SAE INTERNATIONAL

# AEROSPACE RECOMMENDED PRACTICE

ARP5543

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# Aircraft Wheel Inflation Valves Incorporating an Inflation Pressure Gauge

RATIONALE

ARP5543 has been reaffirmed to comply with the SAE five-year review policy.

## 1. SCOPE

This specification covers the recommended design, construction, performance and testing requirements for aircraft wheel inflation valves incorporating an inflation pressure gauge which are mounted on the aircraft wheel. These valve/gauge assemblies should be appropriate for use on all aircraft types supported by tubeless tire/wheel assemblies.

## 2. APPLICABLE DOCUMENTS

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

### 2.1 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.

AS5202 Port or Fitting End, Internal Straight Thread, Design Standard

AS33514 Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal

### 2.2 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI/NCSL Z540-1 General Requirements for Calibration Laboratories and Measuring and Test Equipment





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**http://www.sae.org/technical/standards/ARP5543**

2.3 U.S. Government Publications

Airworthiness Directive 87-08-09 Nitrogen Inflation Requirements; Available from: www.faa.gov, select “Airworthiness Directives” under Quick Find

Federal Specification A-A-59503, Commercial Item Description Nitrogen, Technical

MIL-STD-810, Environmental Engineering Considerations and Laboratory Tests

RTCA/DO-160, Environmental Conditions and Test Procedures for Airborne Equipment

Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from:

Acquisition Streamlining and Standardization Information System (ASSIST) database (http://assist.daps.dla.mil), Standardization Documents Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia, PA 19111-5094.

2.4 Other Industry Standards

Tire and Rim Association Standards (Annual Publication)

ETRTO (European Tire & Rim Technical Organization Standards)

3. GENERAL REQUIREMENTS

3.1 Intended Use

The inflation valve/gauge assembly described in this publication is designed for attachment directly to aircraft wheel assemblies. The inflation valve/gauge assembly is intended to be used to inflate and deflate the tire/wheel assembly and measure the difference between the internal tire pressure and the ambient atmospheric pressure. Valve thread details and installation torques should follow Tire & Rim Association Standards. In no case should this product be installed in an overpressure relief valve location.

3.2 Inflation Media

The valve/gauge assembly is intended for use with dry gaseous nitrogen, or dry, clean air, where applicable, on braked/unbraked wheels. Nitrogen should conform to Federal Specification A-A-59503 Commercial Item Description Nitrogen, Technical.

3.3 Valve/Gauge Assembly

The mechanical valve/gauge assembly should include a pressure gauge employing a pointer and background pressure graduation marks, a connector for the gauge to be attached to the wheel valve stem, and an integral inflation/deflation valve which would accept a standard inflation chuck and conforms to the applicable Tire & Rim Association (T&RA) standards.

The digital valve/gauge assembly should include a pressure gauge employing a digital display, a connector for the gauge to be attached to the wheel valve stem, and an integral inflation/deflation valve which would accept a standard inflation chuck and conforms to the applicable Tire & Rim Association (T&RA) standards.

3.4 Installation Envelope

The installation envelope may be established by the wheel manufacturer or the airframe manufacturer, as appropriate. Installation should be such as to protect the valve/gauge assembly and to make it easy to read.

3.5 Finishes

Paint or other material, including shock-absorbing material, may be applied. The exterior material should, in its final condition, resist all climatic and chemical conditions of its usual environment. Requirements are further defined in the testing section of this specification.

3.6 Weight

A maximum weight for the valve/gauge assembly may be established by the wheel manufacturer or the airframe manufacturer, as appropriate. The weight so specified should include the valve cap, valve core and all seals or gaskets required for installation.

3.7 Mechanical Gauge Pointer and Face Markings

3.7.1 The gauge should be directly readable with no multiplication factors required.

3.7.2 The pointer position, pressure numerals and pressure graduation marks should be legible from not less than 2 feet (0.6 m). Adequate contrast should be provided between the markings, pointer and background to permit easy reading of the gauge with a flashlight during hours of darkness. Red color should not be used for either markings or background unless the customer request specifies it. The distance between the pointer and background should not allow the possibility of significant parallax errors.

