he finds to be necessary in order to check the calibration and correction report.

WEIGHT RANGE AND CENTER OF GRAVITY

§ 3.71 Weight and balance.

(a) 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.

(b) When low fuel adversely affects balance or stability, the airplane shall be so tested as to simulate the condition existing when the amount of usable fuel on board does not exceed 1 gallon for every 12 maximum continuous horsepower of the engine or engines installed.

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

(a) The place or places for carrying ballast shall be properly designed, installed, and plainly marked as specified in § 3.766.

(b) The Airplane Flight 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 § 3.766 and 3.777.

§ 3.73 *Empty weight.* The empty weight and corresponding center of gravity location shall include all fixed ballast, the unusable fuel supply (see § 3.437), undrainable oil, full engine coolant, and hydraulic fluid. The weight and location of items of equipment installed when the airplane is weighed shall be noted in the Airplane Flight Manual.

§ 3.74 *Maximum weight.*

(a) The maximum weight shall not exceed any of the following:

(1) The weight selected by the applicant.

(2) The design weight for which the structure has been proven, except as provided in Sec. 3.242 for multiengine airplanes.

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

(b) The maximum weight shall not be less than the weights under the loading conditions prescribed in subparagraphs (1) and (2) of this paragraph assuming that the weight of the occupant in each of the seats is 170 pounds for the normal category and 190 pounds for the utility and acrobatic categories, unless placarded otherwise.

(1) All seats occupied, oil to full tank capacity, and at least a fuel supply for one-half hour operation at rated
maximum continuous power.

(2) Fuel and oil to full tank capacities, and minimum crew.

§ 3.75 Minimum weight. The minimum weight shall not exceed the sum of the weights of the following:

(a) The empty weight is defined by § 3.73.

(b) The minimum crew necessary to operate the airplane (170 pounds for each crew member).

(c) One gallon of usable fuel (see § 3.437) for every 12 maximum continuous horsepower for which the airplane is certificated.

(d) Either 1 gallon of oil for each 25 gallons of fuel specified in (c) or 1 gallon of oil for each 75 maximum continuous horsepower for which the airplane is certificated, whichever is greater.

§ 3.76 *Center of gravity position.* If the center of gravity position under any possible loading condition between the maximum weight as specified in § 3.74 and the minimum weight as specified in § 3.75 lies beyond (a) the extremes selected by the applicant, or (b) the extremes for which the structure has been proven, or (c) the extremes for which compliance with all functional requirements were demonstrated, loading instructions shall be provided in the Airplane Flight Manual as specified in § 3.777-3.780.

PERFORMANCE REQUIREMENTS
GENERAL

§ 3.80 Alternate performance requirements . The provisions of §§ 3.84, 3.85, 3.86, and 3.112 (a)(2)(ii) shall not be applicable to airplanes having a maximum certificated take-off weight of 6,000 lbs. or less. In lieu thereof, such airplanes shall comply with the provisions of §§ 3.84a, 3.85a, 3.87, and 3.112(c).

§ 3.81 *Performance.* The following items of performance shall be determined and the airplane shall comply with the corresponding requirements in standard atmosphere and still air.

§ 3.82 *Definition of stalling speeds.*

(a) Vso denotes the true indicated stalling speed, if obtainable, 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),

(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 Vso is being used as a factor to determine a required performance.

(b) Vs1 denotes the true indicated stalling speed, if obtainable, otherwise the calculated value in miles per hour, with:

(1) Engines idling, throttles closed (or not more than sufficient power for zero thrust),

(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 Vs1 is being used,

(3) The weight of the airplane equal to the weight in connection with which Vs1 is being used as a factor to determine a required performance.

(c) These speeds shall be determined by flight tests using the procedure outlined in §3.120.

§ 3.83 *Stalling speed.* Vso at maximum weight shall not exceed 70 miles per hour for (1) single-engine airplanes and (2) multiengine airplanes which do not have the rate of climb with critical engine inoperative specified in §3.85 (b).

TAKE-OFF

§ 3.84 Take-off.

(a) The distance required to take off and climb over a 50-foot obstacle shall be determined under the following conditions:

(1) Most unfavorable combination of weight and center of gravity location,

(2) Engines operating within the approved limitations,

(3) Cowl flaps in the position normally used for take-off.

(b) Upon obtaining a height of 50 feet above the level take-off surface, the airplane shall have attained a speed of not less than 1.3 Vs1 unless a lower speed of not less than Vx plus 5 can be shown to be safe under all conditions, including turbulence and complete engine failure.

(c) The distance so obtained, the type of surface from which made, and the pertinent information with respect to the cowl flap position, the use of flight-path control devices and landing gear retraction system shall be entered in the Airplane Flight Manual. The take-off shall be made in such a manner that its reproduction shall not require an exceptional degree of skill on the part of the pilot or exceptionally favorable conditions.

§ 3.84a *Take-off requirements - airplanes of 6,000 lbs. or less.* Airplanes having a maximum certificated take-off weight of 6,000 lbs. or less shall comply with the provisions of this section.

(a) The elevator control for tail wheel type airplanes shall be sufficient to maintain at a speed equal to 0.8 Vs1 an airplane attitude which will permit holding the airplane on the runway until a safe take-off speed is attained.

(b) The elevator control for nose wheel type airplanes shall be sufficient to raise the nose wheel clear of the takeoff surface at a speed equal to 0.85 Vs1.

(c) The characteristics prescribed in paragraphs (a) and (b) of this section shall be demonstrated with:

(1) Take-off power,

(2) Most unfavorable weight,

(3) Most unfavorable c.g. position.

(d) It shall be demonstrated that the airplane will take off safely without requiring an exceptional degree of piloting skill.

CLIMB

§ 3.85 *Climb*—

(a) Normal climb condition. The steady rate of climb at sea level shall be at least 300 feet per minute, and the steady angle of climb at least 1:12 for landplanes or 1:15 for seaplanes with:

(1) Not more than maximum continuous power on all engines,

(2) Landing gear fully retracted,

(3) Wing flaps in take-off position,

(4) Cowl flaps in the position used in cooling tests specified in §§ 3.581-3.596.

(b) Climb with inoperative engine. All multiengine airplanes having a stalling speed Vso greater than 70 miles per hour or a maximum weight greater than 6,000 pounds shall have a steady rate of climb of at least 0.02 Vso in feet per minute at an altitude of 5,000 feet with the critical engine inoperative and:

(1) The remaining engines operating at not more than maximum continuous power,

(2) The inoperative propeller in the minimum drag position,

(3) Landing gear retracted,

(4) Wing flaps in the most favorable position,

(5) Cowl flaps in the position used in cooling tests specified in §§ 3.581-3.596.

(c) Balked landing conditions. The steady angle of climb at sea level shall be at least 1:30 with:

(1) Take-off power on all engines,

(2) Landing gear extended,

(3) Wing flaps in landing position. If rapid retraction is possible with safety without loss of altitude and without requiring sudden changes of angle of attack or exceptional skill on the part of the pilot, wing flaps may be retracted.

§ 3.85a *Climb requirements* - airplane of 6,000 lbs. or less . Airplanes having a maximum certificated take-off weight of 6,000 lbs. or less shall comply with the requirements of this section.

(a) Climb - take-off climb condition. The steady rate of climb as sea level shall not be less than 10 Vs1 or 300 feet per minute, whichever is the greater, with:

(1) Take-off power,

(2) Landing gear extended,

(3) Wing flaps in take-off position,

(4) Cowl flaps in the position used in cooling tests specified in §§ 3.581 through 3.596.

(b) Climb with inoperative engine. All multiengine airplanes having a stalling speed Vso greater than 70 miles per hour shall have a steady rate of climb of at least 0.02 Vso in feet per minute at an altitude of 5,000 feet with the critical engine inoperative and:

(1) The remaining engines operating at not more than maximum continuous power,

(2) The inoperative propeller in the minimum drag position,

(3) Landing gear retracted,

(4) Wing flaps in the most favorable position,

(5) Cowl flaps in the position used in cooling tests specified in §§ 3.581 through 3.596.

(c) Climb - balked landing conditions. The steady rate of climb at sea level shall not be less than 5 Vso or 200 feet per minute, whichever is the greater, with:

(1) Take-off power,

(2) Landing gear extended,

(3) Wing flaps in the landing position. If rapid retraction is possible with safety, without loss of altitude and without requiring sudden changes of angle of attack or exceptional skill on the part of the pilot, wing flaps may be retracted.

LANDING

§ 3.86 *Landing*

(a) The horizontal distance required to land and to come to a complete stop (to a speed of approximately 3 miles per hour for seaplanes or float planes) from a point at a height of 50 feet above the landing surface shall be determined as follows:

(1) Immediately prior to reaching the 50-foot altitude, a steady gliding approach shall have been maintained, with a true indicated air speed of at least 1.3 Vso.

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

(b) The distance so obtained, the type of landing surface on which made and the pertinent information with respect of cowl flap position, and the use of flight path control devices shall be entered in the Airplane Flight Manual.

§ 3.87 *Landing requirements - airplanes of 6,000 lbs. or less.* For an airplane having a maximum certificated take-off weight of 6,000 lbs. or less it shall be demonstrated that the airplane can be safely landed and brought to a stop without requiring an exceptional degree of piloting skill, and without excessive vertical acceleration, tendency to bounce, nose over, ground loop, porpoise, or water loop.

FLIGHT CHARACTERISTICS

§ 3.105 Requirements. The airplane shall meet the requirements set forth in §§ 3.106 to 3.124 at all normally expected operating altitudes under all critical loading conditions within the range of center of gravity and, except as otherwise specified, at the maximum weight for which certification is sought.

CONTROLLABILITY

§ 3.106 *General*. The airplane shall be satisfactorily controllable and maneuverable during take-off, climb, level flight, drive, and landing with or without power. 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 for multiengine airplanes those conditions normally encountered in the event of sudden failure of any engine. Compliance with "strength of pilots" limits need not be demonstrated by quantitative tests unless the Administrator finds the condition to be marginal. In the latter case they shall not exceed maximum values found by the Administrator to be appropriate for the type but in no case shall they exceed the following limits:

	Pitch	Roll	Yaw
(a) For temporary application:			
Stick	60	30	150
Wheel [1]	75	60	150
(b) For prolonged application.	10	5	20

[1] Applied to rim.

§ 3.107-U *Approved acrobatic maneuvers.* It shall be demonstrated that the approved acrobatic maneuvers can be performed safely. Safe entry speeds shall be determined for these maneuvers.

§ 3.108-A *Acrobatic maneuvers.* It shall be demonstrated that acrobatic maneuvers can be performed readily and safely. Safe entry speeds shall be determined for these maneuvers.

§ 3.109 *Longitudinal control.* The airplane shall be demonstrated to comply with the following requirements:

(a) It shall be possible at all speeds below Vx to pitch the nose downward so that the rate of increase in air speed is satisfactory for prompt acceleration of Vx with:

(1) Maximum continuous power on all engines, the airplane trimmed at Vx.

(2) Power off, airplanes of more than 6,000 pounds maximum weight trimmed at 1.4 Vs1 , and airplanes of 6,000 pounds or less maximum weight trimmed at 1.5 Vs1 .

(3) (i) Wing flaps and landing gear extended and

(ii) Wing flaps and landing gear retracted.

(b) 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.

(1) With power off, flaps retracted, and the airplane trimmed as prescribed in paragraph (a)(2) of this section, the flaps shall be extended as rapidly as possible while maintaining the air speed at approximately 40 percent above the instantaneous value of the stalling speed.

(2) Same as subparagraph (1) of this paragraph, except the flaps shall be initially extended and the airplane trimmed as prescribed in paragraph (a)(2) of this section, then the flaps shall be retracted as rapidly as possible.

(3) Same as subparagraph (2) of this paragraph, except maximum continuous power shall be used.

(4) With power off, the flaps retracted, and the airplane trimmed as prescribed in paragraph (a)(2) of this section, take-off power shall be applied quickly while the same air speed is maintained.

(5) Same as subparagraph (4) of this paragraph, except with the flaps extended.

(6) With power off, flaps extended, and the airplane trimmed as prescribed in paragraph (a)(2) of this section, air speeds within the range of 1.1 Vs1 to 1.7 Vs1 or Vf whichever is the lesser, shall be obtained and maintained.

(c) It shall be possible without the use of exceptional piloting skill to maintain essentially level flight when flap retraction from any position is initiated during steady horizontal flight at 1.1 Vs1 with simultaneous application of not more than maximum continuous power.

§ 3.110 Lateral and directional control.

(a) It shall be possible with multiengine airplanes to execute 15-degree banked turns both with and against the inoperative engine from steady climb at 1.4 Vs1 or Vy for the condition with:

(1) Maximum continuous power on the operating engines,

(2) Rearmost center of gravity,

(3) (i) Landing gear retracted and (ii) Landing gear extended.

(4) Wing flaps in most favorable climb position,

(5) Maximum weight,

(6) The inoperative propeller in its minimum drag condition.

(b) It shall be possible with multiengine airplanes, while holding the wings level laterally within 5 degrees, to execute sudden changes in heading in both directions without dangerous characteristics being encountered. This shall be demonstrated at 1.4 Vs1 or Vy up to heading changes of 15 degrees, except that the heading change at which the rudder force corresponds to that specified in § 3.106 need not be exceeded, with:

(1) The critical engine inoperative,

(2) Maximum continuous power on the operating engine(s),

(3) (i) Landing gear retracted and (ii) Landing gear extended,

(4) Wing flaps in the most favorable climb position,

(5) The inoperative propeller in its minimum drag condition,

(6) The airplane center of gravity at its rearmost position.

§ 3.111 Minimum control speed (Vmc).

(a) A minimum speed shall be determined under the conditions specified below, such that when any one engine is suddenly made inoperative at that speed, it shall be possible to recover control of the airplane, with the one engine still inoperative, and to maintain it in straight flight at that speed, either with zero yaw or, at the option of the applicant, with a bank not in excess of 5 degrees. Such speed shall not exceed 1.3 Vs1, with:

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

(2) Rearmost center of gravity,

(3) Flaps in take-off position,

(4) Landing gear retracted.

(b) In demonstrating this minimum speed, the rudder force required to maintain it shall not exceed forces specified in § 3.106, 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 degrees before recovery is complete.

TRIM

§ 3.112 Requirements.

(a) 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:

(1) Lateral and directional trim in level flight at a speed of 0.9 Vh or at Vc, if lower, with the landing gear and wing flaps retracted:

(2) Longitudinal trim under the following conditions:

(i) During a climb with maximum continuous power at a speed between Vx and 1.4 Vs1,

(a) With landing gear retracted and wing flaps retracted,

(b) With landing gear retracted and wing flaps in the take-off position.

(ii) During a glide with power off at a speed not in excess of 1.4 Vs1,

(a) With landing gear extended and wing flaps retracted,

(b) With landing gear extended and wing flaps extended under the forward center of gravity position approved with the maximum authorized weight.

(c) With landing gear extended and wing flaps extended under the most forward center of gravity position approved, regardless of weight.

(iii) During level flight at any speed from 0.9 Vh to Vx or 1.4 Vs1 with landing gear and wing flaps retracted.

(b) In addition to the above, multiengine airplanes shall maintain longitudinal and directional trim at a speed between Vy and 1.4 Vs1 during climbing flight with the critical of two or more engines inoperative, with:

(1) The other engine(s) operating at maximum continuous power.

(2) The landing gear retracted,

(3) Wing flaps retracted,

(4) Bank not in excess of 5 degrees.

(c) For aircraft having a maximum certificated take-off weight of 6,000 lbs. or less, the value specified in subdivision (a) (2) (ii) of this section shall be 1.5 V s1 or, if the stalling speed V s1 is not obtainable in the particular configuration, 1.5 times the minimum steady flight speed at which the airplane is controllable.

STABILITY

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

§ 3.114 Static longitudinal stability. In the configurations outlined in § 3.115 and with the airplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system shall be such that:

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

§ 3.115 Specific conditions. In conditions set forth in this section, within the speeds specified, the stable slope of stick force versus speed curve shall be such that nay 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 40 lbs. at any speed between 1.1 Vs1 and 1.3 Vs1 with:

(1) Wing flaps in the landing position,

(2) The landing gear extended,

(3) Maximum weight,

(4) Throttles closed on all engines,

(5) Airplanes of more than 6,000 pounds maximum weight trimmed at 1.4 Vs1 , and airplanes of 6,000 pounds or less maximum weight trimmed at 1.5 Vs1.

(b) Climb. The stick force curve shall have a stable slope at all speeds between 1.2 Vs1 and 1.6 Vs1 with:

(1) Wing flaps retracted,

(2) Landing gear retracted,

(3) Maximum weight,

(4) 75 percent of maximum continuous power,

(5) The airplane trimmed at 1.4 Vs1.

(c) Cruising. (1) Between 1.3 Vs1 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 40 pounds with:

(i) Landing gear retracted,

(ii) Wing flaps retracted,

(iii) Maximum weight,

(iv) 75 percent of maximum continuous power,

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

(2) Same as subparagraph (1) of this paragraph, except that the landing gear shall be extended and the level flight trim speed need not be exceeded.

§ 3.116 Instrumented stick force measurements. Instrumented stick force measurements need not be made when changes in speed are clearly reflected by changes in stick forces and the maximum forces obtained in the above conditions are not excessive.

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

§ 3.118 Directional and lateral stability—

(a) Three-control airplanes.

(1) The static directional stability, as shown by the tendency to recover from a skid with rudder free, shall be positive for all flap positions and symmetrical power conditions, and for all speeds from 1.2 Vs1 up to the maximum permissible speed.

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

(i) Be positive at the maximum permissible speed.

(ii) Not be negative at a speed equal to 1.2 Vs1.

(3) In straight steady sideslips (unaccelerated forward slips), the aileron and rudder control movements and forces shall increase steadily, but not necessarily in constant proportion, as the angle of sideslip is increased; the rate of increase of the movements and forces 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 150 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.

(4) Any short-period oscillation occurring between stalling speed and maximum permissible speed shall be heavily damped with the primary controls (i) free and (ii) in a fixed position.

(b) Two-control (or simplified) airplanes.

(1) The directional stability shall be shown to be adequate by demonstrating that the airplane in all configurations can be rapidly rolled from a 45-degree bank to a 45-degree bank in the opposite direction without exhibiting dangerous skidding characteristics.

(2) Lateral stability shall be shown to be adequate by demonstrating that the airplane will not assume a dangerous attitude or speed when all the controls are abandoned for a period of 2 minutes. This demonstration shall be made in moderately smooth air with the airplane trimmed for straight level flight at 0.9 Vh (or at Vc, if lower), flaps and gear retracted, and with rearward center of gravity loading.

(3) Any short period oscillation occurring between the stalling speed and the maximum permissible speed shall be heavily damped with the primary controls (i) free and (ii) in a fixed position.

STALLS

§3.120 *Stalling demonstration.*

(a) Stalls shall be demonstrated under two conditions:

(1) With power off, and

(2) With a power setting of not less than that required to show compliance with the provisions of § 3.85 (a) for airplanes of more than 6,000 pounds maximum weight, or with 90 percent of maximum continuous power for airplanes of 6,000 pounds or less maximum weight.

