Exemption No. 6558

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
KANSAS CITY, MISSOURI 64106

In the matter of the petition of	*	
	*	
RAYTHEON AIRCRAFT COMPANY	*	Regulatory Docket No. 132CE
	*	
for exemption from §§ 23.25, 23.29, 23.235, 23.471, 23.473, 23.477, 23.479, 23.481, 23.483, 23.485, 23.493, 23.499, 23.723, 23.725, 23.726, 23.727, 23.959, 23.1583(c)(1) and (2), Appendix C23.1, Appendix D23.1, through Amendment 23-52 of Title 14 of the Code of Federal Regulations	*	

GRANT OF EXEMPTION

By letter dated August 13, 1996, Mr. A. C. Jackson, Group Manager, Product Design Assurance & FAA Liaison, Raytheon Aircraft Company, P.O. Box 85, Wichita, Kansas 67201-0085 petitioned for an exemption from §§ 23.25, 23.29, 23.235, 23.471, 23.473, 23.477, 23.479, 23.481, 23.483, 23.485, 23.493, 23.499, 23.723, 23.725, 23.726, 23.727, 23.959, 23.1583(c)(1) and (2), Appendix C23.1, Appendix D23.1, through Amendment 23-52 of Title 14 of the Code of Federal Regulations to permit modification of the Raytheon Model 390 airplane landing gear loads and associated airframe loads required by 14 CFR Part 23.

The petitioner requires relief from the following regulation(s):

Sections 23.25, 23.29, 23.235, 23.471, 23.473, 23.477, 23.479, 23.481, 23.483, 23.485, 23.493, 23.499, 23.723, 23.725, 23.726, 23.727, 23.959, 23.1583(c)(1) and (2), Appendix C23.1, Appendix D23.1, through Amendment 23-52 of Title 14 of the Code of Federal Regulations.

The petitioner supports its request with the following information:

"The purpose of this petition for exemption is to permit modification of the Model 390 landing gear loads and associated airframe loads required by FAR Part 23 (Airworthiness Standards for Normal, Utility, Acrobatic, and Commuter Category Airplanes) to those proposed in the attachment. These proposed requirements are identical in content to those of FAR Part 25 (Airworthiness Standards for Transport Category Airplanes).

"Rationale: Ground (Landing Gear) Loads requirements in FAR Part 23 are tailored for full stall type landings (as expected in light, entry level aircraft or those flown by student pilots) by specifying 2/3-g wing lift at touchdown. Small jet aircraft certified under FAR Part 25 like the larger transport category aircraft are flown onto the runway (not landed post stall), therefore FAR Part 25 specifies 1-g wing lift at touchdown reducing the resulting landing gear loads and associated airframe loads.

"The Model 390 is a light jet aircraft that will be flown only by type rated pilots and will therefore be operated and landed like the larger transport aircraft (flown onto the runway with 1-g wing lift at touchdown).

"Equivalent Level of Safety. The proposed landing ground loads (attached) are the same as the FAR Part 25 requirements and combined with the requirement for type rated pilots, will provide an equivalent level of safety to the FAR Part 23 Ground Load requirements. The equivalent level of safety is assured by the requirement for a type rating on the Model 390. The requirement for a type rating to fly the Model 390 requires that the pilot's experience, knowledge and skill level are adequate to ensure the Model 390 is flown and landed like the medium and large transport category airplanes certified under FAR Part 25. The proposed loads are more appropriate for the Model 390.

"Public Interest. The reduced ground (landing gear and associated airframe) loads resulting from the proposed 1-g wing lift at touch down vs. the 2/3-g specified in FAR Part 23 Para. § 23.723(b) will reduce the weight of the Model 390 landing gear and its support structure. This will permit increased payload without the need to increase the maximum takeoff weight. This serves the public interest by providing greater efficiency, i.e., less power/noise, less fuel, less cost, and less exhaust emissions, based on requirements to transport a given payload from point to point.

"An estimated weight reduction of 40 lbs per aircraft would result in 3 lbs of fuel savings on a typical mission. Estimated annual fuel savings of 1,000 lbs per aircraft multiplied by an expected fleet of 850 Model 390 airplanes would result in an overall reduction in fuel consumption of 850,000 lbs annually."

Raytheon proposes, in the public interest and to provide a level of safety equal to that provided by the rule, that the requested exemption to §§ 23.25, 23.29, 23.235, 23.471, 23.473, 23.477, 23.479, 23.481, 23.483, 23.485, 23.493, 23.499, 23.723, 23.725, 23.726, 23.727, 23.959, 23.1583(c)(1) and (2), Appendix C23.1, Appendix D23.1, through Amendment 23-52 of Title 14 of the Code of Federal Regulations include the following requirements:

23.25 Weight limits.

(a) Maximum weight. The maximum weight is the highest weight at which compliance with each applicable requirement of this part (other than those complied with at the design landing weight) is shown. The maximum weight must be established so that it is -

(1) Not more than the least of -

(i) The highest weight selected by the applicant; or

(ii) The design maximum weight, which is the highest weight at which compliance with each applicable structural loading condition of this part (other than those complied with at the design landing weight) is shown; or

(iii) The highest weight at which compliance with each applicable flight requirement is shown, and

(2) Not less than the weight with -

(i) Each seat occupied, assuming a weight of 170 pounds for each occupant for normal and commuter category airplanes, and 190 pounds for utility and acrobatic category airplanes, except that seats other than pilot seats may be placarded for a lesser weight; and

(A) Oil at full capacity, and

(B) At least enough fuel for maximum continuous power operation of at least 30 minutes for day VFR approved airplanes and at least 45 minutes for night VFR and IFR approved airplanes; or

(ii) The required minimum crew, and fuel and oil to full tank capacity.

(b) Minimum weight. The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established so that it is not more than the sum of

(1) The empty weight determined under § 23.29;

(2) The weight of the required minimum crew (assuming a weight of 170 pounds for each crewmember); and

(3) The weight of -

(i) For turbojet powered airplanes, 5 percent of the total fuel capacity of that particular fuel tank arrangement under investigation, and

(ii) For other airplanes, the fuel necessary for one-half hour of operation at maximum continuous power.

Weight limits.

(a) *Maximum weights.* Maximum weights corresponding to the airplane operating conditions (such as ramp, ground taxi, takeoff, en route, and landing) environmental conditions (such as altitude and temperature), and loading conditions (such as zero fuel weight, center of gravity position and weight distribution) must be established so that they are not more than—

(1) The highest weight selected by the applicant for the particular conditions; or

(2) The highest weight at which compliance with each applicable structural loading and flight requirement is shown; or

(3) The highest weight at which compliance is shown with the certification requirements of part 36 of this chapter.

(b) *Minimum weight.* The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established so that it is not less than—

(1) The lowest weight selected by the applicant;

(2) The design minimum weight (the lowest weight at which compliance with each structural loading condition of this part is shown); or

(3) The lowest weight at which compliance with each applicable flight requirement is shown.

23.25 Weight limits. (Cont'd)

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23-7, 34 FR 13086, Aug. 13, 1969; Amdt. 23-21, 43 FR 2317, Jan. 16, 1978; Amdt. 23-34, 52 FR 1825, Jan. 15, 1987; Amdt. 23-45, 58 FR 42156, Aug. 6, 1993; Amdt. 23-50, 61 FR 5183, Feb. 9, 1996]

No Existing Requirements.

Center of gravity limits.

The extreme forward and the extreme aft center of gravity limitations must be established for each practicably separable operating condition. No such limit may lie beyond—

(a) The extremes selected by the applicant;

(b) The extremes within which the structure is proven; or

(c) The extremes within which compliance with each applicable flight requirement is shown.

23.29 Empty weight and corresponding center of gravity.

(a) The empty weight and corresponding center of gravity must be determined by weighing the airplane with -

(1) Fixed ballast;

(2) Unusable fuel determined under § 23.959; and

(3) Full operating fluids, including -

(i) Oil;

(ii) Hydraulic fluid; and

(iii) Other fluids required for normal operation of airplane systems, except potable water, lavatory precharge water, and water intended for injection in the engines.

(b) The condition of the airplane at the time of determining empty weight must be one that is well defined and can be easily repeated.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964; 30 FR 258, Jan. 9, 1965, as amended by Amdt. 23-21, 43 FR 2317, Jan. 16, 1978]

Empty weight and corresponding center of gravity.

(a) The empty weight and corresponding center of gravity must be determined by weighing the airplane with—

(1) Fixed ballast;

(2) Unusable fuel determined under the "Unusable fuel supply" paragraph and

(3) Full operating fluids, including—

(i) Oil;

(ii) Hydraulic fluid; and

(iii) Other fluids required for normal operation of airplane systems, except potable water, lavatory precharge water, and fluids intended for injection in the engine.

(b) The condition of the airplane at the time of determining empty weight must be one that is well defined and can be easily repeated.

23.235 Operation on unpaved surfaces.

The airplane must be demonstrated to have satisfactory characteristics and the shock-absorbing mechanism must not damage the structure of the airplane when the airplane is taxied on the roughest ground that may reasonably be expected in normal operation and when takeoffs and landings are performed on unpaved runways having the roughest surface that may reasonably be expected in normal operation.

[Amdt. 23-45, 58 FR 42159, Aug. 6, 1993; Amdt. 23-50, 61 FR 5192, Feb. 9, 1996]

Taxiing condition.

The shock absorbing mechanism may not damage the structure of the airplane when the airplane is taxied on the roughest ground that may reasonably be expected in normal operation.

Ground Loads

23.471 General.

The limit ground loads specified in this subpart are considered to be external loads and inertia forces that act upon an airplane structure. In each specified ground load condition, the external reactions must be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner.

GROUND LOADS

GENERAL.

(a) *Loads and equilibrium.* For limit ground loads--

(1) Limit ground loads obtained under this subpart are considered to be external forces applied to the airplane structure; and

(2) In each specified ground load condition, the external loads must be placed in equilibrium with the linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centers of gravity.* The critical centers of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element. Fore and aft, vertical, and lateral airplane centers of gravity must be considered. Lateral displacements of the c.g. from the airplane centerline which would result in main gear loads not greater than 103 percent of the critical design load for symmetrical loading conditions may be selected without considering the effects of these lateral c.g. displacements on the loading of the main gear elements, or on the airplane structure provided —

(1) The lateral displacement of the c.g. results from random passenger or cargo disposition within the fuselage or from random unsymmetrical fuel loading or fuel usage; and

(2) Appropriate loading instructions for random disposable loads are included under the provisions of the "Operating Limitations" paragraph (c)(1) to ensure that the lateral displacement of the center of gravity is maintained within these limits.