3.7.3 The mechanical gauge should be designed in a minimum of two different operating ranges. The recommendation for normal operational ranges are 0 to 250 psi (0 to 17.2 bar) and 200 to 500 psi (13.8 to 34.5 bar). The 0 to 250 psi (0 to 17.2 bar) range should be marked in 5-psi (0.3 bar) increments, maximum. The 200 to 500 psi (13.8 to 34.5 bar) range should be marked in 10-psi (0.7 bar) increments, maximum.

3.7.4 The pointer tip should overlay the applicable pressure graduation mark at all pressure readings. The pointer tip should be thinner than the mark thickness, if possible. The pointer should also overlay at least half of the length of the shortest dial mark.

3.7.5 Pressure zones should NOT be color-coded. Changes in recommended tire pressures over time render color codes ineffective and can be confusing.

3.7.6 The dial face should be mechanically attached to the gauge to prevent movement.

3.7.7 The gauge should continuously display tire inflation pressure, including those times at which inflation or deflation is being performed.

3.7.8 At ambient atmospheric pressure, the gauge pointer should be at the zero marked position within the accuracy requirements listed in 4.2.

3.8 Digital Display

3.8.1 An electronic digital readout may be used in place of the mechanical pointer in 3.6.

3.8.2 A digital display should be legible from not less than 2 feet (0.6 m) in direct sunlight, if self illuminating, or with a flashlight during hours of darkness.

3.8.3 The digital display should display in 1 psi increments, maximum.

3.8.4 The batteries which power the digital units should be located in a separate compartment which does not expose other circuitry during battery changes.

3.8.5 A low battery or gauge malfunction indicator should be provided.

3.8.6 To preserve battery life, a push to read button, or equivalent, may be installed.

3.8.7 Digital measuring equipment should be constructed such that normal ground operation of the aircraft electrical systems should not interfere with proper display and accuracy, nor should the digital measuring system interfere with any active aircraft system.

3.8.8 The wheel or airframe manufacturer should specify if EMC (Electromagnetic Compatibility) is required, and, if so, the specification and levels required as well as proof of compliance and/or qualification.

3.9 Gauge Lens (Crystal or Cover Glass)

3.9.1 The lens of the gauge should be transparent, impact resistant, and scratch resistant and not be affected by extraneous fluids or the operating environment including the pressure changes due to altitude.

3.9.2 The lens should be designed to stop the intrusion of dust, dirt, moisture, fluids or other substances which may obscure the gauge face. Hermetic sealing is not recommended.

3.10 Inflation/Deflation Valve/Gauge Assembly Part

The part of the valve/gauge assembly which is used for inflation or deflation should extend above the lens sufficiently to accept standard inflation chucks and should conform to the applicable Tire & Rim Association (T&RA) standards.

The part of the valve/gauge assembly which is used for inflation or deflation should only be placed off the axis of the unit if it can be demonstrated that a standard tire inflation chuck cannot be attached with the part of the valve/gauge assembly used for inflation or deflation at the most critical position with respect to the wheel.

3.11 Valve Cap

The part of the valve/gauge assembly which is used for inflation and deflation should have a valve cap for valve core protection against moisture, contaminants, etc., and will contain the inflation pressure should the core fail. The valve cap used and installation should conform to the applicable Tire and Rim Association (T&RA) standards.

3.12 Valve Core (Used in the Inflation/Deflation Gauge Part)

3.12.1 The desired size of valve core may be specified by the wheel manufacturer or the airframe manufacturer, as appropriate.

3.12.2 The valve core and its installation should conform to Tire and Rim Association (T&RA) standards.

3.13 Identification

Each production valve/gauge assembly should be marked with the manufacturer's part number, manufacturer's name and/or logo, serial number, date of manufacture, calibration date, and appropriate markings, as applicable.