(b) In either condition required by paragraph (a) of this section it shall be possible, with flaps and landing gear in any position, with center of gravity in the position least favorable for recovery, and with appropriate airplane weights, to show compliance with the applicable requirements of paragraphs (c) through (f) of this section.

(c) For airplanes having independently controlled rolling and directional controls, it shall be possible to produce and to correct roll by unreversed use of the rolling control and to produce and correct yaw by unreversed use of the directional control up until the time the airplane pitches in the maneuver prescribed in paragraph (g) of this section.

(d) For two-control airplanes having either interconnected lateral and directional controls or for airplanes having only one of these controls, it shall be possible to produce and to correct roll by unreversed use of the rolling control without producing excessive yaw up until the time the airplane pitches in the maneuver prescribed in paragraph (g) of this section.

(e) During the recovery portion of the maneuver, it shall be possible to prevent more than 15 degrees roll or yaw by the normal use of controls, and any loss of altitude in excess of 100 feet or any pitch in excess of 30 degrees below level shall be entered in the Airplane Flight Manual.

(f) A clear and distinctive stall warning shall precede the stalling of the airplane, with the flaps and landing gear in any position, both in straight and turning flight. The stall warning shall begin at a speed exceeding that of stalling by not less than 5 but not more than 10 miles per hour and shall continue until the stall occurs.

(g) In demonstrating the qualities required by paragraphs (c) through (f) of this section, the procedure set forth in subparagraphs (1) and (2) of this paragraph shall be followed.

(1) With trim controls adjusted for straight flight at a speed of approximately 1.4 V_{s1} for airplanes of more than 6,000 pounds maximum weight, or approximately 1.5 V_{s1} for airplanes of 6,000 pounds or less maximum weight, the speed shall be reduced by means of the elevator control until the speed is slightly above the stalling speed; then

(2) The elevator control shall be pulled back at a rate such that the airplane speed reduction does not exceed 1 mile per hour per second until a stall is produced as evidenced by an uncontrollable downward pitching motion of the airplane, or until the control reaches the stop. Normal use of the elevator control for recovery shall be allowed after such pitching motion has unmistakably developed.

§ 3.121 Climbing stalls. When stalled from an excessive climb attitude it shall be possible to recover from this maneuver without exceeding the limiting air speed or the allowable acceleration limit.

§ 3.122 Turning flight stalls. When stalled during a coordinated 30-degree banked turn with 75 percent maximum continuous power on all engines, flaps and landing gear retracted, it shall be possible to recover to normal level flight without encountering excessive loss of altitude, uncontrollable rolling characteristics, or uncontrollable spinning tendencies. These qualities shall be demonstrated by performing the following maneuver: After a steady curvilinear level coordinated flight condition in a 30-degree bank is established and while maintaining the 30-degree bank, the airplane shall be stalled by steadily and progressively tightening the turn with the elevator control until the airplane is stalled or until the elevator has reached its stop. When the stall has fully developed, recovery to level flight shall be made with normal use of the controls.

§ 3.123 One-engine-inoperative stalls. Multiengine airplanes shall not display any undue spinning tendency and 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 percent of maximum continuous power, except that the power need not be greater than that at which the use of maximum control travel just holds the wings laterally level in approaching the stall. The operating engines may be throttled back during the recovery from the stall.

SPINNING

§ 3.124 Spinning—

(a) Category N. All airplanes of 4,000 lbs. or less maximum weight shall recover from a one-turn spin with the controls applied normally for recovery in not more than one additional turn and without exceeding either the limiting air speed or the limit positive maneuvering load factor for the airplane. In addition, there shall be no excessive back pressure either during the spin or in the recovery. It shall not be possible to obtain uncontrollable spins by means of any possible use of the controls. Compliance with these requirements shall be demonstrated at any permissible combination of weight and center of gravity positions obtainable with all or any part of the designed useful load. All airplanes in category N, regardless of weight, shall be placarded against spins or demonstrated to be “characteristically incapable of spinning” in which case they shall be so designated. (See paragraph (d) of this section.)

(b) Category U. Airplanes in this category shall comply with either the entire requirements of paragraph (a) of this section or the entire requirements of paragraph (c) of this section.

(c) *Category A.* All airplanes in this category shall be capable of spinning and shall comply with the following:

(1) At any permissible combination of weight and center of gravity position obtainable with all or part of the design useful load, the airplane shall recover from a six-turn spin, or from any point in a six-turn spin, in not more than 1 « additional turns after the application of the controls in the manner normally used for recovery.

(2) It shall be possible to recover from the maneuver prescribed in subparagraph (1) of this paragraph without exceeding either the limiting air speed or the limit positive maneuvering load factor of the airplane.

(3) It shall not be possible to obtain uncontrollable spins by means of any possible use of the controls.

(4) A placard shall be placed in the cockpit of the airplane setting forth the use of the controls required for recovery from spinning maneuvers.

(d) Category NU. When it is desired to designate an airplane as a type "characteristically incapable of spinning," the flight tests to demonstrate this characteristic shall also be conducted with:

(1) A maximum weight 5 percent in excess of the weight for which approval is desired,

(2) A center of gravity at least 3 percent aft of the rearmost position for which approvals is desired,

(3) An available up-elevator travel 4 degrees in excess of that to which the elevator travel is to be limited by appropriate stops.

(4) An available rudder travel 7 degrees, in both directions, in excess of that to which the rudder travel is to be limited by appropriate stops.

GROUND AND WATER CHARACTERISTICS

§ 3.143 Requirements. All airplanes shall comply with the requirements of §§ 3.144 to 3.147.

§ 3.144 Longitudinal stability and control. 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 dangerous or uncontrollable proposing at any speed at which the airplane is normally operated on the water.

§ 3.145 Directional stability and control.

(a) There shall be no uncontrollable looping tendency in 90-degree cross winds up to a velocity equal to 0.2 Vso at any speed at which the aircraft may be expected to be operated upon the ground or water.

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

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

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

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

FLUTTER AND VIBRATION

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

SUBPART C—STRENGTH REQUIREMENTS
GENERAL

§ 3.171 Loads.

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

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

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

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

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

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

FLIGHT LOADS

§ 3.181 General. Flight load requirements shall be complied with at critical altitudes within the range in which the airplane may be expected to operate and at all weights between the minimum design weight and the maximum design weight, with any practicable distribution of disposable load within prescribed operating limitations stated in § 3.777-3.780.

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

SYMMETRICAL FLIGHT CONDITIONS (FLAPS RETRACTED)

§ 3.183 General. The strength requirements shall be met at all combinations of air speed and load factor on and within the boundaries of a pertinent V-n diagram, constructed similarly to the one shown in Figure 3-1, which represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria of §§ 3.185 and 3.187. This diagram will also be used in determining the airplane structural operating limitations as specified in Subpart G.

§ 3.184 Design air speeds. The design air speeds shall be chosen by the designer except that they shall not be less than the following values:

V_c (design cruising speed)

$= 38 \sqrt{W/S}$ (NU)

$= 42 \sqrt{W/S}$ (A)

except that for values of W/S greater than 20, the above numerical multiplying factors shall be decreased linearly with W/S to a value of 33 at W/S=100: And further provided, That the required minimum value need be no greater than
0.9 Vh actually obtained at sea level.

V_d (design dive speed)

$= 1.40\ V_c$ min (N)

$= 1.50\ V_c$ min (U)

$= 1.55\ V_c$ min (A)

except that for values of W/S greater than 20, the above numerical multiplying factors shall be decreased linearly with W/S to a value of 1.35 at W/S=100. (Vc min is the required minimum value of design cruising speed specified above.)

V_p (design maneuvering speed)

$= V_s \sqrt{n}$ where:

V_s = computed stalling speed with flaps fully retracted at the design weight, normally based on the maximum airplane normal force coefficient, C_{NA}.

N= limit maneuvering load factor used in design,

except that the value of Vp need not exceed the value of Vc used in design.

§ 3.185 Maneuvering envelope. The airplane shall be assumed to 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 specified in § 3.186 at all speeds up to Vd,

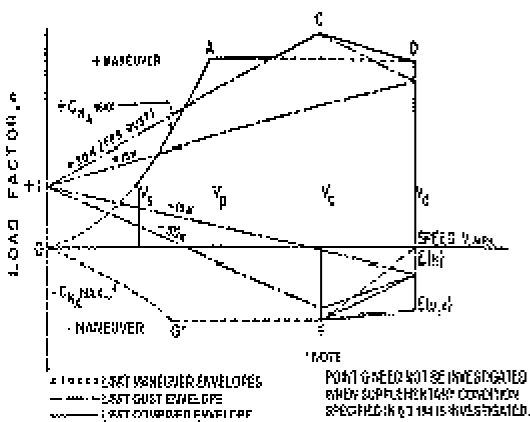

FIG. 3-5—(V-n) DIAGRAM (FLIGHT ENVELOPE)

(b) The negative maneuvering load factor specified in § 3.188 at speed Vc; and factors varying linearly with speed from the specified value at Vc to 0.0 at Vd for the N category and -1.0 at Vd for the A and U categories.

§ 3.186 Maneuvering load factors.

[(a) The positive limit maneuvering load factors shall not be less than the following values:

$$n = 2.1 + \frac{24{,}000}{W + 10{,}000} \text{ -----------Category N}$$

except that n need not be greater than 3.8 and shall not be less than 2.5.]

n = 4.4--------------------------------Category U
n = 6.0--------------------------------Category A

(b) The negative limit maneuvering load factors shall not be less than -0.4 times the positive load factor for the N and U categories, and shall not be less than -0.5 times the positive load factor for the A category.

(c) 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. (See also § 3.106.)

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

(a) Positive (up) and negative (down) gusts of 30 feet per second nominal intensity at all speeds up to Vc,

(b) Positive and negative 15 feet per second gusts at Vd. Gust load factors shall be assumed to vary linearly between Vc and Vd.

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

$$n = 1 + \frac{KUV_m}{575\,(W/S)}$$

where: $K = \frac{1}{2}(W/S)^{1/4}$ (for W/S < 16 p.s.f.)

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

U = nominal gust velocity, f.p.s.
(Note that the "effective sharp-edged gust" equals KU.)
V = airplane speed, m.p.h.
m = slope of lift curve, CL per radian, corrected for aspect ratio.
W/S = wing loading, p.s.f.

[Figure 3-2 Deleted.]

§ 3.189 Airplane equilibrium. In determining the wing loads and linear inertia loads corresponding to any of the above specified flight conditions, the appropriate balancing horizontal tail load (see § 3.215) shall be taken into account in a rational or conservative manner. Incremental horizontal tail loads due to maneuvering and gusts (see §§ 3.216 and 3.217) shall be reacted by angular inertia of the complete airplane in a rational or conservative manner.

FLAPS EXTENDED FLIGHT CONDITIONS

§ 3.190 Flaps extended flight conditions.

(a) 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 fully deflected at the design flap speed Vf resulting in limit load factors within the range determined by the following conditions:

(1) Maneuvering, to a positive limit load factor of 2.0.

(2) Positive and negative 15-feet-per-second gusts acting normal to the flight path in level flight. The gust load factors shall be computed by the formula of § 3.188.

Vf shall be assumed not less than 1.4 Vs of 1.8 Vsf whichever is greater, where:

Vs = the computed stalling speed with flaps fully retracted at the design weight

Vsf = the computed stalling speed with flaps fully extended at the design weight except that when an automatic flap load limiting device is employed, the airplane may be designed for critical combinations of air speed and flap position permitted by the device. (See also § 3.338.)

(b) In designing the flaps and supporting structure, slipstream effects shall be taken into account as specified in § 3.223.

Note: In determining the external loads on the airplane as a whole, the thrust, slip-stream, and pitching acceleration may be assumed equal to zero.

UNSYMMETRICAL FLIGHT CONDITIONS

§ 3.191 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.

(a) Rolling conditions. The airplane shall be designed for (1) unsymmetrical wing loads appropriate to the category, and (2) the loads resulting from the aileron deflections and speeds specified in § 3.222, in combination with an airplane load factor of at least two-thirds of the positive maneuvering factor used in the design of the airplane. Only the wing and wing bracing need be investigated for this condition.

Note: These conditions may be covered as noted below:

(a) Rolling accelerations may be obtained by modifying the symmetrical flight conditions shown in Figure 3-1 as follows:

(1) Acrobatic category. In conditions A and F assume 100 percent of the wing air load acting on one side of the plane of symmetry and 60 percent on the other.

(2) Normal and utility categories. In condition A, assume 100 percent of the wing air load acting on one side of the airplane and 70 percent on the other. For airplanes over 1,000 pounds design weight, the latter percentage may be increased linearly with weight up to 80 percent at 25,000 pounds.

(b) The effect of aileron displacement on wing torsion may be accounted for by adding the following increment to the basic airfoil moment coefficient over the aileron portion of the span in the critical condition as determined by the note under § 3.222:

$$\Delta_{cm} = -.01\delta$$

where:

Δ_{cm} = moment coefficient increment

δ = down aileron deflection in degrees in critical condition

(b) Yawing conditions. The airplane shall be designed for the yawing loads resulting from the vertical surface loads specified in §§ 3.219 to 3.221.

SUPPLEMENTARY CONDITIONS

§ 3.194 Special condition for rear lift truss. When a rear lift truss is employed, it shall be designed for conditions of reversed airflow at a design speed of:

$$V = 10 \sqrt{W/S} \div 10 \text{ (m.p.h.)}$$

Note: It may be assumed that the value of CL is equal to -0.8 and the chordwise distribution is triangular between a peak at the trailing edge and zero at the leading edge.

§ 3.195 Engine torque effects.

(a) Engine mounts and their supporting structures shall be designed for engine torque effects combined with certain basic flight conditions as described in subparagraphs (1) and (2) of this paragraph. Engine torque may be neglected in the other flight conditions.

(1) The limit torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads from flight condition A. (See Fig. 3-1.)

(2) The limit torque corresponding to maximum continuous power and propeller speed, acting simultaneously with the limit loads from flight condition A. (See Fig. 3-1.)

(b) 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 factor shall be 2, 3, and 4, respectively.

§ 3.196 Side load on engine mount. The limit load factor in a lateral direction for this condition shall be at least equal to one-third of the limit load factor for flight condition A (see Fig. 3-1) except that it shall not be less than 1.33. Engine mounts and their supporting structure shall be designed for this condition which may be assumed independent of other flight conditions.

CONTROL SURFACE LOADS

§ 3.211 General. The control surface loads specified in the following sections shall be assumed to occur in the symmetrical and unsymmetrical flight conditions as described in §§ 3.189-3.191. See Figures 3-3 to 3-10 for acceptable values of control surface loadings which are considered as conforming to the following detailed rational requirements.

§ 3.212 Pilot effort. In the control surface loading conditions described, 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 3-11. In applying this criterion, proper consideration shall be given to the effects of control system boost and servo mechanisms, tabs, and automatic pilot systems in assisting the pilot.

§ 3.213 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 such cases the tabs shall be considered to be deflected in the direction which would assist the pilot and the deflection shall correspond to the maximum expected degree of "out of trim" at the speed for the condition under consideration.

HORIZONTAL TAIL SURFACES

§ 3.214 Horizontal tail surfaces. The horizontal tail surfaces shall be designed for the conditions set forth in §§ 3.215-3.218.

§ 3.215 Balancing loads. A horizontal tail balancing load is defined as that necessary to maintain the airplane in equilibrium in a specified flight condition with zero pitching acceleration. The horizontal tail surfaces shall be designed for the balancing loads occurring at any point on the limit maneuvering envelope, Figure 3-1, and in the flap conditions. (See § 3.190.)

Note: The distribution of Figure 3-7 may be used.

§ 3.216 Maneuvering loads.

(a) At maneuvering speed Vp assume a sudden deflection of the elevator control to the maximum upward deflection as limited by the control stops or pilot effort, whichever is critical.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-8 may be used. In determining the resultant normal force coefficient for the tail under these conditions, it will be permissible to assume that the angle of attack of the stabilizer with respect to the resultant direction of air flow is equal to that which occurs when the airplane is in steady unaccelerated flight at a flight speed equal to Vp. The maximum elevator deflection can then be determined from the above criteria and the tail normal force coefficient can be obtained from the data given in NACA Report No. 688, "Aerodynamic Characteristics of Horizontal Tail Surfaces," or other applicable NACA reports.

(b) Same as case (a) except that the elevator deflection is downward.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-8 may be used.

(c) At all speeds above Vp the horizontal tail shall be designed for the maneuvering loads resulting from a sudden upward deflection of the elevator, followed by a downair deflection of the elevator such that the following combinations of normal acceleration and angular acceleration are obtained:

Condition	Airplane normal acceleration *n*	Angular acceleration radian/sec.^{2}
Down load	1.0	$+\frac{20}{V} n_m (n_m - 1.5)$
Up load	n_m	$-\frac{20}{V} n_m (n_m - 1.5)$

Acceptable values of limit average maneuvering control surface loadings can be obtained from Figure 3-3 (b) as follows:

HORIZONTAL TAIL SURFACES

(1) Condition § 3.216 (a):

Obtain $\bar{w}$ as function of W/S and surface deflection;

Use Curve C for deflection 10° or less;

Use Curve B for deflection 20°;

Use Curve A for deflection 30° or more;

(Interpolate for other deflections);

Use distribution of Figure 3-8.

(2) Condition § 3.216 (b):

Obtain $\bar{w}$ from Curve B. Use distribution of Figure 3-8.

VERTICAL TAIL SURFACES

(3) Condition § 3.219 (a):

Obtain $\bar{w}$ as function of W/S and surface deflection in same manner as outlined in (1) above, use distribution of Figure 3-8;

(4) Condition § 3.219 (b):

Obtain $\bar{w}$ from Curve C, use distribution of Figure 3-7;

(5) Condition § 3.219 (c):

Obtain $\bar{w}$ from Curve A, use distribution of Figure 3-9. (Note that condition § 3.220 generally will be more critical than this condition.)

AILERONS

(6) In lieu of conditions § 3.222 (b):

Obtain $\bar{w}$ from Curve B, acting in both up and down directions. Use distribution of Figure 3-10.
where:

n_m = positive limit maneuvering load factor used in the design of the airplane.
V = initial speed in miles per hour.