(c) *Landing gear dimension data.* Figure 1 of appendix A contains the basic landing gear dimension data.

23.473 Ground load conditions and assumptions.

(a) The ground load requirements of this subpart must be complied with at the design maximum weight except that §§ 23.479, 23.481, and 23.483 may be complied with at a design landing weight (the highest weight for landing conditions at the maximum descent velocity) allowed under paragraphs (b) and (c) of this section.

(b) The design landing weight may be as low as -

(1) 95 percent of the maximum weight if the minimum fuel capacity is enough for at least one-half hour of operation at maximum continuous power plus a capacity equal to a fuel weight which is the difference between the design maximum weight and the design landing weight; or

(2) The design maximum weight less the weight of 25 percent of the total fuel capacity.

(c) The design landing weight of a multiengine airplane may be less than that allowed under paragraph (b) of this section if -

(1) The airplane meets the one engine inoperative climb requirements of § 23.67(b)(1) or (c); and

(2) Compliance is shown with the fuel jettisoning system requirements of § 23.1001.

(d) The selected limit vertical inertia load factor at the center of gravity of the airplane for the ground load conditions prescribed in this subpart may not be less than that which would be obtained when landing with a descent velocity (V), in feet per second, equal to 4.4 (W/S)1/4, except that this velocity need not be more than 10 feet per second and may not be less than seven feet per second.

(e) Wing lift not exceeding two-thirds of the weight of the airplane may be assumed to exist throughout the landing impact and to act through the center of gravity. The ground reaction load factor may be equal to the inertia load factor minus the ratio of the above assumed wing lift to the airplane weight.

(f) If energy absorption tests are made to determine the limit load factor corresponding to the required limit descent velocities, these tests must be made under § 23.723(a).

(g) No inertia load factor used for design purposes may be less than 2.67, nor may the limit ground reaction load factor be less than 2.0 at design maximum weight, unless these lower values will not be exceeded in taxiing at speeds up to takeoff speed over terrain as rough as that expected in service.

Ground load conditions and assumptions.

(a) For the landing conditions specified herein; that is, level landing, tail-down landing, one-wheel landing, and side load, the following apply:

(1) The selected limit vertical inertia load factors at the center of gravity of the airplane may not be less than the values that would be obtained—

(i) In the attitude and subject to the drag loads associated with the particular landing condition;

(ii) With a limit descent velocity of 10 f.p.s. at the design landing weight (the maximum weight for landing conditions at the maximum descent velocity); and

(iii) With a limit descent velocity of 6 f.p.s. at the design takeoff weight (the maximum weight for landing conditions at a reduced descent velocity).

(2) Airplane lift, not exceeding the airplane weight, may be assumed to exist throughout the landing impact and to act through the center of gravity of the airplane.

(b) The prescribed descent velocities may be modified if it is shown that the airplane has design features that make it impossible to develop these velocities.

(c) The minimum limit inertia load factors corresponding to the required limit descent velocities must be determined in accordance with the "Shock absorption tests" subparagraph (a).

23.473 Ground load conditions and assumptions. (Cont'd)

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23-7, 34 FR 13090, Aug. 13, 1969; Amdt. 23-28, 47 FR 13315, Mar. 29, 1982; Amdt. 23-45, 58 FR 42160, Aug. 6, 1993; Amdt. 23-48, 61 FR 5147, Feb. 9, 1996]

23.477 Landing gear arrangement.

Sections 23.479 through 23.483, or the conditions in Appendix C, apply to airplanes with conventional arrangements of main and nose gear, or main and tail gear.

23.479 Level landing conditions.

(a) For a level landing, the airplane is assumed to be in the following attitudes:

(1) For airplanes with tail wheels, a normal level flight attitude.

(2) For airplanes with nose wheels, attitudes in which -

(i) The nose and main wheels contact the ground simultaneously; and

(ii) The main wheels contact the ground and the nose wheel is just clear of the ground.

The attitude used in paragraph (a)(2)(i) of this section may be used in the analysis required under paragraph (a)(2)(ii) of this section.

(b) When investigating landing conditions, the drag components simulating the forces required to accelerate the tires and wheels up to the landing speed (spin-up) must be properly combined with the corresponding instantaneous vertical ground reactions, and the forward acting horizontal loads resulting from rapid reduction of the spin-up drag loads (spring-back) must be combined with vertical ground reactions at the instant of the peak forward load, assuming wing lift and a tire sliding coefficient of friction of 0.8. However, the drag loads may not be less than 25 percent of the maximum vertical ground reactions (neglecting wing lift).

Landing gear arrangement.

Level landing, tail-down landing, one-wheel landing, and side load conditions apply to airplanes with conventional arrangements of main and nose gears, when normal operating techniques are used.

Level landing conditions.

(a) In the level attitude, the airplane is assumed to contact the ground at forward velocity components, ranging from V_{L1} to 1.25 V_{L2}, parallel to the ground, and to be subjected to the load factors prescribed in the "Ground load conditions and assumptions" paragraph (a)(1) with—

(1) V_{L1} equal to V_{SO} (TAS) at the appropriate landing weight and in standard sea level conditions; and

(2) V_{L2} equal to V_{SO} (TAS) at the appropriate landing weight and altitudes in a hot-day temperature of 41°F. above standard.

(b) The effects of increased contact speeds must be investigated if approval of downwind landings exceeding 10 knots if desired.

(c) Assuming that the following combinations of vertical and drag components act at the axle centerline, the following apply:

(1) For the condition of maximum wheel spin-up load, drag components simulating forces required to accelerate the wheel rolling assembly up to the specified ground speed must be combined with the vertical ground reactions existing at the instant of peak drag loads. The coefficient of friction between the tires and the ground may be established by considering the effects of skidding velocity and tire pressure. However, this coefficient of friction need not be more than 0.8. This condition must be applied to the landing gear, directly affected attaching structure, and large mass items such as external fuel tanks and nacelles.

23.479 Level landing conditions. (Cont'd)

(c) In the absence of specific tests or a more rational analysis for determining the wheel spin-up and spring-back loads for landing conditions, the method set forth in appendix D of this part must be used. If appendix D of this part is used, the drag components used for design must not be less than those given by appendix C of this part.

(d) For airplanes with tip tanks or large overhung masses (such as turbopropeller or jet engines) supported by the wing, the tip tanks and the structure supporting the tanks or overhung masses must be designed for the effects of dynamic responses under the level landing conditions of either paragraph (a)(1) or (a)(2)(ii) of this section. In evaluating the effects of dynamic response, an airplane lift equal to the weight of the airplane may be assumed.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23-17, 41 FR 55464, Dec. 20, 1976; Amdt. 23-45, 58 FR 42160, Aug. 6, 1993]

Level landing conditions. (Cont'd)

(2) For the condition of maximum wheel vertical load, an aft acting drag component of not less than 25 percent of the maximum vertical ground reaction must be combined with the maximum ground reaction of the "Ground load conditions and assumptions" paragraph.

(3) For the condition of maximum springback load, forward-acting horizontal loads resulting from a rapid reduction of the spin-up drag loads must be combined with the vertical ground reactions at the instant of the peak forward load. This condition must be applied to the landing gear, directly affected attaching structure, and large mass items such as external fuel tanks and nacelles.

(d) For the level landing attitude for airplanes with nose wheels, shown in figure 2 of appendix A, the conditions specified in paragraphs (a) through (c) of this section must be investigated, assuming the following attitudes:

(1) An attitude in which the main wheels are assumed to contact the ground with the nose wheel just clear of the ground.

(2) If reasonably attainable at the specified descent and forward velocities, an attitude in which the nose and main wheels are assumed to contact the ground simultaneously. For this attitude—

(i) The nose and main gear maybe separately investigated under the conditions in paragraph (c)(1) and (3) of this section; and

(ii) The pitching moment is assumed, under the condition in paragraph (c)(2) of this section, to be resisted by the nose gear.

23.481 Tail down landing conditions.

(a) For a tail down landing, the airplane is assumed to be in the following attitudes:

(1) For airplanes with tail wheels, an attitude in which the main and tail wheels contact the ground simultaneously.

(2) For airplanes with nose wheels, a stalling attitude, or the maximum angle allowing ground clearance by each part of the airplane, whichever is less.

(b) For airplanes with either tail or nose wheels, ground reactions are assumed to be vertical, with the wheels up to speed before the maximum vertical load is attained.

Tail-down landing conditions.

(a) In the tail-down attitude, the airplane is assumed to contact the ground at forward velocity components, ranging from V_{L1} to V_{L2}, parallel to the ground, and is subjected to the load factors prescribed in the "Ground load conditions and assumptions" paragraph (a)(1) with—

(1) V_{L1} equal to V_{SO} (TAS) at the appropriate landing weight and in standard sea level conditions; and

(2) V_{L2} equal to V_{SO} (TAS) at the appropriate landing weight and altitudes in a hot-day temperature of 41° F. above standard.

The combination of vertical and drag components specified in the "Level landing condition" paragraph (c)(1) and (3) is considered to be acting at the main wheel axle centerline.

(b) For the tail-down landing condition for airplanes with nose wheels, the airplane is assumed to be at an attitude corresponding to either the stalling angle or the maximum angle allowing clearance with the ground by each part of the airplane other than the main wheels, in accordance with figure 3 of appendix A, whichever is less.

23.483 One wheel landing conditions.

For the one wheel landing condition, the airplane is assumed to be in the level attitude and to contact the ground on one side of the main landing gear. In this attitude, the ground reactions must be the same as those obtained on that side under § 23.479.

One-wheel landing conditions.

For the one-wheel landing condition, the airplane is assumed to be in the level attitude and to contact the ground on one side of the main landing gear, in accordance with figure 4 of appendix A. In this attitude—

(a) The ground reactions must be the same as those obtained on that side under the "Level landing condition" paragraph (c)(2) and

(b) Each unbalanced external load must be reacted by airplane inertia in a rational or conservative manner.

23.485 Side load conditions.

(a) For the side load condition, the airplane is assumed to be in a level attitude with only the main wheels contacting the ground and with the shock absorbers and tires in their static positions.

(b) The limit vertical load factor must be 1.33, with the vertical ground reaction divided equally between the main wheels.

