



AEROSPACE RECOMMENDED PRACTICE

ARP986™

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Superseding ARP986C

(R) Guide for Qualification Testing of Aircraft Air Valves

RATIONALE

This report presents general recommended practices for qualification of aircraft air valves. The methods include qualification by analysis, similarity and testing. Detailed customer specifications shall supersede any requirements contained herein.

Revision D is issued to align the document with current qualification practices, service experience and the SAE Style Manual.

ARP986D has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) defines recommended analysis and test procedures for qualification of pneumatically, electrically, manually, and hydraulically actuated air valves. They may be further defined as valves that function in response to externally applied forces or in response to variations in upstream and/or downstream duct air conditions in order to maintain a calibrated duct air condition (e.g., air flow, air pressure, air temperature, air pressure ratio, or air shutoff).

Qualification testing performed on the airplane to verify compatibility of the valve function and stability as part of a complete system is outside the scope of this document.

Refer to ARP1270 for design and certification requirements for cabin pressurization control system components.

As this document is only a guide, it does not supersede or relieve any requirements contained in detailed Customer specifications.

1.1 Purpose

The purpose of this ARP is to provide the aircraft industry with a guide for qualification of aircraft air valves.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

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

ARP1270	Aircraft Cabin Pressurization Criteria
AIR1539	Environmental Control System Contamination
ARP4014	Aircraft Turbine Engine Pneumatic Component Contaminated Air Endurance Test
AS4073	Air Cycle Air Conditioning Systems for Military Air Vehicles
AS4273	Fire Testing of Fluid Handling Components for Aircraft Engines and Aircraft Engine Installations
ARP4418	Procedure for Sampling and Measurement of Engine Generated Contaminants in Bleed Air Supplies from Aircraft Engines Under Normal Operating Condition
AIR4766/1	Air Quality for Commercial Aircraft Cabin Particulate Contaminants
AIR5455	Impact of Changes in Test Dust Contaminants and Particle Counter Calibration on Laboratory Filter Element Performance and Fluid Cleanliness Classes

2.1.2 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI/NCSL Z540.3 Requirements for the Calibration of Measuring and Test Equipment

2.1.3 Battelle Publications

Available from Battelle, 505 King Avenue Columbus, OH 43201, <http://projects.battelle.org/mmpds/>

MMPDS Metallic Materials Properties Development and Standardization Handbook

2.1.4 European Aviation Safety Agency Publications

Available from European Aviation Safety Agency, Postfach 10 12 53, D-50452 Cologne, Germany, Tel: +49-221-8999-000, www.easa.eu.int.

CS-25 Certification Specifications for Large Aeroplanes

2.1.5 Federal Aviation Administration Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

AC 20-135 Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria

AC 25-22 Certification of Transport Airplane Mechanical Systems

AC 25-24 Sustained Engine Imbalance

AC 25.863 Flammable Fluid Fire Protection

AC 33.17-1A Engine Fire Protection

Order 8110.51 Acceptability of Previously Approved Certification Compliance Data From Foreign Sources

2.1.6 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

or if using the Switzerland address:

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 10012 Measurement Management Systems

ISO 12103-1 Road vehicles - Test dust for filter evaluation; Part 1: Arizona test dust

ISO 2685 Aircraft - Environmental Test Procedure for Airborne Equipment - Resistance to Fire in Designated Fire Zones Second Edition

2.1.7 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

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

2.1.8 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

JSSG-2007 Engines, Aircraft, Turbine

JSSG-2009 Department of Defense Joint Services Specification Guide: Air Vehicle Subsystems

MIL-HDBK-310 Global Climatic Data for Developing Military Products

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-461 Electromagnetic Emission and Susceptibility, Requirements for the Control of Electromagnetic Interference

MIL-STD-810¹ Environmental Engineering Considerations and Laboratory Tests

2.1.9 Ministry of Defense Publications

Available from Ministry of Defense, Directorate of Standardization, Stan BM&D, Room 1138, Kentigern House, 65 Brown Street, Glasgow G2 8EXNW, Suite 805, Tel: 0141-224-2531.

