



# AEROSPACE RECOMMENDED PRACTICE

ARP1493

REV. C

Issued 1979-07  
Reaffirmed 2007-07  
Revised 2008-06  
Stabilized 2013-11

Superseding ARP1493B

## Wheel and Hydraulically Actuated Brake Design and Test Requirements for Military Aircraft

### RATIONALE

Due to current U.S. government rules effecting sharing of information regarding military technology and services (i.e. ITAR, EAR, etc.) further updates to this document will no longer be possible.

### STABILIZED NOTICE

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## TABLE OF CONTENTS

|       |                                                              |    |
|-------|--------------------------------------------------------------|----|
| 1.    | SCOPE.....                                                   | 3  |
| 1.1   | Purpose.....                                                 | 3  |
| 2.    | REFERENCES.....                                              | 3  |
| 2.1   | Applicable Documents .....                                   | 3  |
| 2.1.1 | SAE Publications.....                                        | 3  |
| 2.1.2 | ASTM Publications.....                                       | 4  |
| 2.1.3 | U.S. Government Publications.....                            | 4  |
| 2.2   | Definitions .....                                            | 4  |
| 2.2.1 | Design Drawings.....                                         | 4  |
| 2.2.2 | Normal Operating Pressure .....                              | 4  |
| 2.2.3 | Normal Parking Pressure.....                                 | 4  |
| 2.2.4 | Maximum Operating Pressure .....                             | 5  |
| 2.2.5 | Weights and Speeds.....                                      | 5  |
| 2.2.6 | Loads .....                                                  | 5  |
| 3.    | REQUIREMENTS .....                                           | 6  |
| 3.1   | Drawings .....                                               | 6  |
| 3.1.1 | Design Proposal Drawings.....                                | 6  |
| 3.1.2 | Interface Drawings .....                                     | 6  |
| 3.2   | Materials.....                                               | 7  |
| 3.3   | Protective Treatment.....                                    | 7  |
| 3.4   | Detail Design Requirements .....                             | 7  |
| 3.4.1 | Wheel Design Requirements .....                              | 7  |
| 3.4.2 | Brake Design Requirements .....                              | 9  |
| 3.4.3 | Detail Design Requirements - General.....                    | 10 |
| 3.4.4 | Interface Definition for Wheel and Brake Detail Design ..... | 11 |
| 3.5   | Capability Requirements.....                                 | 14 |
| 3.5.1 | Performance.....                                             | 14 |
| 3.5.2 | Reliability.....                                             | 14 |
| 3.5.3 | Maintainability .....                                        | 14 |
| 3.5.4 | Braking Capacity .....                                       | 15 |
| 3.5.5 | Wheel Capacity .....                                         | 19 |
| 3.5.6 | Compatibility Requirements .....                             | 19 |
| 3.5.7 | Environment.....                                             | 19 |

|        |                                                  |    |
|--------|--------------------------------------------------|----|
| 4.     | QUALITY ASSURANCE PROVISIONS .....               | 20 |
| 4.1    | Product Verification .....                       | 20 |
| 4.1.1  | Stress Analysis .....                            | 20 |
| 4.2    | Test Methods .....                               | 20 |
| 4.2.1  | Radial Load Test .....                           | 20 |
| 4.2.2  | Design Landing Radial Load Test .....            | 21 |
| 4.2.3  | Combined Load Test .....                         | 21 |
| 4.2.4  | Burst Test .....                                 | 22 |
| 4.2.5  | Roll Test .....                                  | 22 |
| 4.2.6  | Tubeless Wheel Pressure Test .....               | 23 |
| 4.2.7  | Dynamic Torque Test .....                        | 23 |
| 4.2.8  | Lining Fusion Test .....                         | 26 |
| 4.2.9  | Turnaround Dynamic Torque Test .....             | 26 |
| 4.2.10 | Compatibility Tests .....                        | 26 |
| 4.2.11 | Structural Torque Test .....                     | 26 |
| 4.2.12 | Overpressure Test .....                          | 26 |
| 4.2.13 | Endurance Test .....                             | 27 |
| 4.2.14 | Extreme Temperature Test .....                   | 27 |
| 4.2.15 | Extreme Temperature Test .....                   | 27 |
| 4.2.16 | Service Test .....                               | 28 |
| 4.2.17 | Safety of Flight Tests .....                     | 28 |
| 4.3    | Quality Conformance Tests .....                  | 28 |
| 4.3.1  | Tests of Materials and Parts .....               | 28 |
| 4.3.2  | Tests of Wheel Assemblies .....                  | 28 |
| 4.3.3  | Tests of Brake Assemblies .....                  | 29 |
| 4.3.4  | Replacement Wheel and Brake Assemblies .....     | 30 |
| 4.3.5  | Replacement Wheel and Brake Assembly Parts ..... | 30 |
| 5.     | NOTES .....                                      | 30 |
| 5.1    | Data Submittal .....                             | 30 |
| 5.2    | Conformance to Test Samples .....                | 31 |
| 5.3    | Reprocurement Specification .....                | 31 |
| 5.4    | Interface Document .....                         | 31 |