4. PERFORMANCE

4.1 Pressures

4.1.1 Operational Inflation Pressure Range

Valve/gauge assemblies should be designed for one of two operational inflation pressure ranges, either 0 to 250 psi (0 to 17.2 bar) or 200 to 500 psi (13.8 to 34.5 bar).

4.1.2 Valve/Gauge Assembly Proof and Burst Pressure

4.1.2.1 Proof Pressure (1.5 times maximum nominal pressure)

a. The 0 to 250 psi (0 to 17.2 bar) valve/gauge assembly should remain operational and should not be damaged by a proof pressure of 375 psi (25.9 bar) which is sustained for 5 minutes.

b. The 200 to 500 psi (13.8 to 34.5 bar) valve/gauge assembly should remain operational and should not be damaged by a proof pressure of 750 psi (51.7 bar) which is sustained for 5 minutes.

4.1.2.2 Burst Pressure (see Pressure Tests of 5.9)

a. The 0 to 250 psi (0 to 17.2 bar) valve/gauge assembly pressure sensing parts may deform but should not rupture at a minimum pressure of 575 psi (39.6 bar) which is sustained for 3 minutes. When the valve/gauge assembly is burst tested, the valve/gauge assembly should be taken to failure to establish that a benign failure mode exists if the valve/gauge assembly is accidentally over pressurized.

b. The 200 to 500 psi (13.8 to 34.5 bar) valve/gauge assembly pressure sensing parts may deform but should not rupture at a minimum pressure of 1125 psi (77.6 bar) which is sustained for 3 minutes. When the valve/gauge assembly is burst tested, the valve/gauge assembly should be taken to failure to establish that a benign failure mode exists if the valve/gauge assembly is accidentally over pressurized.

4.1.3 Ambient (Atmospheric) Pressures

The valve/gauge assembly should be designed for ambient pressure range variations corresponding to pressure altitude variations from -2000 to 53 000 feet to cover airports under sea level and maximum aircraft operating ceilings.

4.2 Gauge Tolerance

The gauge tolerance should not exceed those values for the pressures and temperatures shown in the following tables:

4.2.1 Gauge Inflation Pressure Range - 0 to 250 psi (0 to 17.2 bar)

TABLE 1

| Temperature – Degrees F (C) | Gauge Tolerances |
|---|---|
| -58 to 22 (-50 to -5.5) | ±2% of Reading or ±2 psi (0.14 bar), whichever is greater |
| 22 to 122 (-5.5 to 50) | ±1% of Reading or ±1 psi (0.07bar), whichever is greater |
| 122 to 160 (50 to 71) | ±2% of Reading or ±2 psi (0.14 bar), whichever is greater |

4.2.2 Gauge Inflation Pressure Range - 200 to 500 psi (13.8 to 34.5 bar)

TABLE 2

| Temperature – Degrees F (C) | Gauge Tolerances |
|---|---|
| -58 to 22 (-50 to -5.5) | ±2% of Reading or ±5 psi (0.34 bar), whichever is greater |
| 22 to 122 (-5.5 to 50) | ±1% of Reading or ±2 psi (0.14 bar), whichever is greater |
| 122 to 160 (50 to 71) | ±2% of Reading or ±5 psi (0.34 bar), whichever is greater |

4.3 Flow Rate Test

The fill rate/time should be identical or not exceed that of the standard valve stem by more than 3 percent. Deflation rate/time with the valve core removed should be identical or not exceed that of the standard valve stem time by more than 5 percent.

4.4 Installation Position

The valve/gauge assembly should be capable of installation on the wheel and capable of operation in any gauge orientation.

4.5 Gauge Response

The gauge pointer (mechanical) or display (digital) should instantaneously respond to increases or decreases in operational pressure due to filling, deflating or fluctuations in tire pressure.

4.6 Ambient (Atmospheric) Temperature

The valve/gauge assembly should be designed to be exposed to ambient temperature from -65 °F (-54 °C) to 250 °F (107 °C) and function in ambient temperatures from -58 °F (-50 °C) to 160 °F (71 °C).

