AEROSPACE STANDARD

AS8860™ REV. B

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Superseding AS8860A

Landing Gear Structural Requirements as
Listed in the MIL-886X Series of Specifications

RATIONALE

This SAE Aerospace Standard (AS) has been revised to correct an error in Table 6, along with other minor errors that were introduced when the previous MIL-A-886X documents were digitized.

FOREWORD

The structural requirements for air vehicles, which include landing gear, were moved from the MIL-A-8860 through MIL-A-8870 into Air Force Guide Specification AFGS-87222; then to the joint service guide specs (JSSG-2002). This SAE Aerospace Standard (AS) is a listing of all the historical requirements from the original MIL specs that pertain to the landing gear and deceleration systems structural elements. This initial version is generally a direct copy of the original wording, tables, figures, etc., from the following military specifications: MIL-A-88608, MIL-A-8861B, MIL-A-8863C, MIL-A-88658, MIL-A-8866C, and MIL-A-8867C. The intent is to document and record all the historical landing gear structural requirements in one place.

TABLE OF CONTENTS

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1. SCOPE

This SAE Aerospace Standard (AS) contains landing gear strength and rigidity requirements which, in combination with other applicable specifications, define the structural design, analysis, test, and data requirements for fixed wing piloted airplanes. These requirements include, but are not limited to, the following:

a. General specifications:

1. The shock-absorption characteristics and strength of landing-gear units and the strength and rigidity of their control systems and of their carry-through structures. Requirements for wheels, tires, and brakes as they affect air vehicle ground loads are also included.

2. The strength of structures integral with the airplane provided for transmitting catapulting forces to the airplanes, and for engaging shipboard and shore-based arresting gear, and barricades.

3. The strength of anchor-line clamps, and the airplane strength for hoisting, jacking, towing, tie-down, and other ground- or deck-handling conditions.

4. Structural design, analysis, and test data.

5. Laboratory and flight tests performed to obtain information regarding strength rigidity and loads.

6. Definitions.

b. Landing and ground handling loads.

c. Ground loads for Navy acquired airplanes.

d. Miscellaneous loads.

e. Reliability requirements, repeated loads, fatigue and damage tolerance.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2175 Castings, Classification and Inspection of

AMS5343 Steel, Corrosion-Resistant, Investment Castings 16Cr - 4.1Ni - 0.28Cb (Nb) - 3.2Cu Homogenization, Solution, and Precipitation Heat Treated (H1000) 150 ksi (1034 MPa) Tensile Strength (17-4)

AMS-A-21180 Aluminum-Alloy Castings, High Strength

AMS-A-22771	Aluminum Alloy Forgings, Heat Treated
AMS-F-7190	Forging, Steel, For Aircraft/Aerospace Equipment and Special Ordnance Applications
AMS-QQ-A-367	Alluminum Alloy Forgings

2.1.2 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-A-21180	Aluminum Alloy Castings, High Strength (Cancelled—Superseded by AMS-A-21180)
MIL-A-22771	Aluminum Alloy Forgings, Heat Treated (Cancelled—Superseded by AMS-A-22771)
MIL-A-8860	Airplane Strength and Rigidity General Specification for Fixed Wing Piloted Airplanes
MIL-A-8861	Airplane Strength and Rigidity Flight Loads
MIL-A-8863	Airplane Strength and Rigidity Ground Loads for Navy Procured Airplanes
MIL-A-8865	Airplane Strength and Rigidity Miscellaneous Loads
MIL-A-8866	Airplane Strength and Rigidity Reliability Requirements, Repeated Loads, and Fatigue
MIL-A-8867	Airplane Strength and Rigidity Wound Tests
MIL-A-8868	Airplane Strength and Rigidity Data and Reports (Cancelled)
MIL-A-8869	Airplane Strength and Rigidity Special Weapons Effects
MIL-A-8870	Airplane Strength and Rigidity, Vibration, Flutter and Divergence
MIL-D-8706	Data and Tests, Engineering, Contract Requirements for Aircraft Weapon Systems (Cancelled)
MIL-D-8708	Demonstration Requirements for Airplanes
MIL-F-7190	Forgings, Steel, for Aircraft/Aerospace Equipment and Special Ordnance Applications (Cancelled—Superseded by AMS-F-7190)
MIL-F-83142	Forging, Titanium Alloys, for Aircraft and Aerospace Applications
MIL-HDBK-5	Aerospace Vehicle Structures, Metallic Materials and Elements for (Cancelled)
MIL-HDBK-17	Composite Materials Handbook
MIL-HDBK-23	Structural Sandwich Composites (Cancelled)
MIL-HDBK-310	Global Climatic Data for Developing Military Products
MIL-HDBK-2066	Catapulting and Arresting Gear Forcing Functions for Aircraft Structural Design
MIL-L-22589	Launching System, Nose Gear Type, Aircraft
MIL-STD-1374	Weight and Balance Data Reporting Forms for Aircraft (Cancelled—Superseded by SAWE-RP8)
MIL-STD-2066	Catapulting and Arresting Gear Forcing Functions for Aircraft Structural Design (Cancelled—Superseded by MIL-STD-2066)

MIL-STD-210 Climatic Extremes for Military Equipment (Cancelled—Superseded by MIL-HDBK-310)

MIL-STD-2175 Castings, Classification and Inspection of (Cancelled—Superseded by AMS2175)

MIL-T-6053 Test Impact, Shock Absorber, Landing Gear, Aircraft

MIL-T-81259 Tie-downs, Airframe Design, Requirements for

MIL-A-18717 Arresting Hook Installations, Aircraft

QQ-A-367 Aluminum Alloy Forgings (Cancelled—Superseded by AMS-QQ-A-367)

2.1.3 NAVAIR Publications

Naval Air Warfare Center - Aircraft Division (Code AB43300), 48298 Shaw Rd., Building 1461, Patuzent River, MD 20670-1900.

SAWE-RP8 Weight and Balance Data Reporting Forms for Aircraft (including Rotorcraft)

SD-24 General Specification for Design and Construction of Aircraft Weapon Systems

2.1.4 ANSI Accredited Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ANSI Y10.7 Letter Symbols for Aeronautical Sciences

2.1.5 NASA Publications

NASA Technical Services, NASA STI Program STI Support Services, Mail Stop 148, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-9658, Fax: 757-864-6500, http://ntrs.nasa.gov/.

NASA SP7 Dictionary of Technical Terms for Aerospace Use

2.1.6 Other Publications

Copies of these documents are available online at https://www.ngdc.noaa.gov/.

COSEA U.S. National Atmoshere, 1976

2.2 Definitions and Symbols

Documents COESA-Standard Atmosphere, MIL-STD-210 (cancelled—superseded by MIL-HDBK-310), and NASA SP7 (Dictionary of Technical Terms for Aerospace Use) on nomenclature and atmospheric properties will apply.

2.2.1 Configuration

2.2.1.1 BASIC

All devices such as flaps, slats, slots, cockpit enclosures, landing gear, speed limiting devices, and bomb bay doors shall be in their closed or retracted positions, unless such a device is a scheduled maneuvering surface.

2.2.1.2 DIVE-RECOVERY OR HIGH-DRAG

These are the same as the basic configuration, except that the speed limiting devices shall be in the fully open positions as limited by the available actuating force or power.

2.2.1.3 HIGH-LIFT

This is the same as basic configuration, except that any device used to increase lift shall be in the maximum lift position and alternatively in critical intermediate positions.

2.2.1.4 LANDING APPROACH

This is the same as basic configuration except that landing gear, landing flaps, and other devices that are extended or open for landing-shall be in the landing positions. If the positions of dive brakes or other devices can affect loads on doors, flaps, or control surfaces, then these devices shall be in their critical positions.

2.2.1.5 TAKEOFF

This is the same as basic configuration, except that the landing flaps and other devices that are extended or operated for takeoff shall be in the takeoff positions.

2.2.1.6 MODEL TYPES OF AIRPLANES

Airplane model types are defined as follows:

CB	Carrier Based
LB	Land Based
LBT	Land Based Trainer
STOL	Short Takeoff and Landing
VA	Attack airplane
VC	Cargo airplane
VE	Electronic airplane
VF	Fighter airplane
VO	Observation airplane
VP	Patrol airplane
VR	Reconnaissance airplane
VS	Antisubmarine airplane
VT	Trainer airplane
VU	Utility airplane
VW	Weather airplane

2.2.2 Design Weights

The gross weights to be used in conjunction with the loading conditions of MIL-A-8861, MIL-A-8863, MIL-A-8865, MIL-A-8866, MIL-A-8869, and MIL-A-8870 are the applicable gross weights defined in this section and all lesser gross weights, down to and including the minimum flying gross weight, at which critical loads are achieved.

2.2.2.1 MINIMUM FLYING GROSS WEIGHT

The minimum flying gross weight for all types of airplanes is composed of the weight empty, as defined in MIL-STD-1374 (cancelled—superseded by SAWE-RP8), plus the following:

a. 5% of internal fuel. (For flying qualities and for flutter, divergence and other aero elastic considerations, zero fuel should also be assumed.)

b. Oil consistent with 5% internal fuel.

c. Minimum crew.

d. No disposable armament or ammunition.

e. No other useful load item.

2.2.2.2 BASIC FLIGHT DESIGN GROSS WEIGHT

For Classes VT, VP, VS, VE, W-J, VC, and VR, this weight is the takeoff gross weight with basic mission useful load. For all other classes, the basic flight design gross weight is the weight of the airplane with basic mission useful load minus the weight of 40% of maximum internal takeoff fuel. These weights are applicable to flight loads.

2.2.2.3 MAXIMUM DESIGN GROSS WEIGHT

The maximum design gross weight is the weight of the airplane with maximum internal and maximum external load for which provision is required, with no reductions permitted for fuel used during taxi, warm-up, or climb-out. This weight applies to:

a. Ground maneuvering, ground handling, and miscellaneous ground loads.

b. Catapulting loads.

c. Takeoff loads.

d. In-flight refueling conditions.

e. Flight loads at takeoff gross weight.

f. Wheel jacking (for wing and fuselage jacking, if jacking is required for changing wheels and tires).

g. Flutter, divergence, and other aero elastic instability prevention, and vibration and aero acoustics.

2.2.2.4 CARRIER LANDING DESIGN GROSS WEIGHT

The carrier landing design gross weight for jet and turbo-propeller types is the weight of the fully loaded airplane (with missile, special weapons, guns and ammunition, and empty auxiliary fuel tanks), minus the weight of all other external stores and minus the weight of all usable fuel except that required for 20 minutes loiter at sea level with all engines operating, plus 5% takeoff fuel, plus fuel for 10 minutes operation with static normal thrust at sea level. For reciprocating engine types, this weight shall be as defined above except that the fuel removed shall be at least 60% of the takeoff usable fuel. For carrier-based primary or basic trainers, the carrier landing design gross weight is the weight of the fully loaded airplane. These gross weights are applicable to:

a. Carrier arrested landings.

b. Shipboard emergency recovery (barricade).

c. Shipboard securing.

2.2.2.5 LANDPLANE LANDING DESIGN GROSS WEIGHT

The landplane landing design gross weight applies to land-based types and to field landings of carrier-based types. For trainers, this weight is the maximum design gross weight of 2.2.2.3 minus the weight of external stores. For all other types, this weight is the maximum design gross weight of 2.2.2.3 minus the weight of external fuel and minus the weight of 60% internal fuel. These weights are applicable to:

a. Landing ashore, including field carrier landing practice (FCLP), of carrier-based airplanes.

b. Field arrested landings.

c. Jacking, other than wheel jacking.

2.2.2.6 MAXIMUM LANDPLANE LANDING DESIGN GROSS WEIGHT

The maximum landing design gross weight applicable to landings ashore is the weight of 2.2.2.3 less the following items:

a. Assist-takeoff fuel.

b. Droppable fuel and tanks.

c. Dumpable fuel.

d. Any other items expended during or immediately after takeoff as routine takeoff procedure.

2.2.2.7 HOISTING DESIGN GROSS WEIGHT

The hoisting design gross weight is the weight of the airplane with maximum internal and external load for which provision is required minus the weight of crew and external stores.

2.2.3 Speeds

Speeds are in knots based upon the international nautical mile.

2.2.3.1 CALIBRATED AIRSPEED (CAS)

The indicated airspeed corrected for installation and instrument errors.

2.2.3.2 EQUIVALENT AIRSPEED (EAS)

The true airspeed multiplied by the square root of the air density ratio at the altitude concerned.

2.2.3.3 INDICATED AIRSPEED (IAS)

The reading of the airspeed indicator uncorrected for instrument, installation, and compressibility errors.

2.2.3.4 TRUE AIRSPEED (TAS)

The speed at which the airplane moves through the air surrounding it.

2.2.3.5 CATAPULT END AIRSPEED

The catapult end airspeed as defined in the detailed specification.

2.2.3.6 LEVEL FLIGHT MAXIMUM SPEED (VM)

The maximum speed attainable at the basic flight design gross weight in the basic configuration in level flight with maximum available thrust, including use of afterburners (and rocket thrust augmentation if applicable).

2.2.3.7 LIMIT SPEED (FLIGHT) (VL)

For the basic and high drag configurations, the maximum attainable speed commensurate with the operational use of the airplane considering shallow and steep dive angles, thrust, operation and non-operation of speed brakes, and inadvertent upsets from gusts.

2.2.3.8 LIMIT SPEED (LANDING AND TAKEOFF) (VL)

The maximum speed for the landing approach and takeoff configurations. This speed is the highest of: 120% of the maximum speed attainable with use of afterburner, if applicable, without exceeding 200 feet altitude after takeoff from runway or carrier deck, over the period of time required to convert from the takeoff to the basic configuration; 120% of the best climb speed at sea level; or 1.75VS in the basic configuration. The gross weight shall be the maximum design gross weight.

2.2.3.9 MINIMUM APPROACH SPEED (V_{PA} MIN)

The minimum approach speed as defined in the detailed specification.

2.2.3.10 STALLING SPEED (VS)

The minimum speed for level flight at sea level in the basic configuration with zero thrust.

2.2.3.11 STALLING SPEED WITH POWER (V_{SPA})

The minimum speed for level flight at sea level in the landing configuration with the power or thrust required to provide satisfactory wave-off characteristics.

2.2.4 Miscellaneous

2.2.4.1 ABRUPT DISPLACEMENT OF CONTROLS

Where these specifications require an abrupt displacement of controls by application of a specified force or displacement in a specified time interval, it is not required that hinge moments, power or boost system maximum rates, or maximum displacements be exceeded.