DEF STAN 00-35 Environmental Handbook for Defence Materiel, Part 4: Natural Environments

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

Chepil, William Stephen - "Sedimentary Characteristics of Dust Storms; [Part] 1, Sorting of Wind-eroded Soil Material; [Part] 2, Visibility and Dust Concentration; [Part] 3, Composition of Suspended Dust", American Journal of Science, January 1, 1957

Chepil, W. S. and Woodruff, N. P. - "Sedimentary Characteristics of Dust Storms; Part II, Visibility and Dust Concentration", American Journal of Science, February 1, 1957

Chepil, W. S. - "Sedimentary Characteristics of Dust Storms; Part III, Composition of Suspended Dust", American Journal of Science, March 1, 1957

2.3 Definitions

2.3.1 SHUTOFF VALVE

A shutoff valve controls the flow of air by opening or closing the flow passage. It is used in such a manner that it is not stopped in intermediate positions.

¹ This document contains several references to the test methods of MIL-STD-810. The test methods are identified in the following format in the MIL-STD-810: Method 511.5 for Explosive Atmosphere (example only). For references in this ARP to MIL-STD-810 test methods, the references only include the base number (i.e., Method 511), and the specific test revision should be used as determined per 2.1 herein.

2.3.2 VARIABLE POSITION VALVE

A variable position valve controls the flow of air by selective throttling of the flow passage. Intermediate areas may be infinitely or incrementally selectable.

2.3.3 RELIEF VALVE

A relief valve is a modulating valve that limits supplied pressure by dumping air from a system or compartment to a lower pressure region.

2.3.4 CHECK VALVE

A valve that allows flow in a single direction only.

2.3.5 REGULATING VALVE

A regulating valve controls downstream pressure based on feedback criteria, such as pressure, temperature or flow rate, from the system in which it operates and a built-in or user-provided setpoint.

2.3.6 TEST ARTICLE

Depending on the testing to be performed, the test article may be a production representative part or part modified by addition of pressure and temperature test ports, fittings for attachment of position indicators, installation of thermocouples at internal locations inaccessible on the complete assembly and as required by the Customer technical specification. The test article may also be of a unique configuration, such as a subassembly whose function cannot be verified as part of the complete assembly, or where a destructive test on a subassembly is quicker and less expensive than on a complete assembly.

2.3.7 FLAME TEST

The flame test requirement imposed on an aircraft valve depends on whether the valve must be fire proof or fire resistant.

Federal Aviation Administration (FAA) AC 20-135 and AC 33.17-1A provide FAA civil aircraft criteria for determination of fire protection requirements and guidance on qualification requirements for air valves.

2.3.8 DESTRUCTIVE TEST

Destructive tests are those tests that may damage the valve's function or use for further testing. Typical destructive tests are burst pressure, fire-resistance and fire-proof tests. Following a destructive test the valve may or may not have to be operational or meet normal functional requirements.

2.3.9 DEVELOPMENT TEST

A Development Test (or Company Test) is generally defined as a test performed by the valve Supplier or Customer without FAA or European Aviation Safety Agency (EASA) conformity and/or without an FAA, EASA, or designee approved test procedure. Test results from Development Testing may be accepted for qualification testing to non-FAA qualification requirements. Test results from Development Testing may also be accepted for certification testing in countries whose regulation authority require only company conformity inspection documentation.

2.3.10 DESIGN ASSURANCE TEST

A Design Assurance Test (also known as Requirements Verification Testing) is performed to verify the valve will meet key function and performance requirements of the Customer specification and is not necessarily a test to show compliance to an FAA or EASA regulation. Design Assurance Testing is performed as part of the development test or at the completion of development testing to ensure that the valve design is suitable and ready to proceed to qualification. The specific Design Assurance Tests and acceptance criteria should be specified in the Customer specification.

2.3.11 QUALIFICATION TEST

A Qualification Test is performed to show that a component or system is capable of meeting the design, function, performance, safety and/or reliability requirements of the Customer specification.