(c) The limit side inertia factor must be 0.83, with the side ground reaction divided between the main wheels so that -

(1) 0.5 (W) is acting inboard on one side; and

(2) 0.33 (W) is acting outboard on the other side.

(d) The side loads prescribed in paragraph (c) of this section are assumed to be applied at the ground contact point and the drag loads may be assumed to be zero.

[Amdt. 23-45, 58 FR 42160, Aug. 6, 1993]

Side load conditions.

(a) For the side load condition, the airplane is assumed to be in the level attitude with only the main wheels contacting the ground, in accordance with figure 5 of appendix A.

(b) Side loads of 0.8 of the vertical reaction (on one side) acting inward and 0.6 of the vertical reaction (on the other side) acting outward must be combined with one-half of the maximum vertical ground reactions obtained in the level landing conditions. These loads are assumed to be applied at the ground contact point and to be resisted by the inertia of the airplane. The drag loads may be assumed to be zero.

No Existing Requirement

Rebound landing condition.

(a) The landing gear and its supporting structure must be investigated for the loads occurring during rebound of the airplane from the landing surface.

(b) With the landing gear fully extended and not in contact with the ground, a load factor of 20.0 must act on the unsprung weights of the landing gear. This load factor must act in the direction of motion of the unsprung weights as they reach their limiting positions in extending with relation to the sprung parts of the landing gear.

No Existing Requirement

Ground handling conditions.

Unless otherwise prescribed, the landing gear and the airplane structure must be investigated for the conditions in the "Takeoff run, Braked roll, Turning, Nose wheel yaw, and Pivoting condition" paragraphs with the airplane at the design ramp weight (the maximum weight for ground handling conditions). No wing lift may be considered. The shock absorbers and tires may be assumed to be in their static position.

No Existing Requirement

Takeoff run.

The landing gear and the airplane structure are assumed to be subjected to loads not less than those obtained under conditions described in the "Taxiing condition" paragraph.

23.493 Braked roll conditions.

Under braked roll conditions, with the shock absorbers and tires in their static positions, the following apply:

(a) The limit vertical load factor must be 1.33.

(b) The attitudes and ground contacts must be those described in § 23.479 for level landings.

(c) A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction of 0.8 must be applied at the ground contact point of each wheel with brakes, except that the drag reaction need not exceed the maximum value based on limiting brake torque.

Braked roll conditions.

(a) For an airplane with a nose wheel, the limit vertical load factor is 1.2 at the design landing weight, and 1.0 at the design ramp weight. A drag reaction equal to the vertical reaction, multiplied by a coefficient of friction of 0.8, must be combined with the vertical reaction and applied at the ground contact point of each wheel with brakes. The following two attitudes, in accordance with figure 6 of appendix A must be considered:

(1) The level attitude with the wheels contacting the ground and the loads distributed between the main and nose gear. Zero pitching acceleration is assumed.

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

(b) A drag reaction lower than that prescribed in paragraphs (a) of this section may be used if it is substantiated that an effective drag force of 0.8 times the vertical reaction cannot be attained under any likely loading condition.

23.499 Supplementary conditions for nose wheels.

In determining the ground loads on nose wheels and affected supporting structures, and assuming that the shock absorbers and tires are in their static positions, the following conditions must be met:

(a) For aft loads, the limit force components at the axle must be -

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A drag component of 0.8 times the vertical load.

(b) For forward loads, the limit force components at the axle must be -

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A forward component of 0.4 times the vertical load.

(c) For side loads, the limit force components at ground contact must be -

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A side component of 0.7 times the vertical load.

(d) For airplanes with a steerable nose wheel that is controlled by hydraulic or other power, at design takeoff weight with the nose wheel in any steerable position, the application of 1.33 times the full steering torque combined with a vertical reaction equal to 1.33 times the maximum static reaction on the nose gear must be assumed. However, if a torque limiting device is installed, the steering torque can be reduced to the maximum value allowed by that device.

(e) For airplanes with a steerable nose wheel that has a direct mechanical connection to the rudder pedals, the mechanism must be designed to withstand the steering torque for the maximum pilot forces specified in § 23.397(b).

[Amdt. 23-48, 61 FR 5147, Feb. 9, 1996]

Turning.

In the static position, in accordance with figure 7 of appendix A, the airplane is assumed to execute a steady turn by the nose gear steering, or by application of sufficient differential power, so that the limit load factors applied at the center of gravity are 1.0 vertically and 0.5 laterally. The side ground reaction of each wheel must be 0.5 of the vertical reaction.

Nose-wheel yaw.

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

(b) With the airplane assumed to be in static equilibrium with the loads resulting from the use of brakes on one side of the main landing gear, the nose gear, its attaching structure, and the fuselage structure forward of the center of gravity must be designed for the following loads:

(1) A vertical load factor at the center of gravity of 1.0.

(2) A forward acting load at the airplane center of gravity of 0.8 times the vertical load on one main gear.

(3) Side and vertical loads at the ground contact point on the nose gear that are required for static equilibrium.

(4) A side load factor at the airplane center of gravity of zero.

(c) If the loads prescribed in paragraph (b) of this section result in a nose gear side load higher than 0.8 times the vertical nose gear load, the design nose gear side load may be limited to 0.8 times the vertical load, with unbalanced yawing moments assumed to be resisted by airplane inertia forces.

(d) For other than the nose gear, its attaching structure, and the forward fuselage structure the loading conditions are those prescribed in paragraph (b) of this section, except that—

(1) A lower drag reaction may be used if an effective drag force of 0.8 times the vertical reaction cannot be reached under any likely loading condition; and

(2) The forward acting load at the center of gravity need not exceed the maximum drag reaction on one main gear, determined in accordance with the "Braked roll conditions" paragraph (a).

(e) With the airplane at design ramp weight, and the nose gear in any steerable position, the combined application of full normal steering torque

Nose - Wheel Yaw. (Cont'd)

and a vertical force equal to the maximum static reaction on the nose gear must be considered in designing the nose gear, its attaching structure, and the forward fuselage structure.

Pivoting.

(a) The airplane is assumed to pivot about one side of the main gear with the brakes on that side locked. The limit vertical load factor must be 1.0 and the coefficient of friction 0.8.

(b) The airplane is assumed to be in static equilibrium, with the loads being applied at the ground contact points, in accordance with figure 8 of Appendix A.

Reversed braking.

(a) The airplane must be in a three point static ground attitude. Horizontal reactions parallel to the ground and directed forward must be applied at the ground contact point of each wheel with brakes. The limit loads must be equal to 0.55 times the vertical load at each wheel or to the load developed by 1.2 times the nominal maximum static brake torque, whichever is less.

(b) For airplanes with nose wheels, the pitching moment must be balanced by rotational inertia.

23.723 Shock absorption tests.

(a) It must be shown that the limit load factors selected for design in accordance with § 23.473 for takeoff and landing weights, respectively, will not be exceeded. This must be shown by energy absorption tests except that analysis based on tests conducted on a landing gear system with identical energy absorption characteristics may be used for increases in previously approved takeoff and landing weights.

(b) The landing gear may not fail, but may yield, in a test showing its reserve energy absorption capacity, simulating a descent velocity of 1.2 times the limit descent velocity, assuming wing lift equal to the weight of the airplane.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964; 30 FR 258, Jan. 9, 1965, as amended by Amdt. 23-23, 43 FR 50593, Oct. 30, 1978; Amdt. 23-49, 61 FR 5166, Feb. 9, 1996]

Shock absorption tests.

(a) It must be shown that the limit load factors selected for design in accordance with the "Ground load conditions and assumptions" paragraph for takeoff and landing weights, respectively, will not be exceeded. This must be shown by energy absorption tests except that analyses based on earlier tests conducted on the same basic landing gear system which has similar energy absorption characteristics may be used for increases in previously approved takeoff and landing weights.

(b) The landing gear may not fail in a test, demonstrating its reserve energy absorption capacity, simulating a descent velocity of 12 f.p.s. at design landing weight, assuming airplane lift not greater than the airplane weight acting during the landing impact.

23.725 Limit drop tests.

(a) If compliance with § 23.723(a) is shown by free drop tests, these tests must be made 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 those determined by the following formula:

h (inches) = 3.6 (W/S) 1/2

However, the free drop height may not be less than 9.2 inches and need not be more than 18.7 inches.

(b) If the effect of wing lift is provided for in free drop tests, the landing gear must be dropped with an effective weight equal to

$$W(e) = W * \frac{[h + (1 - L) * d]}{(h + d)}$$

where -

W(e) = the effective weight to be used in the drop test (lbs);

h = specified free drop height (inches);

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

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

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

W = W(n) for nose wheel units (lbs), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0 g downward and 0.33 g forward; and

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

(c) The limit inertia load factor must be determined in a rational or conservative manner, during the drop test, using a landing gear unit attitude, and applied drag loads, that represent the landing conditions.

Limit drop tests.

(a) If compliance with the "Shock absorption tests" paragraph (a) is shown by free drop tests, these tests must be made on the complete airplane, or on units consisting of a wheel, tire, and shock absorber, in their proper positions, from free drop heights not less than—

(1) 18.7 inches for the design landing weight conditions; and

(2) 6.7 inches for the design takeoff weight conditions.

(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced mass, the landing gear must be dropped with an effective mass equal to

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

where—

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

h=specified free drop height (inches):

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

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

W=W_N for nose wheel units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0g downward and 0.25g forward; and

L=the ratio of the assumed airplane lift to the airplane weight, but not more than 1.0

(c) The drop test attitude of the landing gear unit and the application of appropriate drag loads during the test must simulate the airplane landing conditions in a manner consistent with the development of a rational or conservative limit load factor value.

(d) The value of d used in the computation of W_e in paragraph (b) of this section may not exceed the value actually obtained in the drop test.

(e) The limit inertia load factor n must be determined from the free drop test in paragraph (b) of this section according to the following formula:

23.725 Limit drop tests. (Cont'd)

(d) The value of d used in the computation of W(e) in paragraph (B) of this section may not exceed the value actually obtained in the drop test.

(e) The limit inertia load factor must be determined from the drop test in paragraph (b) of this section according to the following formula:

n = n(j) * (W(e) / W) + L

where -

n(j) = the load factor developed in the drop test (that is, the acceleration (dv/dt) in g's recorded in the drop test) plus 1.0; and
W(e), W, and L are the same as in the drop test computation.

