



AEROSPACE RECOMMENDED PRACTICE

ARP5146™

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Assessment of Aircraft Wheel Sealing Systems

RATIONALE

ARP5146 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE:

1.1 Scope:

This SAE Aerospace Recommended Practice (ARP) is intended to provide guidance on verifying the integrity of inflation pressure sealing systems of aircraft wheel/tire assemblies.

1.2 Purpose:

Aircraft wheel/tire assemblies can maintain inflation integrity only if the entire sealing system, consisting of the tire, wheel, inflation valve, over pressure relief devices, pressure monitoring systems, valve caps, gauges, fuse plugs, O-rings, seal glands and interfaces/boundaries between these components, successfully contains the tire inflation gas.

This document is to be used as a guide for sealing system validation when new design concepts not proven in service are being employed. It may also be used for evaluating alternate design approaches, material changes and trouble shooting service problems.

The design of the sealing system and the need for verification testing are left to the discretion of the wheel manufacturer, and the cognizant wheel design and configuration controller.

This document is not intended to be a new qualification/certification standard.

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1.3 Background:

When an aircraft wheel/tire assembly loses inflation pressure, the tire is generally suspect. However, any component within the wheel/tire assembly may be a leakage path. The creation of this document was originally requested by aircraft tire OEMs (Original Equipment Manufacturers) to provide a recommended practice for evaluating the entire sealing system for both new designs and when evaluating service performance of existing designs.

Current commercial and military specification requirements such as TSO-C135, TSO-C26d, and ARP1493 provide a good indication of sealing integrity if inflation pressure is monitored during the performance of the qualification tests defined in these specifications. A critical evaluation of the system is verified during the aircraft certification tests (flight testing). Depending on the aircraft type and landing gear configuration, numerous tire/wheel assemblies, up to 200 or more, can be involved in these flight tests, giving significant opportunity for assessing sealing system integrity.

Approved seals, maintenance and trouble-shooting procedures for commercial wheels are typically defined in the wheel manufacturer's Component Maintenance Manual (CMM). Use of any other than approved seal and maintenance or non-approved hardware interfacing with the seals invalidates the airworthiness of the wheel as established by the TSO approval. Similarly, for military wheels, the Technical Order (TO) is utilized and it relates to the qualification status of the wheel.

Although a separate procedure for assessing the seal integrity of aircraft wheel/tire assemblies is not currently accepted industry practice, at least one regional jet wheel required the inflated wheel and tire to be exposed to three cycles of temperature extremes from -65 °F (-54 °C) to 225 °F (107 °C) in a 24-hour period with no greater than 5% pressure loss.

2. REFERENCES:

2.1 Applicable Documents:

The following publications may be applicable or are provided as references.

- 2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1493 Wheel and Brake Design and Test Requirements for Military Aircraft

ARP5265 Minimum Operational and Maintenance Responsibilities for Aircraft Tire Usage

AMS-P-83461 Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275 °F (135 °C)

- 2.1.2 Federal Specifications: Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

TSO-C135 Transport Airplane Wheels and Wheel and Brake Assemblies

TSO-C26d Aircraft Wheels, Brakes, and Wheel / Brake Assemblies for Part 23, 27, and 29 Aircraft

- 2.1.3 AIA/NAS Publications: Available from Aerospace Industries Association of America Inc., 1250 Eye Street, NW, Washington, DC 20005.

NAS 1613 Seal Element, Packing, Preformed, Ethylene Propylene Rubber

3. SEALING SYSTEM DESIGN:

3.1 General:

The aircraft wheel tubewell design, combined with the stiffness of tubeless aircraft tires, does not permit the tire bead to be mounted over the wheel flange. Aircraft wheels are designed to accommodate the tire on the tubewell, between wheel flanges, prior to final wheel assembly and tire inflation. This requires that one of the wheel flanges is removable or that the wheel be split into two halves. For the wheel to provide an airtight structure for a mating tubeless tire, a primary wheel seal is required at the mating sealing surfaces of the removable wheel flange or wheel halves. Normally this is an O-ring type seal.

Smaller seals are used to prevent leakage at the inflation valve, over-pressurization release device, thermal fuse plugs, as well as at other ports to accommodate components such as a pressure gauge or a sensor for a tire pressure indicating system. Again, these ports generally utilize O-ring type seals.

