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AEROSPACE RECOMMENDED PRACTICE

ARP 1493

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Revised

WHEEL & BRAKE DESIGN AND TEST REQUIREMENTS FOR MILITARY AIRCRAFT

1. PURPOSE

This Aerospace Recommended Practice (ARP) provides recommended practices for the design and testing of wheels and brakes for new design military aircraft. It is intended for use by airframe and military personnel in formulating detail design and performance specifications. It is not intended to be used as a procurement document in replacement of MIL-W-5013.

2. APPROVAL NOTE

This report has been originated by SAE A-5A Panel.

3. REQUIREMENTS

3.1 Drawings:

3.1.1 Design Proposal Drawings: Design proposal drawings prepared by the manufacturer shall include the following:

a. Reference to the applicable specification.

b. Two-view and cross-sectional drawing including definition of the rim flange, brake and wheel mounting, hydraulic installation data, and envelope description.

c. Material, principal manufacturing process, and finish definition for all 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: stack mass, new and worn, swept area, mean radius, and piston area.

f. Brake performance predictions, including: pressure-volume curve defining the pressure to begin brake piston movement, pressure to cause disk contact, and brake release pressure. Predicted brake-torque-pressure relationships, static and dynamic for the design energy conditions with a hot and cold stack, wet and dry. The expected wear rates for the design conditions defined in Tables I and II shall also be included.

g. Other technical information required to communicate the design.

3.1.2 Interface Drawing: Component or assembly interface drawings suitable for alternate source procurement shall be the subject of separate contract by specific request.

3.2 Materials: Unless otherwise specified in the procurement specification, the following materials shall be used for the major components:

Wheel Halves:	Forged aluminum 2014-T6 or 2014-T61, or other suitable alloy, except cast aluminum may be used for wheels with 6.0" (152.4 mm) rim diameter or less.
Tie Bolts:	220,000 maximum heat treatment steel, with appropriate MS head form, Lubtorked per MIL-T-5544.
Brake Housing:	Forged or cast aluminum of suitable alloy.
Torque Tube & Back Plate:	Cast or forged steel AMS 6302 or AMS 4340. Cast or forged titanium 6-4 annealed. Ductile iron. MIL-I-114665.

3.3 Protective Treatment: Unless otherwise specified in the procurement specification, aluminum alloy shall be anodized in accordance with MIL-A-8625, Type I or II, all over after cold working.

In addition, all exterior surfaces shall be painted with one coat of wash primer in accordance with MIL-C-8514 followed by one coat of lacquer primer in accordance with MIL-P-7962, followed by two coats of acrylic-nitrocellulose lacquer in accordance with MIL-L-19537.

3.4 Detail Design Requirements:

3.4.1 Wheel Design Requirements: The design of all new wheels shall be of the demountable flange type or divided type to facilitate tire changing. The wheel-tire-interface dimensions shall conform to AND contour standards for existing MIL-T-5041 tires. Where a standard tire does not exist, the rim contour shall conform to Tire & Rim Association recommendations.

3.4.1.1 Tie Bolts: Wheel tie bolts, where used, shall be of the through-type with nuts; no inserts shall be permitted. If chamfered washers are used, they shall be chamfered on both sides.

3.4.1.2 Demountable Flange: Demountable flange wheel configuration shall be designed in a manner which will prevent the flange and its retaining device from leaving the wheel in case a flat tire occurs while the wheel is rolling.

3.4.1.3 Wheel Fatigue: It is recommended that a system for tracking accumulated wheel mileage in service be established. Accordingly, wheels will incorporate tire change counters or an alternative concept consistent with the aircraft maintenance philosophy.

3.4.1.4 Bearings: Wheel bearings shall be of the tapered roller type.

3.4.1.5 Lubricant and Lubricant Retainers: Suitable retainers shall be provided to prevent lubricant from reaching the braking surface and to prevent foreign material from entering the bearings. The retainers shall be removable to allow for cleaning and lubrication of the bearings. Where possible, the wheel bearings shall be sealed on a stationary surface. Wheel bearing seals shall not be designed to rub on the stationary or permanent portion of the brake housing or strut. Rubbing surface shall be on an individual part that is inexpensive to replace so that any wear shall not cause condemnation of the brake or strut. Applicable requirements of MIL-STD-838 and MIL-HDBK-275 shall be observed. Grease conforming to MIL-G-81322 shall be used to lubricate wheel bearings.

3.4 1.6 Lubrication Fittings: Wheels shall not be fitted with pressure type lubrication fittings except amphibian and beaching gear applications.

3.4.1.7 Wheel Valve and Boss: Tubeless tire valves shall conform to MS27436. The boss and seal which accommodate the valve shall be in accordance with MS33649.

3.4.1.8 Overinflation Valves and Seals: Overinflation devices shall be provided unless deleted by the procurement specification. The valve boss and seal shall be in accordance with MS33649. Reseating type valves, if used, shall be per MIL-P-81958.

3.4.1.9 Tire Pressure Gages: If used, the tire pressure gage shall conform to MIL-G-83016. The gage boss and seal shall be in accordance with MS33649.

3.4.1.10 Valve Cores: Valve core assemblies shall be selected from Tire & Rim Association standards currently in use with the military services.

3.4.1.11 Wheel Mating Seals and Grooves: Seals and grooves shall be in accordance with AS 666. Standard USAF "Shore 70" seal compounds shall be used as defined in QPL-5516 approved compound sources unless the temperature environment exceeds the compound capability.

3.4.1.12 Static Balance: Wheel assemblies shall be statically balanced with the tire and overinflation valves installed within the limits specified in Fig. 1 to the nearest whole ounce-inch. Assembly of the two wheel halves of a split-type wheel assembly in alternate position or assembly of halves of different wheels shall not result in unbalance beyond the specified limits. Static balance operations for wheels may be omitted provided the manufacturer shows by an adequate sampling plan that unbalance requirement is never exceeded.

3.4.1.13 Wheel Thermal Sensitive Pressure Release Devices: A minimum of three fuse plugs shall be provided approximately equally spaced. They shall be located in the wheel tubewell and designed so that tire pressure will be released prior to tire or wheel failure resulting from temperature induced structural degradation. Applicable only to tubeless and braked wheels of sufficient brake capacity to overheat wheels and tires.

3.4.2 Brake Design Requirements:

3.4.2.1 Seals and Glands: Piston-cylinder design shall be in accordance with MIL-G-5514 where feasible. MS28775 seals shall be used unless the temperature environment exceeds the compound capability, in which case, appropriate seals shall be selected.

3.4.2.2 Wear Indicators: The brake assembly shall have a wear pin indicator visible when performing a walk-around inspection.

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

3.4.2.4 Cylinder Liners: Brake cylinder liners shall be furnished and must be designed to be replaceable. If aluminum pistons or cylinder liners are used, the surface wiped by dynamic seals shall be anodized in accordance with MIL-A-8625, Type III. Helicopters may be excepted from this requirement.

3.4.2.5 Inlet and Bleeder Fittings: Brake inlet fittings, threads, and bosses shall be in accordance with MIL-H-5440. Brake bleeder valves shall conform dimensionally to AN 6204 and installed in a boss, inlet fitting, or attaching bolt machined in accordance with AND 10067. A threaded steel insert shall be provided for inlet bosses in nonferrous brake housings. All fittings shall be safetied or suitably locked. Self-sealing couplings, if required by the procurement specification, shall conform to MIL-C-25427. 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 shall be compatible with the full range of operating pressures provided by the aircraft. The brake return mechanism shall fully release to the design travel at a pressure not less than 110 percent of the maximum steady state back pressure as felt by the brake.