For components seeking commercial certification, Qualification Tests can include both certification and non-certification tests, but are generally limited to testing that is required to meet FAA or EASA certification needs. If non-certification tests are included as part of the qualification test then they become a criteria for passing those tests and hence are required for certification since they are in the document. It is recommended that those tests that are not intended to show direct compliance to a certification requirement be part of a design assurance test and those tests required to be in a qualification test (FAA or EASA approved) to be in the actual qualification test procedure.

3. CATEGORIES

The valves as referenced in this ARP are used to modulate and/or shut off the flow of air in aircraft pneumatic systems. For the purpose of this ARP, valves will be grouped into four categories based on the method of actuation:

3.1 Pneumatically Actuated Valves

Pneumatically actuated valves are those valves that utilize gas as the primary power source to position the valve. This includes valves that are electrically controlled, but pneumatically actuated.

3.2 Electrically Actuated Valves

Electrically actuated valves are those valves that rely only on electrical power to position the valve.

3.3 Manually Actuated Valves

Manually actuated valves are those valves that are operated by hand motion applying a force through a mechanical lever or cable system.

3.4 Hydraulically Actuated Valves

Hydraulically actuated valves are those valves that utilize an incompressible fluid such as hydraulic oil or fuel for operation. This includes valves that are electrically controlled, but hydraulically actuated.

4. QUALIFICATION METHODS AND PROCEDURES

The Customer detail specification will define all valve qualification requirements. The specification will identify any requirements that can only be satisfied by test. Requirements in the Customer detail specification supersede all general requirements contained in this document.

4.1 Qualification by Similarity

To prevent duplication of qualification test effort, qualification by similarity to a previously qualified valve can be used. The applicable qualification requirements, such as the installed environment, media pressures and temperatures and duty cycle of the test valve shall be the same or less severe than for the previously qualified valve. Any requirements in the new application that are more severe than what the existing valve is qualified to shall be qualified by test or analysis. In order for the previous qualification to be valid, the previously qualified valve shall have shown adequate reliability in the previous application.

The test valve and the previously qualified valve shall be identical when comparing physical traits for a particular environment. For valves that are derived from previously qualified valves, any design feature that is not identical to that on the previously qualified valve shall be qualified by analysis or test. The similarity analysis shall include a detailed comparison of the two valves that identifies the specific differences between the two and justification for why those differences are acceptable for meeting the requirements of the Customer's specification. The similarity analysis shall address both the changes and the effects of those changes on the qualification of the complete previously qualified valve. The similarity analysis shall provide justification of which portions of the qualification data for the previously qualified valve are still applicable to the new valve. Qualification testing of only the changed components may be acceptable. However, depending on the nature and scope of the changes and the particular qualification requirement, testing of the complete valve may be required. Review of service history and comparison of operating environments shall also be performed on derivative valves to justify acceptance of previously approved qualification data for unchanged portions of the valve.

If the qualification plan is to qualify the valve to some or all requirements by similarity, a qualification by similarity report and all supporting data required to justify claims of similarity shall be submitted and approved by the Customer prior to or concurrently with submittal of the qualification test plan. Supporting data may include copies of assembly drawings and qualification test reports for the previously qualified valve. Conformity inspection records and evidence of FAA, Civil Aviation Authority, or EASA approval of the supporting data may also be required in order for the data to be accepted by the Customer and civil certification agency. For instance, if the original testing was just based on a "statement of conformity" but not a real conformity inspection, then it is highly unlikely that the certification agency will accept that data. Such issues are described in more detail in FAA Order 8110.51.

Reports or excerpts of reports for tests performed on a similar test article may be submitted to substantiate compliance of the new valve on the basis of similarity to another valve. This may be applicable where previously approved qualification data is available for a similar valve or where several similar valves are being qualified concurrently, to eliminate identical testing on similar valves. Use of similarity or analysis in lieu of performing any specific test may be documented in the test procedure or provided in a separate qualification by similarity and analysis report (see 4.2).

Table 1 presents recommended hardware similarity analysis approaches for various qualification requirements.