2.2.4.2 CRITICAL LOADING CONDITION

The design loading condition for which margins of safety indicate the structure is most likely to fail.

2.2.4.3 LOAD FACTOR N

The ratio of a given load to the weight with which the load is associated. If employed, a subscript designates the direction of the load.

2.2.4.4 LIMIT LOAD OR LIMIT LOAD FACTOR

A load or load factor that establishes a strength level for the design of the airplane and components and is the maximum load factor normally authorized for operations. The concept of limit load with a corollary ultimate factor of safety is not employed for landing loads in this specification.

2.2.4.5 ULTIMATE LOAD OR ULTIMATE LOAD FACTOR

Limit load or limit load factor multiplied by a factor of safety, usually 1.5.

2.2.4.6 FAILING LOAD

Load at which failure occurs.

2.2.4.7 PROOF LOAD

Arbitrary load, applied to provide test substantiation of strength and rigidity of a magnitude less than that which would induce permanent deformation or damage to the structure.

2.2.4.8 WING LIFT

Magnitude, usually expressed as percent of airplane weight supported by the wing at landing touch down. Magnitude of load applied to the wing in drop tests.

2.2.4.9 C_L MAX

Maximum aerodynamic lift coefficient.

2.2.4.10 Vv OR SINKING SPEED

Vertical velocity of airplane at landing touchdown.

2.2.4.11 Vv MAX

Specified maximum vertical velocity at landing touchdown.

2.2.4.12 W

Specified weight of the airplane for a test condition.

2.2.4.13 SPRINGY TAB

A tab, which is restrained directly from the control surface by a spring such that during flight the tab deflection is directly proportional to the aerodynamic forces exerted upon it.

2.2.4.14 PILOT LANDING AID TELEVISION (PLAT) HEAD

Protrusion above the carrier deck, on the center line of the landing area that houses the television camera of the pilot landing aid television (PLAT) system.

2.2.4.15 FSD

Full-scale development.

2.2.4.16 MIL-A-8860 SERIES

This series of specifications includes MIL-A-8860, MIL-A-8861, MIL-A-8863, MIL-A-8865, MIL-A-8866, MIL-A-8867, MIL-A-8868 (cancelled), MIL-A-8869, and MIL-A-8870.

3. REQUIREMENTS

3.1 General Specifications (Originally in MIL-A-8860B)

3.1.1 General

The requirements of this specification shall apply to fixed-wing piloted and fixed wing unpiloted airplanes unless specific deviations are granted by the contracting activity. These requirements are selected for general usage on the basis of the particular type of airplane being designed and of the performance of the basic, alternate, and training missions relative to that design. The construction of the airplane shall conform to the manufacturing and process requirements of SD-24, as amended, to provide airplanes, which comply with the design requirements of this specification, MIL-A-8861, MIL-A-8863, MIL-A-8865, MIL-A-8866, MIL-A-8867, MIL-A-8868 (cancelled), MIL-A-8869, and MIL-A-8870.

3.1.1.1 Limit Loads

The load factors and load formulas that are noted in any portion of this specification and the referenced specifications of Section 2 represent limit loads, unless otherwise specified.

3.1.1.2 Ultimate Loads

Except for loading conditions for which specific ultimate loads are delineated, the ultimate loads are obtained by multiplying the limit loads by the ultimate factor of safety. Failure shall not occur at the design ultimate load. The ultimate factor of safety to be used for the design of the structure shall be 1.50, except that in certain cases for considerations of added safety, rigidity, quality assurance, and wear, additional strength or multiplying factors of safety are specified.

3.1.1.3 Deformations

The cumulative effects of elastic, permanent, and thermal deformations that result from application of repeated loads, and from application of design limit loads, shall not:

a. Interfere with the mechanical operation of the airplane.

b. Adversely affect its aerodynamic characteristics.

c. Require repair.

d. Require replacement of parts.

This requirement applies both to flight articles and to structural test articles when loaded statically or dynamically, and when loaded in increments of load or sinking speed as specified for structural tests. This requirement may be waved with specific approval by the contracting activity.

3.1.1.4 Load and Temperature Redistribution

If thermal, elastic and aero elastic deformations of the structure occur as a result of limit flight and ground loading conditions, the external load and temperature distributions shall include the effect of those deformations. Load redistribution's and magnitudes shall include those caused by thermally induced deformations, air load redistribution's caused by surface temperature changes, rigidity changes resulting from thermal stresses and other thermally induced effects, and aero elastically induced deformations.

3.1.1.5 Superimposed Loads

Residual loads remaining after extending or retracting landing gear and flaps, or caused by rigging loads of magnitudes specified by the contractor in the aircraft maintenance instructions, and pre-loads such as those occurring when sway-bracing is fitted, shall be combined with the loads resulting from the pertinent loading conditions. Loads acting upon the aircraft structure as a result of the operation of armament and equipment, blasts, impingement of engine exhaust, and full engine power shall be combined with the loads acting on the aircraft structure at rest on the ground and the loads acting on the aircraft structure during flight for the basic and high drag configurations and during landings, as applicable.

3.1.1.6 Transient Response

The magnitudes and distributions of loads shall include the effects of the dynamic response of the structure resulting from the transient or sudden application of load. Examples include the dynamic response resulting from abrupt maneuvers, landings, taxiing, braking wheels in air, sudden release of catapult holdback force, catapulting, response to catapult-tow forces, arresting, oscillations of arresting gear deck pendants, slipping of arresting hooks on deck pendants, and assisted takeoff-unit loads.

3.1.1.7 Thermal Considerations

The design of the airplane shall include provision for the effects of: heating incidental to operation of power plants and other heat sources from within the airplane including consideration for engine reheat operation. Also, operation in ambient atmospheres consistent with both the cold and hot atmosphere temperature-versus-altitude relationship defined in MIL-STD-210 (cancelled—superseded by MIL-HDBK-310) and extrapolated to cover operational altitudes; aerodynamic heating; and heating encountered during shipboard catapult launch operation, both forward and aft of the raised jet blast deflector (JBD). These effects shall include steady state and transient excursions of the airplane into and out of regimes of aerodynamic heating consistent with its anticipated employment. The design shall include provision for the cumulative effects of the time-temperature-load history of the airplane for its planned service life.

3.1.1.8 Authorized Changes

Government-responsible changes, authorized subsequent to the establishment of the original contract requirements, shall not increase or decrease the appropriate structural design gross weights unless specifically stated by the change. Strength is required in the changed airplane for all loads, load factors, accelerations, and loading conditions which result from application of the structural design requirements of the detail specification to the changed airplane at the specified structural design gross weights.

3.1.1.9 Fail-Safe

The complete airframe shall be designed such that failure of a single structural element will neither cause catastrophic failure of the airplane nor prevent safe continuance of its flight to a planned destination or to an aircraft carrier. Redundancy, alternate load paths and systems, and other fail-safe principles are required to achieve this capability. For this fail-safe requirement, the airframe is defined as including all of the structural elements of major systems and all of the structural connecting and supporting elements of power plant installations. The failure of these elements can cause uncontrollable motions of the airplane within the speed limits for its structural design, prevent the airplane from achieving speeds sufficiently low to effect a safe landing, and reduce the ultimate factor of safety for flight design conditions from 1.5 to a value less than 1.0.

3.1.2 Design Strength

For all design conditions, strength shall be provided so that material yield allowable stresses will not be exceeded at limit loads and material ultimate allowable stresses will not be exceeded at ultimate loads. For repeated-load and fatigue conditions, strength shall be provided so that the fatigue life of the structure will equal or exceed the specified life, including specified scatter factors.

3.1.2.1 Design Data and Allowable Materials Properties

Design data and properties of materials shall be obtained from MIL-HDBK-5 (cancelled) and MIL-HDBK-23 (cancelled) or from other sources subject to acceptance by the contracting activity. SD-24 contains requirements on fibrous composites, which shall be used in lieu of MIL-HDBK-17, and contains additional requirements for the use of high strength steels. Allowable properties based on static and fatigue test data other than handbook data may be used subject to acceptance by the contracting activity. Properties other than those contained in these handbooks shall be substantiated and analyzed with procedures used for corresponding data in the appropriate handbook, except as otherwise indicated for fibrous composites in the applicable requirements of SD-24. Where it is necessary to develop data and properties for metallic and nonmetallic materials and composites, the test materials, processes, and composites shall be those intended for use in production airplanes. Minimum guaranteed properties obtained from the foregoing sources shall be used for design purposes. In MIL-HDBK-5 (cancelled), “A” values shall be used in the design of structural components whose failure would result in loss of the airplane or loss of control of the airplane, and shall be used also for the design of structural components not subjected to structural tests. The “B” values of MIL-HDBK-5 (cancelled) may be used, subject to the approval of the contracting activity, for the design of structural components whose failure would cause a load redistribution which does not cause failure resulting in the loss of the airplane or control. Eighty-five percent of the average values or of the “B” values, whichever is less, shall be used in the design of the composite structural components. For the substantiation of structural integrity by analytical calculations, the nominal gage of material shall be the average gage between tolerances.

3.1.2.1.1 Castings

Castings shall be classified and inspected in accordance with MIL-STD-2175 (cancelled—superseded by AMS2175). Aluminum castings in structural applications shall conform to the requirements of MIL-A-21180 (cancelled—superseded by AMS-A-21180) except that design data and allowable material properties shall be used as specified in 3.1.2.1. Calculated margins of safety using "A" values from MIL-HDBK-5 (cancelled) shall be not less than 0.33 for ultimate calculations. AMS5343 shall be used for 16-4 PH castings. Castings shall not be permitted for any structural application unless specified in the detail specification.

3.1.2.1.2 Forgings

Structural forgings shall be designed and produced in accordance with MIL-F-7190 (cancelled—superseded by AMS-F-7190) for steel, MIL-A-22771 (cancelled—superseded by AMS-A-22771) and QQ-A-367 (cancelled—superseded by AMS-QQ-A-367) for aluminum, and MIL-F-83142 for titanium, as applicable. Grain flow of the forging material shall be such that no undesirable characteristics are inherent in the forging.

3.1.2.2 Properties of Material for Design Purposes

The selection of the physical properties used in structural design shall include a consideration of all factors, which affect the allowable strength. Such factors include, but are not limited to: grain direction; manufacturing processes; nature of static, repeated, transient, vibratory, and shock loads; stress concentration areas; factors or conditions that are conducive to stress corrosion problems; operating environment consistent with overall planned usage; and effects of operating environment on residual physical properties.

3.1.2.2.1 Grain Direction

The allowable stresses used in the design shall not exceed those applicable to the grain directions resulting from fabrication. So far as it is practical, structural members shall be so designed that the directions of the critical stresses are favorably related to the directions of the grain resulting from forging, rolling, extruding, and other fabrication processes.

3.1.2.2.2 Temperature Effects

The selection of allowable stresses used for design shall include consideration of reductions of material strength, both at expected maximum elevated temperatures and at ambient temperatures which follow exposure to elevated temperatures. This includes maximum and minimum exposure temperatures, duration of exposure including cumulative effects, rates of load application, and magnitude of load. Allowable stresses shall be selected on the basis of creep, thermal expansion, joint-fastener relaxation, and elevated-temperature fatigue.

3.1.2.2.3 Vibration Effects

The effects of sustained vibration and repeated loads upon the strength of the material shall be considered in selecting allowable strength values for design.

3.1.3 Establishment of Criteria

It is intended that structural criteria be established on a rational basis. Criteria delineated in this specification and the other specifications in the MIL-A-8860 series shall be used unless other criteria are determined to be more rational, or unless the criteria are found to be inapplicable because of the peculiarities of the aircraft under consideration. New criteria or methods which are proposed by the contractor shall be rational, and shall be submitted to the Naval Air Systems Command for approval prior to use in structural design computations.

3.1.4 Landplane Landing and Ground Handling Loads

Landplane landing and ground handling loads for landplanes shall be in accordance with 3.3. These sections were originally developed in MIL-A-8863.

3.1.5 Additional Loads for Carrier-Based Landplanes

The additional loads for carrier-based landplanes shall be in accordance with 3.4. These sections were originally developed in MIL-A-8863.

3.1.6 Miscellaneous Loads

Miscellaneous loading conditions shall be In accordance with 3.5. These sections were originally developed in MIL-A-8865.

3.1.7 Repeated Loads and Fatigue

Requirements for prevention of fatigue and repeated load damage shall be in accordance with 3.6. These sections were originally developed in MIL-A-8866.

3.1.8 Ground Tests

The static, dynamic, repeated load, and other ground tests required for proof of structural design shall be as specified in 3.7. These sections were originally developed in MIL-A-8867.

3.1.9 Design Requirements for Tie-Downs

Airframe structural requirements for tie-downs shall be in accordance with MIL-T-81259.

3.2 Flight Loads (Originally in MIL-A-8861B)

3.2.1 Applicability

Except as otherwise specified, the requirements specified herein apply to the complete airplane structure. Within the specified ranges of center of gravity (CG) position, strength is required for the specified values of the parameters and any lesser or intermediate values which may be critical and which are practicable of attainment.

3.2.1.1 Gross Weight

The design gross weights for the flight loads and loading conditions specified herein shall be all gross weights from the minimum flying gross weight to the maximum design gross weight. For weights up to the basic flight design gross weight, strength shall be provided for all conditions for the values of parameters specified for the basic flight design gross weights. At higher weight, strength shall be provided for by maintaining a constant mass times load factor (nzW) product, except that the load factor shall be not less than that specified in Table 1 for the maximum design gross weight.

Table 1 - Symmetrical flight parameters (see 3.2.1.1)

Class of Airplane	Symmetrical Flight Limit Load Factor: Basic Flight Design Gross Weight, Max	Basic Flight Design Gross Weight, Min at V_H	All Gross Weights, Min at V_L	Maximum Design Gross Weight, Max	Maximum Design Gross Weight, Min at V_H	Limit Speed V_L	Time for Abrupt Control Displacement t_1, seconds
1	2	3	4	5	6	7	8
VF, VA	7.50	-3.00	-1.00	5.50	-2.00	a, s	0.2
VT	7.50	-3.00	-1.00	4.00	-2.00	s	0.2
VO	6.00	-3.00	0	3.00	-1.00	p, e	0.3
VU	4.00	-2.00	0	2.50	-1.00	c, l	0.3
VS	3.50	-1.00	0	2.50	0	f, i, e	0.4
VW, VR, VP	3.00	-1.00	0	2.50	0	d	0.4

Mission symbols for class of airplane:

A Attack
F Fighter
O Observation
P Patrol
R Reconnaissance
S Antisubmarine
T Trainer
U Utility
W Weather

3.2.1.1.1 Height Distributions

The weight distributions for the basic, high drag, drive recovery, landing approach, and takeoff configuration shall be all those that are critical as a result of all practicable symmetrical and asymmetrical distributions. It shall be determined by consideration of all possible arrangements of variable, disposable, and removable items, including external stores, for which provision is required (including ballast required for structural demonstration tests) within the airplane strength and aerodynamic controllability limits.