3.4.2.7 Operating Media: The brakes shall be compatible with the operating media as defined in the procurement specification for the applicable aircraft.

3.4.3 Detail Design Requirements - General: The wheel and brake assemblies shall conform to the requirements of this specification as amended by the superseding procurement specification. The configuration shall be compatible with the total aircraft performance, maintenance, and operational environment. Wheel-brake assembly design shall be such as to tolerate external loads and braking action which may be associated with proper performance during brake application while aircraft is steered through a turn. Wheel and brake assemblies shall be neutral parts, capable of use on any mounting position on the aircraft. Brake stack removal shall not be required for wheel removal. Standard fasteners shall be used where practical on wheel and brake assemblies.

3.4.3.1 Wheels and brakes shall be designed so that they cannot be improperly assembled or improperly installed on the aircraft where practical.

3.4.3.2 Sufficient rework material shall be provided to allow rework and repair of base material in areas historically troublesome; i.e., bearing bores, wheel tie bolt bosses, and brake attachment bushings.

3.4.3.3 Special Tools: Special or unusual tools and equipment shall not be required for installation, removal, or normal maintenance and inspection of the wheels and brakes unless authorized by the procuring activity.

3.4.3.4 Maintainability: MIL-STD-470 shall be used as a design guide.

3.4.3.5 Identification of Product: All markings shall be legible and easily read.

3.4.3.5.1 Wheel Marking: Wheels shall carry the following information. Integral lettering shall be required; nameplates shall be used only when specifically approved.

a. Size

b. Serial number on both wheel halves, on demountable flange and wheel body, or, in the case of other designs, on similar major wheel parts

c. Manufacturer's name and/or code and drawing number

d. Date of manufacture (month and year, which may be combined with the serial number)

e. Divided-type wheels shall carry a warning note to require deflation of the tire before loosening of the tie bolts. Note: To be in red or contrasting color.

f. Divided-type wheels shall carry a suitable note to clearly describe the method and torque values used in tightening the tie bolts. The note should read: Lubtork to _____ pound-feet (pound-inches). Lubtork shall mean that the bolt threads and the bearing surfaces of the nut, bolthead, and washers shall be lubricated with antiseize compound conforming to MIL-T-5544, or equivalent, with relubrication for each subsequent torque application.

3.4.3.5.2 Brake Marking: Brakes shall carry the following information. Stamping or integral lettering is preferred. If nameplates are required, details shall be submitted with the drawings of 3.1.1.

a. Manufacturer's name and drawing number

b. Date of manufacture (month and year, which may be combined with the serial number)

c. Serial number

d. Operating medium

e. Fastener torque values when necessary

3.4.3.5.3 Location of Marking: When practicable, the drawing number shall be so located as to be readable after assembly of the part in the complete unit.

3.4.3.5.4 Part and Subassembly Marking: Each part and subassembly, except the following, shall be marked with the appropriate part or subassembly drawing numbers:

a. Those which are premanently assembled by welding, brazing, soldering, or riveting. These shall carry the subassembly drawing number.

b. Those which do not have suitable or sufficient surface for the drawing number.

c. Those upon which marking would impair the function or structural integrity.

3.4.3.5.5 Type of Marking: Markings shall be such that they will not be obliterated or effaced as a result of service usage where practical.

3.4.3.5.6 Other Marking: The services may specify or permit other markings required for identification or instruction.

3.4.4 Interface Definition for Wheel and Brake Detail Design: The wheel and brake detail specification provided by the procuring activity shall define the following interface information together with a statement of the basis for the information, whether analytical, test, or estimated:

3.4.4.1 Tires: The following tire data shall be provided:

a. Size designation

b. Dimensions of the bead, maximum/minimum
Static section width
Outside diameter
Loaded radius
Shoulder width
Outside diameter at the burst pressure

c. Weight

d. Rated pressure

e. Ply rating

f. Maximum ply rating for this size

g. Load rating

h. Maximum load rating for this size

i. Polar moment of inertia

j. Vertical and lateral spring rates through bottomed conditions

3.4.4.2 Strut-Axle: The following related strut-axle information shall be provided:

a. Dimensions

b. Material

c. Finish

d. Weight distribution in the axle fork area

e. Deflection with load

f. Fore and aft spring rates

g. Damping

h. Temperature limitations

i. Axle centerline attitude relative to ground line

j. Strength limits

3.4.4.3 Hydraulics: The aircraft hydraulic information shall be provided as follows:

a. Hydraulic oil description and temperature limitations

b. Steady state and maximum back pressure

c. Maximum and minimum available pressure and flow to the brakes during operation

d. Hydraulic fitting callout

e. Definition of anti-spin circuits, if used

f. Displacement available

g. Maximum pressure rate of application

h. Spike surge definition

3.4.4.4 Skid Control System: The following information shall be provided:

a. Wheel speed detector

b. Envelope and mounting information

c. Temperature limitations

d. Dynamic pressure onset and dump rates

e. Concentricity of drive mechanism

3.4.4.5 Aircraft General: The following general information shall be provided:

a. Wheel well temperature profile

b. Orientation on aircraft gear up and gear down

c. Critical g loads during all phases of the operational environment

d. Air loads

e. Maximum allowable envelope

3.5 Capability Requirements:

3.5.1 Performance: The wheels and brakes shall satisfy the test requirements specified in Section 4.

3.5.2 Reliability: Satisfactory completion of all applicable tests in Section 4 shall constitute demonstration of compliance with MIL-STD-785.

3.5.3 Maintainability: MIL-STD-470 shall be used as a design guide. The requirements must be consistent with the system program requirements. Quantitative task allotments shall be identified.

3.5.4 Braking Capacity: The brake energy absorption capacity of the installed wheel and brake assembly shall be defined in the detailed specification and shall consider all aspects of the aircraft detail specification and anticipated realistic operational requirements. It is recommended that the design service life and the design usage be based on the mission requirements with due consideration of the following factors:

a. Total flight hours

b. Total number of flights

c. Total number and type of landings

d. Total service years

e. Mission profiles for each type of mission to be flown. (These profiles will be divided into mission segments, such as taxi, takeoff run, ascent, cruise, low altitude usage, combat maneuvers, etc.) The mission profiles will also stipulate the approximate duration, altitude, speed, and payload requirements for each mission segment.

f. Mission mix or number of flights of each mission.

g. Any other special requirements, such as functional check flights, ground maintenance operational checks, etc.

Unless otherwise specified, the brake shall be designed to provide the number of dynamometer stops defined in Tables I and II.

Testing to Table I is intended to cover capacity requirements, principally for sizing and performance limits, including safety of flight. Table II is intended to represent durability requirements under realistic average operating conditions in actual service.