FIG. 3-3(a)—LIMIT AVERAGE MANEUVERING CONTROL SURFACE LOADINGS

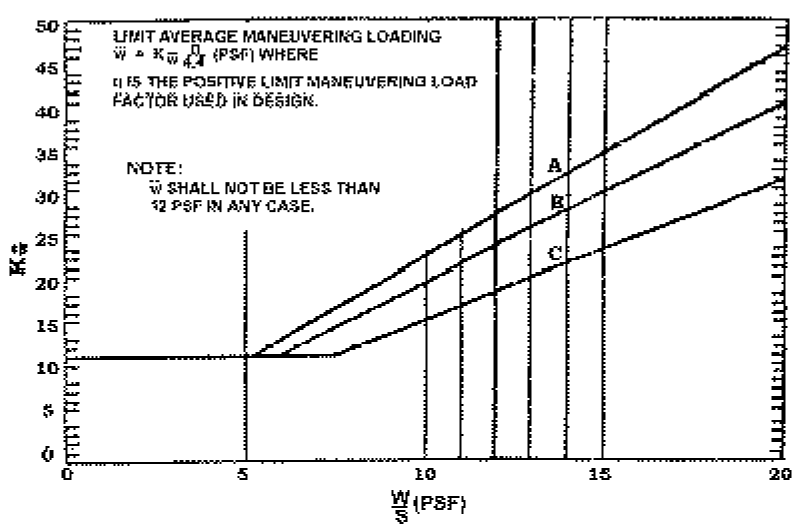

FIGURE 3-3(b) —LIMIT AVERAGE MANEUVERING CONTROL SURFACE LOADING

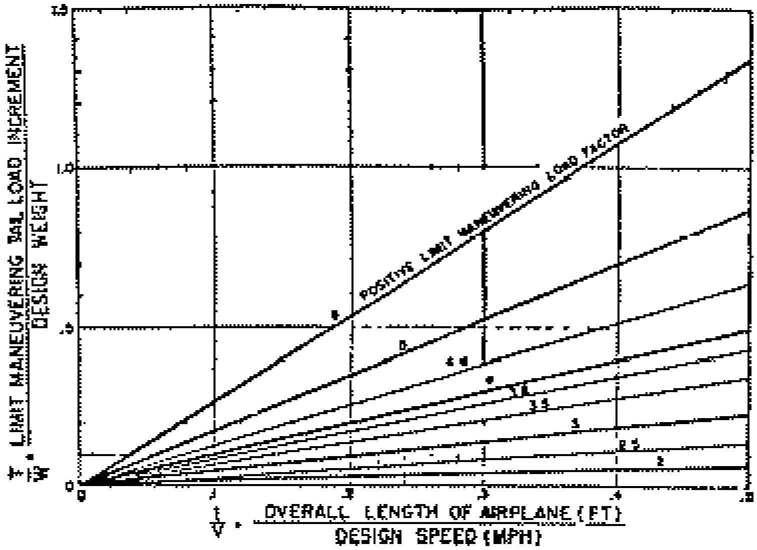

FIG. 3-4 —— MANEUVERING TAIL LOAD INCREMENT (UP OR DOWN)

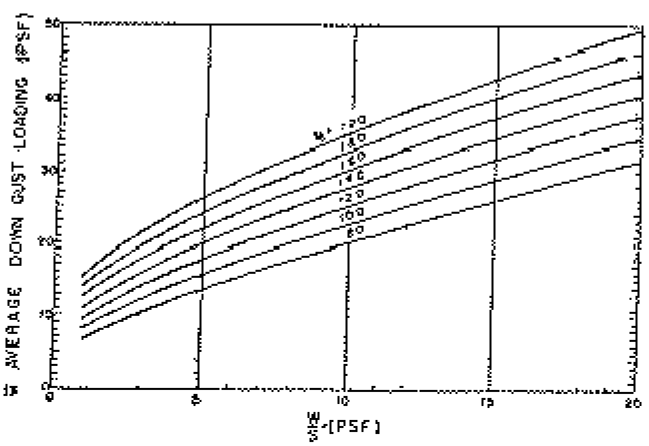

FIG. 3-5(a)—DOWN GUST LOADING ON HORIZONTAL TAIL SURFACE

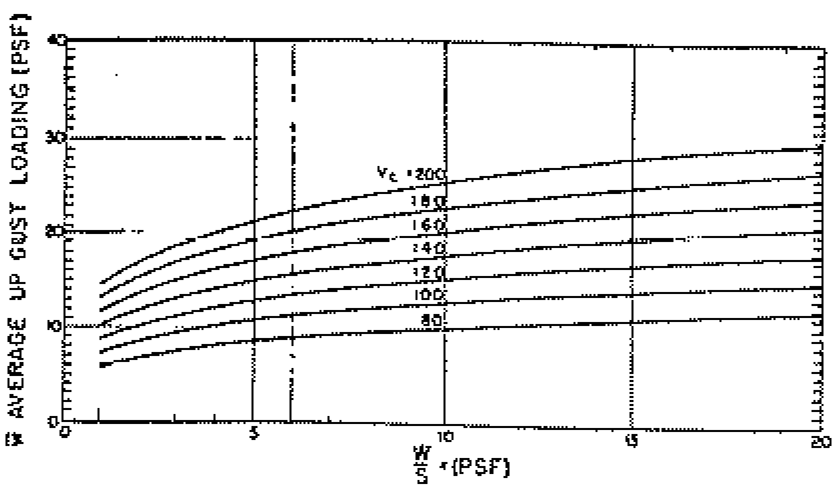

FIG. 3-5(b)—UP GUST LOADING ON HORIZONTAL TAIL SURFACE

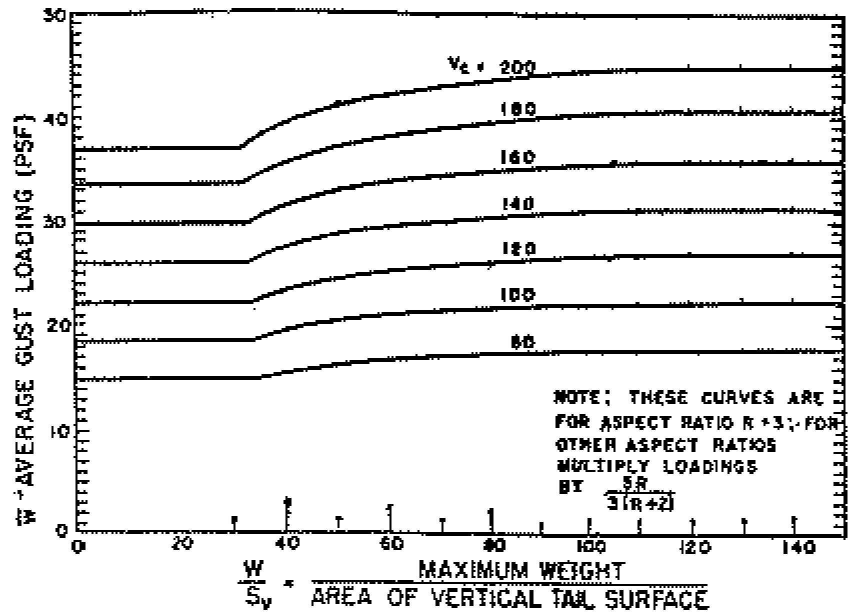

FIG. 3-6 —GUST LOADING ON VERTICAL TAIL SURFACE

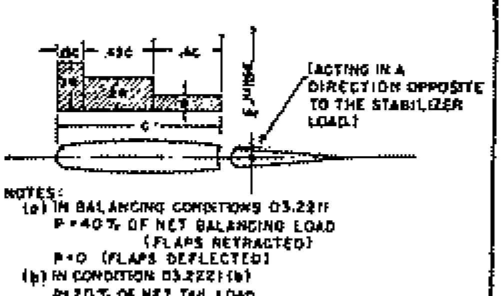

FIG. 3-7 TAIL SURFACE LOAD DISTRIBUTION

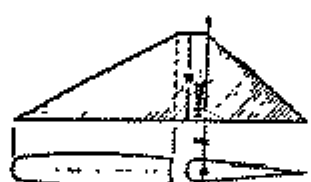

FIG. 3-8 TAIL SURFACE LOAD DISTRIBUTION

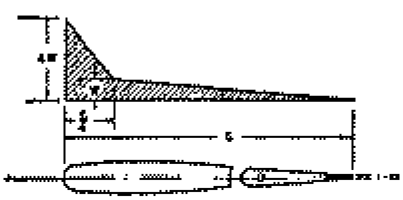

FIG. 3-9 TAIL SURFACE LOAD DISTRIBUTION

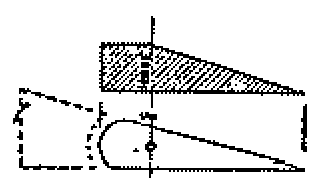

FIG. 3-10 AILERON LOAD DISTRIBUTION

(d) The total tail load for the conditions specified in (c) shall be the sum of: (1) The balancing tail load corresponding with the condition at speed V and the specified value of the normal load factor n, plus (2) the maneuvering load increment due to the specified value of the angular acceleration.

NOTE: The maneuvering load increment of Figure 3-4 and the distributions of Figure 3-8 (for downloads) and Figure 3-9 (for uploads) may be used. These distributions apply to the total tail load.

§ 3.217 Gust loads. The horizontal tail surfaces shall be designed for loads occurring in the conditions specified in paragraphs (a) and (b) of this section.

(a) Positive and negative gusts of 3 0 feet per second nominal intensity at speed V c corresponding with the flight condition specified in § 3.187 (a) with flaps retracted.

NOTE: The average loadings of Figures 3-5 (a) and (b) and the distribution of Figure 3-9 may be used for the total tail loading in this condition.

(b) Positive and negative gusts of 15 feet per second nominal intensity at speed V f corresponding with the flight condition specified in § 3.190 (b) with flaps extended and at speed V d corresponding with the flight condition specified in § 3.187 (b) with flaps retracted.

(c) In determining the total load on the horizontal tail for the conditions specified in paragraphs (a) and (b) of this section, the initial balancing tail loads shall first be determined for steady unaccelerated flight at the pertinent design speeds Vf, Vc, and Vd. The incremental tail load resulting from the gust shall be added to the initial balancing tail load to obtain the total tail load.

NOTE: The incremental tail load due to the gust may be computed by the following formula:

$$\Delta_t = 0.1 K U V S_t a_t \left(1 - \frac{36.5 a_w}{R_w}\right)$$

where:

Δ_t = the limit gust load increment on the tail in pounds;

K = gust coefficient K in § 3.188;

U = nominal gust intensity in feet per second;

V = airplane speed in miles per hour;

S_t = tail surface area in square feet;

a_t = slope of lift curve of tail surface, per degree, corrected for aspect ratio;

a_w = slope of lift curve of wing, per degree; and

R_w = aspect ratio of the wing.

§ 3.218 Unsymmetrical loads. The maximum horizontal tail surface loading (load per unit area), as determined by the preceding sections, shall be applied to the horizontal surfaces on one side of the plane of symmetry and the following percentage of that loading shall be applied on the opposite side:

% = 100-10 (n-1) where:

n is the specified positive maneuvering load factor.

In any case the above value shall not be greater than 80 percent.

VERTICAL TAIL SURFACES

§ 3.219 Maneuvering loads. At all speeds up to Vp:

(a) With the airplane in unaccelerated flight at zero yaw, a sudden displacement of the rudder control to the maximum deflection as limited by the control stops or pilot effort, whichever is critical, shall be assumed.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-8 may be used.

(b) The airplane shall be assumed to be yawned to a sideslip angle of 15 degrees while the rudder control is maintained at full deflection (except as limited by pilot effort) in the direction tending to increase the sideslip.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-7 may be used.

(c) The airplane shall be assumed to be yawed to a sideslip angle of 15 degrees while the rudder control is maintained in the neutral position (except as limited by pilot effort). The assumed sideslip angles may be reduced if is shown that the value chosen for a particular speed cannot be exceeded in the cases of steady slips, uncoordinated rolls from a steep bank, and sudden failure of the critical engine with delayed corrective action.

Note: The average loading of Figure 3-3 and the distribution of Figure 3-9 may be used.

§ 3.220 Gust loads.

(a) The airplane shall be assumed to encounter a gust of 30 feet per second nominal intensity, normal to the plane of symmetry while in unaccelerated flight at speed Vc.

(b) The gust loading shall be computed by the following formula:

$$\overline{w} = \frac{KUVm}{575}$$

where:

$\overline{w}$ = average limit unit pressure in pounds per square foot,

K = $1.33 - \frac{4.5}{(W/S_v)^{3/4}}$ 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 = airplane speed in miles per hour,

m = slope of lift curve of vertical surface, CL per radian, corrected for aspect ratio,

W = design weight in pounds,

Sv = vertical surface area in square feet.

(c) This loading applies only to that portion of the vertical surfaces having a well-defined leading edge.

Note: The average loading of Figure 3-6 and the distribution of Figure 3-9 may be used.

§ 3.221 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 critical vertical surface loading (load per unit area) as determined by §§ 3.219 and 3.220 shall be applied:

(a) To the portion of the vertical surfaces above the horizontal surface, and 80 percent of that loading applied to the portion below the horizontal surface,

(b) To the portion of the vertical surfaces below the horizontal surface, and 80 percent of that loading applied to the portion above the horizontal surface.

AILERONS, WING FLAPS, TABS, ETC.

§ 3.222 Ailerons.

(a) In the symmetrical flight conditions (see §§ 3.183-3.189), the ailerons shall be designed for all loads to which they are subjected while in the neutral position.

(b) In unsymmetrical flight conditions (see § 3.191 (a)), the ailerons shall be designed for the loads resulting from the following deflections except as limited by pilot effort:

(1) At speed Vp it shall be assumed that there occurs a sudden maximum displacement of the aileron control. (Suitable allowance may be made for control system deflections.)

(2) When Vc is greater than Vp, the aileron deflection at Vc shall be that required to produce a rate of roll not less than that obtained in condition (1).

(3) At speed Vd the aileron deflection shall be that required to produce a rate of roll not less than one-third of that which would be obtained at the speed and aileron deflection specified in condition (1).

Note: For conventional ailerons, the deflections for conditions (2) and (3) may be computed from:

$$\delta_2 = \frac{V_A}{V_C}\delta_1 \quad and \quad \delta_3 = \frac{0.5V_A}{V_D}\delta_1$$

where:

δ_1 = total aileron deflection (sum of both aileron deflections) in condition (1).

δ_2 = total aileron deflection in condition (2).

δ_3 = total deflection in condition (3). In the equation for δ_3 the 0.5 factor is used instead of 0.33 to allow for wing torsional flexibility.

(c) The critical loading on the ailerons should occur in condition (2) if Vd is less than 2Vc and the wing meets the torsional stiffness criteria. The normal force coefficient CN for the ailerons may be taken as 0.04δ, where δ is the deflection of the individual aileron in degrees. The critical condition for wing torsional loads will depend upon the basic airfoil moment coefficient as well as the speed, and may be determined as follows:

$$\frac{T_3}{T_2} = \frac{(C_m - .01\,\delta_{3i})\,V_d^2}{(C_m - .01\,\delta_{2i})\,V_c^2}$$

where:

T3/T2 is the ratio of wing torsion in condition (b) (3) to that in condition (b) (2).

δ_{2i} and δ_{3i} are the down deflections of the individual aileron in conditions (b) (2) and (3) respectively.

(d) When T3/T2 is greater than 1.0 condition (b) (3) is critical; when T3/T2 is less than 1.0 condition (b) (2) is critical.

(e) In lieu of the above rational conditions the average loading of Figure 3-3 and the distribution of Figure 3-10 may be used.

§ 3.223 Wing flaps. Wing flaps, their operating mechanism, and supporting structure shall be designed for critical loads occurring in the flap-extended flight conditions (see § 3.190) with the flaps extended to any position from fully retracted to fully extended; except that when an automatic flap load limiting device is employed these parts may be designed for critical combinations of air speed and flap position permitted by the device. (Also see §§ 3.338 and 3.339.) 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 Vs where Vs is the computed stalling speed with flaps fully retracted at the design weight. For investigation of the slipstream condition, the airplane load factor may be assumed to be 1.0.

§ 3.224 Tabs. Control surface tabs shall be designed for the most severe combination of air speed and tab deflection likely to be obtained within the limit V-n diagram (Fig. 3-1) for any usable loading condition of the airplane.

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

CONTROL SYSTEM LOADS

§ 3.231 Primary flight controls and systems.

(a) Flight control systems and supporting structure shall be designed for loads corresponding to 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in §§ 3.211 to 3.225, subject to the following maxima and minima:

(1) The system limit loads need not exceed those which can be produced by the pilot and automatic devices operating the controls.

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

(b) Acceptable maximum and minimum pilot loads for elevator, aileron, and rudder controls are shown in Figure 3-11. 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 attachments of the control system to the control surface horn.

§ 3.232 Dual controls. When dual controls are provided, the systems shall be designed for the pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with § 3.231, except that the individual pilot loads shall not be less than the minimum loads specified in Figure 3-11.

§ 3.233 Ground gust conditions.

(a) The following ground gust conditions shall be investigated in cases where a deviation from the specific values for minimum control forces listed in Figure 3-11 is applicable. The following conditions are intended to simulate the loadings on control surfaces due to ground gusts and when taxiing with the wind.

(b) The limit hinge moment H shall be obtained from the following formula:

$H = KcSq$

where:

H = limit hinge moment (foot-pounds).

c = mean chord of the control surface aft of the hinge line (feet).

S = area of control surface aft of the hinge line (square feet).

q = dynamic pressure (pounds per square foot) to be based on a design speed not less than $10\sqrt{W/S}+10$ miles per hour, except that the design speed need not exceed 60 miles per hour.

K = factor as specified below:

Surface	K
(a) Aileron---Control column locked or lashed in midposition.	+ 0.75
(b) Aileron---Ailerons at full throw; + moment on one aileron, - moment on the other.	±0.50
(c) (d) Elevator---Elevator (c) full up (-), and (d) full down(+).	±0.75
(e) (f) Rudder---Rudder (e) in neutral, and (f) at full throw.	±0.75

(c) As used in paragraph (b) 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.

§ 3.234 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.

GROUND LOADS

§ 3.241 Ground loads. The loads specified in the following conditions shall be considered as the external loads and the inertia forces which occur in an airplane structure. In each of the ground load conditions specified the external reactions shall be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner.

[§ 3.242 Design weight . The design landing weight shall not be less than the maximum weight for which the airplane is to be certificated, except as provided in paragraph (a) or (b) of this section.

(a) A design landing weight equal to not less than 95 percent of the maximum weight shall be acceptable if it is demonstrated that the structural limit load values at the maximum weight are not exceeded when the airplane is operated over terrain having the degree of roughness to be expected in service at all speeds up to the take-off speed. In addition, the following shall apply:

(1) The minimum fuel capacity shall not be less than the total of the capacity prescribed in § 3.440 and of the capacity equivalent to the weight of fuel equal in amount to that by which the maximum weight exceeds the design landing weight.

(2) The operating limitations shall limit the take-off weight in such a manner as to assure that landings in normal operation would not exceed the design landing weight.