3.2.1.2 Center of Gravity (CG) Positions

The design CG positions at each weight and each aerodynamic configuration (position of variable geometry surfaces, size and location of external stores) shall include a tolerance beyond the actual maximum forward and actual maximum-aft positions. Included shall be all weights and aerodynamic configurations which are attainable as a result of all practical symmetrical and asymmetrical distributions of useful load up to the maximum design weight, airplane attitudes and accelerations, fuel sequencing, and airplane flexibility. This tolerance shall be +15% of mean aerodynamic chord (MAC) or 15% of the distance between the most forward and most aft actual values from the complete CG envelope, whichever is greater. This tolerance shall be applied so as to move the design centers of gravity forward of the actual most forward position and aft of the actual most aft position. For airplanes with variable sweep wings, the reference MAC shall be that for the wings landing or takeoff position. Fuel transfer failures which impact the CG location such that it removes the air craft out of the allowable ground operational envelope shall be considered.

3.2.1.2.1 Ballast Support Structure

When sufficient ballast support structure strength cannot be identified and located for ballast weight distribution necessary to meet the specified CG requirements with the specified tolerances, the contractor may use a finite element distribution of the ballast weight throughout the forward or aft portions of the fuselage, as appropriate. When a finite element distribution is used, strength provisions shall be made and appropriately defined for the support-structure(s) for the ballast weight(s) to allow for a 1.0% MAC tolerance on the maximum forward and aft design CG. This deviation shall apply for the design of ballast weight support structure only.

3.2.1.3 Positions of Landing Gear and Doors

Loads on landing gear and doors shall be those resulting from the loading conditions of this specification for the fully opened, intermediate positions, and fully closed positions up to the limit speed for which operation or holding of these components is required. If the airplane's aerodynamic characteristics are significantly affected by the positions of these items, the loads on the airplane shall be those resulting with these items fully opened as well as fully closed, considering each item individually.

3.2.1.4 Deformation of Internal and External Access Closures

Load carrying and nonload carrying internal and external access covers (including doors, panels, hatches, cowlings and other coverings), locking mechanisms, such as landing gear up locks and down locks, access closure latches, and access closure fasteners shall not deflect adversely from their intended positions at loads up to the design limit load for each loading condition for which limit loads are specified. Unlocking, unlatching, or release of access closures, and unlocking or unfastening of mechanisms, shall not occur at loads up to and including design ultimate for loading conditions for which limit or ultimate loads are specified, and at loads up to and including maximum design loads for landing. Access closures shall remain in place under ultimate flight loads if 10% of the fasteners are unfastened or if one latch or quick release fasteners selected at random on each edge of an access closure secured by these fasteners or latches is unfastened. No deflection will occur by which Ram air effects would cause increased loads.

3.3 Landing and Ground Handling Loads (Originally in MIL-A-8862)

3.3.1 General Requirements

When specified performance parameters are insufficient to produce a state of dynamic equilibrium in the aircraft and its components, additional forces are to be applied to achieve equilibrium. These additional forces shall come from a method approved by the procuring activity or by other rational means. The landing load conditions specified herein are applicable to aircraft having conventional landing gear arrangements where each main, nose, or tail gear consists of a single strut gear with single or multiple wheels. When unconventional landing gear arrangements with single or multiple strut nose gear, multiple strut main gears, and other auxiliary gears are used, rational criteria meeting the requirements of this specification shall be prepared for approval by the procuring activity.

3.3.1.1 Weight Distributions and Center of Gravity (CG) Positions

Weight distributions and CG positions used for design shall be all those that are critical and shall include all practicable arrangements of variable and removable items for which provision is required. External store configurations as specified in the airplane detail specification shall be included. The possible weapon release configuration of all specified store configuration must be considered for asymmetric landing condition.

3.3.1.2 Engine Thrust

For landing conditions, engine thrust shall be from zero thrust to maximum available.

3.3.1.3 Fixed, Removable, and Disposable Mass Items

Load factors shall be those required at the specified design weights commensurate with the dynamic response of the structure.

3.3.2 Landing

Strength is required for field landings and for laboratory tests that simulate these landings, see also 3.7. These sections were originally developed in MIL-A-8867.

3.3.2.1 Landing-Loads Analysis

The landing-loads design analysis may be a rational analysis that is acceptable to the procuring activity. As an alternate, the methods of Section 4, except for rough terrain, will be acceptable for design analysis. The vertical component of the ground reaction shall be assumed to develop with time in accordance with Section 4 unless otherwise substantiated in a manner acceptable to the procuring activity. The effects of strut friction and rational strut extension shall be included in the analysis. Conditions to be considered shall be all those critical throughout the landings and shall include at least the following:

a. Maximum spin-up load in combination with the vertical load occurring at the instant of maximum spin-up load.

b. Maximum spring-back load in combination with the vertical load occurring at the instant of maximum spring-back load.

c. Maximum vertical load in combination with the drag load occurring at the instant of maximum vertical load. The drag load shall be not less than one-quarter of the maximum vertical load.

3.3.2.2 Spin-Up and Spring-Back Loads

Spin-up and spring-back loads shall be those developed when the airplane lands on surfaces that develop a sliding friction coefficient of 0.55 between the tire and surface and any lesser values of sliding friction coefficient that are critical. The touchdown speeds shall be 120% of the minimum speed for level flight with landing gear and other devices extended or open in the landing position. (Note: For low inflation pressure may consider 0.8 as maximum coefficient of friction for limit load, and use a ramp function to apply this load over a 0.2 second period. For cross wind considerations may need to use 3 degrees drift angle in determining these loads.)

3.3.2.3 Tire Pressure

Tire pressure shall be the maximum recommended in the inspection and maintenance instructions.

3.3.2.4 Strut Servicing

The air pressure shall be all values between 90% and 110% of the value recommended in the erection and maintenance instructions. The oil volume shall be all values within 90% and 110% of the recommended volume except that if 110% is not attainable, the maximum attainable value shall apply.

3.3.2.4.1 Variation in Servicing of Landing Gear and Tail Bumper

For all takeoff and landing conditions, the shock-strut air or gas pressure, shock-strut oil level, and tire pressure shall be all combinations of the following variations:

a. 15% above and 15% below the recommended air or gas pressure with the shock strut in the fully extended position.

b. 15% above and 15% below the recommended oil volume. If the 15% above variation cannot be attained, the maximum attainable variation shall be used.

c. 20% above and 20% below the recommended tire pressure.

These combinations shall include servicing instructions and ambient temperatures (cold day to tropical day) effects.

3.3.2.5 Wing Lift

The wing lift shall be equal to the airplane weight.

3.3.2.6 Overload Landings

The airplane design shall be such that the design landing-gear reactions are not exceeding when the airplane is landed at a weight of 1.15 times the landplane landing design weight but with an airplane sinking speed of $\sqrt{(1/1.15)}$ times (approximately 0.9325 times) the specified maximum design limit sinking speed.

3.3.2.7 Design Limit-Sinking Speed

Combinations of design weight and sinking speed shall be in accordance with Table 2. For reserve energy absorption, it shall be shown by analysis that the landing gear will not fail during a simulated landing at a descent velocity of 125% of design limit sinking speed at landing design weight. The analysis shall be performed in accordance with MIL-T-6053.

Table 2 - Design limit-sinking speed (see 3.3.2.7)

	Landplane Landing Design Weight	Maximum Landing Design Weight
Primary and Basic Trainers	13.0 FPS	8.5 FPS
All Other Classes	10.0 FPS	6.0 FPS

3.3.2.8 Symmetrical Landings

The airplane shall land in the attitudes shown in Table 3 at the design limit sinking speed.

Table 3 - Symmetrical landing attitudes (see 3.3.2.8)

Number	Attitude	Description	Applicable to
1	Three-point	Main and nose wheels in contact with the ground	Nose-wheel types
2	Two-point	Main wheels in contact with the ground, with the nose wheel just clear and not carrying the load throughout the landing	Nose-wheel types
3	Tail down	Main wheels in contact with the ground with the airplane at angle of pitch for maximum lift or at maximum angle permitting ground clearance of all parts of the airplane, except if fitted with tail bumper, the tail bumper shall be completely compressed, whichever is the lesser angle	Nose-wheel types
4	Three-point	Main and tail wheels in contact with the ground	Tail-wheel types
5	Level	Longitudinal axis of the airplane level	Tail-wheel types

3.3.2.9 Drift Landing

The airplane shall be in the two point or level attitude with only the main wheels on the ground. The vertical reaction on each main gear shall be equal to one-half of the maximum vertical reaction obtained from two-point and level symmetrical landings. The side load on one main gear shall consist of an inward acting load of 0.8 times the specified vertical reaction at that gear. The side load at the other main gear shall consist of an outward acting load of 0.6 times the specified vertical reaction at that gear. Both side loads shall act simultaneously at the ground and be resisted by inertia of the airplane. Drag loads shall be zero.

3.3.3 Ground Operation

Acceptable runway roughness shall be in accordance with the data specified in Figures 1 and 2.

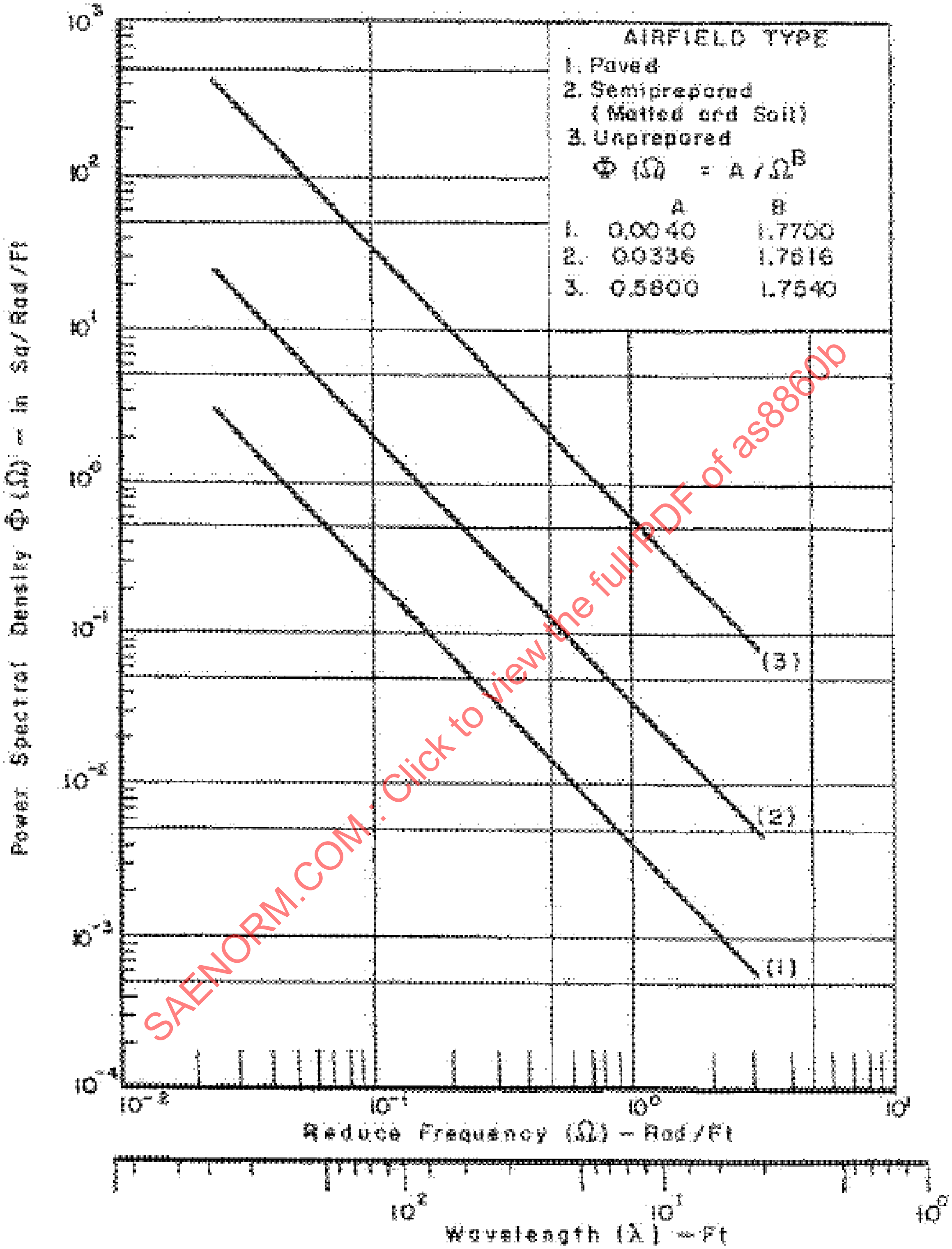


Figure 1 - Power spectral density levels for paved, semi-prepared, and unprepared airfields (see 3.3.3 and 3.3.3.4.1)