TABLE I

WHEEL BRAKE CAPACITY REQUIREMENTS

Type of Aircraft	No. of Dynamometer Stops	Average Rate of Deceleration 1/ (ft/sec/sec)	Aircraft Weight Condition	Energy Credit 2/ Reversed Propeller or Engine Thrust	Energy Credit 2/ Drag Parachute
1. Rotary Wing	20	6	Basic design gross	Not applicable	
	1	8.8	Max landing gross	No	
2. Research and other types not listed	As specified by the procuring activity				
3. Land and Carrier Based:					
Fixed Wing	30 3/	10	Landplane landing design gross	Yes 4/	Yes 4/
	3 3/	10	Maximum landing gross	No	Yes 4/
	1 6/	10	Maximum landing gross or Maximum design gross (RTO) 5/	No	No
				No	Yes 4/

1/ Aircraft deceleration and dynamometer deceleration shall be consistent with the approved brake energy analysis.

2/ The amount of energy credit shall be approved by the procuring activity in each instance.

3/ The 30-3 dynamic torque sequence shall be conducted with 3 sequences of 10 landplane landing design gross weight stops followed by one maximum landing gross weight stop.

4/ If used in standard landing procedure.

5/ Test to whichever condition is the more critical.

6/ A new brake shall be used for the RTO stop. This brake may be conditioned prior to the RTO demonstration.

GENERAL NOTES

a. The calculations for Table I capacity requirements shall represent the worse situation as they affect overall sizing of the brakes.

b. Maximum operating pressure will be applied to the brake assembly and released prior to each of the 30-3-1 stop demonstrations.

c. Success criteria:

(1) 30-3 Sequence:

KE absorption
Torque pressure relationship
No failed parts permitted
No malfunctions
No lining fusing
Fuse plugs must not activate
Thermal limits applicable
Stop distance

(2) RTO Test:

KE absorption
Stop distance
Brake torque pressure relationship
No malfunctioning
Fuse plug activation
Thermal limits as applicable

TABLE II

WHEEL BRAKE FIELD SERVICE LIFE SPECTRUM

Applicable to all land and carrier based type aircraft listed in Line 3 of Table I. All conditions are to represent average expected operational aircraft in service. The design goal of the wheel brake will be _____ landings in accordance with the following service life spectrum less RTO.

Brake Stop Description	Typical Field Service Landing	Short Field Landing	Overweight Landing 3/	Aborted Mission
Kinetic Energy (ft-lb)				
Deceleration (ft/sec/sec)				
Tire Load (lb)				
Brake on Velocity (kts)				
Flywheel Inertia Equivalent (lb)				
Taxi Distance @ 30 knots (ft)	7500 before & after stop	3000 before & after stop	7500 before & after stop	3000 before stop
Number of 30 knot Stops during Taxi (One of which is to be at max effort)	2 before & after stop	2 before & after stop	2 before & after stop	2 before stop
Number of Stops and Sequence of Stops at each Condition (Read left to right & top to bottom)	5 5 20 60 5 1/ 5	- 1 1 - - -	1 - - 3 1 -	- - - - - 1 2/
TOTALS	100	2	5	1

1/ Using wear data obtained, calculate the safe removal point in aircraft service. At this point, rework the stack of heat sink members and/or linings such that the minimum thickness remains for the final 12-stop demonstration.

2/ The worn brake RTO stop is conducted to determine the aborted mission KE capacity of a worn brake and to demonstrate the ability of the brake to complete an aborted mission stop to reasonable conditions. See General Note a.

3/ Maximum energy landing.

GENERAL NOTES

a. For Table II, the analysis is to be based on realistic average conditions expected to be experienced in service usage of the aircraft.

b. The brake assembly and the wheel assembly used for the 30-3 sequence of Table I shall be used for the testing per Table II. The brake will be refurbished with a new complement of disks or other heat sink members, linings, and seals.

c. The brake drag and energy absorbed during taxi shall be consistent with the operational environment defined for the specific aircraft. Cooling air of 30 knots may be used during all taxis. Taxi snubs during rolling may be specified if applicable to the aircraft system.

d. Extrapolate wear data achieved as testing proceeds to judge the conformity of performance to the design goal.

TABLE II (Cont'd.)

e. Maximum operating pressure will be applied to the brake assembly and released prior to each of the 108 stop demonstrations.

f. Success criteria:

Wear	No failed parts
Brake drag	No binding
Component distortion	No malfunctioning
Torque pressure relationship	Stop distance
Thermal limits if applicable	

3.5.4.1 Landing and Takeoff Brake Capacity Analysis: The design brake energy shall be the result of a rational aircraft and aircraft operational analysis and shall be approved by the procuring activity. For the analysis, the following criteria shall apply unless stated otherwise: On the landplane landing, maximum landing and rejected takeoff conditions, the brakes shall be instantaneously applied to a torque level associated with the effectively available dry concrete tire-friction level. The ground velocity of brake application shall be sea level standard, velocity of lift-off or touchdown at the static aircraft tail interference angle of attack power off. The service energy condition will be defined from the average service landing weight, landing rollout, and braking techniques anticipated for the aircraft. The landplane landing, maximum landing, and maximum takeoff weights shall be as defined in MIL-A-8860.

3.5.4.2 Operational Energy Analysis: An aircraft operational energy analysis shall be performed which considers the total operational environment required of the aircraft. The results of the analysis shall be approved by the procuring activity and reflected in the brake test program.

3.5.4.2.1 Turnaround Capacity: In the event a mission turnaround requirement is placed upon the total aircraft system, a special brake dynamic torque test sequence shall be conducted demonstrating the required capability. The test sequence shall be subject to the approval of the government procuring activity.

3.5.5 Wheel Capacity: The rated load capacity of each landing wheel on an aircraft shall be equal to or greater than the maximum load that the wheel will be subject to at maximum towing or taxiing static design gross weight of the aircraft. Additionally, nose wheels shall carry a dynamic rating equivalent to the actual maximum dynamic load for the condition of load shifting onto the nose gear during braking. In cases where auxiliary wheels do not normally support static loads (as in wingtip protection wheels), the wheel capacity will be determined by the procuring activity, based on appropriate dynamic loading calculations. A complete static and dynamic analysis of the main and auxiliary wheel loads shall be made by the aircraft manufacturer. From this analysis a loading spectrum shall be prepared.

3.5.6 Compatibility Requirements: Wheel and brake assemblies shall be subjected to laboratory tests for the purpose of proving compatibility of the wheel and brake assembly with the airplane brake system. Dynamometer stops shall be performed at normal braking energy levels with the brakes actuated by a system simulating a pilot's commands through the airplane's braking system, including any skid control provisions. Additionally, a torque requirement analysis shall be performed which considers wet and dry brake static and dynamic torque requirements of the brake assembly during the expected operational aircraft environment. The results of the analysis shall result in the brake pressure torque requirements definition in the procurement specification and shall be demonstrated during qualification testing.

These compatibility tests shall be designed to accumulate evidence that:

a. The overall brake system has characteristics that permit the pilot to safely control the airplane's velocity during ground operations.

b. The individual system components function as required to achieve overall system performance.

c. The durability or structural integrity on any individual brake system component is not impaired by operating under simulated braking conditions and that the system components fit together and function as required, including laboratory test axles which simulate the characteristics of the aircraft axle.

3.5.7 Environment: The following design and performance requirements shall be identified in the detail specification:

3.5.7.1 Temperature Environment: Wheel and brake assemblies shall be designed for satisfactory operations at all ambient temperatures in the range of -65°F to +160°F (-54°C to +71°C). In the event that the environment of a specific installation exceeds these values, the actual condition shall govern. Those elements which form part of the hydraulic system shall meet the operating temperatures of MIL-H-5440. All elements shall be compatible with the heat generated by usage of the brake as defined herein. The mission profile for each aircraft application shall be reviewed so that a rational analysis of maximum allowable wheel bead ledge temperature and time at temperature can be made and detail design requirements established as a result of this analysis. In the absence of an acceptable analysis, the wheel bead ledge temperature shall not be permitted to exceed 350°F (177°C) for the maximum landing gross (3 stop) condition of Table I.