## 1. SCOPE

This document covers military aircraft wheel and hydraulically actuated brake equipment.

### 1.1 Purpose

This document provides recommended practices for designing and testing wheels and hydraulically actuated brakes for use on new designs of military aircraft. Intended users are airframe and military personnel who prepare detail design and performance specifications. It is not intended to be a procurement document. This document provides updated information to MIL-W-5013 which has been classified inactive for new design.

## 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 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|         |                                                                                         |
|---------|-----------------------------------------------------------------------------------------|
| ARP597  | Wheels and Brakes, Supplementary Criteria for Design Endurance Civil Transport Aircraft |
| AS707   | Thermal Sensitive Inflation Pressure Release Devices for Tubeless Aircraft Wheels       |
| ARP813  | Maintainability Recommendations for Aircraft Wheels and Brake Design                    |
| ARP1619 | Replacement and Modified Brakes and Wheels                                              |
| ARP5146 | Assessment of Aircraft Wheel Sealing Systems                                            |
| AS5202  | Port or Fitting End, Internal, Straight Thread, Design Standard                         |
| AS5440  | Hydraulic Systems, Aircraft, Design and Installation Requirements for                   |
| AIR5451 | A Guide to Landing Gear System Integration                                              |
| ARP5481 | Recommended Wheel Tie Bolt Preload Procedure                                            |
| ARP5600 | Disposition of Damaged Wheels Involved in Accidents/Incidents                           |
| AS8860  | Landing Gear Structural Requirements as Listed in the MIL-886X Series of Specifications |
| AS25427 | Coupling Assembly, Hydraulic, Self-Sealing, Quick Disconnect                            |
| AS28775 | Packing, Preformed, Hydraulic, +275°F (O-Ring)                                          |
| AMS2175 | Castings, Classification and Inspection of                                              |

### 2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

ASTM E 1417 Standard Practice for Liquid Penetrant Testing

ASTM E 1444 Standard Practice for Magnetic Particle Testing

### 2.1.3 U.S. Government Publications

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, <http://assist.daps.dla.mil/quicksearch/>.

JSSG-226 Aircraft Structures, General Specification

MIL-A-8625 Anodic Coatings for Aluminum and Aluminum Alloys

MIL-HDBK-275 Lubricants Fluids and Compounds for use in Flight Vehicles and Components, Selection Guide

MIL-HDBK-838 Lubrication of Military Equipment

MIL-P-83461 Packing, Preformed, Petroleum Hydraulic Fluid Resistant Improved Performance at 275°F (135° C) for use in Boss Fittings, Sizes and Tolerances

MIL-PRF-23377 Primer Coatings; Epoxy, High-Solids

MIL-PRF-85285 Coating, Polyurethane, Aircraft and Support Equipment

MIL-W-5013 Wheel and Brake Assemblies, Aircraft, General Specification (for Reference Only - Inactive for New Design)

MS27436 Cable Configuration, Grounding Aircraft

MS27611 Valve, Hydraulic Bleeder, Aircraft Wheel Brake

## 2.2 Definitions

### 2.2.1 Design Drawings

The terms “specification control drawing” or “applicable design drawing” used in this document mean the design drawing prepared by and available from the procuring activity.

### 2.2.2 Normal Operating Pressure

The term “normal operating pressure” means the brake hydraulic pressure required to produce an aircraft deceleration in accordance with the procurement document, as determined by the average of the distance averaged pressure measurements in landplane landing design gross weight tests specified in 4.2.7.

### 2.2.3 Normal Parking Pressure

The term “normal parking pressure” means the brake hydraulic pressure required to lock the wheel at the rated static load specified for the wheel.