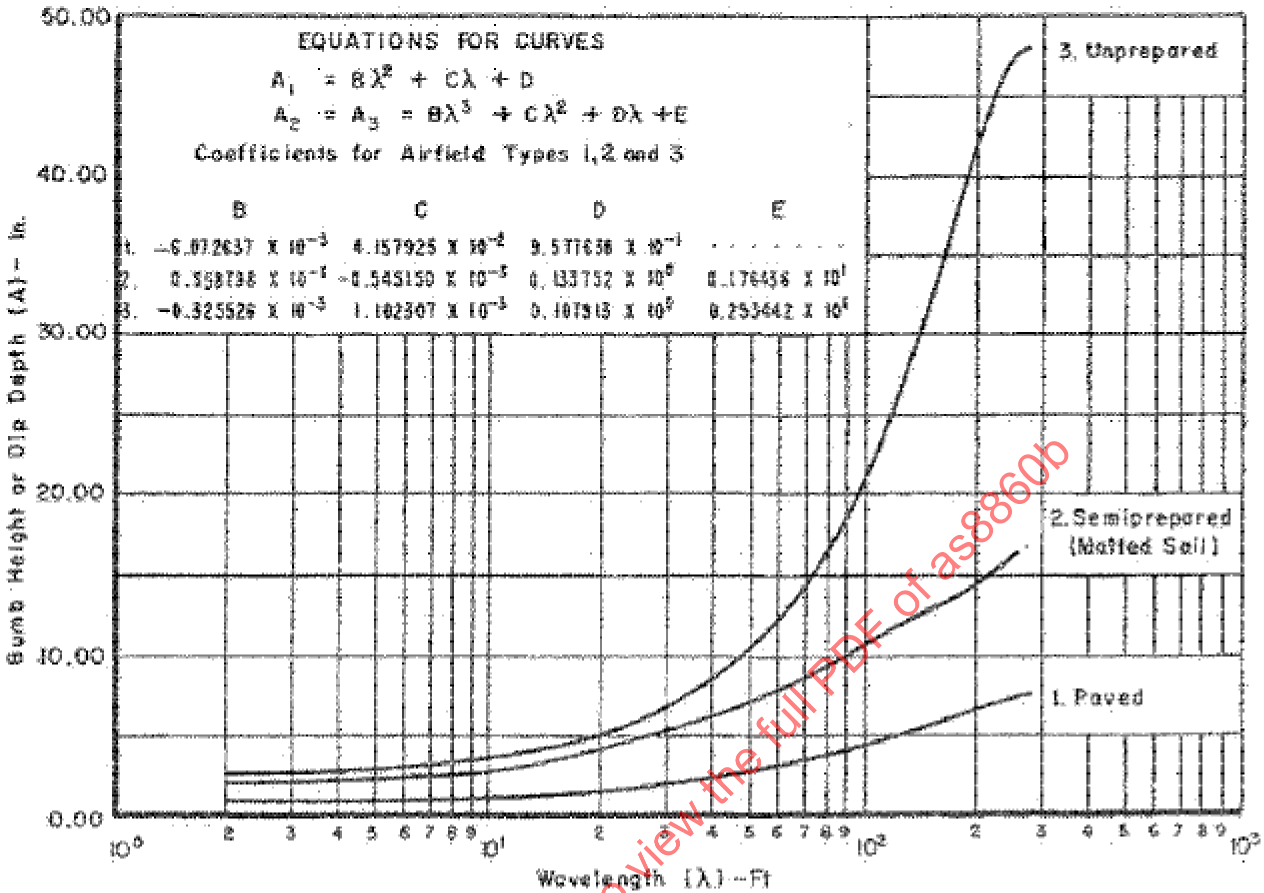


Figure 2 - Discrete 1-cosine bump heights or cosine-1 dip depths for paved, semi-prepared, and unprepared airfields (see 3.3.3 and 3.3.3.4.1)

3.3.3.1 Braking

With the landing gear and tires in their static positions and the airplane moving in a straight-ahead direction, the maximum drag reaction at each wheel equipped with brakes in contact with the ground shall be 0.8 times the vertical reaction at each wheel. For bare soil fields, at each unbraked wheel the drag reaction shall be 0.2 times the vertical reaction while the braked wheel shall remain at 0.8 times the vertical reaction. (Note: For dynamic simulations, consider ramping up to 0.8 within 0.5 second. If brake torque control/limiter is used, apply the rate from the limiter to the simulation instead of the ramp time.)

3.3.3.1.1 Two-Point Braked Roll

For nose-wheel-type airplanes, the airplane shall be in a two-point attitude. For tail-wheel types, the airplane reference axis shall be horizontal. The vertical load factor acting at the airplane CG shall be derived by rational analysis from applicable runway roughness parameters. Alternately, it shall be acceptable to use CG load factors of 1.2 at the landplane landing design weight and 1.0 at the maximum design weight. Drag reactions specified in 3.3.3.1 shall be combined with the vertical reaction.

3.3.3.1.2 Three-Point Braked Roll

For nose-wheel-type airplanes only, the airplane shall be in the three-point attitude. The vertical load factor acting at the airplane CG shall be derived by rational analysis from applicable runway roughness parameters. Alternately, it shall be acceptable to use CG load factors of 1.2 at the landplane landing design weight and 1.0 at the maximum design weight. Drag reactions specified in 3.3.3.1 shall be combined with the vertical reaction.

3.3.3.1.4 Unsymmetrical Braking

For nose-wheel airplanes only, the airplane shall be in the three-point attitude. The vertical load factor at the airplane CG shall be 1.0. The main gear on one side of the airplane shall be braked and developing a drag load as specified in 3.3.3.1. The airplane shall be placed in static equilibrium with side loads at the main and nose gear reacting the yaw moment, and with vertical loads at the main and nose gear reacting the pitching moment. The forward acting load at the airplane CG shall be equal to the summation of the main gear drag loads. The side load at the CG shall be zero. The side load at the nose gear shall be acting at the ground and need not exceed the vertical reaction multiplied by a coefficient of friction of 0.8. The nose gear shall be aligned in a fore-and-aft direction.

3.3.3.1.5 Reverse Braking

For nose-wheel-type airplanes, the airplane shall be in the two-point attitude. For tail-wheel type airplanes, the airplane shall be in the three-point attitude. The vertical load factor at the CG is 1.0. A forward acting drag reaction as specified in 3.3.3.1 shall be combined with the vertical reactions.

3.3.3.2 Turning

The airplane in the three-point attitude shall execute steady turns by the following means:

a. Unsymmetrical thrust or nose gear steering.

b. Unsymmetrical thrust or nose gear steering with symmetrical braking.

c. Differential braking.

The ratio of side load to vertical load shall be limited to 0.5 on any wheel and the sum of the side loads shall equal 0.5W except that this value need not exceed a value that would result in overturning. For braking conditions, the drag load on the braked wheels shall be such that the vector sum of the drag load and side load will not exceed 0.8 of the vertical load. The vertical load may be devised by a rational analysis of standard runway roughness parameters or, alternately, by use of an airplane CG load factor of 1.2 at landplane landing design weight and 1.0 at the maximum design weight. For bare soil fields, at each unbraked wheel the drag reaction shall be 0.2 times the vertical reaction. The vertical load factor shall be derived by a rational analysis of the applicable runway roughness data.

3.3.3.3 Pivoting

With brakes locked on the wheels of the gear unit about which the airplane is rotating, the airplane shall pivot about one wheel, or in the case of multiple wheels, about the centroid of the contact area of all wheels in the gear unit. The vertical load factor at the CG shall be 1.0 and the tire coefficient of friction shall be 0.8.

3.3.3.4 Taxiing

The airplane shall be designed for the loads resulting from a dynamic analysis of taxiing over runway profiles specified herein. The effects of weight, CG position, mass distribution, ground speed, and landing gear characteristics shall be included.

3.3.3.4.1 Dynamic Taxi

Dynamic taxi analysis shall be performed for the airframe using both a continuous runway profile and discrete step and (1-cosine) bump and depression inputs. The applicable runways of Figures 1 and 2 shall be used in the analysis at all weights up to and including the maximum takeoff weight as defined by the contract document. The effect of aerodynamic lift and engine thrust shall be included commensurate with the aircraft capabilities. Pitch, translation, and roll rigid body modes and all significant symmetric and anti-symmetric flexible modes for the airframe and landing gear shall be used. The gear's complete nonlinear air spring and hydraulic damping simulation for the oleo and tire shall be included. The aircraft response to the following inputs shall include all combinations of aircraft velocity (V) and contour wavelengths (λ):

a. Runway profile elevations used in the continuous analysis shall have power spectral densities (PSDs), which equal or exceed the spectra shown on Figure 1.

b. The terrain roughness contours used to define the airfield surfaces for the discrete input shall be step inputs up to 1 inch for paved, 2 inches for semi-prepared surfaces, step inputs up to 4 inches for unprepared surfaces, and single and two (1-cosine) shaped bump and depressions. The maximum amplitudes for the bump and depression inputs shall be those of the applicable surfaces on Figure 2. The aircraft shall approach the contours at all critical angles from 0 to 90 degrees to the crest line of the contours.

3.3.3.4.2 2.0 g Taxi

Alternately, with the approval of the procuring activity, the sum of the vertical loads acting at the ground shall be 2.0W where Wis the airplane weight and encompasses the design weight, CG, and mass distribution envelope of the air vehicle. The total load of 2.0W shall be reacted at each mass item. For the nose gear design, 3.0W shall be used instead of 2.0W. No wing lift shall be considered for the 2.0W taxiing condition.

3.3.3.5 Special Tail-Gear Conditions

The airplane shall be in the three-point attitude with the tail gear swiveled 90 degrees from the trailing position, or the maximum angle obtainable, whichever is less. A side load, acting at the axle of the tail gear, equal to the maximum static vertical reaction shall be combined with the maximum static vertical reaction. If the tail gear is equipped with a shimmy damper, lock, or steering mechanism, the side load shall be applied both in the swiveled and trail positions with the side load acting at the ground for the trail position.

3.3.3.6 Tail-Gear Obstruction

The airplane loads shall be those resulting from dropping the airplane on its tail gear rotationally through 5 inches while the tail gear is swiveled 180 degrees from its trail position. The oleo strut of the tail gear shall be compressed to 50% of full stroke or statically, whichever is less, and restrained from further extension but not restrained from compression. The surface on which the tail gear is dropped shall be inclined up and aft at a 0.25 slope.

3.3.3.7 Arresting Gear

The following criteria shall apply to those systems wherein the procuring activity has specified the requirement for an arresting gear. The type of ground arrestment system shall be specified by the procuring activity. The magnitude, directions, and distribution of external and internal loads shall be all those that occur throughout the arresting operation. These loads shall properly take into account the time histories of the arresting forces and the resultant response of the airplane structure, with appropriate consideration of the characteristics of tire, shock absorbing, and damping devices. The arresting loads shall act in the plane of the arresting cable and shall act through the center of the hook point radius at the cable groove through points laterally displaced to the right. And, alternately, to the left of this point a distance equal to half the hook point radius at the cable groove. The side load resulting from the eccentricity shall act to increase the side load at the hook attachment to the fuselage. The design loads shall be based on the aircraft maximum design weight at V_{SL}.

3.3.4 Handling Conditions

3.3.4.1 Towing

The airplane shall be in the three-point attitude. The resultant of the vertical reactions at the wheels shall be equal to the weight of the airplane and shall pass though the CG. The towing conditions shall be as specified in Table 4. The values of T used in obtaining the towing loads specified in Table 4 are those defined on Figure 3. These towing loads shall act parallel to the ground. The side component of the tow load at the main gear shall be reacted by a side force at the static ground line at the wheel to which the load is applied. In cases where the load directions specified cannot be obtained because of the airplane configuration or because of the type of auxiliary gear swiveling provided, the maximum attainable angle of specified load that will not result in side load on the auxiliary wheel shall apply. Additional loads necessary for equilibrium, considering each separately, shall be as follows:

a. Inertia of the airplane.

b. If a tow point is at or near a main gear unit, a force acting at the axle of the wheel nearest the tow point in a direction opposite to the component of the tow load, parallel to the plane of symmetry, equal in magnitude to this component, or the vertical reaction at a main gear (whichever is less), combined with internal loads required for equilibrium. If a tow point is at the plane of symmetry, a force acting at the axle of the auxiliary wheel, in a direction opposite to the direction of the tow load, equal in magnitude to this tow load or the vertical reaction at the auxiliary wheel (whichever is less), combined with internal loads necessary for equilibrium.

Table 4 - Towing conditions (see 3.3.4.1. and 3.4.10.1)

Condition	Towing Load: Direction from Forward, degrees	Towing Load: Magnitude	Rotation of Auxiliary Wheel Relative to Normal Position	Tow Point
1	0	0.75T	--	At or near each main gear
2	±30			
3	180			
4	±150			
5	0	T	0	At auxiliary gear or near plane of symmetry
6	180			
7	0	T	180	
8	180			
9	Maximum angle	0.5T	Maximum angle	
10	Maximum angle plus 180			
11	Maximum angle	0.5T	Maximum angle plus 180	
12	Maximum angle plus 180			

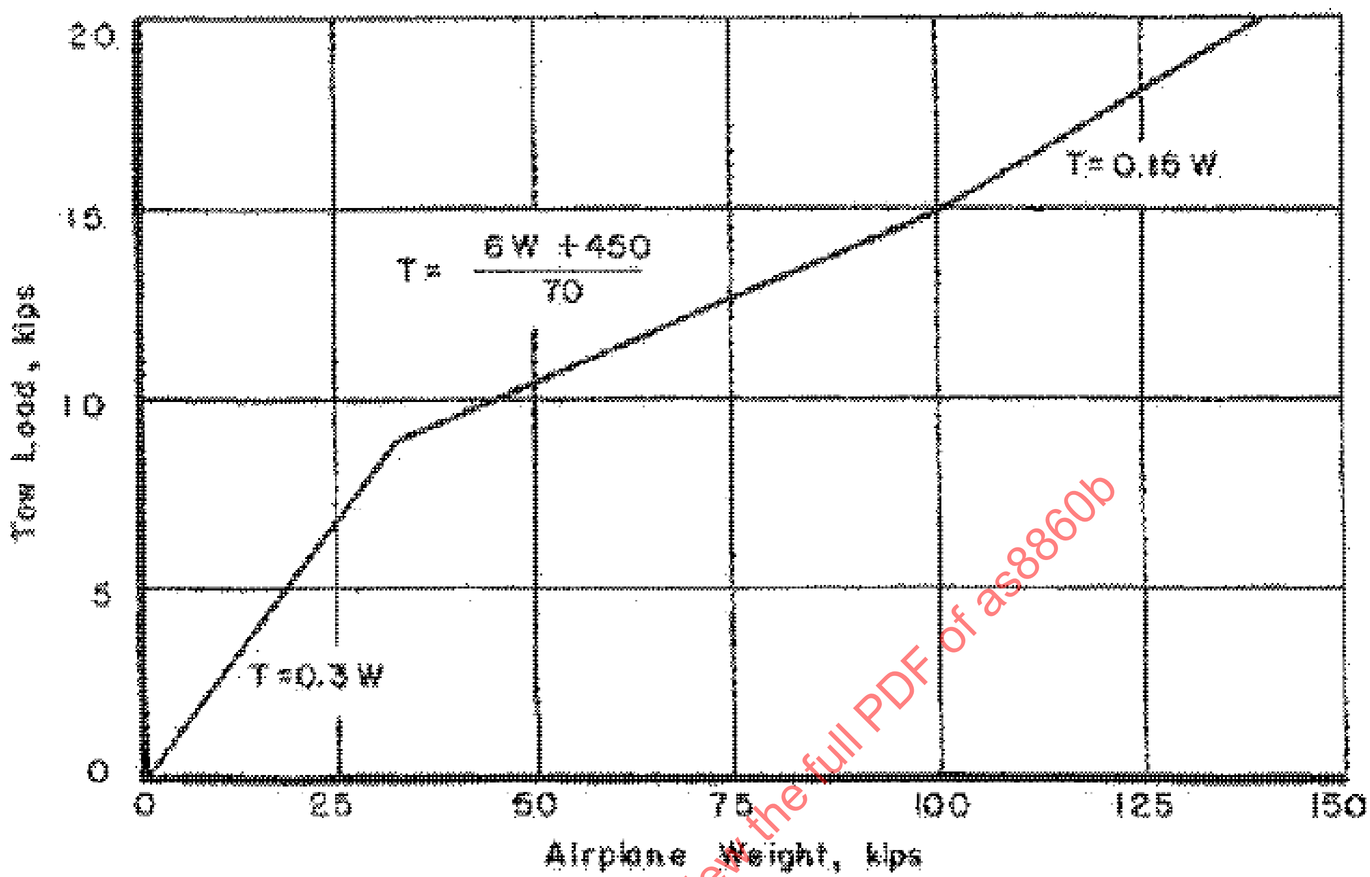


Figure 3 - Tow loads (see 3.3.4.1 and 3.4.10.1)

3.3.4.2 Jacking

Jacking loads shall be in accordance with Table 5. The vertical load shall act singly and in combination with the horizontal load acting in any direction. The horizontal loads at the jack points shall be so reacted by internal forces that there will be no change in the vertical loads at the jack points.