3.5.7.2 Humidity Requirements: The wheel and brake and its components shall function satisfactorily in an environment of relative humidity up to 100 percent, including conditions in which condensation occurs in the form of water or frost.

3.5.7.3 Fungus Requirements: The wheel and brake and its components shall operate satisfactorily after exposure to fungus conditions as encountered in tropical climates.

3.5.7.4 Vibration Requirements: The wheel and brake and its components shall operate satisfactorily when exposed to mechanical vibration induced by the dynamics of the system and the acoustical noise realistically encountered on the aircraft in the area of mounting.

3.5.7.5 Dust Requirements: The wheel and brake and its components shall operate satisfactorily under conditions consisting of blowing sand or dust particles as encountered in desert areas.

3.5.7.6 Salt Fog Requirements: The wheel and brake and its components shall operate satisfactorily when conditions are imposed which simulate the environment of sea coast region.

3.5.7.7 Acceleration Requirements: The wheel and brake and its components shall function properly when exposed to translational accelerations consistent with that encountered on the aircraft.

3.5.7.8 Shock Requirements: The wheel and brake and its components shall withstand any shock loading expected in operation, handling, or transportation. Unless otherwise determined, the wheel and brake shall be subjected to 50g's acceleration in all directions while operating, except those units designed for carrier operation shall be subjected to 200g's.

3.6 Workmanship: Workmanship and finish shall be of the quality necessary to produce wheel and brake assemblies that are free from defects which affect proper functioning in service.

3.6.1 Castings: Magnesium and aluminum castings shall be produced in accordance with AS 586.

3.6.2 Forgings: Forgings shall be of high quality and uniform condition and shall be free from blisters, fins, folds, seams, laps, cracks, segregations, or other defects which would adversely affect their strength and serviceability.

4. QUALITY ASSURANCE PROVISIONS

4.1 Product Verification: Product verification of design and performance requirements may be made by analysis, demonstration, similarity, or by tests.

4.1.1 Life Cycle Cost Analysis: Life cycle cost analysis shall be prepared to predict the ownership cost.

4.1.2 Stress Analysis: The manufacturer shall prepare a stress analysis covering the wheel and brake assembly. All static and fatigue loads shall be analyzed and margins of safety noted for critical parts. Requirements outlined in MIL-A-8868 shall govern preparation of the Stress Analysis Report.

4.2 Classification of Tests: The inspection and testing of wheel and brake assemblies shall be classified as follows:

a. Preproduction tests (see 4.3)

b. Quality conformance tests (see 4.5)

4.3 Preproduction Testing:

4.3.1 Preproduction Test Samples: The preproduction test samples shall be representative of the production assembly. Samples shall be tested in the manner designated in the contract, purchase order, invitation for bids, or as authorized by the procuring activity.

4.3.2 Preproduction Tests: The preproduction tests shall consist of all of the tests of this specification as specified under 4.4. The option of witnessing all or part of the testing shall be extended to the government engineering activity. Two weeks' advance notice will be furnished to the responsible government activity on the start of preproduction testing.

4.4 Test Methods:

4.4.1 Radial Load Test: This test shall be performed by applying the radial load to the wheel through a tire inflated to an initial pressure equal to the rated inflation pressure (or as specified in the procuring document for shipboard operations). Either air or water inflation may be used. If the tire is filled with water, the water shall be bled off during loading to approximate the same tire deflection that would result if air inflation were used, and the inflation pressure shall not exceed the pressure at maximum tire deflection. The load shall be applied to the wheel and perpendicular to the axle centerline by means of an axle passing through the hub. The tire shall be loaded directly against a flat, nondeflecting surface. Deflection and permanent set readings shall be taken at suitable points on the wheel to indicate deflections of the wheel rim at the bead seat, hubs, and other critical areas. Wheels intended for tubeless tire mounting shall be so tested with said mountings unless otherwise specified. The required radial load tests are specified below.

4.4.1.1 Yield Radial Load Test: The wheel shall support the yield radial load applied consecutively at 90°, 180°, and 270°, followed by three more load applications at the 0° position. The 0° position shall be the most critical load contact point which shall normally include the valve hole. The 90° increments may be altered when structural conditions indicate. The successive loadings at the 0° position shall not cause radial permanent set increments of increasing magnitude. The permanent set increment caused by the last loading (at the 0° position) shall not exceed 5 percent (or .005 in. (.127 mm) whichever is greater) of the total deflection caused by the last loading. There shall be no yielding of the wheel such as would result in loose bearing cups, air leakage, or interference in any critical clearance areas. The bearing cups and cones and rollers shall be used for this test.

4.4.1.2 Ultimate Radial Load Test: The ultimate load shall be applied at the 0° position of the same wheel on which the yield radial loads were applied. The wheel shall support the ultimate load for 10 seconds after which there shall be no cracks in any areas. The bearing cones may be replaced with conical bushings, but the cups shall be used. If desired, a tubeless tire may be replaced with tire and tube.

4.4.2 Design Landing Radial Load Test: The load shall be applied in the same manner as described in 4.4.1. The load shall be supported for not less than 10 seconds, and the resulting permanent set shall not produce loose bearing cups, air leakage, interference in critical running areas, or make the wheel unsuitable for further service. The tire inflation pressure shall be the maximum design operating pressure for the condition being simulated. For Navy aircraft intended for shipboard use, the wheel shall be loaded for this test condition through 1-3/8 in. (35 mm) diameter cable or steel bar that simulates statically the wheel design landing load plus the load imposed by rolling over or landing on a 1-3/8 in. (35 mm) diameter cable. If a cable is used, the specimen shall be at least 3 ft (914 mm) long with ends secured to prevent looseness. Unless otherwise specified by the procuring activity, the wheel shall be loaded perpendicular to the axle centerline.

4.4.3 Combined Load Test: The combined load test shall be performed by applying the load to the wheel through a tire inflated to an initial pressure equal to the rated inflation pressure or the carrier design operating pressure. Air or water inflation pressure may be used. If the tire is filled with water, the water shall be bled off during loading to approximate the same tire deflection that would result if air inflation were used, and inflation shall not exceed the pressure at maximum tire deflection. Yield loads shall be applied in both inboard and outboard directions on the same wheel and at the ground angle and magnitude determined by the airframe manufacturer in accordance with applicable specifications. The wheel and tire assembly shall be mounted on an axle passing through the hub. The tire shall be loaded directly against a flat, nondeflecting surface so that the combined load is as ascertained above. The loads shall be applied simultaneously, either continuously or in increments of approximately 10 percent of the specified values. Readings shall be taken at suitable points on the wheel to indicate deflections and permanent sets. The required combined load tests are specified below.

For the yield and ultimate combined load tests, it is permissible to limit the tire deflection to that deflection achieved under limit load conditions of vertical and lateral loads by use of load transfer blocks (saddle type) which bear directly on wheel rim structure. Another alternative, where justifiable, is the use of tire inflation exceeding the aforementioned values.