(f) The value of n determined in accordance with paragraph (e) may not be more than the limit inertia load factor used in the landing conditions in § 23.473.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23-7, 34 FR 13091, Aug. 13, 1969; Amdt. 23-48, 61 FR 5148, Feb. 9, 1996]

23.726 Ground load dynamic tests.

(a) If compliance with the ground load requirements of §§ 23.479 through 23.483 is shown dynamically by drop test, one drop test must be conducted that meets § 23.725 except that the drop height must be -

(1) 2.25 times the drop height prescribed in § 23.725(a); or

(2) Sufficient to develop 1.5 times the limit load factor.

(b) The critical landing condition for each of the design conditions specified in §§ 23.479 through 23.483 must be used for proof of strength.

(Amdt. 23-7, Eff. 9/14/69)

Limit drop tests. (Cont'd)

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

where—
n=the load factor developed in the drop test (that is, the acceleration of *dv/dt* in *g*'s recorded in the drop test) plus 1.0; and
W_e , *W*, and *L* are the same as in the drop test computation.

(f) The value of *n* determined in paragraph (e) of this section may not be more than the limit inertia load factor used in the landing conditions in the "Ground load conditions and assumptions" paragraph.

Ground load dynamic tests

(a) If compliance with the ground load requirements of the "Level Landing Conditions", "Tail Down Landing Conditions", and "One-Wheel Landing Conditions" paragraphs is shown dynamically by drop test, one drop test must be conducted that meets the "Limit Drop Tests" paragraph except that the drop height must be-

(1) 2.25 times the drop height prescribed in "Limit Drop Tests" paragraph (a); or

(2) Sufficient to develop 1.5 times the limit load factor.

(b) The critical landing condition for each of the design conditions specified in the "Level Landing Conditions", "Tail Down Landing Conditions", and "One-Wheel Landing Conditions" paragraphs must be used for proof of strength.

23.727 Reserve energy absorption drop test.

(a) If compliance with the reserve energy absorption requirement in § 23.723(b) is shown by free drop tests, the drop height may not be less than 1.44 times that specified in § 23.725.

(b) If the effect of wing lift is provided for, the units must be dropped with an effective mass equal to $W_e = Wh/(h+d)$, when the symbols and other details are the same as in § 23.725.

(Amdt. 23-7, Eff. 9/14/69)

Reserve energy absorption drop tests.

(a) If compliance with the reserve energy absorption condition specified in the "Shock absorption tests" paragraph (b) is shown by free drop tests, the drop height may not be less than 27 inches.

(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced mass, the landing gear must be dropped with an effective mass,

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

where the symbols and other details are the same as in the "Limit drop tests" paragraph (b)

23.959 Unusable fuel supply.

(a) The unusable fuel supply for each tank must be established as not less than that quantity at which the first evidence of malfunctioning occurs under the most adverse fuel feed condition occurring under each intended operation and flight maneuver involving that tank. Fuel system component failures need not be considered.

(b) The effect on the usable fuel quantity as a result of a failure of any pump shall be determined.

[Amdt. 23-7, 34 FR 13093, Aug. 13, 1969, as amended by Amdt. 23-18, 42 FR 15041, Mar. 17, 1977; Amdt. 23-51, 61 FR 5136, Feb. 9, 1996]

Unusable fuel supply.

The unusable fuel quantity for each fuel tank and its fuel system components must be established at not less than the quantity at which the first evidence of engine malfunction occurs under the most adverse fuel feed condition for all intended operations and flight maneuvers involving fuel feeding from that tank. Fuel system component failures need not be considered.

23.1583 Operating limitations.

(c) Weight. The airplane flight manual must include -

(1) The maximum weight; and

(2) The maximum landing weight, if the design landing weight selected by the applicant is less than the maximum weight.

Operating limitations.

(a) Weight and loading distribution. The weight and center of gravity limits required by the "Weight limits" paragraph and the "Center of gravity limits' paragraph must be furnished in the Airplane flight Manual. All of the following information must be presented either in the Airplane Flight Manual or in a separate weight and balance control and loading document which is incorporated by reference in the Airplane Flight Manual:

Operating limitations. (Cont'd)

(1) The condition of the airplane and the items included in the empty weight as defined in accordance with the "Empty weight and corresponding center of gravity" paragraph.

(2) Loading instructions necessary to ensure loading of the airplane within the weight and center of gravity limits, and to maintain the loading within these limits in flight.

(3) If certification for more than one center of gravity range is requested, the appropriate limitations, with regard to weight and loading procedures, for each separate center of gravity range.

Appendix C

Basic Landing Conditions

C23.1 Basic landing conditions.

Condition	Tail wheel type		Nose wheel type		
	Level landing	Tail-down landing	Level landing with inclined reactions	Level landing with nose wheel just clear of ground	Tail-down landing
Reference section	23.479(a)(1)	23.481(a)(1)	23.479(a)(2)(i)	23.479 (a)(2)(ii)	23.481(a)(2) and (b)
Vertical component at c.g	nW	nW	nW	nW	nW
Fore and aft component at c.g	KnW	0	KnW	KnW	0
Lateral component in either direction at c.g	0	0	0	0	0
Shock absorber extension (hydraulic shock absorber)	Note (2)	Note (2)	Note (2)	Note (2)	Note (2)
Shock absorber deflection (rubber or spring shock absorber), percent.	100%	100%	100%	100%	100%
Tire deflection	Static	Static	Static	Static	Static
Main wheel loads (both wheels) (V_r)	$(n-L)W$	$(n-L)Wb/d$	$(n-L)Wa'/d'$	$(n-L)W$	$(n-L)W$
Main wheel loads (both wheels) (D_r)	KnW	0	$KnWa'/d'$	KnW	0
Tail (nose) wheel loads (V_f)	0	$(n-L)Wa/d$	$(n-L)Wb'/d'$	0	0
Tail (nose) wheel loads (D_f)	0	0	$KnWb'/d'$	0	0
Notes	(1), (3), and (4)	(4)	(1)	(1), (3), and (4)	(3) and (4)

NOTE (1). K may he determined as follows: K=0.25 for W=3,000 pounds or less; K=033 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 is assumed to occur throughout the shock absorber stroke from 25 percent deflection to 100 percent deflection unless otherwise shown and the load factor must be used with whatever shock absorber extension is most critical for each element of the landing gear.

NOTE (3). Unbalanced moments must be balanced by a rational conservative method.

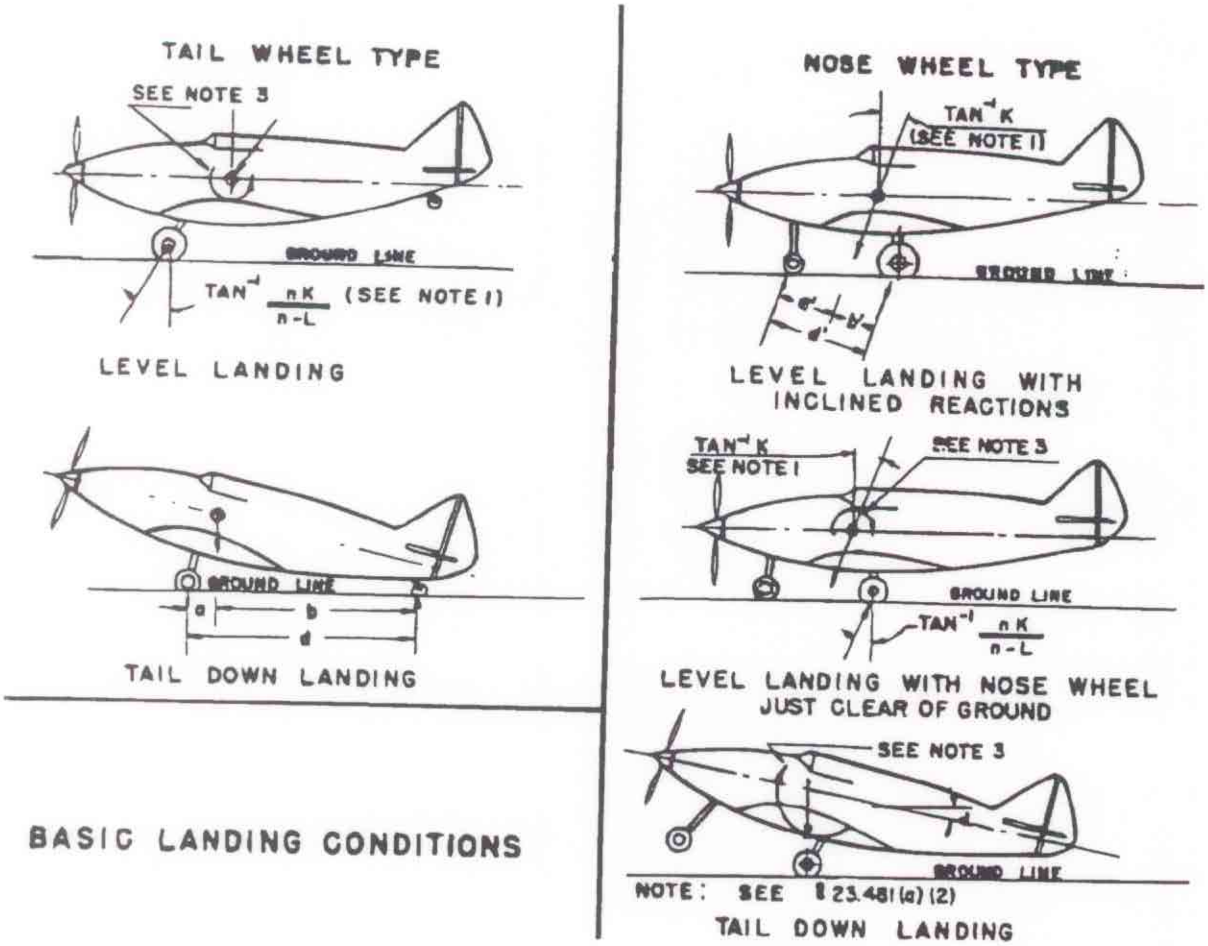
NOTE (4). L is defined in § 23.725(b).

NOTE (5). n is the limit inertia load factor, at the c.g. of the airplane, selected under 23.473(d), (f), and (g).

(Amdt. 23–7, Eff. 9/14/69)

APPENDIX C (Cont'd)

AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC AND COMMUTER



EXISTING FAR23 REQUIREMENT

Appendix D

[Wheel Spin-Up and Spring-Back Loads]

D23.1 Wheel spin up loads.