4.7 Extraneous Fluids/Contaminants/Ozone/Ultraviolet Light

Valve/gauge assembly operational performance and external surfaces, including the lens, and any seals or sealants, should not be affected by hydraulic fluids, greases and lubricating oils, fuels, disinfectants, water, solvents, cleaning and de-icing fluids.

The valve/gauge assembly operational performance and external surfaces should also be resistant to ozone and ultraviolet light.

4.8 Endurance Test

Valve/gauge assemblies should be tested for endurance by cycling the pressure from zero to the maximum indicated pressure using hydraulic fluid or gas for 40 000 cycles. Upon completion of these tests, the test valve/gauge assembly should meet the test performance values and tolerances specified in 4.2.

5. QUALIFICATION TESTING

5.1 Test Valve/Gauge Assemblies

The valve/gauge assemblies to be tested should be identical to production valve/gauge assemblies. The tests specified should be run on two valve/gauge assemblies.

5.2 Test Conditions

5.2.1 Unless otherwise noted, nitrogen or clean dry air (nitrogen is preferred) should be used when valve/gauge assembly pressurization is required.

5.2.2 Unless otherwise noted, tests should be conducted at room temperature, 70 °F ± 10 °F (21 °C ± 5.5 °C).

5.2.3 Unless otherwise specified, tests may be performed in any sequence except that the burst test specified in 5.9 should be done last.

5.3 Preliminary to Testing

Prior to running the tests specified, the valve/gauge assembly should be examined, inspected, measured and weighed to assure conformity with those specified properties which can be visually determined

5.4 Valve/Gauge Assembly Accuracy Test

5.4.1 Valve/gauge assembly tolerance test at 70 °F ± 10 °F (21 °C ± 5.5 °C).

5.4.2 Valve/Gauge Assembly Accuracy Tests

Upon completion of these tests, the valve/gauge assembly should meet the acceptance test performance values and tolerances specified in 4.2.

5.4.2.1 For a 0 to 250 psi gauge, the test gauge should be compared with a calibrated laboratory gauge which has an accuracy of 0.1% and the pressure raised to 200 psi (17.2 bar). The test gauge error should not exceed 2 psi (0.14 bar).

5.4.2.2 Slowly raise the test pressure to 250 psi (17.2 bar). The test gauge error should not exceed 2.5 psi (0.17 bar).

5.4.2.3 Lower the test pressure to 200 psi (13.8 bar). The test gauge error should not exceed 2 psi (0.14 bar).

5.4.2.4 For a 200 to 500 psi gauge, the test gauge should be compared with a calibrated laboratory gauge which has an accuracy of 0.1% and the pressure raised to 400 psi (27.6 bar). The test gauge error should not exceed 4 psi (0.28 bar).

5.4.2.5 Slowly raise the test pressure to 500 psi (34.5 bar). The test gauge error should not exceed 5 psi (0.34 bar).

5.4.2.6 Lower the test pressure to 400 psi (27.6 bar). The test gauge error should not exceed 4 psi (0.28 bar).

5.5 Performance Tests

5.5.1 Surge Pressure Test

A valve/gauge assembly should withstand a surge pressure increase from 0 to the maximum operational pressure of the gauge range being tested. The unit should comply with the test performance values and tolerances specified in 4.2 at the conclusion of this test.

5.5.2 Low Temperature Test

A valve/gauge assembly should be exposed to an ambient temperature of -65 °F (-54 °C) for 4 hours minimum prior to testing. The gauge should then be tested for gauge error at -58 °F (-50 °C), and then the test should be repeated on the gauge at room temperature. The unit should comply with the test performance values and tolerances specified in 4.2 at the conclusion of this test.

5.5.3 High Temperature Test

A valve/gauge assembly should be subjected to an ambient temperature as follows: Uniformly raise the temperature to 160 °F (71 °C) and hold for 20 minutes. Perform the gauge accuracy tests. The unit should comply with the test performance values and tolerances specified in 4.2 at the conclusion of the test.