3.2 O-ring and Gland Geometry:

The size and contour of the primary wheel seal gland is based on many considerations including stress, wheel deflection, interface considerations, O-ring cross-section diameter, O-ring squeeze, and O-ring circumferential stretch. Since the main seal of the wheel is a static and relatively low-pressure application where pressure fluctuations are small, back-up rings are generally not required. Extrusion of the seal at the gland interface is controlled by the built-in clearance of the mating wheel components. Proper configuration and location of the gland is necessary to eliminate pinching, minimize abrasion, and to maintain proper positioning of the seal during assembly and operation of the wheel.

The configuration of the gland is designed to develop sealing ability by the mechanical squeeze on (compression of) the O-ring when assembled in the wheel. The O-ring is typically stretched during installation to retain it in position during wheel assembly. This stretch reduces the cross section of the seal and should be considered when determining that adequate sealing squeeze is provided. Other factors contributing to the required seal squeeze are seal material, cross-sectional tolerance of the seal, gland dimension tolerances and surface finishes, diametric clearance, thermal expansion and/or contraction, concentricity of component dimensions, and compression set.

3.3 O-ring Material:

Material selection is based on design considerations such as operating and storage temperature requirements, durometer value, compression set resistance, abrasion resistance, sealing surfaces, shelf life, and compatibility with bearing grease and hydraulic fluid. O-ring lubricants are selected to ensure compatibility with the seal compound. The two most popular rubber compound families for commercial airplane wheel application are EPDM/EPR (ethylene propylene) and nitrile. The choice depends on the application, operating environment and service experience.

3.4 System Temperature Environments:

Seal systems are designed to be capable of maintaining inflation pressure over the temperature extremes experienced during wheel operation. System performance includes low and high temperature exposure in the wheel wells. Some wheel wells do not have full doors, and the wheel is directly exposed to ambient airstream conditions of the flight profile. This results in exposure to extreme low temperature conditions during flight. Fixed landing gear systems have obvious exposure to ambient and airstream conditions.

4. RECOMMENDED TESTS FOR SEAL SYSTEM VERIFICATION:

The wheel manufacturer, and cognizant wheel design and configuration controller (airframe manufacturer and/or military procurement office) establish the scope of the verification testing based on similarity to proven designs operating in similar environments. The standard diffusion and leakage tests, which form a part of the wheel and tire qualification, have existed for many years, are still relevant, and continue unchanged. Reference TSO-C26d, TSO-C135, and TSO-C62d. Monitoring pressure retention during wheel and wheel/brake qualification laboratory tests and during flight tests provide other avenues for verifying the sealing system integrity. Low temperature operating environments are of particular concern relative to wheel sealing system performance. The test wheel/tire assembly configuration must be documented to provide a basis for airworthiness compliance.

4.1 Wheel Seal Assessment Tests:

The following tests are recommended as one way to evaluate pressure retention capability. Effort is directed to minimize or neutralize the impact of external factors such as tire growth, ambient temperature changes, and gas diffusion through the tire itself. The purpose of 4.1.1 and 4.1.2 is to condition the wheel/tire assembly so that any degradation in performance resulting from the temperature soak tests can be quantified. Test 4.1.1 requires the use of a brake in the test and can be run independently, as can 4.1.2. The tests of 4.1.3 and 4.1.4 must be performed in sequence.

4.1.1 Seal Temperature Conditioning for Braked Wheels Using a Brake Test Dynamometer:

The purpose of this test is to demonstrate the seal robustness to the thermal operating environment of the wheel. The seal performance should not be compromised under operating conditions that would not cause thermal fuse plug release. In developing a thermal profile for the test, consideration should be given to the wear state of the brake, new or worn, depending on the thermal behavior of the wheel-tire and brake assembly, and the residual heat in the wheel-tire and brake assembly from previous energy events, taxi sequence and/or landing activity.

The Design Landing condition may provide a foundation for this test, however, depending on the category of aircraft, another condition other than the Design Landing might be desirable, such as the Service Cycle or Fuse Plug No-melt cycle for commercial transports.

Temperature and pressure instrumentation recommendations are contained in Appendix A.

Dangerous combinations of pressure and temperature can be achieved during this test. Personnel must be protected from either tire or wheel explosive failures. It is recommended that new tires be used to conduct this test. Tire pressure and temperatures must be checked remotely for the duration of this test.