4.4.3.1 Yield Combined Load Test: The wheel shall support the components of the yield combined load applied consecutively at 90°, 180°, and 270°, followed by three more load applications at the 0° position. Each load application shall be sustained for a minimum of 10 seconds. The 0° position shall be the most critical load contact point which shall normally include the valve hole. The 90° increments may be altered when structural conditions dictate. The successive loadings at the 0° position shall not cause permanent set increments of increasing magnitude. There shall be no yielding of the wheel such as would result in loose bearing cups, air leakage through the wheel or past the wheel seal, or interference in any critical clearance areas. The bearing cups and cones and rollers shall be used for this test. A conventional tire may be used when testing a tubeless wheel only when it has been demonstrated that pressure will be lost due to the inability of the tire bead to remain properly positioned when under load.

4.4.3.2 Wheel-Brake Interference: For wheel assemblies used in conjunction with brakes, the yield load test of 4.4.1.1, 4.4.2, and 4.4.3.1 must be run with the brake installed, and it shall be determined that no interference exists.

4.4.3.3 Ultimate Combined Load Test: The ultimate combined load shall be applied at the 0° position of the same wheel on which the respective yield combined load tests were performed. The ultimate load shall be sustained for a minimum of 10 seconds after which there shall be no cracks in any area. The wheel shall be loaded in the most critical direction. The bearing cones may be replaced with conical bushings, but the cups shall be used. Tubeless tire mountings may be replaced with conventional tire and tube.

4.4.4 Burst Test: The burst test load shall be applied to the wheel by means of hydrostatic pressure in the tire. A tire and tube may be used when testing a tubeless tire wheel by adding the necessary valve hole to the test article. Wheels of land-based aircraft shall be tested to a burst pressure of 3.5 times the rated tire pressure, at the rated static load of the wheel or the burst strength of the tire, whichever is least. Wheels of carrier-based aircraft shall be tested to 4.5 times the rated tire pressure or to the burst strength of the tire, whichever is least. Helicopter wheels shall be tested to a burst pressure producing not less than 3.0 times the axial load which results from the tire pressure required for the static wheel load at the taxi gross weight. Alternate specifications may be specified by the procuring activity.

4.4.5 Roll Test: The roll test shall consist of a series of landings or a continuous roll of the wheel assembly against a rotating road wheel. Roll tests shall be performed with tires having the same size and ply rating as will be installed for aircraft usage. Tubeless tires shall be used when testing tubeless wheels. Roll test tire inflation pressure shall be the flat-surface inflation, as specified by the procuring activity, applicable to the loading condition imposed. For each loading condition, the roll test tire inflation pressure shall be constant. All tire test pressures, road wheel sizes, and mileage shall be reported in the preproduction test report. Roll tests shall be performed in accordance with the following procedures and conditions and shall not result in cracks or other evidence of failure. Final inspection shall be made with all hardware removed from the structural components.

a. Thermal Conditioning: Prior to roll testing, all wheels utilizing shot peening, roll burnishing, or other cold-working processes shall have been subjected to thermal conditioning equivalent to the cumulative temperature-time history resulting from brake heat dissipation experienced during the dynamic torque tests of 4.4.8 except for the rejected takeoff condition. Thermal conditioning may be accomplished by performing dynamic torque testing, by simulation of the thermal distribution in the wheel utilizing a simulated brake heat sink to produce the same temperatures encountered during the dynamic torque testing, or by a suitable oven heat soak.

b. Stress Measurement: The stresses in the bead seat or other areas affected by the tire shall be measured for each loading condition and for each test inflation pressure which is utilized. The stress measurements shall be reported in the preproduction test report.

c. Minimum Roll Distance: The applied loading conditions and roll distances will be supplied by the procuring activity. The minimum requirement shall be 1,500 miles (2,400 km) at loads encountered on the aircraft at maximum taxi gross weight.

(1) A suitable portion of the roll test shall be conducted at the static rated capacity. A minimum combined load roll of 60 miles (96 km) in each direction shall be conducted with combined radial and side loads corresponding to those produced by a .20g turn at maximum design gross weight.

(2) Helicopter wheels are not subject to the loading conditions in (1) above unless specified in the detail specification. Instead, helicopter wheels shall be rolled 250 miles (400 km) minimum with an applied radial load not less than the static wheel reaction based on helicopter maximum taxi gross weight.

(3) Wheels for carrier-based aircraft shall be subjected to a roll test which simulates catapult takeoff loads. The conditions for this test shall be proposed by the aircraft manufacturer and approved by the Naval Air Systems Command.

(4) 50 percent of the straight roll portion of the roll test for carrier-based aircraft wheels shall be conducted with the tire inflated to the pressure required for shipboard operation.

d. Extended Roll Test: Upon completion of the minimum roll requirement, the roll test conditions shall be repeated until wheel failure occurs. Tie bolt or bearing failure after the minimum portion of the test has been completed will not be construed as wheel failure. The roll to failure portion of this test may be concluded prior to failure provided four times the required roll test distance has been obtained on the test wheel. The preproduction test report shall be amended to include these data.

4.4.5 (Cont'd.)

e. Alternate Tests: When specified by the procurement document, alternate test arrangements representing combined loads or spectrum tests will be required.

4.4.6 Tubeless Wheel Pressure Test:

4.4.6.1 Dynamic Pressure Test: The tubeless tire and wheel assembly shall be rolled under the load specified by the roll test (4.4.5) for 25 miles (40 km) with no pressure drop greater than 5 percent or 5 psi, whichever is less. Mileage accumulated during this test may be used in computing the total mileage in the roll test.

4.4.7 Wheel Preproduction Approval Limitation: Wheels designed and preproduction approved for tubeless tire use, when used with conventional tire and tube, shall require no further test except the customary mounting test. Suitable caution shall be taken if tubes are used in wheels fitted with fusible plugs to indicate that the functioning of the fusible plugs may be impaired.

4.4.8 Dynamic Torque Test: The dynamic torque tests shall be in accordance with the conditions outlined on the applicable specification drawing or in the procurement specification. Unless otherwise specified, the number of stops shall be as specified in Section 3. The wheel and brake shall successfully complete the test sequence defined in Tables I and II. Table I testing is fundamentally for the purpose of establishing braking capacity and performance capability. Table II testing is a demonstration of field service life. Success criteria listed on Tables I and II apply.

Brake Wear Characterization: Brake wear data from each of the significant test conditions is to be extrapolated and a curve plotted relating brake life for the various energy conditions represented.

Unless otherwise specified, all carbon brake assemblies shall be wear characterized as follows to enable predicting life cycle costs:

a. Wear rate in "inches/1000 stops" at 5 and 10 fps^2 deceleration at stack loadings from taxi stop to the maximum landing energy level.

b. Wear rate for taxi drag conditions in "inches/1000 miles" vs "drag force" sufficient data points shall be demonstrated as approved by the procuring activity.

During these tests, the brake assembly may be disassembled to enhance learning during development-qualification testing. Parts may not be changed or removed except as noted at the beginning of taxiing per Table II. The brake may have the lining dust removed by the use of an air hose or equivalent with the wheel removed. When the wheel assembly is re-installed, the brake rotating disk must be placed in the same position and in relationship with the other disks and wheel disk drive keys as they were when the wheel was removed. After completion of the test, all parts shall be cleaned and inspected for defects using aided inspection methods, such as magnetic particle or dye penetrant. No parts shall have cracked during these tests to the extent of compromising the structural integrity during the 20 or 30-3 stop condition of Table I, or the first 102 stop conditions of Table II. If cracks or defects are present, an analysis shall be performed to determine the origin and cause of the defect and the potential effect of continued service. Tubeless tires shall be used when testing tubeless wheels. The tire shall be the same size and ply rating as the aircraft installed tire. The dynamic torque tests shall be in accordance with the following procedure:

a. Proper kinetic energy values shall be determined from the applicable specification drawing or procurement specification, or from appropriate calculations in accordance with Section 3.