(a) The following method for determining wheel spin up loads for landing conditions is based on NACA T.N. 863. However, the drag component used for design may not be less than the drag load prescribed in § 23.479(b).

F(h max) = 1 / r(e) * sqrt(2 * I(w) * (VH - VC) * n * F(V max) / t(s)

where -

F(h max) = maximum rearward horizontal force acting on the wheel (in pounds);

r(e) = effective rolling radius of wheel under impact based on recommended operating tire pressure (which may be assumed to be equal to the rolling radius under a static load of n(j) * W(e)) in feet;

I(w) = rotational mass moment of inertia of rolling assembly (in slug feet);

VH = linear velocity of airplane parallel to ground at instant of contact (assumed to be 1.2 VS0, in feet per second);

VC = peripheral speed of tire, if prerotation is used (in feet per second) (there must be a positive means of prerotation before prerotation may be considered);

n = equals effective coefficient of friction (0.80 may be used);

F(V max) = maximum vertical force on wheel (pounds) = n(j) * W(e), where W(e) and n(j) are defined in § 23.725;

t(s) = time interval between ground contact and attainment of maximum vertical force on wheel (seconds). (However, if the value of F(V max), from the above equation exceeds 0.8 F(v max), the latter value must be used for F(h max).)

(b) The equation assumes a linear variation of load factor with time until the peak load is reached and under this assumption, the equation determines the drag force at the time that the wheel peripheral velocity at radius r(e) equals the airplane velocity. Most shock absorbers do not exactly follow a linear variation of load factor with time. Therefore, rational or conservative allowances must be made to compensate for these variations. On most landing gears, the time for wheel spin up will be less than the time required to develop maximum vertical load factor for the specified rate of descent and forward velocity. For exceptionally large wheels, a wheel peripheral velocity equal to the ground speed may not have been attained at the time of maximum vertical gear load. However, as stated above, the drag spin up load need not exceed 0.8 of the maximum vertical loads.

(c) Dynamic spring-back of the landing gear and adjacent structure at the instant just after the wheels come up to speed may result in dynamic forward acting loads of considerable magnitude. This effect must be determined, in the level landing condition, by assuming that the wheel spin-up loads calculated by the methods of this appendix are reversed. Dynamic spring-back is likely to become critical for landing gear units having wheels of large mass or high landing speeds.

[Amdt. 23-45, 58 FR 42166, Aug. 6, 1993]

Comments on published petition summary:

A summary of this petition was published in the FEDERAL REGISTER for public comment on October 4, 1996 (61 FR 52083). The comment period closed October 24, 1996. No comments were received.

The Federal Aviation Administration's (FAA) analysis is as follows:

To obtain this exemption, the Petitioner must show, as required by § 11.25(b)(5), that: (1) granting the request is in the public interest, and (2) the exemption will not adversely affect safety, or that a level of safety will be provided that is equal to that provided by the rules from which the exemption is sought.

The FAA has carefully reviewed the information contained in the Petitioner's request for exemption. The FAA agrees that the requirements proposed by Beech, which are identical to transport category requirements, will provide for landing gear and associated airframe loads that are adequate and appropriate for a light jet-powered airplane that will be operated only by type rated pilots and landed in the same manner (i.e., flown onto paved runways with one-g wing lift at touchdown) as transport category airplanes certified under 14 CFR part 25.

In consideration of the foregoing, I find that a grant of exemption is in the public interest and will not adversely affect safety. Therefore, pursuant to the authority contained in Sections 313(a) and 601(c) of the Federal Aviation Act of 1958, as amended, delegated to me by the Administrator (14 CFR 11.53), Raytheon Aircraft Company is granted an exemption from §§ 23.25, 23.29, 23.235, 23.471, 23.473, 23.477, 23.479, 23.481, 23.483, 23.485, 23.493, 23.499, 23.723, 23.725, 23.726, 23.727, 23.959, 23.1583(c)(1) and (2), Appendix C23.1, Appendix D23.1, through Amendment 23-52 of Title 14 of the Code of Federal Regulations, to the extent necessary to allow type certification of the Raytheon Model 390 airplane without an exact showing of compliance with these 14 CFR part 23 requirements. For the Model 390, this exemption is subject to the following conditions and limitations:

1. Weight limits.

(a) *Maximum weights.* Maximum weights corresponding to the airplane operating conditions (such as ramp, ground taxi, takeoff, en route, and landing) environmental conditions (such as altitude and temperature), and loading conditions (such as zero fuel weight, center of gravity position and weight distribution) must be established so that they are not more than—

(1) The highest weight selected by the applicant for the particular conditions; or

(2) The highest weight at which compliance with each applicable structural loading and flight requirement is shown; or

(3) The highest weight at which compliance is shown with the certification requirements of part 36 of this chapter.

(b) *Minimum weight.* The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established so that it is not less than—

(1) The lowest weight selected by the applicant;

(2) The design minimum weight (the lowest weight at which compliance with each structural loading condition of this part is shown); or

(3) The lowest weight at which compliance with each applicable flight requirement is shown.

2. Center of gravity limits.

The extreme forward and the extreme aft center of gravity limitations must be established for each practicably separable operating condition. No such limit may lie beyond—

(a) The extremes selected by the applicant;

(b) The extremes within which the structure is proven; or

(c) The extremes within which compliance with each applicable flight requirement is shown.

3. Empty weight and corresponding center of gravity.

(a) The empty weight and corresponding center of gravity must be determined by weighing the airplane with—

(1) Fixed ballast;

(2) Unusable fuel determined under the "Unusable fuel supply" paragraph and

(3) Full operating fluids, including—

(i) Oil;

(ii) Hydraulic fluid; and

(iii) Other fluids required for normal operation of airplane systems, except potable water, lavatory precharge water, and fluids intended for injection in the engine.

(b) The condition of the airplane at the time of determining empty weight must be one that is well defined and can be easily repeated.

4. Taxiing condition.

The shock absorbing mechanism may not damage the structure of the airplane when the airplane is taxied on the roughest ground that may reasonably be expected in normal operation.

5. Ground Loads

General.

(a) *Loads and equilibrium*. For limit ground loads--

(1) Limit ground loads obtained under this subpart are considered to be external forces applied to the airplane structure; and

(2) In each specified ground load condition, the external loads must be placed in equilibrium with the linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centers of gravity*. The critical centers of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element. Fore and aft, vertical, and lateral airplane centers of gravity must be considered. Lateral displacements of the c.g. from the airplane centerline which would result in main gear loads not greater than 103 percent of the critical design load for symmetrical loading conditions may be selected without considering the effects of these lateral c.g. displacements on the loading of the main gear elements, or on the airplane structure provided —

(1) The lateral displacement of the c.g. results from random passenger or cargo disposition within the fuselage or from random unsymmetrical fuel loading or fuel usage; and

(2) Appropriate loading instructions for random disposable loads are included under the provisions of the "Operating Limitations" paragraph (c)(1) to ensure that the lateral displacement of the center of gravity is maintained within these limits.

(c) *Landing gear dimension data*. Figure 1 of appendix A contains the basic landing gear dimension data.

6. Ground load conditions and assumptions.

(a) For the landing conditions specified herein; that is, level landing, tail-down landing, one-wheel landing, and side load, the following apply:

(1) The selected limit vertical inertia load factors at the center of gravity of the airplane may not be less than the values that would be obtained—

(i) In the attitude and subject to the drag loads associated with the particular landing condition;

(ii) With a limit descent velocity of 10 f.p.s. at the design landing weight (the maximum weight for landing conditions at the maximum descent velocity); and

(iii) With a limit descent velocity of 6 f.p.s. at the design takeoff weight (the maximum weight for landing conditions at a reduced descent velocity).

(2) Airplane lift, not exceeding the airplane weight, may be assumed to exist throughout the landing impact and to act through the center of gravity of the airplane.

(b) The prescribed descent velocities may be modified if it is shown that the airplane has design features that make it impossible to develop these velocities.

(c) The minimum limit inertia load factors corresponding to the required limit descent velocities must be determined in accordance with the "Shock absorption tests" subparagraph (a).

7. Landing gear arrangement.

Level landing, tail-down landing, one-wheel landing, and side load conditions apply to airplanes with conventional arrangements of main and nose gears, when normal operating techniques are used.

8. Level landing conditions.

(a) In the level attitude, the airplane is assumed to contact the ground at forward velocity components, ranging from V_{L1} to 1.25 V_{L2}, parallel to the ground, and to be subjected to the load factors prescribed in the "Ground load conditions and assumptions" paragraph (a)(1) with—

(1) V_{L1} equal to V_{SO} (TAS) at the appropriate landing weight and in standard sea level conditions; and

(2) V_{L2} equal to V_{SO} (TAS) at the appropriate landing weight and altitudes in a hot-day temperature of 41°F. above standard.

(b) The effects of increased contact speeds must be investigated if approval of downwind landings exceeding 10 knots if desired.

(c) Assuming that the following combinations of vertical and drag components act at the axle centerline, the following apply:

(1) For the condition of maximum wheel spin-up load, drag components simulating forces required to accelerate the wheel rolling assembly up to the specified ground speed must be combined with the vertical ground reactions existing at the instant of peak drag loads. The coefficient of friction between the tires and the ground may be established by considering the effects of skidding velocity and tire pressure. However, this coefficient of friction need not be more than 0.8. This condition must be applied to the landing gear, directly affected attaching structure, and large mass items such as external fuel tanks and nacelles.

(2) For the condition of maximum wheel vertical load, an aft acting drag component of not less than 25 percent of the maximum vertical ground reaction must be combined with the maximum ground reaction of the "Ground load conditions and assumptions" paragraph.

(3) For the condition of maximum springback load, forward-acting horizontal loads resulting from a rapid reduction of the spin-up drag loads must be combined with the vertical ground reactions at the instant of the peak forward load. This condition must be applied to the landing gear, directly affected attaching structure, and large mass items such as external fuel tanks and nacelles.

(d) For the level landing attitude for airplanes with nose wheels, shown in figure 2 of appendix A, the conditions specified in paragraphs (a) through (c) of this section must be investigated, assuming the following attitudes:

(1) An attitude in which the main wheels are assumed to contact the ground with the nose wheel just clear of the ground.