(b) A design landing weight equal to less than 95 percent of the maximum weight shall be acceptable for multiengine airplanes meeting the one-engine-inoperative climb requirement of § 3.85 (b) or § 3.85a (b) if compliance is shown with the following sections of Part 4b of this subchapter in lieu of the corresponding requirement of this part: The ground load requirements of § 4b.230, the landing gear requirements of §§ 4b.331 through 4b.336, and the fuel jettisoning system requirements of § 4b.437.**]**

§ 3.243 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, in feet per second, equal to the following value:

$V = 4.4 (W/S)^{1/4}$

except that the descent velocity need not exceed 10 feet per second and shall not be less than 7 feet per second. Wing lift not exceeding two thirds of the weight of the airplane may be assumed to exist throughout the landing impact and may be assumed to act through the airplane center of gravity. When such wing lift is assumed, the ground reaction load factor may be taken equal to the inertia load factor minus the ratio of the assumed wing lift to the airplane weight. (See § 3.354 for requirements concerning the energy absorption tests which determine the limit load factor corresponding to the required limit descent velocities.) In no case, however, shall the inertia load factor used for design purposes be less than 2.67, nor shall the limit ground reaction load factor be less than 2.0, unless it is demonstrated that lower values of limit load factor will not be exceeded in taxiing the airplane over terrain having the maximum degree of roughness to be expected under intended service use at all speeds up to take-off speed.

LANDING CASES AND ATTITUDES

§ 3.244 Landing cases and attitudes. For conventional arrangements of main and nose, or main and tail wheels, the airplane shall be assumed to contact the ground at the specified limit vertical velocity in the attitudes described in
§§ 3.245-3.247. (See Figs. 3-12 (a) and 3-12 (b) for acceptable landing conditions which are considered to conform with §§ 3.245-3.247.)

§ 3.245 Level landing—

(a) Tail wheel type.Normal level flight attitude.

(b) Nose wheel type. Two cases shall be considered:

(1) Nose and main wheels contacting the ground simultaneously,

(2) Main wheels contacting the ground, nose wheel just clear of the ground. (The angular attitude may be assumed the same as in subparagraph (1) of this paragraph for purposes of analysis.)

(c) Drag components. In this condition, drag components simulating the forces required to accelerate the tires and wheels up to the landing speed shall be properly combined with the corresponding instantaneous vertical ground reactions. The wheel spin-up drag loads may be based on vertical ground reactions, assuming wing lift and a tire-sliding coefficient of friction of 0.8, but in any case the drag loads shall not be less than 25 percent of the maximum vertical ground reactions neglecting wing lift.

LIMIT PILOT LOADS

Control	Maximum loads for design weight W equal to or less than 5,000 lbs.[1]	Minimum loads.[2]
Aileron:		
Stick	67 pounds	40 pounds.
Wheel[3]	53 D in-pounds[4]	40 D in-pounds
Elevator:		
Stick	167 pounds	100 pounds.
Wheel	200 pounds	100 pounds.
Rudder	200 pounds	130 pounds.

[1]For design weight W greater than 5,000 pounds the above specified maximum values shall be increased linearly with weight to 1.5 times the specified values at a design weight of 25,000 pounds.

[2]If the design of any individual set of control systems or surfaces is such as to make these specified minimum loads inapplicable, values corresponding to the pertinent binge moments obtained according to § 3.233 may be used instead, except that in any case values less than 0.6 of the specified minimum loads shall not be employed.

[3]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.

[4]D = wheel diameter.

FIG. 3-11 —PILOT CONTROL FORCE LIMITS

§ 3.246 Tail down—

(a) Tail wheel type. Main and tail wheels contacting ground simultaneously.

(b) Nose wheel type. Stalling attitude or the maximum angle permitting clearance of the ground by all parts of the airplane, whichever is the lesser.

(c) Vertical ground reactions. In this condition, it shall be assumed that the ground reactions are vertical, the wheels having been brought up to speed before the maximum vertical load is attained.

§ 3.247 One-wheel landing. One side of the main gear shall contact the ground with the airplane in the level attitude. The ground reactions shall be the same as those obtained on the one side in the level attitude. (See § 3.245.)

GROUND ROLL CONDITIONS

§ 3.248 Braked roll. The limit vertical load factor shall be 1.33. The attitude and ground contacts shall be those described for level landings in § 3.245, with the shock absorbers and tires deflected to their static positions. A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction of 0.8 shall be applied at the ground contact point of each wheel having brakes, except that the drag reaction need not exceed the maximum value based on limiting brake torque.

§ 3.249 Side load. Level attitude with main wheels only contacting the ground, with the shock absorbers and tires deflected to their static positions. The limit vertical load factor shall be 1.33 with the vertical ground reaction divided equally between main wheels. The limit side inertia factor shall be 0.83 with the side ground reaction divided between main wheels as follows:
0.5 W acting inboard on one side.
0.33 W acting outboard on the other side.

TAIL WHEELS

§ 3.250 Supplementary conditions for tail wheels. The conditions in §§ 3.251 and 3.252 apply to tail wheels and affected supporting structure.

§ 3.251 Obstruction load. The limit ground reaction obtained in the tail down landing condition shall be assumed to act up and aft through the axle at 45 degrees. The shock absorber and tire may be assumed deflected to their static positions.

§ 3.252 Side load. A limit vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude. When a swivel is provided, the tail wheel shall be assumed swiveled 90 degrees to the airplane longitudinal axis, the resultant ground 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. The shock absorber and tire shall be assumed deflected to their static positions.

NOSE WHEELS

§ 3.253 Supplementary conditions for nose wheels. The conditions set forth in §§ 3.254-3.256 apply to nose wheels and affected supporting structure. The shock absorbers and tires shall be assumed deflected to their static positions.

§ 3.254 Aft load. Limit force components at axle:

Vertical, 2.25 times static load on wheel, Drag, 0.8 times vertical load.

§ 3.255 Forward load. Limit force components at axle:

Vertical, 2.25 times static load on wheel,
Forward, 0.4 times vertical load.

§ 3.256 Side load. Limit force components at ground contact:

Vertical, 2.25 times static load on wheel, Side, 0.7 times vertical load.

SKIPLANES

§ 3.257 Supplementary conditions for skiplanes. The airplane shall be assumed resting on the ground with one main ski frozen in the snow and the other main ski and the tail ski free to slide. A limit side force equal to P/3 shall be applied at the most convenient point near the tail assembly, where P is the static ground reaction on the tail ski. For this condition the factor of safety shall be assumed equal to 1.0.

Amendment 3-10 -- Interchange "nWb'/d" in the third column with "nWa'/d"
[Amendment 3-14 -- Delete the term “n” from all columns in the two lines titled “Main wheel loads (both wheels) Vr ” and “Tail (nose) wheel loads Vf ” and inserting in lieu thereof in each instance the term “(n-L); delete the term “KVr ” from the first and fourth columns of the line titled “Main wheel loads (both wheels.) Dr ” and inserting in lieu thereof in each instance the term “KnW”; delete the term “KVr ” from the third column of the line titled “Main wheel loads (both wheels) Dr ” and inserting in lieu thereof the term “KnWa’/d’; delete the term “KV f ” from the third column of the line titled “Tail (nose) wheel loads D f ” and inserting in lieu thereof the term “KnW b’/d’; add a new note to read as follows: “ NOTE (4). - L is defined in § 3.353.”**]**

Condition	Tail wheel type		Nose wheel type		
	Level landing	Tail-down landing	Level landing with inclined reactions	Level landing with nose wheel just clear of ground	Tail-down landing
Reference section-----	§3.245(a)	§3.246(a)	§ 3.245 (b) (1)	§ 3.245 (b) (2)	§ 3.246 (b) (c)
Vertical component at c.g----------------------	nW	nW	nW	nW	nW
Fore and aft component at c.g.------------------	KnW	0	KnW	KnW	0
Lateral component in either direction at c.g.	0	0	0	0	0
Shock absorber extension (hydraulic shock absorber)---------	Note (2)	Note (2)	Note (2)	Note (2)	Note (2)
Shock absorber deflection (rubber or spring shock absorber)----------------	100%	100%	100%	100%	100%
Tire deflection------------	Static	Static	Static	Static	Static
Main wheel loads (both wheels)-------------{V_r	nW	nWb/d	nWb'/d	nW	nW
{D_r	KV_r	0	KV_r	KV_r	0
Tail (nose) wheel loads ---------------------{V_f	0	nWa/d	nWa'/d	0	0
{D_f	0	0	KV_f	0	0
Notes---------------------	(1) and (3)	--------------	(1)	(1) and (3)	(3)

Note (1).—K may be determined as follows: $K=0.25$ for $W=3{,}000$ pounds or less; $K=0.33$ for $W=6{,}000$ pounds or greater with linear variation of K between these weights.

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

Note (3).—Unbalanced moments shall be balanced by a rational or conservative method.

FIG. 3-12(a)—BASIC LANDING CONDITIONS

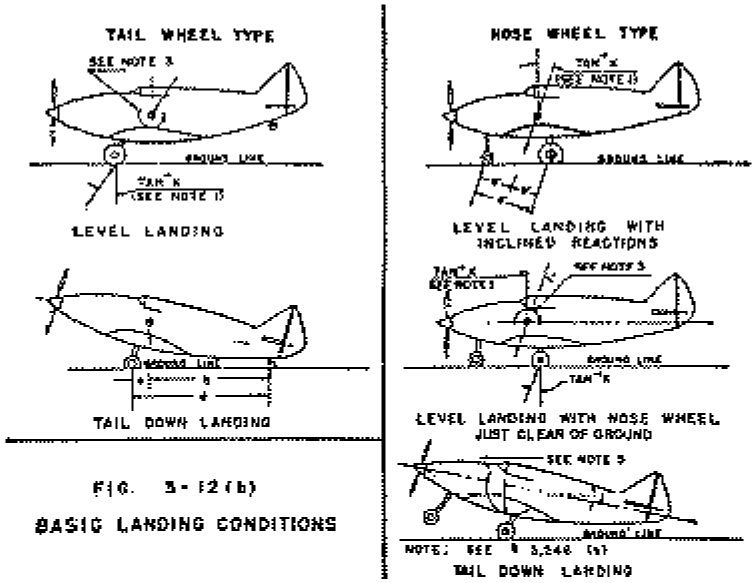

FIG. 3-12(b)
BASIC LANDING CONDITIONS

SUBPART D—DESIGN AND CONSTRUCTION
GENERAL

§ 3.291 General. The suitability of all questionable design details or parts having an important bearing on safety in operation shall be established by tests.

§ 3.292 Materials and workmanship. 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. All workmanship shall be of a high standard.

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

§ 3.294 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 subject to rotation during the operation of the airplane.

§ 3.295 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 of all parts of the structure shall be made.

§ 3.296 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.

STRUCTURAL PARTS

§ 3.301 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. Values contained in ANC-5, ANC-18, and ANC-23, Part II shall be used unless shown to be inapplicable in a particular case.

Note: ANC-5, "Strength of Metal Aircraft Elements," and ANC-18, "Design of Wood Aircraft Structures," and ANC-23, "Sandwich Construction for Aircraft," are published by the Subcommittee on Air Force-Navy-Civil Aircraft Design Criteria, and may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

§ 3.302 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 §§ 3.303-3.306.

§ 3.303 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 under-strength from this cause extremely remote. Minimum variability factors (only the highest pertinent variability factor need be considered) are set forth in §§ 3.304-3.306.

§ 3.304 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 found satisfactory by the Administrator.

§ 3.305 Bearing factors.

(a) The factor of safety in bearing at bolted or pinned joints shall be suitably increased to provide for the following conditions:

(1) Relative motion in operation (control surface and system joints are covered in §§ 3.327-3.347).

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

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

§ 3.306 Fitting factor. Fittings are denied 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 the strength of which is not proved 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.

§ 3.307 Fatigue strength. The structure shall be designed, insofar as practicable, to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service.

FLUTTER AND VIBRATION

§ 3.311 Flutter and vibration prevention measures. Wings, tail, and control surfaces shall be free from flutter, airfoil divergence, and control reversal from lack of rigidity, for all conditions of operation within the limit V-n envelope, and the following detail requirements shall apply:

(a) Adequate wing torsional rigidity shall be demonstrated by tests or other methods found suitable by the Administrator.

(b) The mass balance of surfaces shall be such as to preclude flutter.

(c) The natural frequencies of all main structural components shall be determined by vibration tests or other methods found satisfactory by the Administrator.

WINGS

§ 3.317 Proof of strength. The strength of stressed-skin wings shall be substantiated by load tests or by combined structural analysis and tests.

§ 3.318 Ribs. Rib tests shall simulate conditions in the airplane with respect to torsional rigidity of spars, fixity conditions, lateral support, and attachment to spars. The effects of ailerons and high lift devices shall be properly accounted for.

§ 3.319 Rescinded.

§ 3.320 Rescinded.

CONTROL SURFACES (FIXED AND MOVABLE)

§ 3.327 Proof of strength. Limit load tests of control surfaces are required. Such tests shall include the horn or fitting to which the control system is attached. In structural analyses, rigging loads due to wire bracing shall be taken into account in a rational or conservative manner.

§ 3.328 Installation. Movable tail surfaces shall be so installed that there is no interference between the surfaces or 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, in the event of failure of the adjusting mechanism, will limit its travel to a range permitting safe flight and landing.

§ 3.329 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.

[§ 3.330 Mass balance weights . The supporting structure and the attachment of concentrated mass balance weights which are incorporated on control surfaces shall be designed for the following limit accelerations: 24g normal to the plane of the control surface, 12g fore and aft, and 12g parallel to the hinge line.**]**

CONTROL SYSTEMS

§ 3.335 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 convenience in operation and prevent the possibility of confusion and subsequent inadvertent operation. (See § 3.384 for cockpit controls.)

§ 3.336 Primary flight controls.

(a) Primary flight controls are defined as those used by the pilot for the immediate control of the pitching, rolling, and yawing of the airplane.

(b) For two-control airplanes the design shall be such as to minimize the likelihood of complete loss of the lateral directional control in the event of failure of any connecting or transmitting element in the control system.

§ 3.337 Trimming controls. Proper precautions shall be taken against the possibility of inadvertent, improper, or abrupt tab operations. Means shall be provided to indicate to the pilot the direction of control movement relative to airplane motion and the position of the trim device with respect of the range of adjustment. The means used to indicate the direction of the control movement shall be adjacent to the control, and the means used to indicate the position of the trim device shall be easily visible to the pilot and so located and operated as to preclude the possibility of confusion. Longitudinal trimming devices for single-engine airplanes and longitudinal and directional trimming devices for multiengine airplanes shall be capable of continued normal operation notwithstanding the failure of any one connecting or transmitting element in the primary control system. Tab controls shall be irreversible unless the tab is properly balanced and possesses no unsafe flutter characteristics. 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.

§ 3.338 Wing flap controls. The controls shall be such that when the flap has been placed in any position upon which compliance with the performance requirements is based, the flap will not move from that position except upon further adjustment of the control or the automatic operation of a flap load limiting device. Means shall be provided to indicate the flap position to the pilot. If any flap position other than fully retracted or extended is used to show compliance with the performance requirements, such means shall indicate each such position. The rate of movement of the flaps in response to the operation of the pilot's control, or of an automatic device shall not be such as to result in unsatisfactory flight or performance characteristics under steady or changing conditions of air speed, engine power, and airplane attitude (See § 3.109 (b) and (c).)

§ 3.339 Flap interconnection.

(a) 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.

(b) Where an interconnection is used, in the case of multiengine airplanes, 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 engine airplanes, it may be assumed that 100 percent of the critical air load acts on one side and 70 percent on the other.

§ 3.340 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.

§ 3.341 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 unmistakable warning to the pilot when it is engaged, and

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

§ 3.342 Proof of strength. Tests shall be conducted 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.

§ 3.343 Operation test. An operation test shall be conducted by operating the controls from the pilot compartment with the entire system so loaded as to correspond to the limit air loads on the surface. In this test there shall be no jamming, excessive friction, or excessive deflection.

CONTROL SYSTEM DETAILS

§ 3.344 General. All control systems and operating devices shall be so designed and installed as to prevent jamming, chafing, or interference as a result of inadequate clearances or from cargo, passengers, or loose objects. 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.

§ 3.345 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 primary control systems. The design of cable systems shall be such that there will not be 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 fouling, 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 degrees. 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 binding throughout the range of travel. Provisions for visual inspection shall be made at all fairleads, pulleys, terminals, and turnbuckles.

§ 3.346 Joints. Control system joints subject 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.

§ 3.347 Spring devices. The reliability of any spring devices used in the control system shall be established by tests simulating service conditions, unless it is demonstrated that failure of the spring will not cause flutter or unsafe flight characteristics.

LANDING GEAR
SHOCK ABSORBERS

§ 3.351 Tests. Shock absorbing elements in main, nose, and tail wheel units shall be substantiated by the tests specified in the following section. In addition, the shock absorbing ability of the landing gear in taxiing must be demonstrated in the operational tests of § 3.146.

§ 3.352 Shock absorption tests.

(a) It shall be demonstrated by energy absorption tests that the limit load factors selected for design in accordance with § 3.243 will not be exceeded in landings with the limit descent velocity specified in that section.

(b) In addition, a reserve of energy absorption shall be demonstrated by a test in which the descent velocity is at least 1.2 times the limit descent velocity. In this test there shall be no failure of the shock aborting unit, although yielding of the unit will be permitted. Wing lift equal to the weight of the airplane may be assumed for purposes of this test.

§ 3.353 Limit drop tests.

(a) If compliance with the specified limit landing conditions of § 3.352 (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:

$$h \text{ (inches)} = 3.6\,(W/S)^{0.5}$$

except that the free drop height shall not be less than 9.2 inches and need not be greater than 18.7 inches.

(b) In simulating the permissible wing lift in free drop tests, the landing gear unit shall be dropped with an effective mass equal to:

$$W_e = W\left[\frac{h+(1-L)d}{h+d}\right]$$

where
We = 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 *We* shall not exceed the value actually obtained in the drop tests.
$W = W_M$ or main gear units, and shall be 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 clear, in the case of nose wheel type airplanes).
$W = W_T$ for tail gear units, and shall be equal to the static weight on the tail unit with the airplane in the tail down attitude.
$W = W_N$ for nose wheel units, and shall be equal to the static reaction which will exist at the nose wheel when the mass of the airplane is concentrated at the center of gravity and exerts a force of 1.0g downward and 0.33g forward.
L = ratio of assumed wing lift to airplane weight, not greater than 0.667.

The attitude in which the 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.

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

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

where
nj = the load factor developed in the drop test, i.e., 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 inertia load factor used in the landing conditions, § 3.243.

§ 3.355 Reserve energy absorption drop tests. If compliance with the reserve energy absorption condition specified in § 3.352 (b) is demonstrated by free drop tests, the drop height shall be not less than 1.44 times the drop height specified in § 3.353. In simulating 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 § 3.353.

RETRACTING MECHANISM

§ 3.356 General. The landing gear retracting mechanism and supporting structure shall be designed for the maximum load factors 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 at any air speed up to 1.6Vs1, flaps retracted and any load factors up to those specified for the flaps extended condition, § 3.190. 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 at least 1.6 Vs1 flaps retracted. Positive means shall be provided for the purpose of maintaining the wheels in the extended position.

§ 3.357 Emergency operation. When other than manual power for the operation of the landing gear is employed, an auxiliary means of extending the landing gear shall be provided.

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

§ 3.359 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 the extreme positions. In addition, landplanes shall be provided with an aural or equally effective warning device which shall function continuously after the throttle is closed until the gear is down and locked.

§ 3.360 Control. See § 3.384.