## 2.2.4 Maximum Operating Pressure

The term “maximum operating pressure(s)” means the maximum brake hydraulic pressure(s) supplied at the brake under design conditions.

## 2.2.5 Weights and Speeds

The weight conditions specified in Table 3 and related speeds should be used to establish design values. When the procurement document specifies more severe conditions these should be used instead. For speeds the values in Table 1 should be used:

TABLE 1- WEIGHT AND SPEED CONDITIONS

| Condition                      | Brakes on Speed | Aircraft Weight |
|--------------------------------|-----------------|-----------------|
| Normal Landing                 | 0.9 $V_a$       | LPLGW           |
| Maximum Landing                | 0.9 $V_a$       | MLGW            |
| Rejected Takeoff (RTO)         | 1.0 MWLO        | MTOGW           |
| Worn Brake RTO                 | 1.0 MWLO        | MTOGW           |
| Rapid Turnaround (if required) |                 |                 |
| Landing                        | 0.9 $V_a$       | LPLGW           |
| Taxi-In                        | *               | LPLGW           |
| Taxi-Out                       | *               | MTOGW           |
| RTO                            | 1.0 MWLO        | MTOGW           |

where:

$V_a$  - Standard day approach speed for related weight

LPLGW = Landplane landing gross weight

MLGW = Maximum landing gross weight

MWLO = Rational main wheel lift off speed at sea level standard day or a specified by the procuring activity

MTOGW - Maximum takeoff gross weight

\* = Brake energy is the total amount of braking required to oppose the idle thrust over the taxi distance and the number of anticipated stops during the taxi phase

## 2.2.6 Loads

For the purpose of load testing, the following definitions will apply:

- Limit Load: The maximum load anticipated during all normal conditions of operation as determined by the procurement activity. It should be not less than the load determined by using AS8860 specification, JSSG-2006, or as defined in the aircraft detail specification.
- Yield Load: 1.15 times the limit load.
- Design Ultimate Load: 1.5 times the limit load.
- Design landing loads will be as determined by the procurement activity in accordance with the load conditions of AS8860.

### 3. REQUIREMENTS

The wheel and brake should fulfill all the regulatory and/or any airframe manufacturer's design requirements that are considered applicable to the aircraft being designed.

#### 3.1 Drawings

##### 3.1.1 Design Proposal Drawings

Design proposal drawings prepared by the wheel and brake manufacturer should include the following:

- a. Reference to the applicable specification.
- b. End-view and cross-sectional drawing including definition of the rim flange, brake and wheel mounting, hydraulic interface data, and envelope definition.
- c. Material, principal manufacturing process, and finish definition for all major components.
- d. Wheel static and dynamic loading conditions, brake energy definitions, separate and combined maximum weights for the wheel and brake assemblies.
- e. Brake design parameters, including:
  1. Heat sink mass and definition of heat sink components, new and fully-worn
  2. Swept area
  3. Mean radius
  4. Piston area
- f. Brake performance predictions, including:
  1. Pressure-volume curve defining the pressure to begin brake piston movement
  2. Pressure to cause disk contact
  3. Brake release pressure (brake rotors are free to rotate)
  4. Maximum system pressure as prescribed by the procuring activity to provide full flow to allow for rudder, spoilers, speed brakes, etc.
- g. Other technical information required communicating the design

##### 3.1.2 Interface Drawings

Interface drawings should be developed and approved by the procuring activity that define the applicable interfaces with tolerances for the wheels and brakes. This should include but not limited to all interfaces with the axle, landing gear, hydraulic system, hub cap, brake temperature or tire pressure monitoring system as applicable. Component or assembly interface drawings suitable for alternate source procurement should be the subject of separate contract by specific request.

### 3.2 Materials

Unless otherwise specified in the procurement specification, the following materials are commonly used for the major components:

- a. Aluminum components: Forged aluminum alloys of 2040-T6, 7050-T74, 2014-T6 or 2014-T61 are suitable alloys for wheel halves and brake housings

### 3.3 Protective Treatment

Unless otherwise specified in the procurement specification, aluminum alloy should be anodized in accordance with MIL-A-8625, Type II or III, all over after cold working.

In addition, all exterior surfaces should be painted with one coat of MIL-PRF-23377 primer and two coats of MIL-PRF-85285 urethane topcoat.

### 3.4 Detail Design Requirements

#### 3.4.1 Wheel Design Requirements

Wheel design should meet the specified requirements with all tire part numbers specified by the procuring agency.