5.5.4 Acceleration Test

5.5.4.1 Valve/Gauge Assembly Parallel to Axle

The valve/gauge assembly should be installed in a simulated wheel with the centerline of the gauge parallel to the axis of rotation. The 0 to 250 psi (0 to 17.2 bar) range gauge should be pressurized to 200 psi (13.8 bar). The 200 to 500 psi (13.8 to 34.5 bar) range gauge should be pressurized to 400 psi (27.6 bar).

5.5.4.2 The rotating speed should be increased from zero to a speed that will result in a centrifugal acceleration of 2000 g at the centerline of the gauge. This speed should be maintained for 5 seconds and then returned to zero. This test should be repeated a minimum of 300 cycles. At the conclusion of the test, the gauge should meet the requirements of the test performance values and tolerances specified in 4.2.

5.5.4.3 Valve/Gauge Assembly at Angle to Axle

A valve/gauge assembly should be installed in a simulated wheel where the centerline of the gauge is oriented at an angle of 45 degrees relative to the parting (split) line of the wheel, is within a plane which contains the axle centerline, and, is where the fill port of the gauge points inboard towards the axle. The valve/gauge assembly should be installed such that the 200-psi (13.8 bar) (for a 0 to 250 psi (0 to 17.2 bar) range mechanical gauge) or 400 psi (26.7 bar) (for a 200 to 500 psi (13.8 to 34.5 bar) range mechanical gauge) graduation mark points at the axle (defined for these tests as the 6 o'clock position). For a digital gauge, the readout display should be pointing at the axle (defined for these tests as the 6 o'clock position). The 0 to 250 psi (0 to 17.2 bar) range gauge should then be pressurized to 200 psi ± 10 psi (13.8 bar ± 0.7 bar). The 200 to 500 psi (13.8 to 34.5 bar) range gauge should be pressurized to 400 psi ± 10 psi (27.6 bar ± 0.7 bar).

The rotating speed should be increased from zero to a speed that will result in a centrifugal acceleration of 2000 g at the centerline of the gauge. This speed should be maintained for 5 seconds and then returned to zero. This test should be repeated for a minimum of 75 cycles at each position, with the gauge oriented at the 3, 6, 9, and 12 o'clock positions (a total of 300 cycles). At the conclusion of the test, the gauge should meet the requirements of the test performance values and tolerances specified in 4.2.

5.5.5 Installation Torque Tests

5.5.5.1 Valve/Gauge Assemblies (.3125-24 Thread) Designed For Use in AS5202 Bosses

The valve/gauge assembly should be installed in a standard AS5202 boss and torqued to 45 in-lb (5.2 Nm). Torque and untorque a minimum of 50 times. There should be no visible evidence of distortion, yielding or thread galling of the valve/gauge assembly or the boss.

5.5.5.2 Valve/Gauge Assemblies (.500-20 Thread) Designed For Use in AS5202 Bosses

The valve/gauge assembly should be installed in a standard AS5202 boss and torqued to 200 in-lb (22.7 Nm). Torque and untorque a minimum of 50 times. There should be no visible evidence of distortion, yielding or thread galling of the valve/gauge assembly or the boss.

5.5.6 Over Torque Tests

5.5.6.1 Valve/Gauge Assemblies (.3125-24 Thread) Designed For Use in AS5202 Bosses

The test valve/gauge assembly should be installed in a standard AS5202 boss and torqued to 65 in-lb (7.5 Nm). Torque one time. Valve/gauge assemblies utilizing a .3125-24 thread should not show any visible evidence of distortion, yielding (deformation), loss of lens, loss of accuracy and other damage of the valve/gauge assembly at an installation torque of 65 in-lb (7.5 Nm).

5.5.6.2 Valve/Gauge Assemblies (.500-20 Thread) Designed For Use in AS5202 Bosses

The test valve/gauge assembly should be installed in a standard AS5202 boss and torqued to 300 in-lb (34.0 Nm). Torque one time. Valve/gauge assemblies utilizing a .500-20 thread should not show any visible evidence of distortion, yielding (deformation), loss of lens, loss of accuracy and other damage of the valve/gauge assembly at an installation torque of 300 in-lb (34.0 Nm).