(2) If reasonably attainable at the specified descent and forward velocities, an attitude in which the nose and main wheels are assumed to contact the ground simultaneously. For this attitude—

(i) The nose and main gear maybe separately investigated under the conditions in paragraph (c)(1) and (3) of this section; and

(ii) The pitching moment is assumed, under the condition in paragraph (c)(2) of this section, to be resisted by the nose gear.

9. Tail-down landing conditions.

(a) In the tail-down attitude, the airplane is assumed to contact the ground at forward velocity components, ranging from V_{L1} to V_{L2}, parallel to the ground, and is subjected to the load factors prescribed in the "Ground load conditions and assumptions" paragraph (a)(1) with—

(1) V_{L1} equal to V_{SO} (TAS) at the appropriate landing weight and in standard sea level conditions; and

(2) V_{L2} equal to V_{SO} (TAS) at the appropriate landing weight and altitudes in a hot-day temperature of 41° F. above standard.

The combination of vertical and drag components specified in the "Level landing condition" paragraph (c)(1) and (3) is considered to be acting at the main wheel axle centerline.

(b) For the tail-down landing condition for airplanes with nose wheels, the airplane is assumed to be at an attitude corresponding to either the stalling angle or the maximum angle allowing clearance with the ground by each part of the airplane other than the main wheels, in accordance with figure 3 of appendix A, whichever is less.

10. One-wheel landing conditions.

For the one-wheel landing condition, the airplane is assumed to be in the level attitude and to contact the ground on one side of the main landing gear, in accordance with figure 4 of appendix A. In this attitude—

(a) The ground reactions must be the same as those obtained on that side under the "Level landing condition" paragraph (c)(2) and

(b) Each unbalanced external load must be reacted by airplane inertia in a rational or conservative manner.

11. Side load conditions.

(a) For the side load condition, the airplane is assumed to be in the level attitude with only the main wheels contacting the ground, in accordance with figure 5 of appendix A.

(b) Side loads of 0.8 of the vertical reaction (on one side) acting inward and 0.6 of the vertical reaction (on the other side) acting outward must be combined with one-half of the maximum vertical ground reactions obtained in the level landing conditions. These loads are assumed to be applied at the ground contact point and to be resisted by the inertia of the airplane. The drag loads may be assumed to be zero.

12. Rebound landing condition.

(a) The landing gear and its supporting structure must be investigated for the loads occurring during rebound of the airplane from the landing surface.

(b) With the landing gear fully extended and not in contact with the ground, a load factor of 20.0 must act on the unsprung weights of the landing gear. This load factor must act in the direction of motion of the unsprung weights as they reach their limiting positions in extending with relation to the sprung parts of the landing gear.

13. Ground handling conditions.

Unless otherwise prescribed, the landing gear and the airplane structure must be investigated for the conditions in the "Takeoff run, Braked roll, Turning, Nose wheel yaw, and Pivoting condition" paragraphs with the airplane at the design ramp weight (the maximum weight for ground handling conditions). No wing lift may be considered. The shock absorbers and tires may be assumed to be in their static position.

14. Takeoff run.

The landing gear and the airplane structure are assumed to be subjected to loads not less than those obtained under conditions described in the "Taxiing condition" paragraph.

15. Braked roll conditions.

(a) For an airplane with a nose wheel, the limit vertical load factor is 1.2 at the design landing weight, and 1.0 at the design ramp weight. A drag reaction equal to the vertical reaction, multiplied by a coefficient of friction of 0.8, must be combined with the vertical reaction and applied at the ground contact point of each wheel with brakes. The following two attitudes, in accordance with figure 6 of appendix A must be considered:

(1) The level attitude with the wheels contacting the ground and the loads distributed between the main and nose gear. Zero pitching acceleration is assumed.

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

(b) A drag reaction lower than that prescribed in paragraphs (a) of this section may be used if it is substantiated that an effective drag force of 0.8 times the vertical reaction cannot be attained under any likely loading condition.

16. Turning.

In the static position, in accordance with figure 7 of appendix A, the airplane is assumed to execute a steady turn by the nose gear steering, or by application of sufficient differential power, so that the limit load factors applied at the center of gravity are 1.0 vertically and 0.5 laterally. The side ground reaction of each wheel must be 0.5 of the vertical reaction.

17. Nose-wheel yaw.

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

(b) With the airplane assumed to be in static equilibrium with the loads resulting from the use of brakes on one side of the main landing gear, the nose gear, its attaching structure, and the fuselage structure forward of the center of gravity must be designed for the following loads:

(1) A vertical load factor at the center of gravity of 1.0.

(2) A forward acting load at the airplane center of gravity of 0.8 times the vertical load on one main gear.

(3) Side and vertical loads at the ground contact point on the nose gear that are required for static equilibrium.

(4) A side load factor at the airplane center of gravity of zero.

(c) If the loads prescribed in paragraph (b) of this section result in a nose gear side load higher than 0.8 times the vertical nose gear load, the design nose gear side load may be limited to 0.8 times the vertical load, with unbalanced yawing moments assumed to be resisted by airplane inertia forces.

(d) For other than the nose gear, its attaching structure, and the forward fuselage structure the loading conditions are those prescribed in paragraph (b) of this section, except that—

(1) A lower drag reaction may be used if an effective drag force of 0.8 times the vertical reaction cannot be reached under any likely loading condition; and

(2) The forward acting load at the center of gravity need not exceed the maximum drag reaction on one main gear, determined in accordance with the "Braked roll conditions" paragraph (a).

(e) With the airplane at design ramp weight, and the nose gear in any steerable position, the combined application of full normal steering torque and a vertical force equal to the maximum static reaction on the nose gear must be considered in designing the nose gear, its attaching structure, and the forward fuselage structure.

18. Pivoting.

(a) The airplane is assumed to pivot about one side of the main gear with the brakes on that side locked. The limit vertical load factor must be 1.0 and the coefficient of friction 0.8.

(b) The airplane is assumed to be in static equilibrium, with the loads being applied at the ground contact points, in accordance with figure 8 of Appendix A.

19. Reversed braking.

(a) The airplane must be in a three point static ground attitude. Horizontal reactions parallel to the ground and directed forward must be applied at the ground contact point of each wheel with brakes. The limit loads must be equal to 0.55 times the vertical load at each wheel or to the load developed by 1.2 times the nominal maximum static brake torque, whichever is less.

(b) For airplanes with nose wheels, the pitching moment must be balanced by rotational inertia.

20. Shock absorption tests.

(a) It must be shown that the limit load factors selected for design in accordance with the "Ground load conditions and assumptions" paragraph for takeoff and landing weights, respectively, will not be exceeded. This must be shown by energy absorption tests except that analyses based on earlier tests conducted on the same basic landing gear system which has similar energy absorption characteristics may be used for increases in previously approved takeoff and landing weights.

(b) The landing gear may not fail in a test, demonstrating its reserve energy absorption capacity, simulating a descent velocity of 12 f.p.s. at design landing weight, assuming airplane lift not greater than the airplane weight acting during the landing impact.

21. Limit drop tests.

(a) If compliance with the "Shock absorption tests" paragraph (a) is shown by free drop tests, these tests must be made on the complete airplane, or on units consisting of a wheel, tire, and shock absorber, in their proper positions, from free drop heights not less than—

(1) 18.7 inches for the design landing weight conditions; and

(2) 6.7 inches for the design takeoff weight conditions.

(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced mass, the landing gear must be dropped with an effective mass equal to

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

where—

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

h=specified free drop height (inches):

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

$W = W_m$ for main gear units (lbs.), equal to the static weight on that unit with the airplane in the level attitude (with the nose wheel clear in the case of nose wheel type airplanes);
$W = W_N$ for nose wheel units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0g downward and 0.25*g* forward; and
L=the ratio of the assumed airplane lift to the airplane weight, but not more than 1.0

(c) The drop test attitude of the landing gear unit and the application of appropriate drag loads during the test must simulate the airplane landing conditions in a manner consistent with the development of a rational or conservative limit load factor value.

(d) The value of *d* used in the computation of W_e in paragraph (b) of this section may not exceed the value actually obtained in the drop test.

(e) The limit inertia load factor *n* must be determined from the free drop test in paragraph (b) of this section according to the following formula:

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

where—
n=the load factor developed in the drop test (that is, the acceleration of *dv/dt* in *g*'s recorded in the drop test) plus 1.0; and
W_e , W, and L are the same as in the drop test computation.

(f) The value of *n* determined in paragraph (e) of this section may not be more than the limit inertia load factor used in the landing conditions in the "Ground load conditions and assumptions" paragraph.

22. Ground load dynamic tests

(a) If compliance with the ground load requirements of the "Level Landing Conditions", "Tail Down Landing Conditions", and "One-Wheel Landing Conditions" paragraphs is shown dynamically by drop test, one drop test must be conducted that meets the "Limit Drop Tests" paragraph except that the drop height must be-

(1) 2.25 times the drop height prescribed in "Limit Drop Tests" paragraph (a); or

(2) Sufficient to develop 1.5 times the limit load factor.

(b) The critical landing condition for each of the design conditions specified in the "Level Landing Conditions", "Tail Down Landing Conditions", and "One-Wheel Landing Conditions" paragraphs must be used for proof of strength.

23. Reserve energy absorption drop tests.

(a) If compliance with the reserve energy absorption condition specified in the "Shock absorption tests" paragraph (b) is shown by free drop tests, the drop height may not be less than 27 inches.

(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced mass, the landing gear must be dropped with an effective mass,

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

where the symbols and other details are the same as in the "Limit drop tests" paragraph (b)

24. Unusable fuel supply.

The unusable fuel quantity for each fuel tank and its fuel system components must be established at not less than the quantity at which the first evidence of engine malfunction occurs under the most adverse fuel feed condition for all intended operations and flight maneuvers involving fuel feeding from that tank. Fuel system component failures need not be considered.

25. Operating limitations.

(a) Weight and loading distribution. The weight and center of gravity limits required by the "Weight limits" paragraph and the "Center of gravity limits' paragraph must be furnished in the Airplane Flight Manual. All of the following information must be presented either in the Airplane Flight Manual or in a separate weight and balance control and loading document which is incorporated by reference in the Airplane Flight Manual:

(1) The condition of the airplane and the items included in the empty weight as defined in accordance with the "Empty weight and corresponding center of gravity" paragraph.

(2) Loading instructions necessary to ensure loading of the airplane within the weight and center of gravity limits, and to maintain the loading within these limits in flight.