WHEELS AND TIRES

§ 3.361 *Wheels.* Main wheels and nose wheels shall be of an approved type. The maximum static load rating of each main wheel and nose wheel shall not be less than the corresponding static ground reaction under the design maximum weight of the airplane and the critical center of gravity position. The maximum limit load rating of each main wheel and nose wheel shall not be less than the maximum radial limit load determined in accordance with the applicable ground load requirements of this part. (See §§ 3.241 through 3.256.)

§ 3.362 Tires. A landing gear wheel may be equipped with any make or type of tire, provided that the approved tire rating is not exceeded under the following conditions:

(a) Load on each main wheel tire equal to the corresponding static ground reaction under the design maximum weight of the airplane and the critical center of gravity position.

(b) 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 most critical 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 principle 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 marking shall include the make, size, number of plies, and identification marking of the proper tire.

Note: Rescinded.

BRAKES

§ 3.363 Brakes. Brakes shall be installed which are adequate to prevent the airplane from rolling on a paved runway while applying take-off power to the critical engine, and of sufficient capacity to provide adequate speed control during taxiing without the use of excessive pedal or hand forces.

SKIS

§ 3.364 *Skis.* Skis shall be of an approved type. The maximum limit load rating of each ski shall not be less than the maximum limit load determined in accordance with the applicable ground load requirements of this part. (See §§ 3.241 through 3.257.)

§ 3.365 Rescinded.

§ 3.366 Rescinded.

HULLS AND FLOATS

§ 3.371 *Seaplane main floats.* Seaplane main floats shall be of an approved type and shall comply with the provisions of § 3.265. In addition, the following shall apply.

(a) *Buoyancy.* Each seaplane main float shall have a buoyancy of 80 percent in excess of that required to support the maximum weight of the seaplane in fresh water.

(b) *Compartmentation.* Each seaplane main float for use on airplanes of 2,500 pounds or more maximum weight shall contain not less than 5 watertight compartments, and those for use on airplanes of less than 2,500 pounds maximum weight shall contain not less than 4 such compartments. The compartments shall have approximately equal volumes.

§ 3.372 Buoyancy (boat seaplanes). The hulls of boat seaplanes and amphibians shall be divided into watertight compartments in accordance with the following requirements:

(a) In airplanes of 5,000 pounds or more maximum weight, the compartments shall be so arranged that, with any two adjacent compartments flooded, the hull and auxiliary floats (and tires, if used) will retain sufficient buoyancy to support the maximum weight of the airplane in fresh water.

(b) In airplanes of 1,500 to 5,000 pounds maximum weight, the compartments shall be so arranged that, with any one compartment flooded, the hull and auxiliary floats (and tires, if used) will retain sufficient buoyancy to support the maximum weight of the airplane in fresh water.

(c) In airplanes of less than 1,500 pounds maximum weight, watertight subdivision of the hull is not required.

(d) Bulkheads may have watertight doors for the purpose of communication between compartments.

§ 3.373 Water stability. Auxiliary floats shall be so arranged that when completely submerged in fresh water, they will provide a righting moment which is at least 1.5 times the upsetting moment caused by the airplane being tilted. A greater degree of stability may be required by the Administrator in the case of large flying boats, depending on the height of the center of gravity above the water level, the area and location of wings and tail surfaces, and other considerations.

FUSELAGE
PILOT COMPARTMENT

§ 3.381 General.

(a) 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.

(b) The primary flight control units listed on Figure 3-14, excluding cables and control rods, shall be so located with respect to the propellers that no portion of the pilot or controls lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub and making an angle of 5° forward or aft of the plane of rotation of the propeller.

§ 3.382 Vision. The pilot compartment shall be arranged to afford the pilot a sufficiently extensive, clear, and undistorted view for the safe operation of the airplane. During flight in a moderate rain condition, the pilot shall have an adequate view of the flight path in normal flight and landing, and have sufficient protection from the elements so that his vision is not unduly impaired. This may be accomplished by providing an openable window or by a means for maintaining a portion of the windshield in a clear condition without continuous attention by the pilot. The pilot compartment shall be free of glare and reflections which would interfere with the pilot's vision. For airplanes intended for night operation, the demonstration of these qualities shall include night flight tests.

§ 3.383 Pilot windshield and windows. All glass panes shall be of a nonsplintering safety type.

§ 3.384 Cockpit controls.

(a) All cockpit controls shall be so located and, except for those the function of which is obvious, identified as to provide convenience in operation including provisions to prevent the possibility of confusion and consequent inadvertent operations. (See Fig. 3-14 for required sense of motion of cockpit controls.) The controls shall be so located and arranged that when seated it will be readily possible for the pilot to obtain full and unrestricted movement of each control without interference form either his clothing or the cockpit structure.

(b) Identical power-plant controls for the several engines in the case of multiengine airplanes shall be so located as to prevent any misleading impression as to the engines of which they relate.

Control	Movement and actuation
Primary:	
Aileron	Right (clockwise) for right wing down.
Elevator	Rearward for nose up.
Rudder	Right pedal forward for nose right.
Power plant:	
Throttle	Forward to open.

Figure 3-14 Cockpit Controls

§ 3.385 Instruments and markings. See § 3.661 relative to instrument arrangement. The operational markings, instructions, and placards required for the instruments and controls are specified in §§ 3.756 to 3.765.

EMERGENCY PROVISIONS

§ 3.386 Protection. The fuselage shall be designed to give reasonable assurance that each occupant, if he makes proper use of belts or harness for which provisions are made in the design, will not suffer serious injury during minor crash conditions as a result of contact of any vulnerable part of his body with any penetrating or relatively solid object, although it is accepted that parts of the airplane may be damaged.

(a) The ultimate accelerations to which occupants are assumed to be subjected shall be as follows:

	N, U	A
Upward	3.0g	4.5g
Forward	9.0g	9.0g
Sideward	1.5g	1.5g

(b) For airplanes having retractable landing gear, the fuselage in combination with other portions of the structure shall be designed to afford protection of the occupants in a wheels-up landing with moderate descent velocity.

(c) If the characteristics of an airplane are such as to make a turn-over reasonably probable, the fuselage of such an airplane in combination with other portions of the structure shall be designed to afford protection of the occupants in a complete turn-over.

Note: In § 3.386 (b) and (c), a vertical ultimate acceleration of 3g and a friction coefficient of 0.5 at the ground may be assumed.

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

§ 3.387 Exits.

(a) Closed cabins on airplanes carrying more than 5 persons shall be provided with emergency exits consisting of movable windows or panels or of additional external doors which provide a clear and unobstructed opening, the minimum dimensions of which shall be such that a 19-by-26-inch ellipse may be completely inscribed therein. 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 in all probable attitudes resulting from a crash. The method of opening shall be simple and obvious, and the exits shall be so arranged and marked as to be readily located and operated even in darkness. Reasonable provisions shall be made against the jamming of exits as a result of fuselage deformation. The proper functioning of exits shall be demonstrated by tests.

(b) The number of emergency exits required is as follows:

(1) Airplanes with a total seating capacity of more than 5 persons, but not in excess of 15, shall be provided with at least one emergency exit or one suitable door in addition to the main door specified in § 3.389. This emergency exit, or second door, shall be on the opposite side of the cabin from the main door.

(2) Airplanes with a seating capacity of more than 15 persons shall be provided with emergency exits or doors in addition to those required in paragraph (b) (1) of this section. There shall be one such additional exit or door located either in the top or side of the cabin for every additional 7 persons or fraction thereof above 15, except that not more than four exits, including doors, will be required if the arrangement and dimensions are suitable for quick evacuation of all occupants.

(c) If the pilot compartment is separated from the cabin by a door which is likely to block the escape in the event of a minor crash, it shall have its own exit, but such exit shall not be considered as an emergency exit for the passengers.

(d) In categories U and A exits shall be provided which will permit all occupants to bail out quickly with parachutes.

§ 3.388 Fire precautions—

(a) Cabin interiors. Only materials which are flash resistant shall be used. In compartments where smoking is to be permitted, the wall and ceiling linings, the covering of all upholstering, floors, and furnishings shall be flame-resistant. Such compartments shall be equipped with an adequate number of self contained ash trays. All other compartments shall be placarded against smoking.

(b) Combustion heaters. If combustion heaters are installed, they shall be of an approved type. The installation shall comply with applicable parts of the powerplant installation requirements covering fire hazards and precautions. All applicable requirements concerning fuel tanks, lines, and exhaust systems shall be considered.

PERSONNEL AND CARGO ACCOMMODATIONS

§ 3.389 Doors. Closed cabins on all airplanes carrying passengers shall be provided with at least one adequate and easily accessible external door. No passenger door shall be so located with respect to the propeller discs as to endanger persons using the door.

[§ 3.390 Seats and berths. All seats and berths shall be of an approved type. They and their supporting structures shall be designed for an occupant weighing at least 170 pounds (190 pounds with parachute for seats intended for the acrobatic and utility categories) and for the maximum load factors corresponding with all specified flight and ground load conditions including the emergency landing conditions prescribed in § 3.386. The provisions of paragraphs (a) through (d) of this section shall also apply:

(a) Pilot seats shall be designed for the reactions resulting from the application of pilot forces to the primary flight controls as prescribed in § 3.231.

(b) All seats in the U and A categories shall be designed to accommodate passengers wearing parachutes, unless placarded in accordance with § 3.74 (b).

(c) Berths shall be so designed that the forward portion is provided with a padded end board, a canvass diaphragm, or other equivalent means, capable of withstanding the static load reaction of the occupant when subjected to the forward accelerations prescribed in § 3.386. Berths shall be provided with an approved safety belt and shall be free from corners or protuberances likely to cause serious injury to a person occupying the berth during emergency conditions. Berth safety belt attachments shall withstand the critical loads resulting from all relevant flight and ground load conditions and from the emergency landing conditions of § 3.386 with the exception of the forward load.

(d) In determining the strength of the attachment of the seat and berth to the structure, the accelerations prescribed in § 3.386 shall be multiplied by a factor of 1.33.

§ 3.391 Deleted.**]**

§ 3.392 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. Suitable provisions shall be made to prevent the contents of cargo compartments form becoming a hazard by shifting. Such provisions shall be adequate to protect the passengers from injury by the contents of any cargo compartment when the ultimate forward acting accelerating force is 4.5g.

§ 3.393 Ventilation. All passenger and crew compartments shall be suitably ventilated. Carbon monoxide concentration shall not exceed 1 part in 20,000 parts of air.

MISCELLANEOUS

§ 3.401 Leveling marks. Leveling marks shall be provided for leveling the airplane on the ground.

SUBPART E—POWER-PLANT INSTALLATIONS; RECIPROCATING ENGINES GENERAL

§ 3.411 Components.

(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 continued safety of operation.

(b) All components of the power-plant installation shall be constructed, arranged, and installed in a manner which will assure the continued safe operation of the airplane and power plant. Accessibility shall be provided to permit such inspection and maintenance as is necessary to assure continued airworthiness.

ENGINES AND PROPELLERS

§ 3.415 Engines. Engines installed in certificated airplanes shall be of a type which has been certificated in accordance with the provisions of Part 13 of this chapter.

§ 3.416 Propellers.

(a) Propellers installed in certificated airplanes shall be of a type which has been certificated in accordance with the provisions of Part 14 of this chapter.

(b) The maximum engine power and propeller shaft rotational speed permissible for use in the particular airplane involved shall not exceed the corresponding limits for which the propeller has been certificated.

§ 3.417 Propeller vibration. In the case of propellers with metal blades or other highly stressed metal components, the magnitude of the critical vibration stresses under all normal conditions of operation shall be determined by actual measurements or by comparison with similar installations for which such measurements have been made. The vibration stresses thus determined shall not exceed values which have been demonstrated to be safe for continuous operation. Vibration tests may be waived and the propeller installation accepted on the basis of service experience, engine or ground tests which show adequate margins of safety, or other considerations which satisfactorily substantiate its safety in this respect. In addition to metal propellers, the Administrator may require that similar substantiation of the vibration characteristics be accomplished for other types of propellers, with the exception of conventional fixed-pitch wood propellers.

§ 3.418 Propeller pitch and speed limitations. The propeller pitch and speed shall be limited to values which will assure safe operation under all normal conditions of operation and will assure compliance with the performance requirements specified in §§ 3.81-3.86.

§ 3.419 Speed limitations for fixed-pitch propellers, ground adjustable pitch propellers, and automatically varying pitch propellers which cannot be controlled in flight,

(a) During take-off and initial climb at best rate-of-climb speed, the propeller, in the case of fixed pitch or ground adjustable types, shall restrain the engine to a speed not exceeding its maximum permissible take-off speed and, in the case of automatic variable-pitch types, shall limit the maximum governed engine revolutions per minute to a speed not exceeding the maximum permissible take-off speed. In demonstrating compliance with this provision the engine shall be operated at full throttle or the throttle setting corresponding to the maximum permissible takeoff manifold pressure.

(b) During a closed throttle glide at the placard, "never-exceed speed" (see § 3.739), the propeller shall not cause the engine to rotate at a speed in excess of 110 percent of its maximum allowable continuous speed.

§ 3.420 Speed and pitch limitations for controllable pitch propellers without constant speed controls. The stops or other means incorporated in the propeller mechanism to restrict the pitch range shall limit

(a) the lowest possible blade pitch to a value which will assure compliance with the provisions of § 3.419 (a), and

(b) the highest possible blade pitch to a value not lower than the flattest blade pitch with which compliance with the provisions of § 3.419 (b) can be demonstrated.

§ 3.421 Variable pitch propellers with constant speed controls.

(a) Suitable means shall be provided at the governor to limit the speed of the propeller. Such means shall limit the maximum governed engine speed to a value not exceeding its maximum permissible take-off revolutions per minute.

(b) The low pitch blade stop, or other means incorporated in the propeller mechanism to restrict the pitch range, shall limit the speed of the engine to a value not exceeding 103 percent of the maximum permissible take-off revolutions per minute under the following conditions:

(1) Propeller blade set in the lowest possible pitch and the governor inoperative.

(2) Engine operating at take-off manifold pressure with the airplane stationary and with no wind.

§ 3.422 Propeller clearance. With the airplane loaded to the maximum weight and most adverse center of gravity position and the propeller in the most adverse pitch position, propeller clearances shall not be less than the following, unless smaller clearances are properly substantiated for the particular design involved:

(a) Ground clearance.

(1) Seven inches (for airplanes equipped with nose wheel type landing gears) or 9 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 subparagraph (1) of this paragraph, 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 § 3.147 can be demonstrated with lesser clearance.

(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.

FUEL SYSTEM

§ 3.429 General. 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 adequate for proper engine functioning under all normal conditions of operation, including all maneuvers and acrobatics for which the airplane is intended.

ARRANGEMENT

§ 3.430 Fuel system arrangement. Fuel systems shall be so arranged as to permit any one fuel pump to draw fuel from only one tank at a time. Gravity feed systems shall not supply fuel to any one engine from more than one tank at a time unless the tank air spaces are interconnected in such a manner as to assure that all interconnected tanks will feed equally. (See also§ 3.439.)

§ 3.431 Multiengine fuel system arrangement . The fuel systems of multiengine airplanes **[ ]** shall be arranged to permit operation in at least one configuration in such a manner that the failure of any one component will not result in the loss of power of more than one engine and will not require immediate action by the pilot to prevent the loss of power of more than one engine. Unless other provisions are made to comply with this requirement, the fuel system shall be arranged to permit supplying fuel to each engine through a system entirely independent of any portion of the system supplying fuel to the other engines.

[NOTE: It is not necessarily intended that fuel tanks proper be separate for each engine if a common tank is provided with separate outlets and the remainder of the fuel system is independent.**]**

§ 3.432 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 any joints, fittings, or other possible sources of leakage installed in such lines are enclosed in a fuel- and fume-proof enclosure which is ventilated and drained to the exterior of the airplane. Bare tubing need not be enclosed but shall be protected where necessary against possible inadvertent damage.

OPERATION

§ 3.433 Fuel flow rate. The ability of the fuel system to provide the required fuel flow rate and pressure shall be demonstrated when the airplane is in the attitude which represents the most adverse condition from the standpoint of fuel feed and quantity of unusable fuel in the tank. During this test fuel shall be delivered to the engine at the applicable flow rate (see §§ 3.434-3.436) and at a pressure not less than the minimum required for proper carburetor operation. A suitable mock-up of the system, in which the most adverse conditions are simulated, may be used for this purpose. 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 § 3.437 (see also §§ 3.440 and 3.672), 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 bypass.

§ 3.434 Fuel flow rate for gravity systems . The fuel flow rate for gravity systems (main and reserve supply) shall be 150 percent of the actual take-off fuel consumption of the engine.

§ 3.435 Fuel flow rate for pump systems. The fuel flow rate for pump systems (main and reserve supply) shall be 0.9 pound per hour for each take-off horsepower or 125 percent 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 the 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.

§ 3.436 Fuel flow rate for auxiliary fuel systems and fuel transfer systems. The provisions of § 3.434 or § 3.435, whichever is applicable, shall also apply to auxiliary and transfer systems with the exception that the required fuel flow rate shall be established upon the basis of maximum continuous power and speed instead of take-off power and speed. A lesser flow rate shall be acceptable, however, in the case of a small auxiliary tank feeding into a large main tank, provided a suitable placard is installed to require that the auxiliary tank must only be opened to the main tank when a predetermined satisfactory amount of fuel still remains in the main tank.

§ 3.437 Determination of unusable fuel supply and fuel system operation on low fuel.

(a) The unusable fuel supply for each tank shall be established as not less than the quantity at which the first evidence of malfunctioning occurs under the conditions specified in this section. (See also § 3.440.) In the case of airplanes equipped with more than one fuel tank, any tank which is not required to feed the engine in all of the conditions specified in this section need be investigated only for those flight conditions in which it shall be used and the unusable fuel supply for the particular tank in question shall then be based on the most critical of those conditions which are found to be applicable. In all such cases, information regarding the conditions under which the full amount of usable fuel in the tank can safely be used shall be made available to the operating personnel by means of a suitable placard or instruction in the Airplane Flight Manual.

(b) Upon presentation of the airplane for test, the applicant shall stipulate the quantity of fuel with which he chooses to demonstrate compliance with this provision and shall also indicate which of the following conditions is most critical from the standpoint of establishing the unusable fuel supply. He shall also indicate the order in which the other conditions are critical from this standpoint:

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

(2) Climb at maximum continuous power at the calculated best angle of climb at minimum weight.

(3) Rapid application of power and subsequent transition to best rate of climb following a power-off glide at 1.3 Vso.

(4) Sideslips and skids in level flight, climb, and glide under the conditions specified in subparagraphs (1), (2), and (3) of this paragraph, of the greatest severity likely to be encountered in normal service or in turbulent air.

(c) In the case of utility category airplanes, there shall be no evidence of malfunctioning during the execution of all approved maneuvers included in the Airplane Flight Manual. During this test the quantity of fuel in each tank shall not exceed the quantity established as the unusable fuel supply, in accordance with paragraph (b) of this section, plus 0.03 gallon for each maximum continuous horsepower for which the airplane is certificated.