Table 5 - Jacking loads (see 3.3.4.2 and 3.4.10.2)

Component	Landing Gear Three-Point Attitude	Other Jack Points Level Attitude
Vertical	1.35 F	2.0 F
Horizontal	0.4 F	0.5 F

F is the static vertical reaction at the jack.

3.3.4.3 Hoisting

When the airplane is in the level attitude, the vertical component shall be $2.0W_H$.

3.3.5 Miscellaneous

3.3.5.1 Rebound

With the landing gear fully extended and not in contact with the ground, a rebound load factor of not less than 20.0 shall act on the unsprung weight of the landing gear along the line of motion of the strut as it approaches the fully extended position. If the landing gear design is such that the rebound load factor is expected to be in excess of 20.0, the anticipated value shall be used.

3.3.5.2 Extension and Retraction of Landing Gear

The following loads shall act separately and simultaneously with the landing gear in each critical position between fully extended and fully retracted:

a. Aerodynamic loads up to the limit speed specified for the takeoff and landing configurations.

b. Inertia loads corresponding to the maximum and minimum symmetrical limit load factors specified for flight in the takeoff and landing configurations.

c. Inertia loads resulting from accelerations of those parts of the landing gear that move relative to the airplane during extension or retraction. The accelerations shall be those resulting from use of maximum available power of the extension and retraction system.

d. Gyroscopic loads resulting from wheels rotating at peripheral speed equal to 1.3 times the stalling speed in the takeoff configuration and retracting or extending at the maximum rates attainable.

3.3.5.3 Braking Wheels in Air

The airplane shall be airborne in the takeoff configuration with the landing gear in any position between fully extended and fully retracted. The airplane vertical load factor shall be 1.0. The airspeed and wheel peripheral speed shall be 1.3 times the stalling speed in the takeoff configuration. The maximum static braking torque shall be applied from zero to the maximum static value in 0.2 second.

3.3.5.4 Load Distribution on Multiple Wheels

The loading conditions specified in 3.3.5.4.1 through 3.3.5.4.5 are applicable to airplanes with landing gear units having multiple wheels.

3.3.5.4.1 Symmetrical Distribution

The wheel loads shall be equally distributed among the wheels on the same axle.

3.3.5.4.2 Unequal Tire Inflation

The wheel loads resulting from the conditions specified in 3.3.2.8, 3.3.2.9, 3.3.3.1.1, 3.3.3.1.2, 3.3.3.2, 3.3.3.4, and 3.3.4.1 and from the symmetrical, unsymmetrical, and drift landings on each landing gear unit having multiple wheels on the same axle shall be so distributed that the loads on the wheels on one side will be increased by 20%, and the loads on the wheels on the other side will be deceased 20%. Except that for drift and turning conditions, the 20% increased loads need not be applied the inboard wheels with the inward acting side load, nor to the outboard wheels with the outboard acting side load.

3.3.5.4.3 Flat-Tire Landing

The ground reaction resulting from the landing conditions, reduced to 60% of the specified loads on each axle, shall be distributed to the wheels having inflated tires.

3.3.5.4.4 Flat-Tire Taxiing

The ground reaction resulting from the taxiing conditions, reduced to 50% of the specified loads on each axle, shall be distributed to the wheels having inflated tires.

3.3.5.4.5 Flat-Tire Towing

The ground on each axle resulting from the specified towing conditions shall be distributed to the wheels having inflated tires.

3.3.5.5 Tail Bumper

The airplane shall be rolling backward at 5 mph and the maximum braking load shall be suddenly applied. The tail bumper load shall be as determined by a dynamic analysis of the motion of the airplane. For landings, the attitude at touchdown shall be attitude number 3 of Table 3. The loads applied to the bumper shall be those determined from a study of the airplane's motion.

3.3.6 Ski Loads

These loads are applicable to ski loads in snow, mud, and on ice.

3.3.6.1 Landing Conditions

The sinking speeds, weights, wing lift, oleo extensions, and specified types of design landing conditions of 3.2 shall apply.

3.3.6.1.1 Coefficient of Friction

The coefficient of friction shall be 0.25.

3.3.6.2 Ground Handling Conditions

3.3.6.2.1 Takeoff and Landing Run

The airplane shall be in the three-point attitude. The vertical load factor at the gear shall be 1.0 at the maximum design weight with a linear variation of load factor to 1.2 at the landplane landing design weight. The coefficient of friction shall be 0.40. Pitching moment shall be balanced by rotational inertia.

3.3.6.2.2 Frozen Ski

The airplane shall be in the three-point attitude with each ski alternately assumed fixed. The loads and torques shall be those resulting from application of maximum engine power or thrust available at -60 °F to the engine(s) on the side opposite from the fixed ski. The loads shall be reached as follows:

a. By main gear ski and nose gear ski.

b. By main gear ski.

3.3.6.2.3 Steering

The nose-gear ski shall resist full steering torque.

3.3.6.3 Load Distribution (All Skis)

3.3.6.3.1 Vertical and Side Loads

Vertical and side loads resulting from the conditions of 3.3.6.2.1 and 3.3.6.2.2 shall be distributed as shown on Figure 4. (Side load shall be applied to either tire or ski where applicable.)

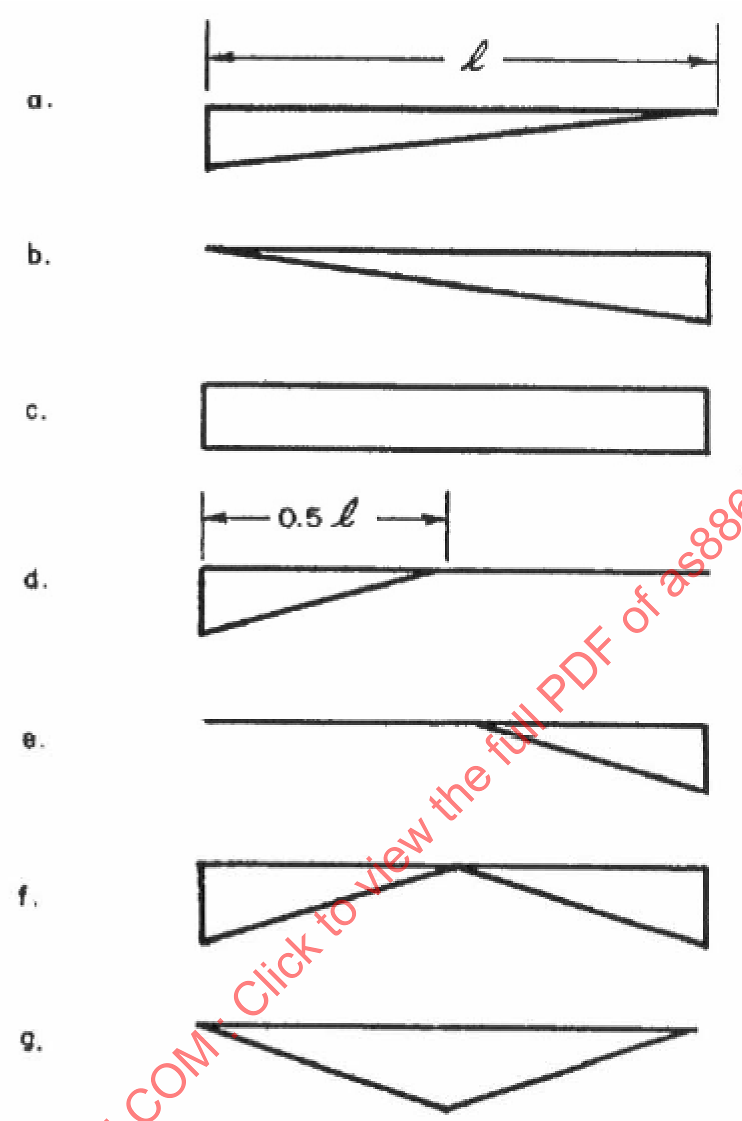


Figure 4 - Tire or ski load distributions (see 3.3.6.3.1 and 3.4.11.4.a. and b.)

3.3.6.3.2 Tread Wise Load

The tread wise load shall be distributed alternately to the inboard and outboard side of the ski as shown on Figure 5, except that for rolled attitude landings, the distribution shall be 3 to 1 .

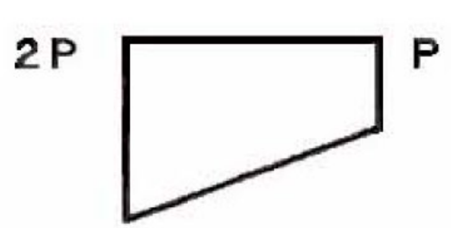


Figure 5 - Tread wise distribution (see 3.3.6.3.2 and 3.4.11.4.b)

3.3.6.3.3 Drag Load

The drag load shall be distributed uniformly along the base of the ski. Side load and drag need not be combined.

3.4 Ground Loads for Navy Acquired Air Vehicles (Originally in MIL-A-8863C)

3.4.1 Height Distribution and Center of Gravity (CG) Positions

Weight distribution and CG positions shall be all those that are critical as defined by all possible arrangements of variable and removable items for which provisions are required including all combinations of partially and fully loaded multiple bomb racks, internal fuel tanks, and external fuel tanks. In addition, these arrangements shall include:

a. The maximum internal fuel loading that can be attained within the applicable design weight with all store stations empty of pylons, adapters, launchers, racks, and stores, and with other useful loadings such as passengers, cargo, guns and ammunition, etc., removed.

b. All asymmetrical store loading configurations which result in the lesser of the following rolling moments:

   1. 1.2 times the maximum rolling moment attainable by loading each-store station, in turn, with all possible combinations of pylons, adapters, launchers, racks, and stores specified to be carried by that store station in the detail specification. As each store station is loaded all other store stations shall be empty of adapters, launchers, racks, stores, etc.

   2. Maximum attainable by loading only one side of the airplane with the other side empty of adapters, launchers, racks, stores, etc.

c. A tolerance of +15% of the MAC or 15% of the distance between the most forward and the most aft actual values from the complete CG envelope, whichever is greater. This tolerance shall be applied so as to move the design CG forward of the nest forward position and aft of the most aft position. For airplanes with variable sweep wings, the reference MAC shall be for the wings in the landing and takeoff position.

3.4.2 Limit and Ultimate Loads

With the exception of barricade loads, all loads specified herein are limit loads. The barricade loads are ultimate loads.

3.4.3 Balance of Forces

For conditions for which parameters or values of parameters are not completely specified to the extent necessary for the airplane and its components to be in complete translational and rotational equilibrium, additional forces, which are determined by a rational method, shall be assumed to act in a manner such that the acceleration of the airplane's component masses are balanced by the externally applied forces. For the loading conditions specified in 3.4.7 (except 3.4.7.1.6), 3.4.8.1 (except 3.4.8.1.5 and 3.4.8.1. 7), 3.4.11.1, 3.4.11.2, and 3.4.11.5, the externally applied forces and airframe responses shall be determined by dynamic/flexible airframe analyses.

3.4.4 Arresting and Catapulting Forces

For carrier-based airplanes, the horizontal components of the arresting hook and catapult tow forces shall be derived from MILSTD-2066 (cancelled—superseded by MIL-HDBK-2066) or additional data provided in the detail specification for all the arresting gears and catapults with which the airplane is required to operate.

3.4.5 Variation in Servicing of Landing Gear and Tail Bumper

For all takeoff and landing conditions the shock-strut air or gas pressure, shock-strut oil level, and tire pressure shall be all combinations of the following variations:

a. 15% above and 15% below the recommended air or gas pressure with the shock strut in the fully extended position.

b. 15% above and 15% below the recommended oil volume. If the 15% above variation cannot be attained, the maximum attainable variation shall be used.

c. 20% above and 20% below the recommended tire pressure.

These combinations shall include servicing instructions and ambient temperatures (cold day to tropical day) effects.

3.4.6 Field Roughness Requirements

For field takeoffs from, and landings on, (a) unprepared sod, clay, or dirt fields; (b) semi-prepared matted sod, clay, or dirt fields; and (c) paved runways, the roughness or range of terrain contours and soil-bearing strength for design shall be as defined on Figure 6. The soil-bearing strength is given in terms of the California Bearing Ratio (CBR) and shall be constant up to a depth of at least one foot. For both the takeoff and landing roll-out requirements, the ground roughness contours for design shall be one minus cosine shaped undulations of constant wave length. Such undulations shall have all combinations of heights and length specified on Figure 6. The shape of the undulations in the lateral direction shall be held constant. The roughness for each type of airplane shall be as follows:

a. Paved runways: Carrier based (CB), land based (LB), land based trainer (LBT), and short takeoff and landing (STOL).

b. Semi-prepared fields: CB and STOL.

c. Unprepared fields: STOL.

d. For ski airplanes, snow and ice covered semi-prepared fields shall apply.