4.4.8 (Cont'd.)

b. A flywheel weight shall be selected which provides an inertia equivalent approximately equal to, but not less than, the effective mass of aircraft per brake based on the rational analysis of 3.5.4.1. The inertia equivalent shall not exceed the desired mass by more than 10% or 1000#, whichever is greater. Energy and drag forces caused by auxiliary braking means such as aerodynamic drag, reversed thrust, and drag chutes may be accommodated by adjusting the inertia downward from the actual aircraft mass. In any cases where residual engine thrust exceeds these auxiliary braking forces, added inertia is to be used. For testing in accordance with Table I, the energy credit is disallowed in certain cases. The inertia adjustments mentioned above do not apply in such cases.

c. The flywheel speed at application of the brake shall be determined as that peripheral speed which, under the chosen flywheel weight, will give the required kinetic energy.

d. The following shall be accomplished: Bring the flywheel to the proper velocity, land the test wheel, apply the prescribed load, apply brake pressure, and bring the test unit to a complete stop. The design specification will identify the required stop time and/or stop distance. The average stop time or distance for any five consecutive landplane landing weight stops shall be equal to the correct stop time or distance for the test condition. All stops which fail to meet the minimum required performance must be compensated by a comparable increase in deceleration within the next five stops. Alternately, added testing, which satisfactorily demonstrates the capability of the brake to produce the deceleration required, may be accomplished.

e. During the dynamic torque test, the brake pressures required to develop static torque suitable to comply with the torque compatibility analysis shall be determined under the following conditions:

(1) With brake at room temperature, approximately 70°F (21°C)

(2) With brake heated by a landplane landing design gross weight energy stop and with static torque test applied as soon as possible after completion of that stop consistent with safety precautions that must be taken

(3) At less than 10 percent, at 50 percent approximately, and again after 90 percent of the number of stops required by Table II, or as otherwise specified by the procuring activity (This test may be conducted by applying a tangential force at the static radius of the tire.)

(4) Consideration shall be given to a test technique on the RTO test of Table I of using pressure representative of maximum antiskid effort for the conditions of a dry concrete runway.

(5) If carbon composite or other water absorbing material is used as brake lining material and aircraft is designated for shipboard operation, the following additional test shall be performed:

0.5 gal (1,892 ml) of water shall be sprayed into heat sink cavity of the brake. The brake shall be able to produce a static torque equivalent to parking a maximum gross weight airplane in any orientation on a 10° slope without movement. The hydraulic pressure for this test shall contribute to establishing the emergency braking pressure for the airplane.

f. During the dynamic torque test, the following data shall be recorded:

(1) Weight and description of wheel, brake, tire, and tube used

(2) Flywheel diameter, inertia equivalent, speeds, and kinetic energies

(3) The test facility shall obtain time-temperature relationships of the following components for the conditions noted and present the data in the formal preproduction test report:

4.4.8 (Cont'd.)

(a) Hydraulic fluid

(b) Wheel adjacent to the fuse plug (if incorporated)

(c) Bead ledge above each brake

(d) Other critical components

Temperature recordings should continue until the hottest portion has cooled to 300°F (149°C). Temperature limits of the bead ledge shall be in accordance with 3.5.7.1 unless otherwise defined in the applicable specification document. A minimum of three design landing stops, two maximum landing weight stops, and the critical one stop test shall be conducted without accelerated cooling after conclusion of the stop. Park the brake with parking pressure and record temperatures of the bead seat, disks, and fluid until temperature peaks are reached without cooling air after a typical field service landing and an overweight landing of Table II. Accelerated air cooling on other stops may be employed after the above-noted components have attained their peak temperature. Cooling air may be used to simulate taxi conditions. Taxiing into the wind should be 35 to 40 knots wind velocity; away from the wind should be 0 to 5 knots. Three additional landing stops shall be monitored with accelerated cooling if used. Accelerated cooling procedures used shall be described. When rolling fans are used, the time of cooling, temperature of cooling air, and velocity at the test brake shall be noted in the test report.

(4) Wheel load

(5) Brake operating pressure (or force) for each stop

(6) Average dynamic torque for each stop

(7) Stopping time for each stop

(8) Static torque information

(9) Fluid displacement for new brake and brake worn to maximum allowable clearance at room temperature for each wear condition

(10) Tangential force at circumference of tire required to rotate wheel, with brake pressure released to back pressure after completion of every fifth stop of Table II

(11) Time required for wheel, brake, and tire assembly, landed against flywheel, to stop flywheel from an initial landing speed of 30 mph. This observation should be made after every fifth stop of Table II, except that it may be omitted when no noticeable brake drag is present.

(12) Brake operating clearance prior to test and at least four times during the test of Table II

(13) The thickness of the lining of each of lined disks and the thickness of each unlined disk at the beginning and at the end of the normal energy stops (including "3" stop or overload conditions where applicable)

4.4.8 (Cont'd.)

(14) The number of missions to wear out a brake shall be estimated by measuring the average wear from Table II testing and prorating this wear to the fully worn condition using data from the disk and/or lining with the least usable friction material remaining at the time of the measurement. This wear position will be consistent with the wear pin indicator setting and shall be such that the aborted mission stop capability remains in the brake.

(15) Time after stop to fuse plug release and energy level of stop

(16) Ability of tubeless tire wheels to retain pressure satisfactorily under braking conditions. Nitrogen inflation is recommended for safety reasons.

(17) Any other information that will be of assistance to ultimate users of the wheel and brake assembly

g. Oscillograph or equivalent traces shall be made during the dynamic torque test, recording the following for each run for submission with the test report:

(1) Flywheel velocity

(2) Test wheel velocity

(3) Brake torque

(4) Brake pressure at the brake port

4.4.8.1 Safe Brake Service Removal Point: Unless otherwise specified, the brake assembly shall have a useful service life on the aircraft until the indicator device has a 100% worn indication. The 100% worn point shall be such than an aborted mission stop per Table II remains in the brake assembly as demonstrated by a suitable laboratory test. The laboratory test specimen shall be worn to the 100% worn indicator point by aircraft, laboratory, by machining or combinations thereof as approved by the procuring activity prior to demonstrating the aborted mission stop of Table II.

4.4.9 Lining Fusion Test: A dynamic test shall be conducted to show that no lining fusion or welding will occur over the full operational range of the brake up to and including the three-stop condition. The test procedure shall be subject to approval of the procuring activity. (Not applicable to brakes having carbon-carbon heat sink materials.)

4.4.10 Turnaround Dynamic Torque Test: Unless otherwise specified, the wheel-brake-tire assembly turnaround capacity shall be sufficient to provide the aircraft with a typical service landing, a 30 knot 2 mile (3.2 km) taxi-in, a 15 minute hold, a 2 mile (3.2 km) taxi out, and abort capability to the maximum landing design energy condition. Thirty (30) knot cooling air may be utilized for the landing stop, taxi, and abort portions of the turnaround demonstration. The turnaround capability shall be laboratory demonstrated on a 90 to 100% worn brake assembly.