(d) In the case of acrobatic category airplanes, there shall be no evidence of malfunctioning during the execution of all approved maneuvers included in the Airplane Flight Manual. During this test the quantity of fuel in each tank shall not exceed that specified in paragraph (c) of this section.

(e) If an engine can be supplied with fuel from more than one tank, it shall be possible to regain the full power and fuel pressure of that engine in not more than 10 seconds (for single engine airplanes) or 20 seconds (for multiengine airplanes) 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.

(f) There shall be no evidence of malfunctioning during take-off and climb for 1 minute at the calculated attitude of best angle of climb at take-off power and minimum weight. At the beginning of this test the quantity of fuel in each tank shall not exceed that specified in paragraph (c) of this section.

§ 3.438 Fuel system hot weather operation . Airplanes with suction lift fuel systems or other fuel system features conducive to vapor formation shall be demonstrated to be free from vapor lock when using fuel at a temperature of 110° F under critical operating conditions.

§ 3.439 Flow between interconnected tanks. In the case of gravity feed systems with tanks who’s 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 § 3.437 (a) and the tanks are full.

FUEL TANKS

§ 3.440 General. Fuel tanks shall be capable of withstanding without failure any vibration, inertia, and fluid and structural loads to which they may be subjected in operation. Flexible fuel tank liners shall be of an acceptable type. Integral type fuel tanks shall be provided with adequate facilities for the inspection and repair of the tank interior. The total usable capacity of the fuel tanks shall be sufficient for not less than one-half hour-operation at rated maximum continuous power (see Sec. 3.74(d). The unusable capacity shall be considered to be the minimum quantity of fuel which will permit compliance with the provisions of § 3.437. The fuel quantity indicator shall be adjusted to account for the unusable fuel supply as specified in § 3.672. If the unusable fuel supply in any tank exceeds 5 percent of the tank capacity or 1 gallon, whichever is greater, a placard and a suitable notation in the Airplane Flight Manual shall be provided to indicate to the flight personnel that the fuel remaining in the tank when the quantity indicator reads zero cannot be used safely in flight. The weight of the unusable fuel supply shall be included in the empty weight of the airplane.

§ 3.441 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 nonmetallic 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: The pressure developed during the maximum limit acceleration of the airplane with a full tank, simultaneously with the application of the critical limit structural loads.

(3) Nonmetallic tanks the walls of which are supported by the airplane structure: Tanks constructed of an acceptable basic tank material and type of construction and with actual or simulated support conditions shall be subjected to a pressure of 2 psi for the first tank of a specific design. The supporting structure shall be designed for the critical loads occurring in the flight or landing strength conditions combined with the fuel pressure loads resulting from the corresponding accelerations.

(b) (1) Tanks with large unsupported or unstiffened flat areas shall be capable of withstanding the following 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 a total amplitude of not less than 1/32 of an inch while filled 2/3 full of water. The frequency of vibration shall be 90 percent of the maximum continuous rated speed of the engine unless some other frequency within the normal operating range of speeds of the engine is more critical, in which case the latter speed shall be employed and the time of test shall be adjusted to accomplish the same number of vibration cycles.

(2) In conjunction with the vibration test, the tank assembly shall be rocked through an anxle 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) Integral tanks which incorporate methods of construction and sealing not previously substantiated by satisfactory test data or service experience shall be capable of withstanding the vibration test specified in paragraph (b) of this section.

(d) (1) Tanks with nonmetallic liners shall be subjected to the sloshing portion of the test outlined under paragraph (b) of this section with fuel at room temperature.

(2) In addition, a specimen liner of the same basic construction as that to be used in the airplane shall, when installed in a suitable test tank, satisfactorily withstand the slosh test with fuel at a temperature of 110°F.

§ 3.442 Fuel tank installation.

(a) The method of supporting tanks shall not be such as to concentrate the loads resulting from the weight of the fuel in the tanks. Pads shall be provided to prevent chafing between the tank and its supports. Materials employed for padding shall be nonabsorbent or shall be treated to prevent the absorption of fuels. If flexible tank liners are employed, they shall be of an approved type, and 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 are apt to cause wear of the liner, unless provisions are made for the protection of the liner at such points or unless the construction of the liner itself provides such protection. A positive pressure shall be maintained within the vapor space of all bladder cells under all conditions of operation including the critical condition of low air speed and rate of descent likely to be encountered in normal operation.

(b) Tank compartments shall be ventilated and drained to prevent the accumulation of inflammable fluids or vapors. Compartments adjacent of tanks which are an integral part of the airplane structure shall also be ventilated and drained.

(c) Fuel tanks shall not be located on the engine side of the fire wall. Not less than one half inch of clear air space shall be provided between the fuel tank and the fire wall. 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 not be located in personnel compartments, except in the case of single-engine airplanes. In such cases fuel tanks the capacity of which does not exceed 25 gallons may be located in personnel compartments, if adequate ventilation and drainage are provided. In all other cases, fuel tanks shall be isolated from personnel compartments by means of fume and fuel proof enclosures.

§ 3.443 Fuel tank expansion space. Fuel tanks shall be provided with an expansion space of not less than 2 percent of the tank capacity, unless the tank vent discharges clear of the aircraft in which case no expansion space will be required. It shall not be possible inadvertently to fill the fuel tank expansion space when the airplane is in the normal ground attitude.

§ 3.444 Fuel tank sump.

(a) Each tank shall be provided with a drainable sump having a capacity of not less than 0.25 percent of the tank capacity or 1/16 gallon, whichever is the greater. It shall be acceptable to dispense with the sump if the fuel system is provided with a sediment bowl permitting ground inspection. The sediment bowl shall also be accessible for drainage. The capacity of the sediment chamber shall not be less than 1 ounce per each 20 gallons of the fuel tank capacity.

(b) If a fuel tank sump is provided, the capacity specified in paragraph (a) of this section shall be effective with the airplane in the normal ground attitude and in all normal flight attitudes.

(c) If a separate sediment bowl is provided in lieu of tank sump, the fuel tank outlet shall be so located that, when the airplane is in the normal ground attitude, water will drain from all portions of the tank to the sediment bowl.

§ 3.445 Fuel tank filler connection.

(a) Fuel tank filler connections shall be marked as specified in § 3.767.

(b) Provision shall be made to prevent the entrance of spilled fuel into the fuel tank compartment or any portions of the airplane other than the tank itself. The filler cap shall provide a fuel-tight seal for the main filler opening. However, small openings in the fuel tank cap for venting purposes or to permit passage of a fuel gauge through the cap shall be permissible.

§ 3.446 Fuel tank vents and carburetor vapor vents.

(a) Fuel tanks shall be vented from the top portion of the expansion space. Vent outlets shall be so located and constructed as to minimize the possibility of their being obstructed by ice or other foreign matter. The vent shall be so constructed as to preclude the possibility of siphoning 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 the outlets of which are interconnected shall also be interconnected. There shall be no undrainable points in the vent line where moisture is apt to accumulate with the airplane in either the ground or level flight attitude. Vents 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 airplane fuel tanks. If more than one fuel tank is provided and it is necessary to use these tanks in a definite sequence for any reason, the vapor vent return line shall lead back to the fuel tank which must be used first unless the relative capacities of the tanks are such that return to another tank is preferable.

§ 3.447-A Fuel tank vents. Provision shall be made to prevent excessive loss of fuel during acrobatic maneuvers including short periods of inverted flight. It shall not be possible for fuel to siphon from the vent when normal flight has been resumed after having executed any acrobatic maneuver for which the airplane is intended.

§ 3.448 Fuel tank outlet. The fuel tank outlet shall be provided with a screen of from 8 to 16 meshes per inch. If a finger strainer is used, the length of the strainer shall not be less than 4 times the outlet diameter. The diameter of the strainer shall not be less than the diameter of the fuel tank outlet. Finger strainers shall be accessible for inspection and cleaning.

FUEL PUMPS

§ 3.449 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 each engine shall be directly driven by the engine. Fuel pumps shall be adequate to meet the flow requirements of the applicable portions of §§ 3.433-3.436.

(b) Emergency fuel pumps shall be provided to permit supplying all engines with fuel in case of the failure of any one engine-driven pump, except that if an engine fuel injection pump which has been certificated as an integral part of the engine is used, an emergency pump is not required. Emergency pumps shall be available for immediate use in case of the failure of any other pump. If both the normal pump and emergency pump operate continuously, means shall be provided to indicate to the crew when either pump is malfunctioning.

LINES, FITTINGS, AND ACCESSORIES

§ 3.550 Fuel system lines, fittings, and accessories. Fuel lines shall be installed and supported in a manner which 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 might exist shall incorporate provisions for flexibility. Flexible hose shall be of an acceptable type.

§ 3.551 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 on the side of the fire wall most remote from the engine.

(b) Shut-off valves shall be so constructed as to make it possible for the flight personnel to reopen the valves rapidly after they have once been closed.

(c) Valves shall be provided with either positive stops or "feel" 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. Valves shall be so installed that the effect of gravity and vibration will tend to turn their handles to the open rather than the closed position.

[(d) Fuel valve handles and their connections to the valve mechanism shall incorporate design features to minimize the possibility of incorrect installation.**]**

§ 3.552 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 removable.

DRAINS AND INSTRUMENTS

§ 3.553 Fuel system drains. Drains shall be provided to permit safe drainage of the entire fuel system and shall incorporate means for locking in the closed position. The provisions for drainage shall be effective in the normal ground attitude.

§ 3.554 Fuel system instruments. (See § 3.655 and §§ 3.670 through 3.673.)

OIL SYSTEM

§ 3.561 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 usable oil tank capacity shall not be less than the product of the endurance of the airplane under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to assure adequate system circulation and cooling.

§ 3.562 Oil cooling. (See § 3.581 and pertinent sections.)

OIL TANKS

§ 3.563 Oil tanks. Oil tanks shall be capable of withstanding without failure all vibration, inertia, and fluid loads to which they might be subjected in operation. Flexible oil tank liners shall be of an acceptable type.

§ 3.564 Oil tank tests. Oil tank tests shall be the same as fuel tank tests (see § 3.441), except as follows:

(a) The 3.5 psi pressure specified in § 3.441 (a) shall be 5 pound psi.

(b) In the case of tanks with nonmetalic liners, the test fluid shall be oil rather than fuel as specified in § 3.441 (d) and the slosh test on a specimen liner shall be conducted with oil at a temperature of 250° F.

§ 3.565 Oil tank installation. Oil tank installations shall comply with the requirements of § 3.442 (a) and (b).

§ 3.566 Oil tank expansion space. Oil tanks shall be provided with an expansion space of not less than 10 percent of the tank capacity or ½ gallon, whichever is greater. it shall not be possible inadvertently to fill the oil tank expansion space when the airplane is in the normal ground attitude.

§ 3.567 Oil tank filler connection. Oil tank filler connections shall be marked as specified in § 3.767.

§ 3.568 Oil tank vent.

(a) Oil tanks shall be vented to the engine crankcase from the top of the expansion space in such a manner that the vent connection is not covered by oil under an normal flight conditions. Oil tank vents shall be so arranged that condensed water vapor which might freeze and obstruct the line cannot accumulate at any point.

(b) Category A. Provision shall be made to prevent hazardous loss of oil during acrobatic maneuvers including short periods of inverted flight.

§ 3.569 Oil tank outlet. The oil tank outlet shall not be enclosed or covered by any screen or other guard which might impede the flow of oil. The diameter of the oil tank outlet shall not be less than the diameter of the engine oil pump inlet. (See also § 3.577.)

LINES, FITTINGS, AND ACCESSORIES

§ 3.570 Oil system lines, fittings, and accessories. Oil lines shall comply with the provisions of § 3.550, except that the inside diameter of the engine oil inlet and outlet lines shall not be less than the diameter of the corresponding engine oil pump inlet and outlet.

§ 3.571 Oil valves. (See § 3.637.)

§ 3.572 Oil radiators. Oil radiators and their support shall be capable of withstanding without failure any vibration, inertia, and oil pressure loads to which they might normally be subjected.

§ 3.573 Oil filters. If the engine is equipped with an oil filter, the filter shall be constructed and installed in such a manner that complete blocking of the flow through the filter element will not jeopardize the continued operation of the engine oil supply system.

§ 3.574 Oil system drains. Drains shall be provided to permit safe drainage of the entire oil system and shall incorporate means for positive locking in the closed position.

§ 3.575 Engine breather lines.

(a) Engine breather lines shall be so arranged that condensed water vapor which might 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 pilot’s windshield. The breather shall not discharge into the engine air induction system.

(b) Category A. In the case of acrobatic type airplanes, provision shall be made to prevent excessive loss of oil from the breather during acrobatic maneuvers including short periods of inverted flight.

§ 3.576 Oil system instruments. See §§3.655, 3.670, 3.671, and 3.674.

§ 3.577 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.

COOLING

§ 3.581 General. The power-plant cooling provisions shall be capable of maintaining the temperatures of all power-plant components, engine parts, and engine fluids (oil and coolant), at or below the maximum established safe values under critical conditions of ground and flight operation.

TESTS

§ 3.582 Cooling tests. Compliance with the provisions of § 3.581 shall be demonstrated under critical ground, water, and flight operating conditions. If the tests are conducted under conditions which deviate from the highest anticipated summer air temperature (see § 3.583), the recorded power-plant temperatures shall be corrected in accordance with the provisions of §§ 3.584 and 3.585. 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 setting shall be those appropriate to the operating conditions. The test procedures shall be as outlined in §§ 3.586 and 3.587.

§ 3.583 Maximum anticipated summer air temperatures. The maximum anticipated summer air temperature 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.

§ 3.584 Correction factor for cylinder head, oil inlet, carburetor air, and engine coolant inlet 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.

§ 3.585 Correction factor 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 first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

§ 3.586 Cooling test procedure for single engine airplanes. This test shall be conducted by stabilizing engine temperatures in flight and then starting at the lowest practicable altitude and climbing for 1 minute at take-off power. At the end of 1 minute, the climb shall be continued at maximum continuous power until at least 5 minutes after the occurrence of the highest temperature recorded. The climb shall not be conducted at a speed greater than the best rate-of-climb speed with maximum continuous power unless:

(a) The slope of the flight path at the speed chosen for the cooling test is equal to or greater than the minimum required angle of climb (see § 3.85 (a)), and

(b) A cylinder head temperature indicator is provided as specified in § 3.675.

§ 3.587 Cooling test procedure for multiengine airplanes—

(a) Airplanes which meet the minimum one-engine-inoperative climb performance specified in § 3.85 (b). The engine cooling test for these airplanes shall be conducted with the airplane in the configuration specified in § 3.85 (b), except that the operating engine(s) shall be operated at maximum continuous power or at full throttle when above the critical altitude. After stabilizing temperatures in flight, the climb shall be started at the lower of the two following altitudes and shall be continued until at least 5 minutes after the highest temperature has been recorded:

(1) 1,000 feet below the engine critical altitude or at the lowest practicable altitude (when applicable).

(2) 1,000 feet below the altitude at which the single-engine-inoperative rate of climb is 0.02 Vso2. The climb shall be conducted at a speed not in excess of the highest speed at which compliance with the climb requirement of § 3.85 (b) can be shown. However, if the speed used exceeds the speed for best rate of climb with one engine inoperative, a cylinder head temperature indicator shall be provided as specified in § 3.675.

(b) Airplanes which cannot meet the minimum one-engine-inoperative climb performance specified in § 3.85 (b). The engine cooling test for these airplanes shall be the same as in paragraph (a) of this section, except that after stabilizing temperatures in flight, the climb (or descent, in the case of airplanes with zero or negative one-engine-inoperative rate of climb) shall be commenced at as near sea level as practicable and shall be conducted at the best rate-of-climb speed (or the speed of minimum rate of descent, in the case of airplanes with zero or negative one-engine-inoperative rate of climb).

LIQUID COOLING SYSTEMS

§ 3.588 Independent systems. Each liquid cooled engine shall be provided with an independent cooling system. The cooling system shall be so arranged that no air or vapor can be trapped in any portion of the system, except the expansion tank, either during filling or during operation.

§ 3.589 Coolant tank. A coolant tank shall be provided. The tank capacity shall not be less than 1 gallon plus 10 percent of the cooling system capacity. 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 percent of the total cooling system capacity. It shall not be possible inadvertently to fill the expansion space with the airplane in the normal ground attitude.

§ 3.590 Coolant tank tests. Coolant tank tests shall be the same as fuel tank tests (see § 3.441), except as follows:

(a) The 3.5 pounds per square inch pressure test of § 3.441 (a) shall be replaced by the sum of the pressure developed during the maximum ultimate acceleration with a full tank or a pressure of 3.5 pounds per square inch, whichever is greater, plus the maximum working pressure of the system.

(b) In the case of tanks with nonmetallic liners, the test fluid shall be coolant rather than fuel as specified in § 3.441 (d), and the slosh test on a specimen liner shall be conducted with coolant at operating temperature.

§ 3.591 Coolant tank installation. Coolant tanks shall be supported in a manner so as to distribute the tank loads 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 nonabsorbent or shall be treated to prevent the absorption of inflammable fluids.

§ 3.592 Coolant tank filler connection. Coolant tank filler connections shall be marked as specified in § 3.767. Provisions shall be made to prevent the entrance of spilled coolant into the coolant tank compartment or any portions of the airplane other than the tank itself. Recessed coolant filler connections shall be drained and the drain shall discharge clear of all portions of the airplane.

§ 3.593 Coolant lines, fittings, and accessories. Coolant lines shall comply with the provisions of § 3.550, except that the inside diameter of the engine coolant inlet and outlet lines shall not be less than the diameter of the corresponding engine inlet and outlet connections.

§ 3.594 Coolant radiators. Coolant radiators shall be capable of withstanding without failure any vibration, inertia, and coolant pressure loads to which they may normally be subjected. Radiators shall be supported in a manner which will permit expansion due to operating temperatures and 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 the nacelle in case of fire cannot impinge upon the radiator.

§ 3.595 Cooling system drains. One or more drains shall be provided to permit drainage of the entire cooling 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. Cooling system drains shall be accessible.

§ 3.596 Cooling system instruments. See §§ 3.655, 3.670, and 3.671.

INDUCTION SYSTEM

§ 3.605 General.

(a) The engine air induction system shall permit supplying an adequate quantity of air to the engine under all conditions of operation.

(b) Each engine shall be provided with at least two separate air intake sources, except that in the case of an engine equipped with a fuel injector only one air intake source need be provided, if the air intake, opening, or passage is unobstructed by a screen, filter, or other part on which ice might form and so restrict the air flow as to affect adversely engine operation. It shall be permissible for primary air intakes to 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 and shall not open within the cowling unless they are so located that the emergence of backfire flames will not result in a hazard. Supplying air to the engine through the alternate air intake system of the carburetor air preheater shall not result in the loss of excessive power in addition to the power lost due to the rise in the temperature of the air.

§ 3.606 Induction system de-icing and antiicing provisions. The engine air induction system shall incorporate means for the prevention and elimination of ice accumulations in accordance with the provisions in this section. 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 sea level engines employing conventional venturi carburetors shall be provided with a preheater capable of providing a heat rise of 90° F. when the engine is operating at 75 percent of its maximum continuous power.