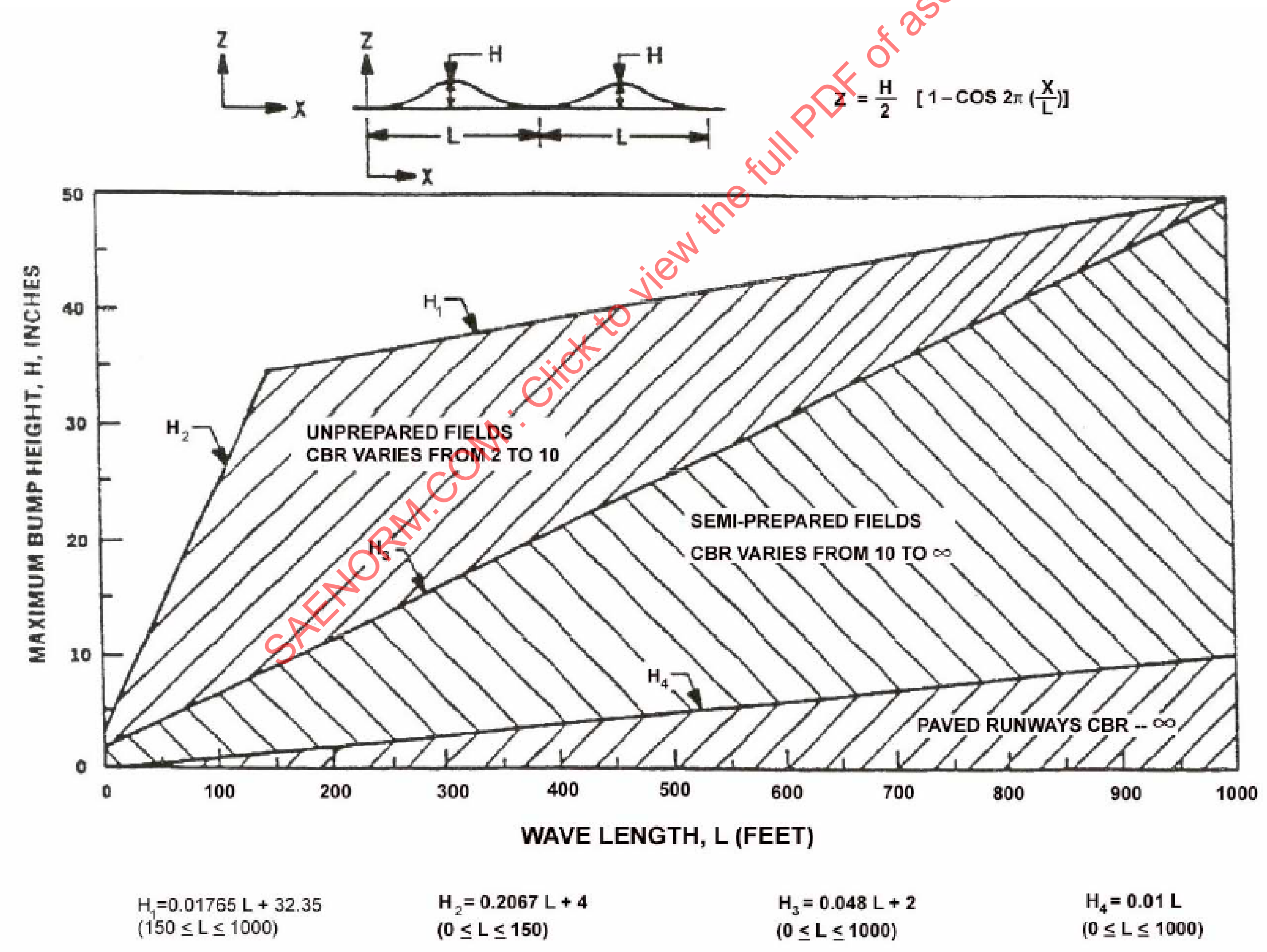


Figure 6 - Ground roughness for landing and takeoff (see 3.4.6)

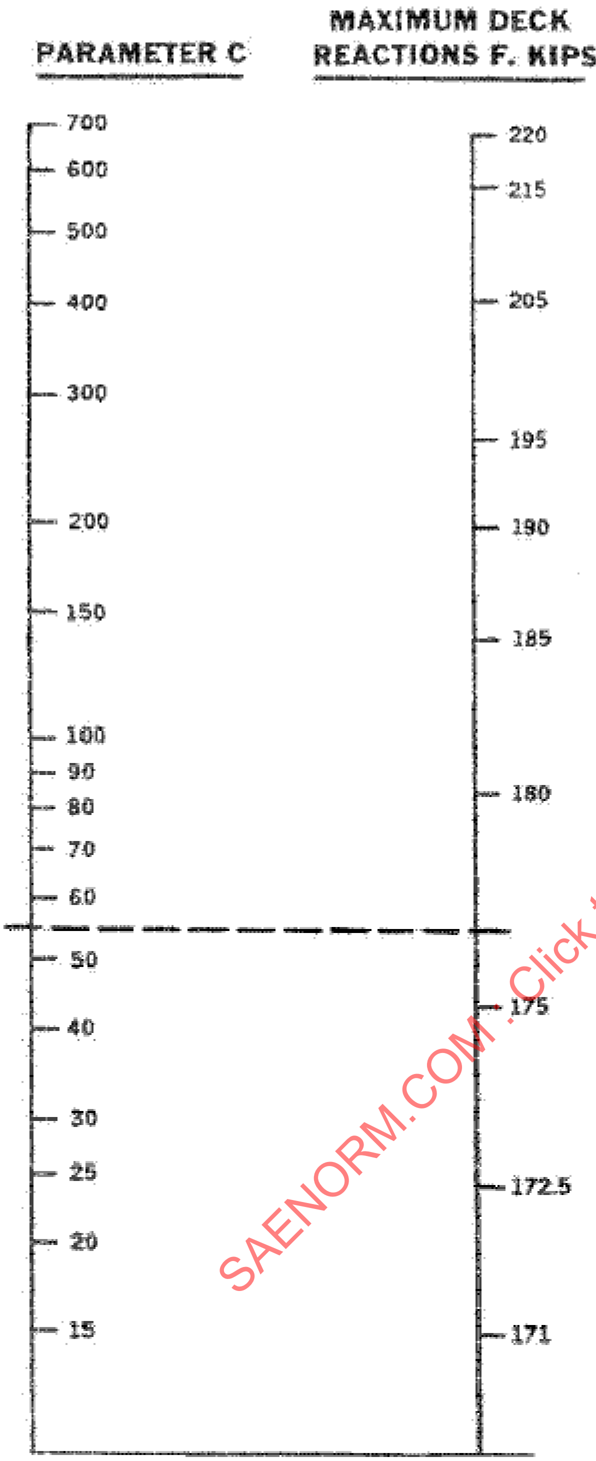
3.4.7 Takeoff

3.4.7.1 Catapult Takeoff

Applicable to carrier based airplanes. The design loads for airplane accessories for catapult launching shall be in accordance with this section.

3.4.7.1.1 Maximum Deck Reactions

The airplane design shall be such that the maximum landing gear vertical load for each landing gear unit separately, which results from the conditions of 3.4.7.1, shall not exceed the allowable deck reactions determined from Figures 7 and 8.



Definitions

P = Rated load of tire, LBS

p = Operational pressure of tire, PSI

r = Rated pressure of tire, PSI

$C = K \frac{P}{p}$

$K = (0.7 \frac{p}{r} + 0.3)^{1/2}$

F = Maximum deck reaction from nomogram

Example-Single Wheel — Find the maximum permissible landing gear deck reaction F for an airplane having a single wheel landing gear with a 30 x 7.7 tire for which:

P = 21,300 LBS

p = 400 PSI

r = 360 PSI

$K = (0.7 \times \frac{400}{360} + 0.3)^{1/2} = 1.04$

$C = 1.04 \times \frac{21,300}{400} = 55$

Max. Permissible Reaction (KIPS)

F = 176.5

Example-Dual Wheels — For dual wheels with the same size tires spaced 14 inches on centers (b') divide the reaction F obtained from this nomogram by the dual wheel load factor K_e from Figure 3:

b' = 14" (Spacing of dual wheels)

K_e = .925

$F' = \frac{176,500}{.925} = 191,000$ LBS

Figure 7 - Maximum allowable vertical deck reaction for a landing: catapult area (see 3.4.7.1.1)

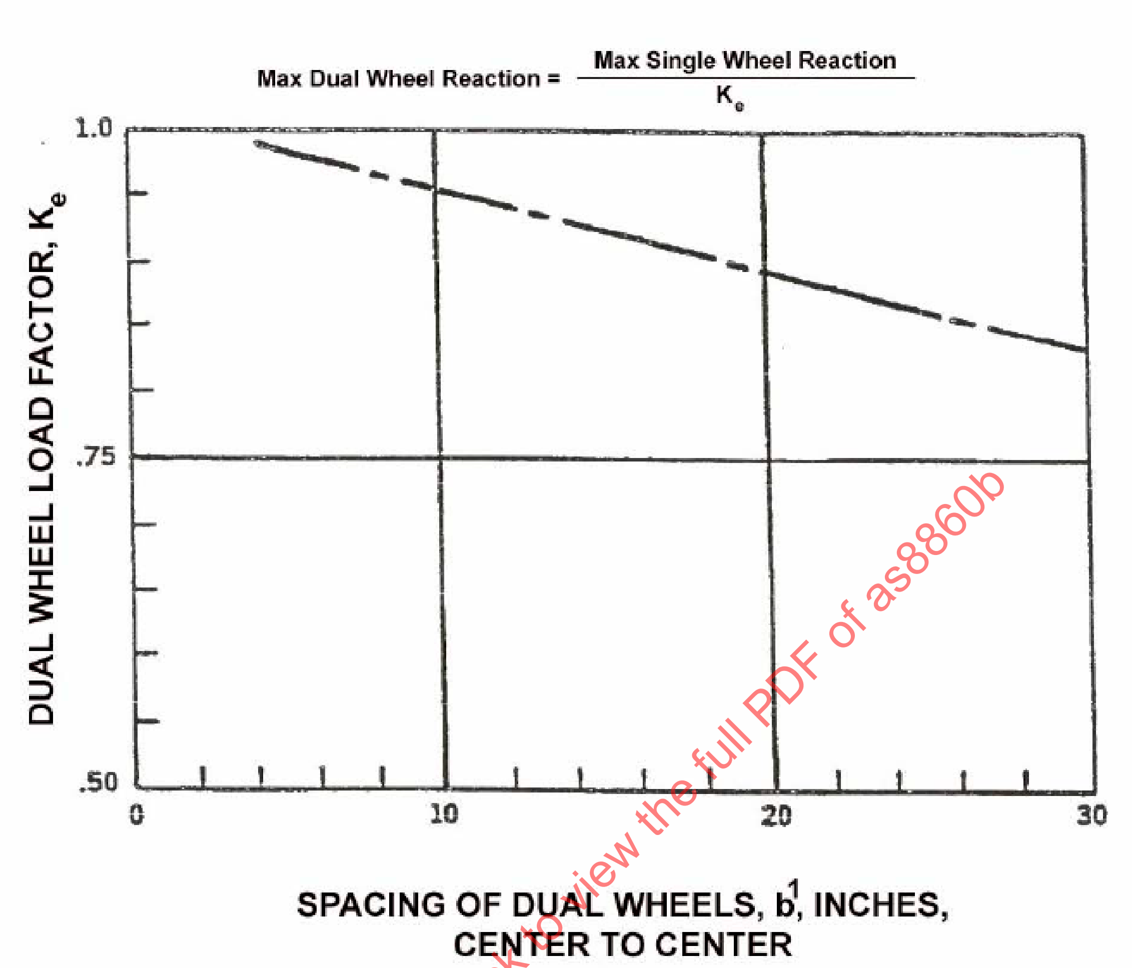


Figure 8 - Dual wheel load factors (see 3.4.7.1.1)

3.4.7.1.2 Holdback Loads

The holdback loads shall be as specified herein.

3.4.7.1.2.1 Buffing

The hold back bar shall engage the slider of the catapult deck hardware at all critical angles resulting from the spotting requirements of MIL-L-22589. During the buffer stroke, a tension load equal to the load H in 3.4.7.1.2.3 shall be applied to the airplane holdback fitting.

3.4.7.1.2.2 Tensioning

The airplane shall be secured to the catapult shuttle by the launch bar and to the deck through the deck ramp structure by the holdback bar, in all critical attitudes, which occur during the tensioning operation. The horizontal component of the tensioning force applied by the catapult shuttle shall be 5500 pounds and shall be reacted by the holdback assembly.

3.4.7.1.2.3 Release

The airplane shall be in all attitudes resulting from the release operation. The deflection of tires and shock struts shall correspond to the forces acting. The tension load H, in pounds, at the airplane holdback fitting shall be:

$$H = 1.65[\frac{T+5500+0.2W}{COS\ THETA}] + 0.06R \quad \text{(Eq. 1)}$$

where:

T = maximum thrust, with thrust-augmentation devices operating, if airplane is so equipped, including surge effects from ignition, at sea level on a cold day, LB

W = maximum design weight, LB

THETA = angle between holdback axis and deck at release

The load in the launch bar shall be that required for equilibrium. The side loads shall be those resulting from the maximum possible misalignment of the launch system resulting from the off-center positions of MIL-L-22589.

R = minimum release element load, LB

3.4.7.1.2.4 Minimum Release Load

The minimum release load R, in pounds, for the release device shall be:

$$R = 1.35[(T + 5500 + 0.2W)/(COS\ THETA)] \quad \text{(Eq. 2)}$$

The symbols are defined in 3.4.7.1.2.3. The allowable tolerance is +6 and -0% of the load R.

3.4.7.1.3 Maximum Catapult Tow Force

For weights ranging from the maximum design weight to the weight required for the primary mission, the catapult tow force shall be the maximum attainable at capacity operation from all catapults from which the airplane is required to operate. For lesser weights, the tow force shall be reduced to that corresponding to the maximum load factor of 3.4.7.1.4. The mean values of the tow forces of 3.4.4 shall be used to determine limit tow force.