##### 3.4.1.1 Tie Bolts

Wheel tie bolts, where used, should be of the through-type with nuts: no inserts should be permitted. If chamfered washers are used, they should be chamfered on both sides. Appropriate MS head form bolts should be used. Appropriate thread lubricant and tie bolt torque procedure (reference ARP5481) should be specified with appropriate substantiation per 3.4.3.5.1.

##### 3.4.1.2 Demountable Flange

Demountable flange wheel configuration should be designed in a manner that prevents the flange and its retaining device from leaving the wheel if a flat tire occurs while the wheel is rolling up to take off speeds. Design consideration should be given to protection against corrosion and fretting.

##### 3.4.1.3 Wheel Fatigue

It is recommended that a system for tracking accumulated wheel usage in service be established. Accordingly, wheels should incorporate removal due date and/or tire change counters or an alternative concept that is consistent with the aircraft maintenance philosophy.

##### 3.4.1.4 Lubricant and Lubricant Retainers

Suitable retainers should be provided to prevent lubricant from reaching the braking surface and to prevent foreign material from entering the bearings. The retainers should be removable to allow for cleaning and lubrication of the bearings. Where possible, the wheel bearings should be sealed on a stationary surface. Wheel bearing seals should be designed to not rub on the stationary or permanent portion of the brake housing or strut. Rubbing surfaces should be contained to nonstructural parts that are removed from the aircraft during a typical tire change. Applicable requirements of MIL-HDBK-838 and MIL-HDBK-275 should be observed. A suitable lubricant should be specified.

##### 3.4.1.5 Lubrication Fittings

Wheels should not be fitted with pressure type lubrication fittings except for amphibian and beaching gear applications.

### 3.4.1.6 Wheel Valve and Boss

Tubeless tire valves should conform to MS27436. The boss that accommodates the valve should be in accordance with AS5202.

### 3.4.1.7 Overinflation Protection Devices

Overinflation protection devices should be provided unless deleted by the procurement specification. Valve boss should be in accordance with AS5202.

### 3.4.1.8 Tire Pressure Gages

If used, Integral tire pressure gauges should conform to MIL-G-83016. The gauge boss should be in accordance with AS5202.

### 3.4.1.9 Wheel Mating Seals and Grooves

Seals and sealing cavities should be in accordance with proven design. If the design has not been proven by service experience of a similar configuration in a comparable application, the sealing system should be verified per ARP5146. Standard MIL-P-83461 seal compounds should be used unless other compounds are shown to be preferred for performance, operational, environmental, reliability, maintainability or cost considerations

### 3.4.1.10 Static Balance

Wheel halves should be statically balanced with asymmetrical or nonsymmetrical components installed within the limits specified in Figure 1 to the nearest whole ounce-inch. Assembly of the two wheel halves of a split-type wheel assembly in alternative position or assembly of halves of different wheels should not result in imbalance beyond the specified limits.