4.4.11 Compatibility Tests: Suitable compatibility tests shall be conducted reflecting the results of the analysis and the requirements of 3.5.6 herein and which are reflected in the detailed specification.

4.4.12 Structural Torque Test: The brake shall be actuated at the maximum operating pressure. Tangential load shall then be applied at the static radius of the tire until the applied tangential load equals 1.2 times (1.0 for helicopters) the maximum rated static load of the wheel. The friction surfaces of the brake may be bolted or clamped together or otherwise restrained to withstand the required tangential load of 1.2 times (1.0 for helicopters) the maximum rated static load of the wheel. The wheel and brake shall withstand the structural torque test without failure. In the case of a structural carbon brake, the structural torque test will be conducted on a 100% worn brake as defined in 4.4.8.1. This configuration may be achieved by machining the test specimen to the worn dimensions. Data will be obtained using 1.5 maximum operating pressure to a torque level resulting in slippage or failure,

4.4.12 (Cont'd.)

whichever comes first. In the event the tangential load does not achieve 1.2 times the maximum static rating of the wheel, the carbon heat sink members may be replaced and the test reconducted to achieve 1.2 times the static wheel load tangential load. These replacement disks may be metals of sufficient strength to demonstrate the test.

4.4.12.1 Co-Rotating Wheels: Co-rotating wheels shall also be tested to verify the structural integrity of the co-rotating feature. They shall be subjected to a tangential load of 1.2 times maximum rated load of the wheel applied at the static radius of the tire. There shall be no evidence of failure as a result of this test.

4.4.13 Static Pressure Test: The brake shall be parked for a period of 5 minutes with an applied operating pressure equal to twice the maximum operating pressure. The test shall be conducted with linings and heat sink having thickness comparable to the maximum permissible wear. There shall be no leakage or failure during this test. Pressure shall then be increased until failure occurs and the ultimate pressure shall be recorded.

4.4.14 Endurance: The hydraulic brake shall be subjected to 100,000 cycles (50,000 for helicopters) of application and release of pressure equal to normal operating pressure and 5,000 cycles (2,500 for helicopters) at a pressure equivalent to the maximum operating pressure. This test shall be conducted using a minimum clearance equivalent to the maximum clearance allowable between adjustments. The first portion of the test may be divided into four parts so that 25,000 cycles (12,500 for helicopters) may be applied at each of four positions of brake piston travel conforming to 25 percent, 50 percent, 75 percent, and 100 percent travel, respectively. The rate of cycling shall be not greater than 30 cycles per minute. During and at conclusion of the test, the leakage rate shall be limited as specified in 4.5.3.1.2 and there shall be no evidence of other malfunction. Alternate endurance tests may be used upon written authorization of the procuring activity.

4.4.14.1 Brake Return Pressure: Tests shall be conducted before and after the endurance test (4.4.14) to determine the minimum hydraulic pressure, or force in the case of mechanical brakes, to bring the braking surfaces into contact. Tests shall likewise be conducted to determine the minimum pressure or force at which the braking surfaces disengage on release of pressure. The tests shall be conducted with the brake mounted on a horizontal axle with the wheel assembled. The braking surfaces shall disengage on release of pressure at all pressures below that specified on the applicable design drawing.

4.4.15 Extreme Temperature Test:

4.4.15.1 Aging and Heat Test: The brake, filled with operating fluid, shall be subjected for 7 days to a temperature of 160°F (71°C) for AN seals, 225°F (107°C) for MS seals or better, or higher temperature as required by the particular application other than 3-stop maximum landing conditions. With the brake and operating fluid being maintained at this temperature, the brake shall be cycled 1,000 times at normal operating pressure followed immediately by 25 cycles at maximum operating pressure. Leakage rate shall be limited as specified in 4.5.3.1.2. Where warranted, deviation from the aging temperature and the time specified above may be granted upon presentation of substantiating data to the activity responsible for approval.

4.4.15.2 Cold Test: Upon completion of the aging and heat test (4.4.15.1), the brake, filled with operating fluid under atmospheric pressure, shall be subjected to a temperature of -65°F (-54°C) for a period of 72 hours. There shall be no leakage during this period. With the brake and operating fluid being maintained at this temperature, the brake shall be cycled 25 times at normal operating pressure followed immediately by five cycles at maximum operating pressure. The brake clearance shall be checked between each cycle at maximum operating pressure to insure that the brake releases completely. The time required for the brake to release completely shall be noted. Leakage rate shall be limited as specified in 4.5.3.1.2. Upon completion of the cold test, the brake shall satisfactorily pass the static and dynamic leakage test as specified in 4.5.3.1.1 and 4.5.3.1.2.

4.4.15.3 Special Test Requirements: Special design and test requirements as specified by the procuring activity may supersede the above. The inclusion of any auxiliary feature in the wheel or brake design, such as a tire pressure control system or a safety overpressurization prevention relief valve, shall require a formal demonstration and the procedure and results must be approved in writing by the responsible government procuring activity. The interface will be defined in the development specification.

4.4.16 Service Test: The right is reserved to require suitable service tests of wheels, brakes, or wheel-brake assemblies prior to granting of preproduction approval. This test will consist of a series of flight tests or taxi tests with the equipment installed on the aircraft for which it was designed.

4.4.17 Safety of Flight Tests: The following level of successful testing shall be completed before the wheel or brake equipment or the wheel-brake assembly is considered safe to release for flight test:

a. Wheels:

(1) All static load tests (4.4.1 and 4.4.3)

(2) Burst test (4.4.4)

(3) 60 percent of required roll test (4.4.5)

b. Brakes:

(1) Satisfactory completion of the testing defined in Table I.

c. Safety of flight proved items are deliverable under applicable contract provisions.

4.5 Quality Conformance Tests:

4.5.1 Tests of Materials and Parts: Materials and parts used in the manufacture of wheels and brakes shall be subjected to the following tests when required or specified:

a. Examination of Product: Each wheel and brake component shall be carefully examined to determine conformance to this specification with respect to material, workmanship, finish, dimensions, construction, surface conditions, and marking. This examination shall cover all requirements not specifically covered by other tests specified herein. Nondestructive testing shall be accomplished in accordance with MIL-I-6870.

b. Materials Test:

X-ray Control: Aluminum and magnesium alloy castings shall have X-ray control in accordance with AS 586.

Penetrant Inspection: Unless otherwise authorized by the procuring activity, penetrant inspection shall be in accordance with MIL-I-6866.

Magnetic Inspection: All magnetizable highly stressed parts of wheels and brake assemblies shall be subjected to magnetic inspection in accordance with MIL-I-6868.

Forging Inspection: Inspection shall be in accordance with the applicable material specification.

4.5.2 Tests of Wheel Assemblies: Tests of wheel assemblies shall consist of individual and sampling tests.

4.5.2.1 Individual Tests: Each completed wheel assembly shall be subjected to the examination of product (4.5.1a).

4.5.2.1.1 Wheel Pressure Retention: Suitable processing and inspection shall be accomplished on all wheels intended for use with tubeless tires to assure adequacy to retain rated operating tubeless tire pressure.