3.4.7.1.4 Maximum Catapult Horizontal Load Factor

The maximum quasi-static horizontal load factor of the airplane CG shall be the sum of the maximum attainable tow force corresponding to the primary mission weight plus the maximum horizontal component of thrust divided by the airplane weight for the primary mission. For design of airframe structure, mass items and stores, the maximum horizontal load factor resulting from catapult launch shall be that which is derived from the flexible dynamic analysis.

3.4.7.1.5 Catapult Run

The catapulting loads resulting from all attainable attitudes throughout the catapult run and the off-center positions of MIL-L-22589 shall be determined for all catapulting forces. The engine thrust shall be: (1) the maximum thrust with thrust augmentation devices operating if the airplane is so equipped; (2) intermediate thrust; and (3) maximum continuous thrust. The effects of pretension loads, holdback release catapult stroke run, deck run, shuttle release, weight, and CG variations shall be included.

3.4.7.1.6 Loading Conditions Prior to Catapulting

The loads of this section shall apply to the complete airplane while aft of the JBD and while maneuvering or waiting to be catapulted.

3.4.7.1.6.1 Loads

The forces acting on the airplane shall be those resulting from the maximum attainable pressure in the hydraulic folding system, or maximum attainable system force If other than a hydraulic system is used, in combination with the following:

a. Inertial forces, directed downward normal to the deck that result in a load factor equal to 1.5.

b. Inertial forces, directed downward normal to the deck, that result in a load factor equal to 1.5, and alternately 0.5, combined with aerodynamic forces which result from a steady wind over the deck having velocities from zero to 60 knots from all horizontal directions, plus the superposition of engine exhaust and/or thrust environment aft of the JBD defined as follows:

 1. The airplane positioned at all angles relative to the catapult track from a heading of directly into the JBD to +90 degrees of this heading and at all positions aft of the JBD such that the nearest portion of the airplane is at all points laterally along the J BD. It's also positioned so that all horizontal distances aft of J BD of 8 feet and greater, as measured from a vertical plane through the hinge line of the JBD.

 2. Another airplane positioned on the catapult in battery position at all off-center positions of MIL-L-22589, with all engines running at maximum power (afterburners and/or other thrust augmentation devices operating). This other airplane shall be the present airplane or shall be selected from the current inventory of carrier-based airplanes, whichever produces the most critical velocity and temperature effects on the airplane aft of the JBD.

3.4.7.2 Field Takeoff

Applicable to all types of airplanes. The ground roughness shall be as specified in 3.4.6. During each takeoff, the airplane shall accelerate, using MIL power and, alternately, maximum takeoff power, to takeoff speed over all combinations of bump heights and wavelengths and soil bearing strength.

3.4.8 Landing

Strength is required for landing Impact and landing roll-out on paved runways, semi prepared fields, unprepared fields and carrier decks and for arrested landings on carriers and on expeditionary airfields.

3.4.8.1 Landing Conditions

3.4.8.1.1 Multivariate Distribution of Landing Impact Conditions

The design envelope of initial landing conditions shall include the variables defined in Table 6 for each type of airplane and landing. Such design envelopes shall be determined by combinations of the variables of Table 6 in the form of a multivariate distribution. The distributions of each variable, independently, shall be defined by the normal or Gaussian distribution function for all variables except sinking speed. The sinking speed distribution shall be defined by the Pearson Type III distribution function. The mean and standard deviation define the normal distribution function. The Pearson Type III distribution function is defined by the mean, standard deviation, and skewness coefficient. (For a skewness coefficient of zero, the Pearson Type III function becomes the normal distribution function.) In Table 6, a bar denotes the mean over the parameter symbol, the standard deviation by the symbol o, and the skewness coefficient by the symbol α_3.Extreme conditions for each envelope are defined by those combinations of variables having a joint likelihood of occurrence equal to a constant as determined by the following equation:

$$PT = P(V_{TD} >< V_{TD_i})P(V_E >< V_{E_i})P(V_V >< V_{V_i})P(\theta_P >< \theta_{P_i}) \\ P(\theta_R >< \theta_{R_i})P(\dot{\theta}_R >< \dot{\theta}_{R_i})P(\theta_Y >< \theta_{Y_i})P(d >< d_i) \quad \text{(Eq. 3)}$$

where:

a. The symbols > and < denote greater than and, alternately, less than.

b. V_{TD_i}, V_{E_i}, V_{V_i}, θ_{P_i}, θ_{R_i}, $\dot{\theta}_{R_i}$, θ_{Y_i}, and d_i are the initial conditions for each variable.

c. P is the probability that the value of the variable under consideration is greater than and, alternately, less than the given or i^{th} value of that variable.

d. The equation has the constraint that the symbol > shall be used with the i^{th} values of the variable which is equal to or greater than the mean value and, alternately, the symbol < shall be used with the i^{th} values of the variable which is less than the mean value.

e. The initial conditions for each variable shall be all values between the extreme minimum and extreme maximum.

f. Extreme values for each variable, independently, are those values corresponding to a probability PO of being greater than the maximum value or less than the minimum value. PT is the product of the probabilities P and is equal to a constant times Po. Values of PO and PT shall be as given in Table 6.

Table 6 - Variation of landing impact conditions

Symbol	Variable	Type Landing / Type Airplane	See Notes (e1) CB	See Notes (e2, e3) CB	See Notes (e4) CB	See Notes (e5, e6) CB, LB, ski, STOL	See Notes (e7) LBT	See Notes (e8) STOL
V_A	Approach Speed (KN)	$\overline{V_{TD}}$	1.05V_{PA}	1.05V_{PA}	1.05V_{PA}	1.05V_{PA}	1.05V_{PA}	1.05V_{PA}
		σ_{VTD}	4.0	5.0	5.0	5.0	5.0	5.0
V_E	Engaging or Horizontal Ground Speed (KN)	$\overline{V_E}$	$\overline{V_{TD}}$-20	$\overline{V_{TD}}$	$\overline{V_{TD}}$	$\overline{V_{TD}}$	$\overline{V_{TD}}$	$\overline{V_{TD}}$
		σ_{VE}	5.0	8.0	8.0	8.0	8.0	8.0
V_V	Sinking Speed (FPS)	$\overline{V_V}$	0.128$\overline{V_E}$ but not <11.5	0.0885$\overline{V_E}$ but not <11.6	.112$\overline{V_E}$ -5.32	3.6	8.5	0.044$\overline{V_E}$ +7.5
		σ_{Vv}	0.128$\overline{V_E}$ + 1.667 but not <3.0	2.0	.007$\overline{V_E}$ +1.097	1.33	2.8	0.006$\overline{V_E}$ +2.6
		α_3	0	0	0	0.5	0	0
Θ_P	Airplane Pitch Angle (DEG)	$\overline{\theta_P}$	See note (a)	See note (a)	See note (a)	See note (a)	See note (a)	See note (a)
		$\sigma_{\Theta P}$	2.25	2.25	2.25	2.25	2.25	2.25
Θ_R	Airplane Roll Angle (DEG)	$\overline{\theta_R}$	2.0	2.0	2.0	2.0	2.0	2.0
		$\sigma_{\Theta R}$	2.5	2.5	2.5	2.5	2.5	2.5
$\dot{\theta}_R$	Airplane Roll Rate (DEG/SEC)	$\overline{\dot{\theta}_R}$	0	0	0	0	0	0
		$\dot{\sigma}_{\Theta R}$	3.0	3.0	3.0	3.0	3.0	3.0
Θ_Y	Airplane Yaw Angle (DEG)	$\overline{\theta_Y}$	0	0	0	0	0	0
		$\sigma_{\Theta Y}$	3.0	3.0	3.0	2.5	2.5	3.0
D	Off-Center Engagement Distance (FT)	d	0	0	--	--	--	--
		σ_d	6	6	--	--	--	--
--	--	P_O	1.00E-03	1.00E-03	1.00E-03	1.00E-04	1.00E-03	1.00E-03
--	--	P_T	7.8125E-06	7.8125E-05	1.5625E-05	1.5625E-06	1.5625E-05	1.5625E-05

Notes:

(a) 0 shall correspond to V, to a mean wing-lift-to-weight ratio of 1.1, and to each of the following values of speeds. Separately: V_{PA} and V_m. The mean pitch angle θ shall be determined from that trimmed lift curve for the power approach configuration in free air at sea level on a tropical day.

(b) For flared field landings at the maximum landing design weight for all types of airplanes except LBT, the values of θ shall be reduced by 50% and the mean pitch attitude for the condition of the touchdown speed of V_{rp}.

(c) The airplane pitching velocity θ (radians per second) shall be determined as follows (nose up positive).

$$\dot{\theta}_p = \frac{g}{1.69 V_{TD}}\left(\frac{L}{W} - 1\right) \quad \text{(Eq. 4)}$$

where:

g = 32.2 FPS^2
L = airplane lift, LB
W = airplane weight, LB

(d) For CB airplanes the arresting hook shall engage the first arresting cable. Initial landing gear contact with the deck shall occur at all distances from a distance of 60 feet air of the first arresting cable to that distance forward of the first arresting cable such that arresting hook engagement and lending gear touch down are simultaneous. The arresting force shall be all those forces from the upper to lower boundaries as derived from 3.4.4 for the specified engaging speeds.

(e) Types of landings:
(1) Touch-and-go carrier arrested landing.
(2) Touch-and-go and field arrested landing on prepared and semi-prepared fields.
(3) Field carrier landing practice on prepared runways.
(4) Field landing and arrested landing on prepared runways.
(5) Flared field landing on prepared runways.
(6) Flared field landing on snow and ice-covered semi-prepared fields.
(7) Trainer-field landing on prepared runways.
(8) Vertical and short field landings on prepared, semi-prepared, and unprepared fields.

3.4.8.1.2 Three and Tail-Down Drop Test Conditions

Applicable to all types of airplanes. The wing lift shall be equal to the weight of the airplane. The sinking speed shall be equal to the maximum value, and the touchdown speed shall be all speeds specified in Table 6. The airplane roll angle shall be zero and, alternately, 2.0 degrees. For the three-point landing, the airplane pitch angle shall correspond to that angle for simultaneous contact of all landing gear wheels with shock struts fully extended and tires un-deflected. For the tail-down landing, the airplane pitch angle shall be that angle corresponding to 90% of the maximum lift coefficient (C_L MAX) in level flight using the trimmed lift curve for the power approach configuration in free air at sea level on a tropical day.

3.4.8.1.3 Free-Flight Engagement

Applicable to CB airplanes. The airplane shall engage the arresting cable under the following conditions:

a. The sinking speeds of the airplane CG shall be all those sinking speeds specified in 3.4.8.1.1 that are less than the mean sinking speed.

b. For touchdown-speeds less than V_{TD}, the engaging speeds shall be all values up to V_E, and for touchdown speeds greater than V_{TD}, the engaging speeds shall be all values greater than V_E.

c. The wing lift shall be 1.0 and, alternately, 1.3 times the weight of the airplane. For the latter value of 1.3, the obstruction run-over requirements need not apply

d. The touchdown speeds shall be all speeds between Vp_A and V_{TD} + 12 kN

e. The pitch attitude shall be consistent with the sinking speed, airspeed, and wing lift.

f. The roll attitude shall be 0 degrees and, alternately, 2.0 degrees.

g. Arresting forces shall be all forces from the upper to the lower boundaries as derived from 3.4.4 for the specified engaging speeds.

h. The height of the airplane CG above the deck shall be all values corresponding to wire pickup with the hook in the full-down trail position, to wire pickup with the hook rotated so that the main landing gear wheels touch down simultaneously with wire pickup.

i. The airplane pitching velocity $\dot{\theta}_P$ shall be determined as follows:

$$\dot{\theta}_P = (g/1.69V_{TD})(L/W-1) \quad \text{(Eq. 5)}$$

where:

g = 32.2 FPS^2

L = airplane lift, LB

W = airplane weight, LB

3.4.8.1.4 Taxi-in Engagement

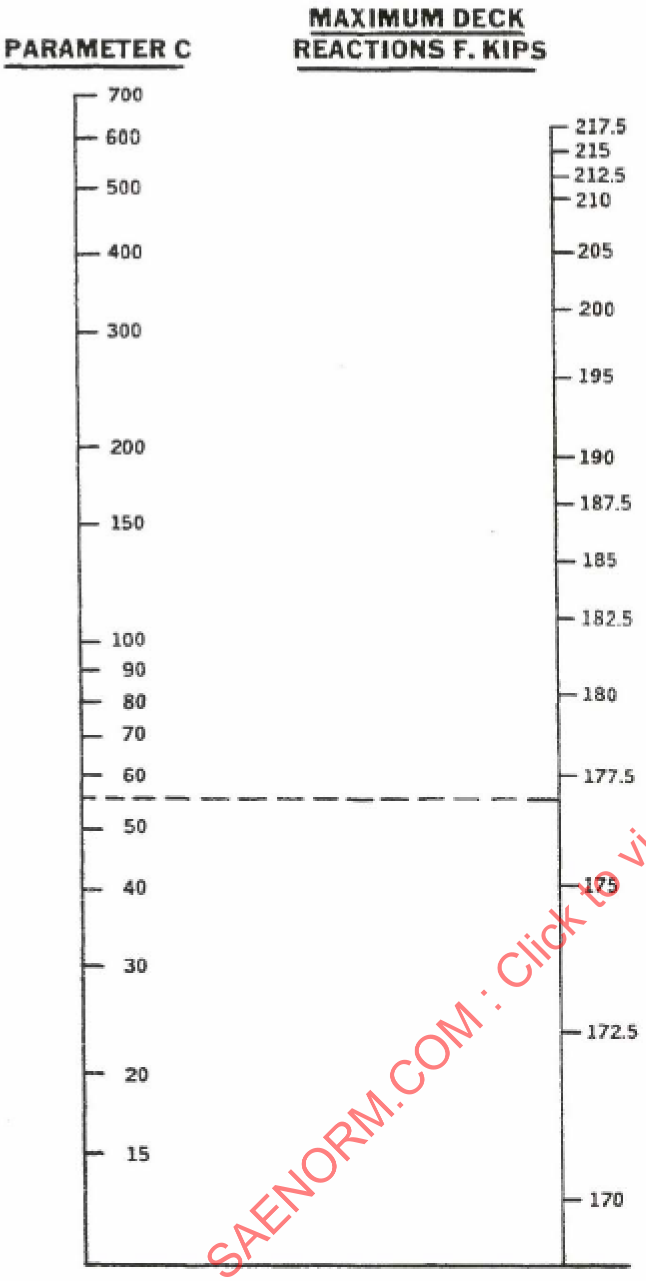
Applicable to CB airplanes. The airplane shall taxi into the arresting gear at all engaging speeds specified in 3.4.8.1.1. The arresting forces shall be all those resulting from the specified engaging speeds applicable to arresting gear for which strength is required. The airplane pitch attitudes shall be the three-point attitude, and, alternately, the maximum tail-down attitude specified in 3.4.8.1.1, or that maximum tail-down attitude that can be attained at the specified engaging speeds for a lift-to-weight ratio of 1.0, whichever is less. The head wind velocity shall be zero.