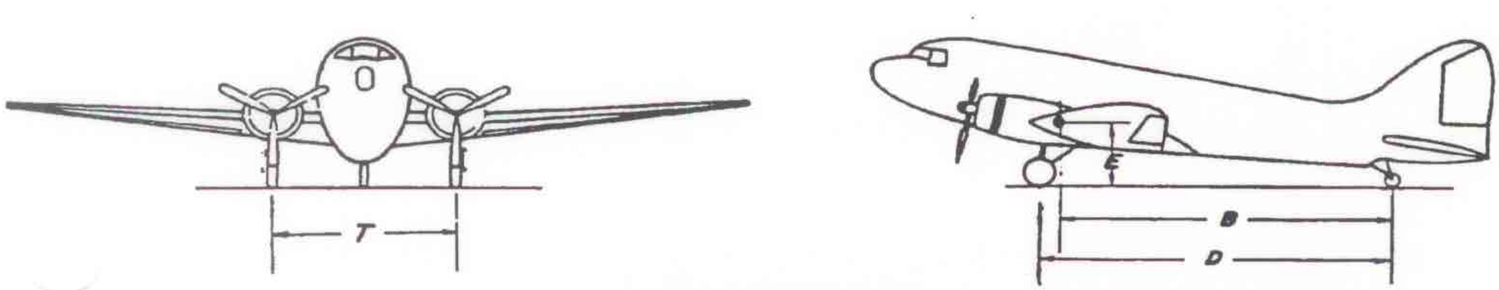
(3) If certification for more than one center of gravity range is requested, the appropriate limitations, with regard to weight and loading procedures, for each separate center of gravity range.

Issued in Kansas City, Missouri on December 12, 1996.

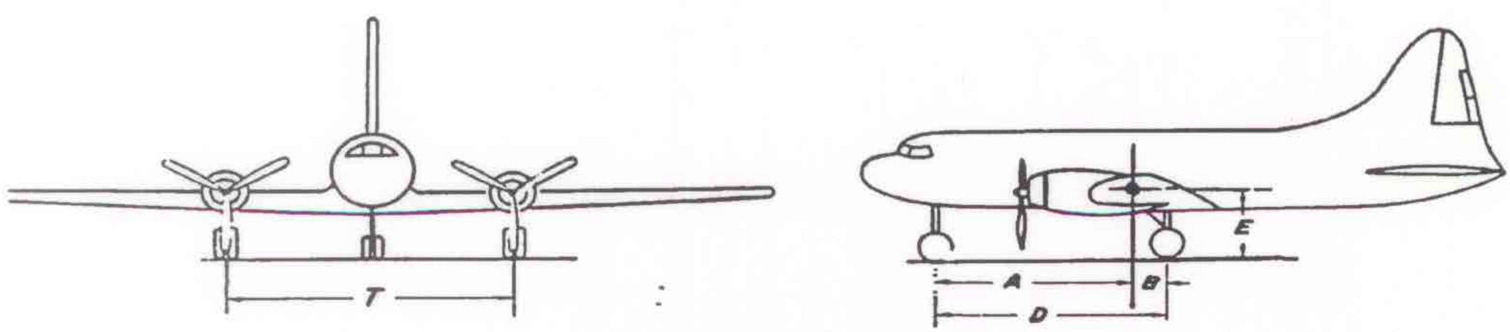
Henry A. Armstrong

Henry A. Armstrong
Manager, (Acting) Small Airplane Directorate

Appendix A



TAIL WHEEL TYPE



NOSE WHEEL TYPE

FIGURE 1—Basic landing gear dimension data.

APPENDIX A (Cont'd)

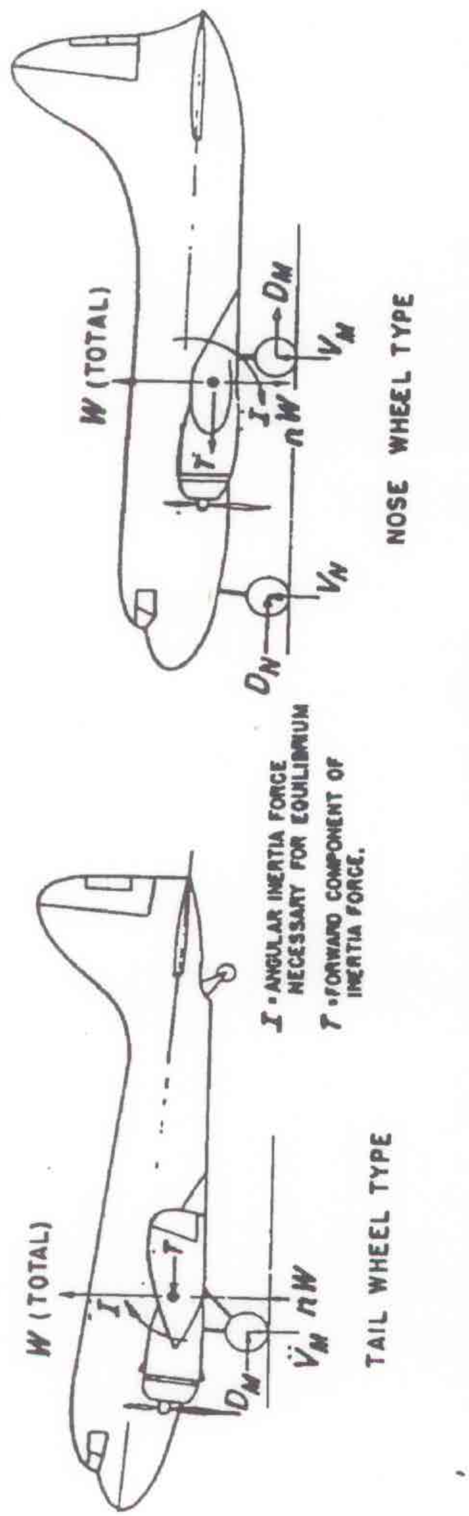


Figure 2—Level landing.

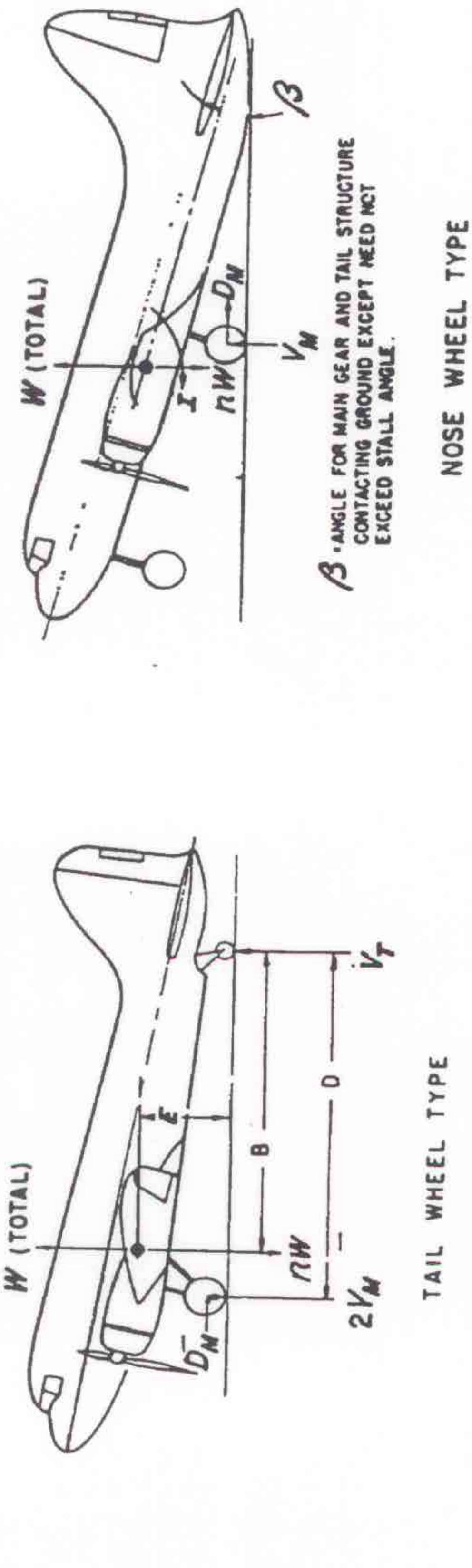


Figure 3—Tail-down landing.

APPENDIX A (Cont'd)

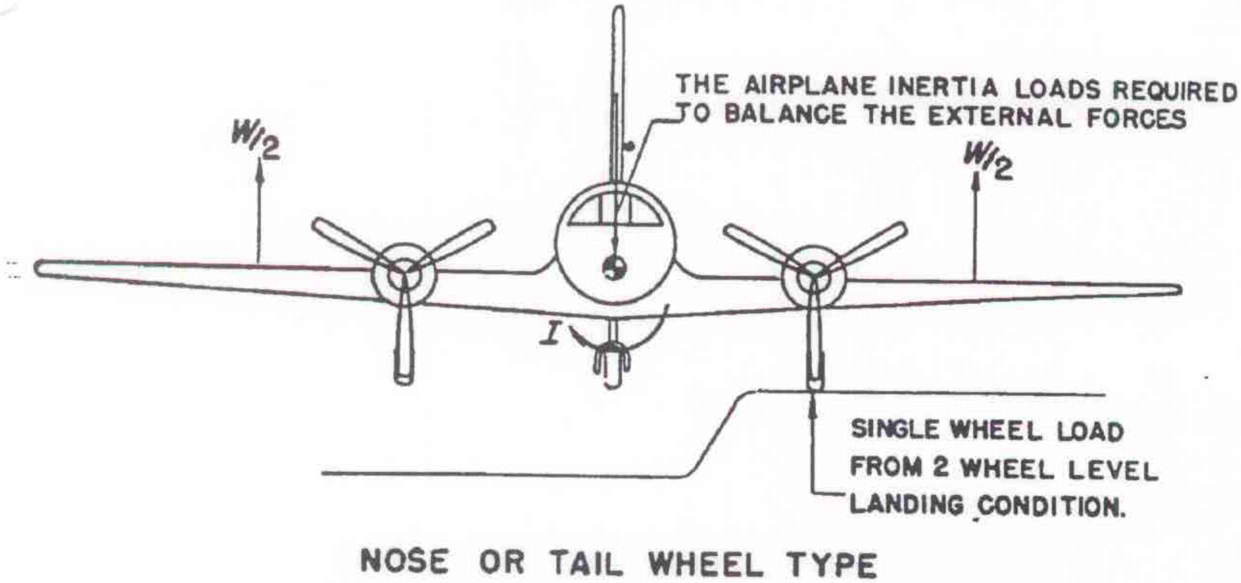


FIGURE 4—One-wheel landing.