(b) 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 75 percent of its maximum continuous power.

(c) 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 percent of its maximum continuous power. However, the preheater need not provide a heat rise in excess of 40°F. if a fluid de-icing system complying with the provisions of §§ 3.607-3.609 is also installed.

(d) Airplanes equipped with sea level engines employing carburetors which embody features tending to reduce the possibility of ice formation shall be provided with a sheltered alternate source of air. The preheat supplied to this alternate air intake shall be not less than that provided by the engine cooling air downstream of the cylinders.

§ 3.607 Carburetor de-icing fluid flow rate. The system shall be capable of providing each engine with a rate of fluid flow, expressed in pounds per hour, of not less than 2.5 multiplied by the square root of the maximum continuous power of the engine. This flow shall be available to all engines simultaneously. The fluid shall be introduced into the air induction system at a point close to, and upstream from, the carburetor. The fluid shall be introduced in a manner to assure its equal distribution over the entire cross section of the induction system air passages.

§ 3.608 Carburetor fluid de-icing system capacity. The fluid de-icing system capacity shall not be less than that required to provide fluid at the rate specified in § 3.607 for a time equal to 3 percent of the maximum endurance of the airplane. However, the capacity need not in any case exceed that required for 2 hours of operation nor shall it be less than that required for 20 minutes of operation at the above flow rate. If the available preheat exceeds 50° F. but is less than 100° F., it shall be permissible to decrease the capacity of the system in proportion to the heat rise available in excess of 50° F.

§ 3.609 Carburetor fluid de-icing system detail design. Carburetor fluid de-icing systems shall comply with provisions for the design of fuel systems, except as specified in §§ 3.607 and 3.608, unless such provisions are manifestly in applicable.

§ 3.610 Carburetor air preheater design. Means shall be provided to assure adequate ventilation of the carburetor air preheater when the engine is being operated in 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.

§ 3.611 Induction system ducts. Induction system ducts shall be provided with drains which will prevent the accumulation of fuel or moisture in all normal ground and flight attitudes. No open drains shall be located on the pressure side of turbo-supercharger installations. Drains shall not discharge in a location which 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.

§ 3.612 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 can reach the engine, unless the available preheat is 100° F, or over and the screen is so located that it can be de-iced by the application of heated air. De-icing of screens by means of alcohol in lieu of heated air shall not be acceptable.

EXHAUST SYSTEM

§ 3.615 General.

(a) 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.

(b) Unless suitable precautions are taken, exhaust system parts shall not be located in close 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 exhaust system components shall be separated from adjacent inflammable portions of the airplane which are outside the engine compartment by means of fireproof shields. Exhaust gases shall not be discharged at a location which 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.

§ 3.616 Exhaust manifold. Exhaust manifolds shall be made of fireproof, corrosion resistant materials, and shall incorporate provisions to prevent failure due to their expansion when heated to operating temperatures. Exhaust manifolds shall be supported in a manner adequate to withstand all vibration and inertia loads to which they might be subjected in operation. Portions of the manifold which are connected to components between which relative motion might exist shall incorporate provisions for flexibility.

§ 3.617 Exhaust heat exchangers.

(a) Exhaust heat exchanges 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 might normally be subjected. Heat exchangers shall be constructed of materials which are suitable for continued operation at high temperatures and which are adequately resistant to corrosion due to products contained in exhaust gases.

(b) Provisions 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 ventilated under all conditions in which they are subject to contact with exhaust gases.

§ 3.618 Exhaust heat exchangers used in ventilating air heating systems. Heat exchangers of this type shall be so constructed as to preclude the possibility of exhaust gases entering the ventilating air.

FIRE WALL AND COWLING

§ 3.623 Fire walls. All engines, auxiliary power units, fuel burning heaters, and other combustion equipment which are intended for operation in flight shall be isolated from the remainder of the airplane by means of fire walls, or shrouds, or other equivalent means.

§ 3.624 Fire wall construction.

[(a) Fire walls and shrouds shall be constructed in such a manner that no hazardous quantity of liquids, gases, or flame could pass from the engine compartment to other portions of the airplane. All openings in the fire wall or shroud shall be sealed tight with fireproof grommets, bushings, or fire-wall fittings, except that, such seals of fire-resistant materials shall be acceptable for use on single-engine airplanes and multiengine airplanes not required to comply with § 3.85 (b) or § 3.85a (b), if such airplanes are equipped with engine(s) having a volumetric displacement of 1,000 cubic inches or less; and if the openings in the fire walls or shrouds are such that, without seals, the passage of a hazardous quantity of flame could not result. **]**

(b) Fire walls and shrouds shall be constructed of fireproof material and shall be protected against corrosion. The following materials have been found to comply with this requirement:

(1) Heat- and corrosion-resistant steel 0.015 inch thick,

(2) Low carbon steel, suitably protected against corrosion, 0.018 inch thick.

§ 3.625 Cowling.

(a) Cowling shall be constructed and supported in such a manner as to be capable of resisting all vibration, inertia, and air loads to which it may normally be subjected. Provision shall be made to permit rapid and complete drainage of all portions of the cowling in all normal ground and flight attitudes. Drains shall not discharge in locations constituting a fire hazard.

(b) Cowling shall be constructed of fire resistant material. All portions of the airplane lying behind openings in the engine compartment cowling shall also be constructed of fire-resistant materials for a distance of at least 24 inches aft of such openings. Portions of cowling which are subjected to high temperatures due to proximity to exhaust system ports or exhaust gas impingement shall be constructed of fireproof material.

POWER-PLANT CONTROLS AND ACCESSORIES
CONTROLS

§ 3.627 Power-plant controls. Power-plant controls shall comply with the provisions of §§ 3.384 and 3.762.Controls shall maintain any necessary position without constant attention by the flight personnel and shall not tend to creep due to control loads or vibration. Flexible controls shall be of an acceptable type. Controls shall have adequate strength and rigidity to withstand operating loads without failure or excessive deflection.

§ 3.628 Throttle controls. A throttle control shall be provided to give independent control for each engine. Throttle controls shall afford a positive and immediately responsive means of controlling the engine(s). Throttle controls shall be grouped and arranged in such a manner as to permit separate control of each engine and also simultaneous control of all engines.

§ 3.629 Ignition switches. Ignition switches shall provide control for each ignition circuit on each engine. It shall be possible to shut off quickly all ignition on multiengine airplanes, either by grouping of the individual switches or by providing a master ignition control.

§ 3.630 Mixture controls. If mixture controls are provided, a separate control shall be provided for each engine. The controls shall be grouped and arranged in such a manner as to permit both separate and simultaneous control of all engines.

§ 3.631 Propeller speed and pitch controls. (See also § 3.421 (a).) If propeller speed or pitch controls are provided, the controls shall be grouped and arranged in such a manner as to permit control of all propellers, both separately and together. The controls shall permit ready synchronization of all propellers on multiengine airplanes.

§ 3.632 Propeller feathering controls. If propeller feathering controls are provided, a separate control shall be provided for each propeller. Propeller feathering controls shall be provided with means to prevent inadvertent operation.

§ 3.633 Fuel system controls. Fuel system controls shall comply with requirements of § 3.551 (c).

§ 3.634 Carburetor air preheat controls. Separate control shall be provided to regulate the temperature of the carburetor air for each engine.

ACCESSORIES

§ 3.635 Power-plant accessories. Engine driven 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 might be present in a free state.

§ 3.636 Engine battery ignition systems.

(a) Battery ignition systems shall be supplemented with a generator which is automatically made available as an alternate source of electrical energy to permit continued engine operation in the event of the depletion of any battery.

(b) The capacity of batteries and generators shall be sufficient to meet the simultaneous demands of the engine ignition system and the greatest demands of any of the airplane's 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 used for engine ignition. (See § 3.629 for ignition switches.)

POWER-PLANT FIRE PROTECTION

§ 3.637 Powerplant fire protection. Suitable means shall be provided to shut off the flow in all lines carrying flammable fluids into the engine compartment of multiengine airplanes required to comply with the provisions of § 3.85 (b).

SUBPART F - EQUIPMENT

§ 3.651 General. The equipment specified in § 3.655 shall be the minimum installed when the airplane is submitted to determine its compliance with the airworthiness requirements. Such additional equipment as is necessary for a specific type of operation is specified in other pertinent parts of the Civil Air Regulations, but, where necessary, its installation and that of the items mentioned in § 3.655 is covered herein.

§ 3.652 Functional and installational requirements. Each item of equipment which is essential to the safe operation of the airplane shall be found by the Administrator to perform adequately the functions for which it is to be used, shall function properly when installed, and shall be adequately labeled as to its identification, function, operational limitations, or any combination of these, whichever is applicable.

BASIC EQUIPMENT

§ 3.655 Required basic equipment. The following table shows the basic equipment items required for type and airworthiness certification of an airplane:

(a) Flight and navigational instruments.

(1) Air-speed indicator (see § 3.663).

(2) Altimeter.

(3) Magnetic direction indicator (see § 3.666)

(b) Power-plant instruments—(1) For each engine or tank. (i) Fuel quantity indicator (see § 3.672).

(ii) Oil pressure indicator.

(iii) Oil temperature indicator.

(iv) Tachometer.

(2) For each engine or tank (if required in reference section). (i) Carburetor air temperature indicator (see § 3.676).

(ii) Coolant temperature indicator (if liquid cooled engines used).

(iii) Cylinder head temperature indicator (see § 3.675).

(iv) Fuel pressure indicator (if pump-fed engines used).

(v) Manifold pressure indicator (if altitude engines used).

(vi) Oil quantity indicator (see § 3.674).

(c) Electrical equipment (if required by reference section).

(1) Master switch arrangement (see § 3.688).

(2) Adequate source(s) of electrical energy (see §§ 3.682 and 3.685).

(3) Electrical protective devices (see § 3.690).

(d) Miscellaneous equipment.

(1) Approved safety belts for all occupants (see Sec. 3.715).

(2) Airplane Flight Manual if required by § 3.777.

INSTRUMENTS; INSTALLATION
GENERAL

§ 3.661 Arrangement and visibility of instrument installations.

(a) Flight, navigation, and power-plant instruments for use by each pilot shall be easily visible to him.

(b) On multiengine airplanes, identical power-plant instruments for the several engines shall be so located as to, prevent any confusion as to the engines to which they relate.

§ 3.662 Instrument panel vibration characteristics. Vibration characteristics of the instrument panel shall not be such as to impair the accuracy of the instruments or to cause damage to them.

FLIGHT AND NAVIGATIONAL INSTRUMENTS

§ 3.663 Air-speed indicating system. This system shall be so installed that the air-speed indicator shall indicate true air speed at sea level under standard conditions to within an allowable installational error of not more than plus or minus 3 percent of the calibrated air speed or 5 miles per hour, whichever is greater, throughout the operating range of the airplane with flaps up from Vc to 1.3 Vs1 and with flaps at 1.3 Vs1. The calibration shall be made in flight.

§ 3.664 Air-speed indicator-marking. The air-speed indicator shall be marked as specified in § 3.757.

§ 3.665 Static air vent system. All instruments provided with static air case connections shall be so vented that the influence of airplane speed, the opening and closing of windows, air-flow variation, moisture, or other foreign matter will not seriously affect their accuracy.

§ 3.666 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. After the direction indicator has been compensated, the installation shall be such that the deviation in level flight does not exceed 10 degrees on any heading. A suitable calibration placard shall be provided as specified in § 3.758.

§ 3.667 Automatic pilot system. If an automatic pilot system is installed:

(a) The system shall be designed so that the automatic pilot can either:

(1) Be quickly and positively disengaged by the human pilot(s) to prevent it from interferring with his control of the airplane, or

(2) Be sufficiently overpowered by one human pilot to enable him to control the airplane.

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

(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 designed so that, within the range of adjustment available to the human pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path under any conditions of flight appropriate to its use either during normal operation or in the event of malfunctioning, assuming
that corrective action is initiated within a reasonable period of time.

§ 3.668 *Gyroscopic indicators* . All gyroscopic instruments installed in airplanes intended for operation under instrument flight rules shall derive their energy from a power source of sufficient capacity to maintain their required accuracy at all airplane speeds above the best rate-of-climb speed. They shall be installed to preclude malfunctioning due to rain, oil, and other detrimental elements. Means shall be provided for indicating the adequacy of the power being supplied to each of the instruments. In addition, the following provisions shall be applicable to multiengine airplanes:

(a) There shall be provided at least two independent sources of power, a manual or an automatic means for selecting the power source, and a means for indicating the adequacy of the power being supplied by each source.

(b) The installation and power supply systems shall be such that failure of one instrument or of the energy supply from one source will not interfere with the proper supply of energy to the remaining instruments or from the other source.

§ 3.669 *Flight director instrument* . If a flight director instrument is installed, its installation shall not affect the performance and accuracy of the required instruments. A means for disconnecting the flight director instrument from the required instruments or their installations shall be provided.

POWER-PLANT INSTRUMENTS

§ 3.670 Operational markings. Instruments shall be marked as specified in § 3.759.

§ 3.671 Instrument lines. Power-plant instrument lines shall comply with the provisions of § 3.550. In addition, instrument lines carrying inflammable fluids or gases under pressure shall be provided with restricted orifices or other safety devices at the source of the pressure to prevent escape of excessive fluid or gas in case of line failure.

§ 3.672 Fuel quantity indicator . Means shall be provided to indicate to the flight personnel the quantity of fuel in each tank during flight. Tanks, the outlet and air spaces of which 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 preclude the possibility of breakage or damage. Sight gauges which form a trap in which water can collect and freeze shall be provided with means to permit drainage on the ground. Fuel quantity gauges 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 § 3.437. Fuel gauges need not be provided for small auxiliary tanks which are used only to transfer fuel to other tanks, provided that the relative size of the tanks, the rate of fuel transfer, and the instructions pertaining to the use of the tanks are adequate to guard against overflow and to assume that the crew will receive prompt warning in case transfer is not being achieved as intended.

§ 3.673 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 bypassing the fuel supply in the event that malfunctioning of the metering component offers a severe restriction to fuel flow.

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

§ 3.675 Cylinder head temperature indicating system for air-cooled 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 § 3.581 is demonstrated at a speed in excess of the speed of best rate of climb.

§ 3.676 Carburetor air temperature indicating system. A carburetor air temperature indicating system shall be provided for each altitude engine equipped with a preheater which is capable of providing a heat rise in excess of 60°F.

ELECTRICAL SYSTEMS AND EQUIPMENT

§ 3.681 Installation.

(a) Electrical systems in airplanes shall be free from hazards in themselves, in their method of operation, and in their effects on other parts of the airplane. Electrical equipment shall be of a type and design adequate for the use intended. Electrical systems shall be installed in such a manner that they are suitably protected from fuel, oil, water, other detrimental substances, and mechanical damage.

(b) Items of electrical equipment required for a specific type of operation are listed in other pertinent parts of the Civil Air Regulations.

BATTERIES

§ 3.682 Batteries. When an item of electrical equipment which is essential to the safe operation of the airplane is installed, the battery required shall have sufficient capacity to supply the electrical power necessary for dependable operation of the connected electrical equipment.

§ 3.683 Protection against acid. If batteries are of such a type that corrosive substance may escape during servicing or flight, means such as a completely enclosed compartment shall be provided to prevent such substances from coming in contact with other parts of the airplane which are essential to safe operation. Batteries shall be accessible for servicing and inspection on the ground.

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

GENERATORS

§ 3.685 Generator. Generators shall be capable of delivering their continuous rated power.

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

§ 3.687 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.

MASTER SWITCH

§ 3.688 Arrangement. If electrical equipment is installed, 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.

§ 3.689 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.

PROTECTIVE DEVICES

§ 3.690 Fuses or circuit breakers. If electrical equipment is installed, 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.

§ 3.691 Protective devices installation. Protective devices in circuits essential to safety in flight shall be so located and identified that fuses may be replaced or circuit breakers reset readily in flight.

§ 3.692 Square fuses. If fuses are used, one spare of each rating or 50 percent spare fuses of each rating, whichever is greater, shall be provided.

ELECTRIC CABLES

§ 3.693 Electric cables. If electrical equipment is installed, the connecting cables used shall be in accordance with recognized standards for electric cable of a slow burning type and of suitable capacity.

SWITCHES

§ 3.694 Switches. Switches shall be capable of carrying their rated current and shall be of such construction that there is sufficient distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting.

§ 3.695 Switch installation. Switches shall be so installed as to be readily accessible to the appropriate crew member and shall be suitably labeled as to operation and the circuit controlled.

INSTRUMENT LIGHTS

§ 3.696 Instrument lights. If instrument lights are required, they shall be of such construction that there is sufficient distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting. They shall provide sufficient illumination to make all instruments and controls easily readable and discernible, respectively.

§ 3.697 Instrument light installation. Instrument lights shall be installed in such a manner that their direct rays are shielded from the pilot's eyes. Direct rays shall not be reflected from the windshield or other surfaces into the pilot's eyes.

LANDING LIGHTS

§ 3.698 Landing lights. If landing lights are installed, they shall be of an acceptable type.

§ 3.699 Landing light installation. Landing lights shall be so installed that there is no dangerous glare visible to the pilot and also so 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.

POSITION LIGHTS

§ 3.700 Position light system installation.

(a) General. The provisions of §§ 3.700 through 3.703 shall be applicable to the position light system as a whole, and shall be complied with if a single circuit type system is installed. 1 The single circuit system shall include the items specified in paragraphs (b) through (f) of this section.

(b) Forward position lights . Forward position lights shall consist of a red and a green light spaced laterally as far apart as practicable and installed forward on the airplane in such a location that, with the airplane in normal flying position, the red light is displayed on the left side and the green light is displayed on the right side. The individual lights shall be of an approved type.

(c) Rear position light . The rear position light shall be a white light mounted as far aft as practicable. The light shall be of an approved type.

(d) Circuit. The two forward position lights and the rear position light shall constitute a single circuit.

(e) Flasher. If employed, an approved position light flasher for a single circuit system shall be installed. The flasher shall be such that the system is energized automatically at a rate of not less than 60 nor more than 120 flashes per minute with an on-off ratio between 2.5:1 and 1:1. Unless the flasher is of a fail-safe type, means shall be provided in the system to indicate to the pilot when there is a failure of the flasher and a further means shall be provided for turning the lights on steady in the event of such failure.

(f) Light covers and color filters . Light covers or color filters used shall be of noncumbustible material and shall be constructed so that they will not change color or shape or suffer any appreciable loss of light transmission during normal use.

§ 3.701 Position light system dihedral angles . The forward and rear position lights as installed on the airplane shall show unbroken light within dihedral angles specified in paragraphs (a) through (c) of this section.

(a) Dihedral angle L (left) shall be considered formed by two intersecting vertical planes, one parallel to the longitudinal axis of the airplane and the either at 110° to the left of the first, when looking forward along the longitudinal axis.

(b) Dihedral angle R (right) shall be considered formed by two intersecting vertical planes, one parallel to the longitudinal axis of the airplane and the other at 110° to the right of the first, when looking forward along the longitudinal axis.