5.6 Shock Tests

5.6.1 Valve/Gauge Assembly Parallel to Axle

A valve/gauge assembly with the valve cap installed, if applicable, at the proper torque, should be installed in a simulated wheel with the centerline of the valve/gauge assembly parallel to the axis of rotation. The gauge should be pressurized to 200 psi (13.8 bar) for the 0 to 250 psi (0 to 17.2 bar) range gauge and 400 psi (26.7 bar) for the 200 to 500 psi (13.8 to 34.5 bar) range gauge. The following shock loads should be applied in a direction parallel to the parting (split) line of the wheel.

0.030 second triangular shock pulse of 50 g
0.015 second triangular shock pulse of 50 g

For a 0 to 250 psi (0 to 17.2 bar) mechanical valve/gauge assembly, each test should be repeated 100 times with the 200 psi (13.8 bar) dial mark or readout display for a digital gauge located at the 3, 6, 9 and 12 o'clock positions for a total of 400 cycles. For a 200 to 500 psi (13.8 to 34.5 bar) mechanical valve/gauge assembly, each test should be repeated 100 times with the 400 psi (26.7 bar) dial mark or readout display for a digital gauge located at the 3, 6, 9 and 12 o'clock positions for a total of 400 cycles. Upon completion of these tests, the gauge should meet the test performance values and tolerances specified in 4.2.

5.6.2 Valve/Gauge Assembly at Angle to Axle

The valve/gauge assembly with the valve cap installed, if applicable, at the proper torque, should be installed in a simulated wheel where the centerline of the valve/gauge assembly is oriented at an angle of 45 degrees relative to the parting (split) line of the wheel, is within a plane which contains the axle centerline, and is where the fill port of the valve/gauge assembly points inboard towards the axle. The mechanical valve/gauge assembly should be installed such that the 200-psi (13.8 bar) graduation mark or read out display for the digital gauge points at the axle (defined for these tests as the 6 o'clock position). The valve/gauge assembly should be pressurized to 200 psi (13.8 bar).

Repeat the tests in 5.6.1. Upon completion of these tests, the valve/gauge assembly should meet the test performance values and tolerances specified in 4.2.

5.7 Endurance Test

For a 0 to 250 psi (0 to 17.2 bar) valve/gauge assembly, the gauge should be cycled from 10 psi ± 10 psi (0.7 bar ± 0.7 bar) to 250 psi ± 25 psi (17.2 bar ± 1.7 bar) using hydraulic fluid or gas for 40 000 cycles. One cycle should consist of going from 0 to 250 psi (0 to 17.2 bar) and returning to 0 psi (0 bar) at a rate not to exceed 20 cycles per minute. Upon completion, the test valve/gauge assembly should meet the test performance values and tolerances specified in 4.2.

For a 200 to 500 psi (13.8 to 34.5 bar) valve/gauge assembly, the gauge should be cycled from 10psi ± 10 psi (0.7 bar ± 0.7 bar) to 500 psi ± 50 psi (34.5 bar ± 3.4 bar) using hydraulic fluid or gas for 40 000 cycles. One cycle should consist of going from 200 to 500 psi (13.8 to 34.5 bar) and returning to 200 psi (13.8 bar) at a rate not to exceed 20 cycles per minute. Upon completion, the test gauge should meet the test performance values and tolerances specified in 4.2.

5.8 Flow Rate Test

For both 0 to 250 psi (0 to 17.2 bar) and 200 to 500 psi (13.8 to 34.5 bar) gauges, the fill rate time measurements should be made by measuring the time to reach the rated tire inflation pressure in a tire/wheel assembly. Then the core of the valve should be removed and a time measurement should be made measuring the time for the inflation pressure to come out of the tire/wheel assembly.

The same time measurements should be done using a standard valve stem. The flow rate differences between the standard valve stem and the valve/gauge assembly should not be greater than specified in 4.3.