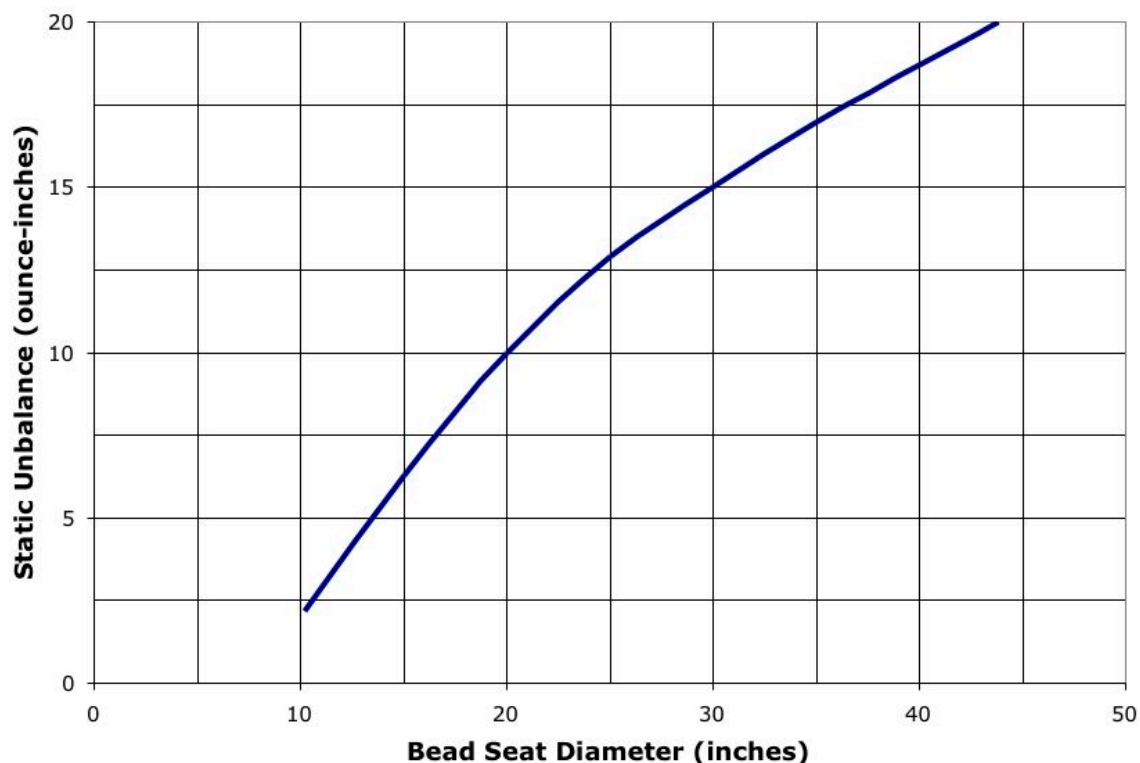


FIGURE 1 - ALLOWABLE STATIC IMBALANCE

#### 3.4.1.11 Braked Wheel Thermal Sensitive Pressure Release Devices (Fuse Plugs)

Braked Wheel Thermal Sensitive Pressure Release Devices (Fuse Plugs): A minimum of three fuse plugs should be provided and located in the wheel tubewell area approximately equally spaced about the wheel. They should be designed so that tire pressure will be released prior to tire or wheel failure resulting from temperature induced structural degradation. The wheel bead ledge temperature should not be permitted to exceed 400 °F (204 °C) without fuse plug release. The fuse plugs should not release during tests at maximum landing weight (Table 3) (Reference AS707).

#### 3.4.1.12 Wheel Burst Factor

The following wheel burst load factors apply to wheel tests:

TABLE 2 - WHEEL BURST FACTORS

| Type of Aircraft       | Factor Times Rated Inflation Pressure |
|------------------------|---------------------------------------|
| Land Based Aircraft    | 3.5                                   |
| Carrier Based Aircraft | 4.5                                   |
| Helicopter             | 3.0                                   |

#### 3.4.2 Brake Design Requirements

##### 3.4.2.1 Seals and Glands

Piston cylinder design sealing cavities should be in accordance with proven design. AS28775 seals should be used unless the performance, operational, environmental, reliability, maintainability or cost requirement compliance justifies an alternative seal geometry or compound selection. Other configurations of seals may be used with prior approval.

##### 3.4.2.2 Wear Indicators

The brake assembly should have wear indicators that are visible during a walk around inspection. The indicators should show "go-no go" status without the need for measuring tools.

##### 3.4.2.3 Automatic Adjusters

Automatic adjusters should be provided to compensate for brake lining wear where needed. Brake assemblies should be designed for the most practical protection of the brake adjusters.

##### 3.4.2.4 Cylinder Liners

Brakes should be designed with replaceable cylinder liners. If aluminum pistons or cylinder liners are used, the surface wiped by dynamic seals should be anodized in accordance with MIL-A-8625, Type III or other protective coating approved by the procuring activity. Helicopters are frequently waived of this requirement.

##### 3.4.2.5 Inlet and Bleeder Fittings

Brake inlet fittings, threads, and bosses should be in accordance with AS5440. Brake bleeder valves should conform dimensionally to MS27611 and be installed in a boss, inlet fitting, or attaching bolt machined in accordance with AS5202. A threaded steel insert should be provided for inlet bosses in nonferrous brake housings. All fittings should be safetied or suitably locked. Self-sealing couplings, if required by the procurement specification, should conform to AS25427. As an option, self-sealing, quick-disconnect assemblies may be provided to enable brake assemblies to be bled in the shop rather than on the aircraft, if appropriate to the aircraft maintenance philosophy.

##### 3.4.2.6 Brake Operating Pressure and Release

The brake should be compatible with the full range of operating pressures provided by the aircraft. The brake return mechanism should fully release to the design travel at a pressure not less than 110% of the maximum steady state backpressure imposed on the brake.