4.5.2.2 Sampling Tests: Wheels shall be selected at random and inspected for runout as specified in the radial and lateral runout test (4.5.2.2.1). The number of sample wheels shall be selected in accordance with MIL-STD-105, using inspection level III and an acceptable quality level of 1.5. For purposes of applying the acceptance-rejection criteria of MIL-STD-105, a defective wheel shall be as defined in 4.5.2.2.1.

4.5.2.2.1 Radial and Lateral Runout: The radial runout of bead seats and the lateral runout of the rim flanges shall not exceed the following values:

a. Bead seat runout (radial) 0.005 in. +0.0005 in. per in. of bead seat diameter.

b. Lateral runout of the rim flanges 0.002 in. +0.001 in. per in. of bead seat diameter.

Indicator readings shall be taken as close to the bead seat radius as possible. Readings shall be taken with bearing cups installed and with cones of the same part number as shown on the original approved drawing or on the applicable specification control drawing. A defective wheel is a wheel having any one runout reading in excess of the above specified limits.

4.5.3 Tests of Brake Assemblies: Each completed brake shall be subjected to the following individual tests:

a. Examination of product (4.5.1)

b. Functional and leakage test (4.5.3.1)

Quality conformance tests shall be conducted with fluids compatible with the seals, seal lubricants, and design operating media. Upon completion of the tests, the excess fluid shall be drained, but a corrosion-preventive film of compatible oil or fluid shall be allowed to remain in the cylinders. (WARNING: In pneumatic components, do not use a material conducive to a "diesel explosion" hazard.) The cylinder shall then be suitably capped to prevent leakage of the preservative media.

4.5.3.1 Functional and Leakage Test: Quality conformance tests shall be in accordance with 4.5.3.1.1 and 4.5.3.1.2. Each complete brake submitted for acceptance under contract shall be tested with fluid compatible with that specified for use on the aircraft. Alternate actuation media and processes may be used upon written authorization of the procuring activity. Each completed brake submitted for acceptance under contract shall be subjected to a functional test for which written approval of the procedure has been received from the procuring activity. The brake shall be tested with hydraulic fluid for which the brake was designed.

4.5.3.1.1 Static Leakage Test: The brake shall be parked for a period of 5 min. with an applied operating pressure equal to 1-1/2 times (1.0 for helicopters) the maximum operating pressure. The brake shall then be parked for a period of 5 min. with an applied pressure of 5 psi. There shall be no measurable leakage (less than one drop) or permanent set during these tests. Deflection and permanent set measurements are not required for quality conformance tests (4.5.3).

4.5.3.1.2 Dynamic Leakage Test: The brake shall be subjected to 25 cycles of the application and release of maximum operating pressure. Leakage at static seals shall not exceed a trace. Leakage at moving seals shall not exceed one drop of fluid per each 3 in. of peripheral seal length.

5. NOTES

5.1 Data Submittal: Data submittal requirements should include the following:

a. The airframe manufacturer should submit the following data for review prior to inclusion in or with a specification document:

(1) Brake energy analysis as defined in 3.5.4

(2) Combined radial side load requirements as defined in 4.4.3

(3) Applicable interface data 3.4.4

(4) Wheel load spectrum in accordance with 3.5.5

b. The manufacturer should submit a stress analysis to the procuring activity within 90 days after receiving preproduction test report approval. For items procured as replacement hardware, the stress analysis should be submitted concurrent with and as a part of the test report (see 3.4.3.3).

c. Drawings for each interface component of the approved preproduction assembly should be submitted within 60 days after receipt of approval (see 3.1.2).

d. A test procedures document will be prepared and submitted to and approved by the responsible government procuring activity. The test procedures document shall include the following:

(1) A complete and detailed listing of all test procedures and the sequence in which each test will occur

(2) A complete description of the data to be recorded, a description of the recording equipment, and a sample of similar test data previously recorded on a similar test

(3) A description of the equipment to be used in the test and how this equipment will be assembled for testing

The procedure shall be in accordance with the approved specification and the intended data recording shall be acceptable to the government procuring activity. No variations may be permitted without written approval of the responsible government activity.

A test procedures document should be submitted to the responsible government procuring activity for approval not less than 45 days before the start of formal preproduction testing and the Government will respond within 30 days. These tests should not begin before the 45 days have elapsed or until approval is received, whichever is the earlier, or the tests will be subject to rerun.

e. In the event preproduction tests are authorized to be conducted by the wheel and brake manufacturer or by a commercial laboratory having suitable equipment, complete test reports shall be prepared for approval by the activity responsible for granting preproduction approval or of the aircraft manufacturer, as applicable. The test report shall include the following:

(1) A statement of requirements and a statement of the results for each test required by the procurement specification.

(2) Actual recorded oscillograph or equivalent data for each run of the dynamic torque brake test with suitable calibration data to permit evaluation

(3) A copy of operator instructions and comments

(4) Certification of the accuracy of the recording instruments

5.1 (Cont'd.)

A preproduction test report should be submitted to the responsible government procuring activity for approval within 60 days after completion of the test. When the wheel and brake assemblies are designed for use on Navy aircraft, one copy of the report should also be forwarded to the Naval Air Systems Command, Department of the Navy, Washington, DC 20360.

f. If the preproduction tests extend beyond 45 calendar days from the start, an interim progress report should be published and every subsequent 30 days that the test effort continues. The report should contain a summary of the results of all preproduction testing to date, a description of the difficulties and failures encountered with the test item, and expected completion schedule. Distribution should be made the same as for the final preproduction test schedule report.

g. The preproduction test report should be amended to include the extended roll test data of 4.4.5 d within 180 days (or as approved by the procuring activity) after receipt of approval of the original test report.

h. The procuring activity shall provide a statement of intended usage of the airplane suitable for use in determining the field service life spectrum requirement of Table II.

5.2 Conformance to Test Samples: It is to be understood that wheel or brake assemblies supplied under contract will be identical to, or completely interchangeable with, samples tested and found satisfactory, except that:

a. Minor changes in drawings, parts, or materials may be made without prior approval of the procuring activity, provided they do not adversely affect the strength, performance, interchangeability, weight, or material physical properties of the part or assembly. Notice of such changes should be submitted to the government inspector for information. The right is reserved to disapprove any such changes which are considered to adversely affect the abovementioned characteristics.

b. Other changes from preproduction samples should not be made without prior approval of the procuring activity.

5.3 Definitions:

5.3.1 Design Drawings: The terms "specification control drawing" or "applicable design drawing" referred to in this specification will be interpreted as meaning the design drawing prepared by and available from the procuring activity.

5.3.2 Normal Operating Pressure: Normal operating pressure will be interpreted as meaning that pressure, or mechanical force in the case of mechanical brakes, required to produce an aircraft deceleration in accordance with the procurement document, as determined by an average of pressure measurements in landplane landing design gross weight tests specified in 4.4.8.

5.3.3 Normal Parking Pressure: Normal parking pressure will be interpreted as meaning that pressure, or mechanical force in the case of mechanical brakes, required to lock the wheel at a load equal to the rated static load specified for the wheel on the applicable design drawing, assuming a coefficient of friction of 0.31 between the tire and the ground.

5.3.4 Maximum Operating Pressure: Maximum operating pressure(s) will be interpreted as meaning the maximum pressure(s) which the aircraft system can supply to the brake under design conditions.

5.3.5 Weights and Speeds: The weight conditions specified in Table I and related speeds are defined in the MIL-A-8860 series or MIL-S-8698, as applicable.