(c) Dihedral angle A (aft) shall be considered formed by two intersecting vertical planes making angles of 70° to the right and 70° to the left, respectively, looking aft along the longitudinal axis, to a vertical plane passing through the longitudinal axis.

[§ 3.702 Position light distribution and intensities.

(a) General. The intensities prescribed in this section are those to be provided by new equipment with all light covers and color filters in place. Intensities shall be determined with the light source operating at a steady value equal to the average luminous output of the light source at the normal operating voltage of the airplane. The light distribution and intensities of position lights shall comply with the provisions of paragraph (b) of this section.

(b) Forward and rear position lights. The light distribution and intensities of forward and rear position lights shall be expressed in terms of minimum intensities in the horizontal plane, minimum intensities in any vertical plane, and maximum intensities in overlapping beams within dihedral angles L, R, and A, and shall comply with the provisions of subparagraphs (1) through (3) of this paragraph.

(1) Intensities in horizontal plane. The intensities in the horizontal plane shall not be less than the values given in Figure 3-15. (The horizontal plane is the plane containing the longitudinal axis of the airplane and is perpendicular to the plane of symmetry of the airplane).

(2) Intensities above and below horizontal. The intensities in any vertical plane shall not be less than the appropriate value given in Figure 3-16, where I is the minimum intensity prescribed in Figure 3 -15 for the corresponding angles in the horizontal plane. (Vertical planes are planes perpendicular to the horizontal plane.)

(3) Overlaps between adjacent signals. The intensities in overlaps between adjacent signals shall not exceed the value given in Figure 3-17, except that higher intensities in the overlaps shall be acceptable with the use of main beam intensities substantially greater than the minima specified in Figures 3-15 and 3-16 if the overlap intensities in relation to the main beam intensities are such as not to affect adversely signal clarity.

Dihedral Angle (light involved)	Angle from right or left of longitudinal axis, measured from dead ahead	Intensity (Candles)
L and R (forward red and green)	0° to 10°	40
	10° to 20°	30
	20° to 110°	5
A (Rear white)	110° to 180°	20

Figure 3-15.--Minimum Intensities in the Horizontal Plane of Forward and Rear Position Lights.

Angle above or below horizontal	Intensity
0°	1.00 I
0° to 5°	0.90 I
5° to 10°	0.80 I
10° to 15°	0.70 I
15° to 20°	0.50 I
20° to 30°	0.30 I
30° to 40°	0.10 I
40° to 90°	at least 2 candles

Figure 3-16.–Minimum Intensities in any Vertical Plane of Forward and Rear Position Lights.

Overlaps	Maximum Intensity	
	Area A (Candles)	Area B (Candles)
Green in dihedral angle L	10	1
Red in dihedral angle R	10	1
Green in dihedral angle A	5	1
Red in dihedral angle A	5	1
Rear white in dihedral angle L	5	1
Rear white in dihedral angle R	5	1

NOTE: Area A includes all directions in the adjacent dihedral angle which pass through the light source and which
intersect the common boundary plane at more than 10 degrees but less than 20 degrees. Area B includes all directions in the adjacent dihedral angle which pass through the light source and which intersect the common boundary plane at more than 20 degrees.

Figure 3-17.--Maximum Intensities in Overlapping Beams of Forward and Rear Position Lights. **]**

§ 3.703 Color specifications . The colors of the position lights shall have the International Commission on Illumination chromatically coordinates as set forth in paragraph (a) through (c) of this section.

(a) Aviation red.
y is not greater than 0.335,
z is not greater than 0.002;

(b) Aviation green .
x is not greater than 0.440 - 0.320y,
x is not greater than y - 0.170,
y is not less than 0.390 - 0.170x;

(c) Aviation white.
x is not less than 0.350,
x is not greater than 0.540,
y - yo is not numerically greater than 0.01, y o being the y coordinate of the Planckian radiator for which x o = x.

RIDING LIGHT

§ 3.704 Riding light.

(a) When a riding (anchor) light is required for a seaplane, flying boat, or amphibian, it shall be capable of showing a white light for at least 2 miles at night under clear atmospheric conditions.

(b) The riding light shall be installed to show the maximum unbroken light practicable when the airplane is moored or drifting on the water. Externally hung lights shall be acceptable.

§ 3.705 Rescinded.

SAFETY EQUIPMENT; INSTALLATION

§ 3.711 Marking. Required safety equipment which the crew is expected to operate at a time of emergency, such as flares and automatic life raft releases, shall be readily accessible and plainly marked as to its method of operation. When such equipment is carried in lockers, compartments, or other storage places, such storage places shall be marked for the benefit of passengers and crew.

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

§ 3.713 Flare requirements. When parachute flares are required, they shall be of an approved type.

§ 3.714 Flare installation. Parachute flares shall be releasable from the pilot compartment and so installed that danger of accidental discharge is reduced to a minimum. The installation shall be demonstrated in flight to eject flares satisfactorily, except in those cases where inspection indicates a ground test will be adequate. If the flares are ejected so that recoil loads are involved, structural provisions for such loads shall be made.

§ 3.715 *Safety belts.* Safety belts shall be of an approved type. In no case shall the rated strength of the safety belt be less than that corresponding with the ultimate load factors specified in § 3.386(a), taking due account of the dimensional characteristics of the safety belt installation for the specific seat or berth arrangement. Safety belts shall be attached so that no part of the anchorage will fail at a load lower than that corresponding with the ultimate load factors specified in equal to those specified in Sec. 3.86(a) multiplied by a factor ot 1.33. **[**In the case of safety belts for berths, the forward load factor need not be applied.**]**

EMERGENCY FLOTATION AND SIGNALING EQUIPMENT

§ 3.716 Rafts and life preservers. Rafts and life preservers shall be of an approved type.

§ 3.717 Installation. 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. The strength of the line shall be such that it will break before submerging the empty raft.

§ 3.718 Signaling device. Signaling devices, when required by other parts of the Civil Air Regulations, shall be accessible, function satisfactorily, and be free from any hazard in their operation.

RADIO EQUIPMENT; INSTALLATION

§ 3.721 General. Radio equipment and installations in the airplane shall be free from hazards in themselves, in their method of operation, and in their effects on their components of the airplane.

MISCELLANEOUS EQUIPMENT; INSTALLATION

§ 3.725 Accessories for multiengine airplanes. Engine driven accessories essential to the safe operation of the airplane shall be so distributed among two or more engines that the failure of any one engine will not impair the safe operation of the airplane by the malfunctioning of these accessories.

HYDRAULIC SYSTEMS

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

§ 3.727 Tests. Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of the hydraulic system shall fail, malfunction, or experience a permanent set. The proof load of any system shall be 15 times the maximum operating pressure of that system.

§ 3.728 Accumulators. Hydraulic accumulators or pressurized reservoirs shall not be installed on the engine side of the fire wall, except when they form an integral part of the engine or propeller.

SUBPART G—OPERATING LIMITATIONS AND INFORMATION

§ 3.735 General. Means shall be provided to inform adequately the pilot and other appropriate crew members 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. (See §§ 3.755 and 3.777.)

LIMITATIONS

§ 3.737 Limitations. The operating limitations specified in §§ 3.738-3.750 and any similar limitations shall be established for any airplane and made available to the operator as further described in §§ 3.755-3.780, unless its design is such that they are unnecessary for safe operation.

AIR SPEED

§ 3.738 Air speed. Air-speed limitations shall be established as set forth in §§ 3.739-3.743.

§ 3.739 Never-exceed speed (Vne). This speed shall not exceed the lesser of the following:

(a) 0.9 Vd chosen in accordance with § 3.184.

(b) 0.9 times the maximum speed demonstrated in accordance with § 3.159, but shall not be less than 0.9 times the minimum value of Vd permitted by § 3.184.

§ 3.740 Maximum structural cruising speed (Vno). This operating limitation shall be:

(a) Not greater than Vc chosen in accordance with § 3.184.

(b) Not greater than 0.89 times Vne established under § 3.739.

(c) Not less than the minimum Vc permitted in § 3.184.

§ 3.741 Maneuvering speed (Vp). (See § 3.184.)

§ 3.742 Flaps-extended speed (Vfe).

(a) This speed shall not exceed the lesser of the following:

(1) The design flap speed, Vf chosen in accordance with § 3.190.

(2) The design flap speed chosen in accordance with § 3.223, but shall not be less than the minimum value of design flap speed permitted in §§ 3.190 and 3.223.

(b) Additional combinations of flap setting, air speed, and engine power may be established, provided the structure has been proven for the corresponding design conditions.

§ 3.743 Minimum control speed (Vmc).(See § 3.111.)

POWER PLANT

§ 3.744 Power plant. The power plant limitations in §§ 3.745 through 3.747 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.

§ 3.745 Take-off operation.

(a) Maximum rotational speed (revolutions per minute).

(b) Maximum permissible manifold pressure (if applicable).

(c) The time limit upon the use of the corresponding power.

(d) Where the time limit of paragraph (c) of this section exceeds 2 minutes, the maximum allowable temperatures for cylinder head, oil, and coolant outlet if applicable.

§ 3.746 Maximum continuous operation,

(a) Maximum rotational speed (revolutions per minute).

(b) Maximum permissible manifold pressure (if applicable).

(c) Maximum allowable temperatures for cylinder head, oil, and coolant outlet if applicable.

§ 3.747 Fuel octane rating. The minimum octane rating of fuel required for satisfactory operation of the power plant at the limits of §§ 3.745 and 3.746.

AIRPLANE WEIGHT

§ 3.748 Airplane weight. The airplane weight and center of gravity limitations are those required to be determined by § 3.71.

MINIMUM FLIGHT CREW

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

TYPES OF OPERATION

§ 3.750 Types of operation. The type of operation to which the airplane is limited shall be established by the category in which it has been found eligible for certification and by the equipment installed. (See the appropriate operating parts of the Civil Air Regulations.)

MARKINGS AND PLACARDS

§ 3.755 Markings and placards.

(a) 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 cannot be easily erased, disfigured, or obscured. Additional informational placards and instrument markings having a direct and important bearing on safe operation may be required by the Administrator when unusual design, operating, or handling characteristics so warrant.

(b) When an airplane is certificated in more than one category, the applicant shall select one category on which all placards and markings on the airplane shall be based. The placard and marking information for the other categories in which the airplane is certificated shall be entered in the Airplane Flight Manual. A reference to this information shall be included on a placard which shall also indicate the category on which the airplane placards and markings are based.

INSTRUMENT MARKINGS

§ 3.756 Instrument markings. The instruments listed in §§ 3.757-3.761 shall have the following limitations marked thereon. When these markings are placed on the cover glass of the instrument, adequate provision shall be made to maintain the correct alignment of the glass cover with the face of the dial. All arcs and lines shall be of sufficient width and so located as to be clearly and easily visible to the pilot.

§ 3.757 Air-speed indicator.

(a) True indicated air speed shall be used:

(1) The never-exceed speed, Vne—a radial red line (see § 3.739).

(2) The caution range—a yellow arc extending from the red line in (1) above to the upper limit of the green arc specified in (3) below.

(3) The normal operating range—a green arc with the lower limit at Vs1, as determined in § 3.82 with maximum weight, landing gear and wing flaps retracted, and the upper limit at the maximum structural cruising speed established in § 3.740.

(4) The flap operating range—a white arc with the lower limit at Vso as determined in § 3.82 at the maximum weight, and the upper limit at the flaps-extended speed in § 3.742.

(b) When the never-exceed and maximum structural cruising speeds vary with altitude, means shall be provided which will indicate the appropriate limitations to the pilot throughout the operating altitude range.

§ 3.758 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 greater than 30-degree increments.

§ 3.759 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 marred with a yellow arc. Ranges of engine speed which are restricted as a result of excessive engine or propeller vibration shall be marked with a red arc.

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

§ 3.761 Fuel quantity indicator. When the unusable fuel supply for any tank exceeds 1 gallon or 5 percent of the tank capacity, whichever is greater, a red band shall be placed on the indicator extending from the calibrated zero reading (see § 3.437) to the lowest reading obtainable in the level flight attitude, and a suitable notation in the Airplane Flight Manual shall be provided to indicate the flight personnel that the fuel remaining in the tank when the quantity indicator reaches zero cannot be used safely in flight. (See § 3.672.)

CONTROL MARKINGS

§ 3.762 General. All cockpit controls, with the exception of the primary flight controls, shall be plainly marked as to their function and method of operation.

§ 3.763 Aerodynamic controls. The secondary controls shall be suitably marked to comply with §§ 3.337 and 3.338.

§ 3.764 Power-plant fuel controls.

(a) Controls for fuel tank selector valves shall be marked to indicate the position corresponding to each tank and to all existing cross feed positions.

(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 must be used.

(c) On multiengine airplanes, controls for engine valves shall be marked to indicate the position corresponding to each engine.

(d) The usable capacity of each tank shall be indicated adjacent to or on the fuel tank selector control.

§ 3.765 Accessory and auxiliary controls.

(a) When a retractable landing gear is used, the indicator required in § 3.359 shall be marked in such a manner that the pilot can ascertain at all times when the wheels are secured in the extreme positions.

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

MISCELLANEOUS

§ 3.766 Baggage compartments, ballast location, and special seat loading limitations.

(a) 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.

(b) When the maximum permissible weight to be carried in a seat is less than 170 pounds (see § 3.74), a placard shall be permanently attached to the seat structure which states the maximum allowable weight of occupants to be carried.

§ 3.767 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 § 3.437.)

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

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

§ 3.768 Emergency exit placards. Emergency exit placards and operating controls shall be colored red. A placard shall be located adjacent to the control(s) which clearly indicates it to be an emergency exit and describes the method of operation. (See § 3.387.)

§ 3.769 Approved flight maneuvers—

(a) Category N. A placard shall be provided in front of and in clear view of the pilot stating: "No acrobatic maneuvers including spins approved."

(b) Category U. A placard shall be provided in front of and in clear view of the pilot stating: "Acrobatic maneuvers are limited to the following: ------------(List approved maneuvers).

(c) Category A. A placard shall be provided in clear view of the pilot which lists all approved acrobatic maneuvers and the recommended entry air speed for each. If inverted flight maneuvers are not approved, the placard shall bear a notation to this effect.

§ 3.770 Operating limitations placard. A placard shall be provided in clear view of the pilot stating: "This airplane must be operated as a ----------------- or --------------- category airplane in compliance with the operating limitations stated in the form of placards, markings, and manuals."

§ 3.771 Airspeed placards. The following airspeed limitations shall be shown on placards in view of the pilot:

(a) Maximum speed with landing gear extended, if the airplane is equipped with retractable landing gear.

(b) Minimum control speed with one engine inoperative, for multiengine airplanes.

[(c) Rough air or maneuvering speed determined in accordance with Sec. 3.741. **]**

AIRPLANE FLIGHT MANUAL

§ 3.777 Airplane Flight Manual.

a. An Airplane Flight Manual shall be furnished with each airplane. The portions of this document listed below shall be verified and approved by the Administrator, and shall be segregated, identified, and clearly distinguished from portions not so approved. Additional items of information having a direct and important bearing on safe operation may be required by the Administrator when unusual design, operating, or handling characteristics so warrant.

b. For airplanes having a maximum certificated weight of 6,000 pounds or less an Airplane Flight Manual is not required; instead, the information prescribed in this part for inclusion in the Airplane Flight Manual shall be made available to the operator by the manufacturer in the form of clearly stated placards, markings, or manuals.

§ 3.778 Operating limitations—

(a) Airspeed limitations. Sufficient information shall be included to permit proper marking of the airspeed limitations on the indicator as required in § 3.757. It shall also include the design, maneuvering speed, and the maximum safe air speed at which the landing gear can be safely lowered. In addition to the above information, the significance of the air speed limitations and of the color coding used shall be explained.

(b) Power-plant limitations. Sufficient information shall be included to outline and explain all power-plant limitations (see § 3.744) and to permit marking the instruments as required in § 3.759.

(c) Weight. The following information shall be included:

(1) Maximum weight for which the airplane has been certificated,

(2) Airplane empty weight and center of gravity location,

(3) Useful load,

(4) The composition of the useful load, including the total weight of fuel and oil with tanks full.

(d) Load distribution.

(1) All authorized center of gravity limits shall be stated. If the available space for loading the airplane is adequately placarded or so arranged that any reasonable distribution of the useful load listed in weight above will not result in a center of gravity location outside of the stated limits, this section need not include any other information than the statement of center of gravity limits.

(2) In all other cases this section shall also include adequate information to indicate satisfactory loading combinations which will assure maintaining the center of gravity position within approved limits.

(e) Maneuvers. All authorized maneuvers and the appropriate air-speed limitations as well as all unauthorized maneuvers shall be included in accordance with the following:

(1) Normal category. All acrobatic maneuvers, including spins, are unauthorized. If the airplane has been demonstrated to be characteristically incapable of spinning in accordance with § 3.124 (d), a statement to this effect shall be entered here.

(2) Utility category. All authorized maneuvers demonstrated in the type flight tests shall be listed, together with recommended entry speeds. All other maneuvers are not approved. If the airplane has been demonstrated to be characteristically incapable of spinning in accordance with § 3.124 (d), a statement to this effect shall be entered here.

(3) Acrobatic category. All approved flight maneuvers demonstrated in the type flight tests shall be included, together with recommended entry speeds.

(f) Flight load factor. The positive limit load factors made good by the airplane's structure shall be described here in terms of accelerations.

(g) Flight crew. When a flight crew of more than one is required to operate the airplane safely, the number and functions of this minimum flight crew shall be included.

§ 3.779 Operating procedures. This section shall contain information concerning normal and emergency procedures and other pertinent information peculiar to the airplane's operating characteristics which are necessary to safe operation.

§ 3.780 Performance information.

(a) For airplanes with a maximum certificated take-off weight of more than 6,000 lbs. information relative to the items of performance set forth in subparagraphs (1) through (5) of this paragraph shall be included.

(1) The stalling speed, Vso, at maximum weight,

(2) The stalling speed, Vs1, at maximum weight and with landing gear and wing flaps retracted,

(3) The take-off distance determined in accordance with § 3.84, including the air speed at the 50-foot height, and the airplane configuration, if pertinent,

(4) The landing distance determined in accordance with § 3.86, including the airplane configuration, if pertinent,

(5) The steady rate of climb determined in accordance with § 3.85 (a), (c), and, as appropriate, (b), including the air speed, power, and airplane configuration, if pertinent.

(b) The effect of variation in (a) (2) with angle of bank up to 60 degrees shall be included.

(c) The calculated approximate effect of variations in subparagraphs (3), (4) and (5) of this paragraph with altitude and temperature shall be included.

SUBPART H—IDENTIFICATION DATA

§ 3.791 Identification plate. A fireproof identification plate shall be securely attached to the structure in an accessible location where it will not likely be defaced during normal service. The identification plate shall not be placed in a location where it might be expected to be destroyed or lost in the event of an accident. The identification plate shall contain the identification data required by § 1.50.

§ 3.792 Airworthiness certificate number. The identifying symbols and registration numbers shall be permanently affixed to the airplane structure in compliance with § 1.100 of this chapter.