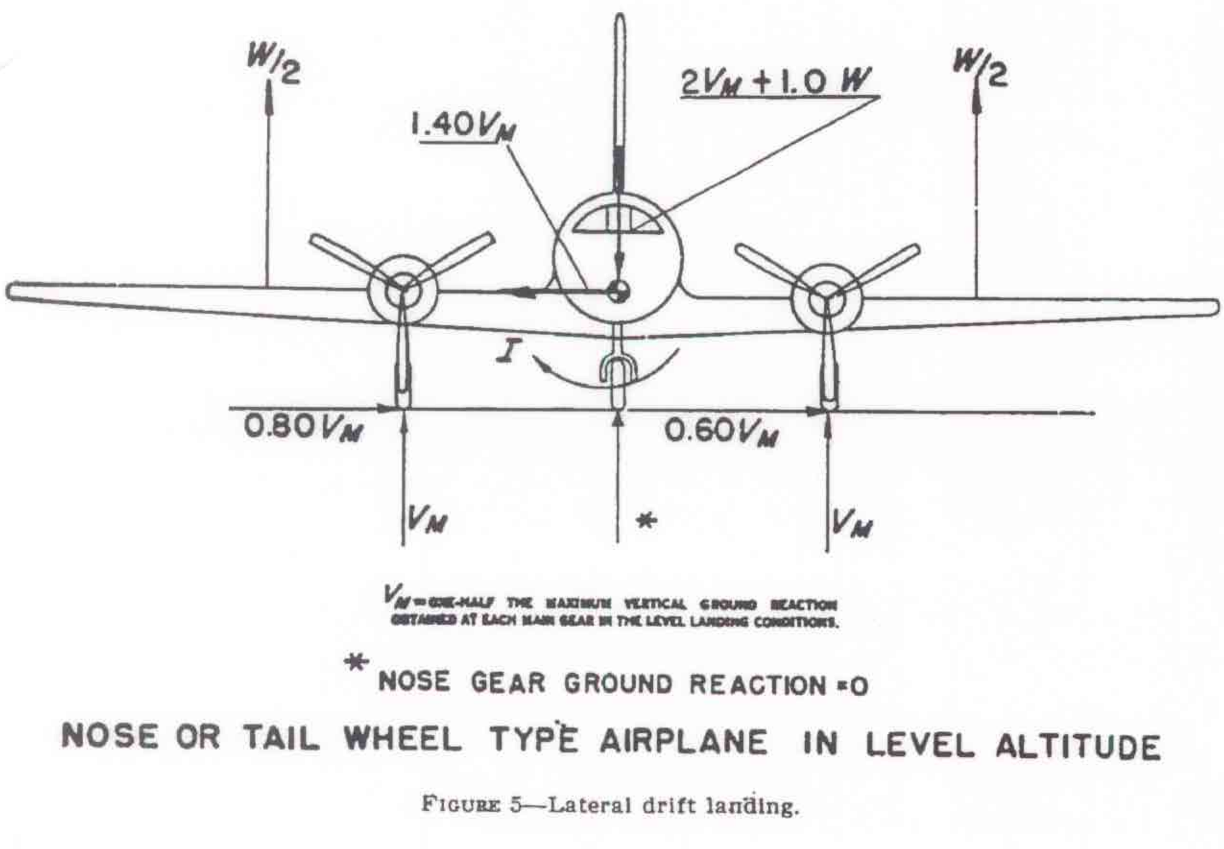


FIGURE 5—Lateral drift landing.

APPENDIX A (Cont'd)

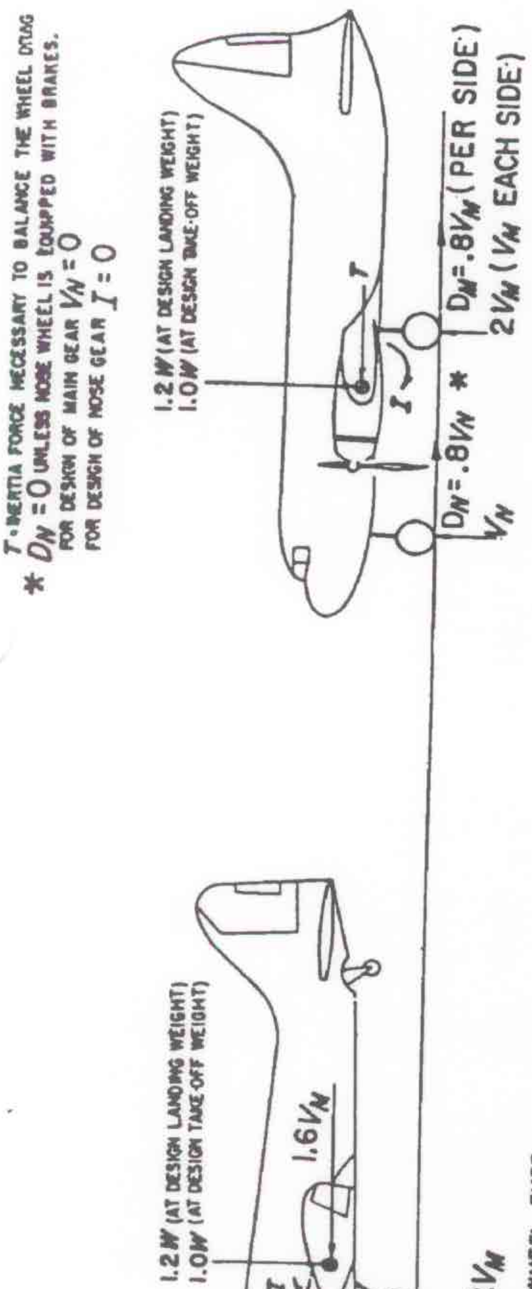


FIGURE 6—Braked roll.

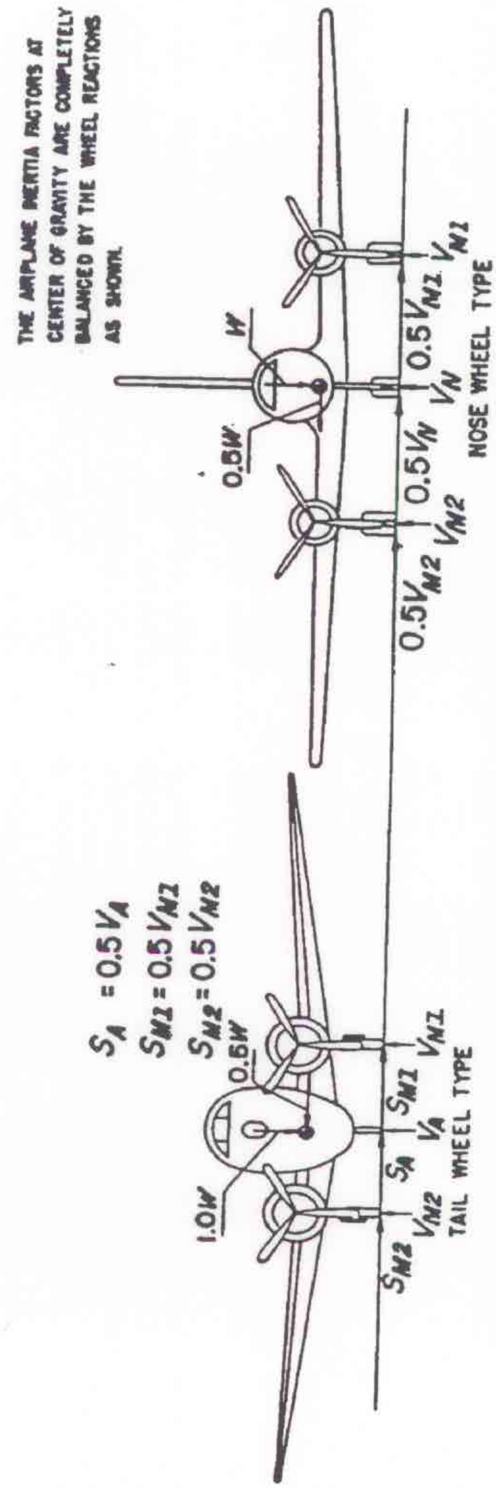


FIGURE 7—Ground turning.

APPENDIX A (Cont'd)

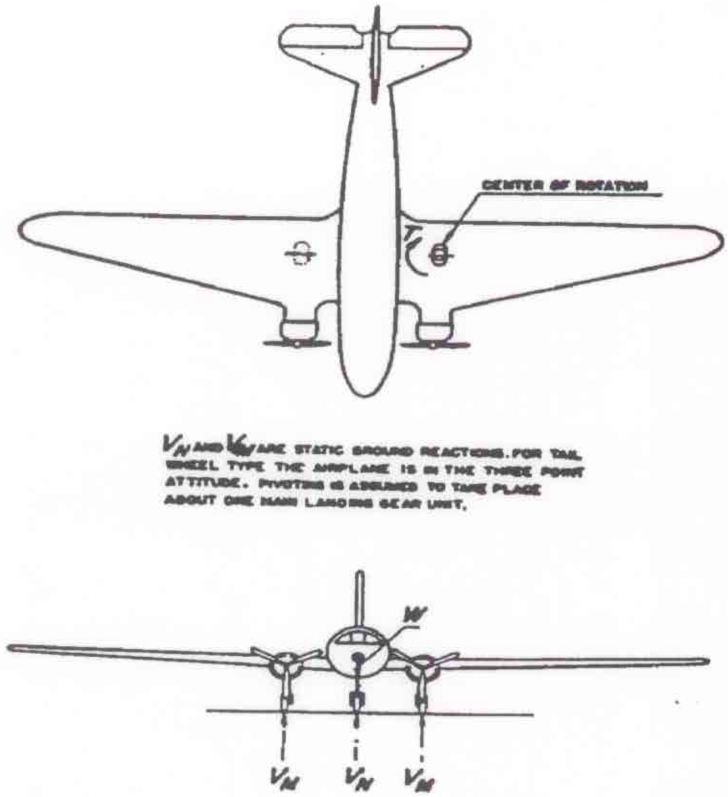


FIGURE 8—Pivoting, nose or tail wheel type.