3.4.8.1.5 Drift Landing

Applicable to all types of airplanes. The shock strut compressed positions shall be all those from 15 to 90% of the maximum stroke of the strut. For auxiliary gears, the vertical ground reaction shall be one half of the maximum vertical load resulting from all specified symmetrical landing impact conditions, excluding obstruction run-over loads, and shall act in combination with a side load of 40% of that vertical load. The side load shall act to the right and, alternately, to the left. If the auxiliary gear is designed to swivel or to be steerable, the specified side load shall be reacted by the swiveling, shimmy damper, or steering mechanism so as to prevent the auxiliary gear from swiveling or turning. In lieu thereof, a more rational method of reacting the specified side load on auxiliary gears through the damper or steering mechanism, as proposed by the contractor in the ground loads criteria report and accepted by the contracting activity, may be used. For the main gear, the vertical ground reaction shall be one half of the maximum vertical load resulting from all specified symmetrical landing impact conditions, excluding obstruction—run-over load. It shall act outwardly and inwardly, in combination with a side load of 60% and 80%, respectively, of that vertical load.

3.4.8.1.6 Maximum Deck Reactions

The design of the airplane shall be such that the maximum landing gear vertical ground loads for each landing gear unit separately, which result from all the conditions of 3.4.8.1.1 through 3.4.8.1.5 shall not exceed the allowable deck reactions determined from Figures 8 and 9 for CB and STOL airplanes, and Figures 10 and 11 for STOL airplanes.



Definitions

- P = Rated load of tire, LBS
- p = Operational pressure of tire, PSI
- r = Rated pressure of tire, PSI
- C = $K \frac{P}{p}$
- K = $(0.7 \frac{p}{r} + 0.3)^{1/2}$
- F = Maximum deck reaction from nomogram

Example-Single Wheel — Find the maximum permissible landing gear deck reaction F for an airplane having a single wheel landing gear with a 30 x 7.7 tire for which:

- P = 21,300 LBS
- p = 400 PSI
- r = 360 PSI
- K = $(0.7 \times \frac{400}{360} + 0.3)^{1/2} = 1.04$
- C = $1.04 \times \frac{21,300}{400} = 55$

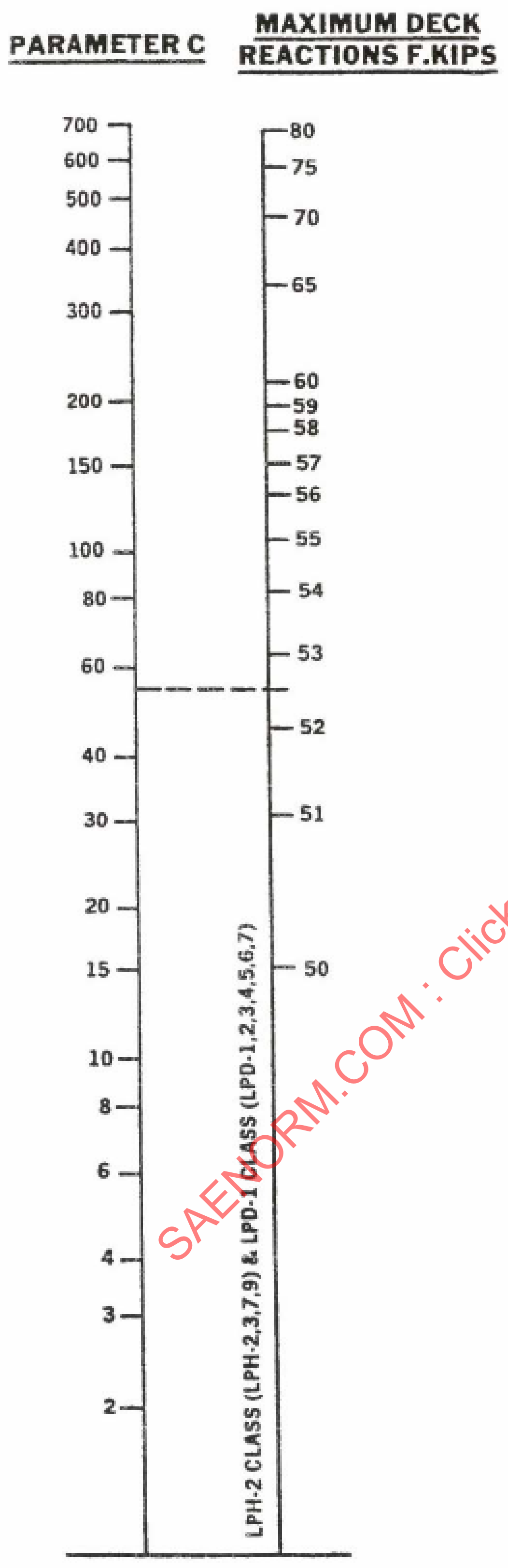
From the nomogram to the left for C=55 the maximum deck reaction of 177 Kips is obtained.

Example-Dual Wheels — For dual wheels with the same size tires spaced 14 inches on centers (b') divide the reaction F obtained from this nomogram by the dual wheel load factor K_e from Figure 3:

K_e = .925

F = $\frac{177}{925 \text{ Kips}}$ = 191.3 Kips

Figure 9 - Maximum allowable vertical deck reaction for a single landing gear: landing area on aircraft carriers (see 3.4.8.1.6)



Definitions

P = Rated load of tire, LBS

p = Operational pressure of tire, PSI

r = Rated pressure of tire, PSI

$C = K \frac{P}{p}$

$K = (0.7 \frac{p}{r} + 0.3)^{1/2}$

F = Maximum deck reaction from nomogram

Example-Single Wheel — Find the maximum permissible landing gear deck reaction F for an airplane having a single wheel landing gear with a 30 x 7.7 tire for which:

P = 21,300 LBS

p = 400 PSI

r = 360 PSI

$K = (0.7 \times \frac{400}{360} + 0.3)^{1/2} = 1.04$

$C = 1.04 \times \frac{21{,}300}{400} = 55$

F = 52,500 LBS

Example-Dual Wheels — For dual wheels with the same size tires,spaced 16 inches on centers (b') divide the reaction F obtained from this nomogram by the dual wheel load factor K_e from Figure 7:

b' = 16" (Spacing of dual wheels)

K_e = 0.65

$F' = \frac{52{,}500}{0.65} = 80{,}800$ LBS

Figure 10 - Maximum landing reaction for single landing gear with single and dual wheels for amphibious warfare ships (see 3.4.8.1.6)

$$\text{Max Dual Reaction} = \frac{\text{Max Single Wheel Reaction}}{K_e}$$

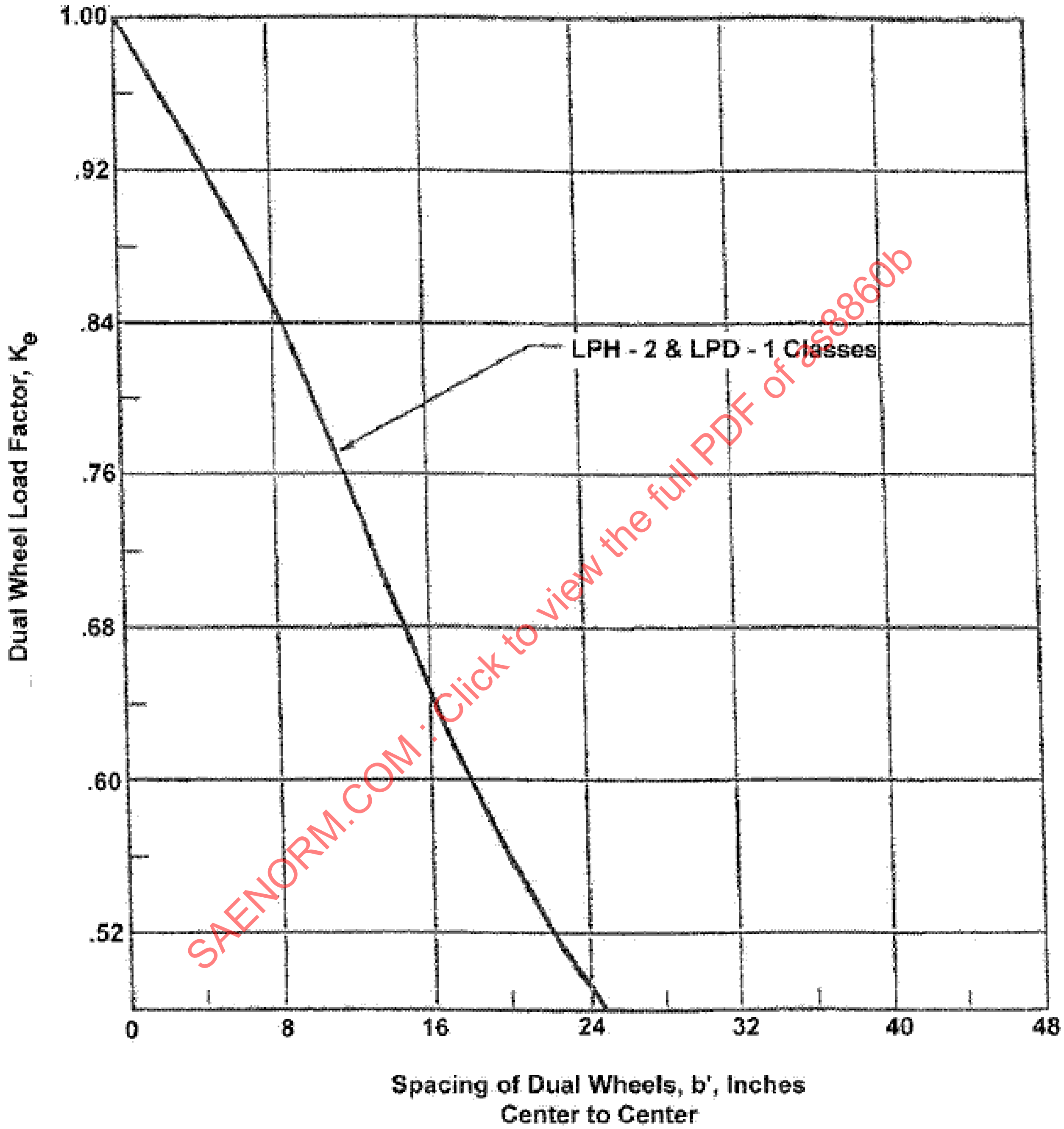


Figure 11 - Dual wheel factors for use with Figure 10 (see 3.4.8.1.6 and Figure 10)

3.4.8.1.7 Arresting

The maximum aft-acting horizontal component of the arresting force shall be the upper boundary of the arresting force specified in 3.4.4 for the most critical arresting gear for which strength is required. The engaging speed shall be the maximum specified in 3.4.8.1.1. The axial arresting hook force shall act in the plane of the arresting cable through the cable groove of hook point. The point of application of this force shall be at all lateral positions from the centerline of the hook point to the left and, alternately, to the right, equal to one half the radius of the hook point. The side load resulting from these laterally displaced loads shall act to increase the side load at the hook attachment to the fuselage.

3.4.8.1.7.1 Arrested Run with Side Load

The airplane pitch attitudes shall be all those specified in 3.4.8.1.1. The landing gear wheels shall be just clear of the deck. A side load of 1.0 times the airplane weight shall act in combination with all aft-acting horizontal components of arresting hook forces in excess of 2.0 times the airplane weight. The direction of the side load shall be to the right and, alternately, to the left.

3.4.8.1.7.2 Arrested Run with Brakes

The airplane shall be in the three-point attitude in a braked roll. The sum of the vertical components of the deck reactions shall be 2.0 times the airplane weight. Drag loads produced by braking at each main wheel shall be equal to 0.8 times the vertical reaction on each main wheel but the sum of these drag loads need not exceed the airplane weight. The side load at the hook point shall be zero.

3.4.9 Ground Maneuvering

3.4.9.1 Braking

Applicable to all types of airplanes equipped with wheels and brakes. The landing gear and tire deflections shall be those corresponding to the applied loads.

3.4.9.1.1 Two-Point Braked Roll

The airplane attitude shall be that corresponding to the auxiliary wheel just clear of the ground. The vertical load factor acting at the CG shall be 1.2 at the landplane landing design gross weight and 1.0 at the maximum design gross weight. A drag reaction, at each wheel in contact with the ground, shall be assumed acting at the ground equal to 0.8 of the vertical reaction and shall be combined with the vertical reaction.

3.4.9.1.2 Three-Point Braked Roll

The airplane shall be in the three-point attitude. The vertical load factor acting at the CG shall be 1.2 at the landplane landing design gross weight and 1.0 at the maximum design gross weight. A drag reaction, at each wheel equipped with brakes, shall be assumed acting at the ground equal to 0.8 of the vertical reaction and shall be combined with the vertical reaction.

3.4.9.1.3 Unsymmetrical Braking

The airplane shall be in the three-point attitude. One main gear shall be assumed braked and developing a drag load at the ground equal to 0.8 of the vertical reaction at that gear. The airplane shall be placed in static equilibrium, with side loads at the main and nose gears reacting the yawing moment, and with vertical loads at the main and nose gears reacting the pitching moment. The forward acting load at the CG shall be 0.8 of the vertical reaction at that main gear which is braked. The side load at the nose gear shall be acting at the ground, and need not exceed the vertical reaction multiplied by a coefficient of friction of 0.8. The nose gear shall be aligned in a fore and aft direction.

3.4.9.1.4 Reverse Braking

The airplane shall be in the two-point attitude with the nose gear fully extended and just clear of the ground. A forward acting drag reaction, acting at the ground equal to 0.8 of the vertical reaction, shall be combined with the vertical reaction for each gear that is equipped with brakes.