Table 1 - Recommended hardware similarity for qualification by similarity

Qualification Requirements	Hardware Similarity ¹
Static loads Duct loads Pressure loads	Identical dimensions/materials/mounting
Dynamic loads Mechanical shock Vibration	Identical size/weight/c.g./ materials/mounting interfaces/ internal spring-mass systems
Chemical (corrosive/oxidizing) Salt Fungus Hydraulic Fluids Fuels, lubricating oil	Identical materials
Wear Contamination Endurance	Identical size/materials and processes/loads
Electrical Electromagnetic Interference (EMI) Dielectric Insulation resistance Bonding Power	Identical electrical part numbers
Ambient Temperature Altitude Humidity	Identical materials/schematic/installation

¹ Departures from identical situations may be allowed for changes to materials, processes, size, weight, etc., as approved by the Customer.

4.2 Qualification by Analysis

To prevent unnecessary test effort, qualification by analysis may be accepted where analytical data shows conclusive evidence that the valve will conform to the requirements of the Customer's technical specification. One method could be the use of accepted industry standard analytical practices. Another method could be by showing the analytical results match actual test results, thereby validating the analytical method. If the qualification plan is to qualify to some or all requirements by analysis, a qualification by analysis report shall be submitted and approved by the Customer prior to or concurrently with submittal of the qualification test plan. Qualification by analysis data shall be approved by the Customer and documented as part of the qualification data.

Qualification by analysis may be accepted where analysis methods are conventional and conservative. Examples of qualification requirements that may be acceptable for compliance by analysis are:

- Valve pressure drop analysis using handbook data
- Chemical or fungal resistance of materials using handbook or manufacturer's data
- Explosive atmosphere
- Proof and burst pressure

Qualification by analysis may not be acceptable to the Customer where:

- Analysis methods are new, novel and unproven
- Requirements are critical to safety or Customer satisfaction
- Airworthiness regulations or Customer specification specifically require a test

4.3 Qualification by Testing

RTCA/DO-160 and MIL-STD-810 provide guidance for general requirements and procedures for qualification testing of equipment. Since they cannot cover all possible equipment designs and functions, these general procedures have to be adapted to the requirements of the particular valve being qualified. As defined in the following sections, these guidance documents shall be used to develop the actual test procedures.

4.3.1 Test Documentation

A test procedure and a test report shall be furnished to the Customer. The Customer will approve the test program as presented in the test procedure and all changes thereto, prior to the start of testing. The test procedure(s) shall stipulate if Customer and/or government witnessing is required.

4.3.1.1 Test Procedures

The valve Supplier will be required to translate the Customer's detail specification requirements into measurable test requirements. The test procedure(s) shall define how to conduct all tests required by the qualification program. The location of the test facility, test equipment, temperature stabilization, test sequence, ambient conditions, test input tolerances, pass-fail criteria, conformity inspection requirements, test witnessing requirements, all data that is required to be recorded, test report format and content shall also be defined in the test procedures.

Qualification and Civil Aviation certification test procedures may be combined in the same document. However, the test procedure document shall clearly identify and segregate the certification and non-certification test sections. Definitions of the setup and instrumentation shall be identified and segregated from test procedures and other data in the test procedure. If multiple tests are to be performed and each one requires a different setup, each setup definition shall be identified and segregated.

The test procedure shall state the part number of the test article. The number of test articles and the particular tests to be performed on each test article shall be defined in the test procedure. It is not necessary to identify the particular test article serial numbers, unless different test article configurations will be required for different tests (for example, assembly or adjustment to an extreme tolerance limit). It is generally undesirable to identify test article serial numbers in a test procedure, in case it becomes necessary to substitute a different equivalent part at the time of the test.

Each section of the test procedure shall list the specific sections and subsections of the Customer's specification for which the data from the testing will be used to show compliance.

The test procedure shall provide clear and precise pass-fail criteria for each test. The test procedure should also require that any measurements required to determine the pass-fail acceptance be recorded. For example, the Customer specification for a proof pressure test may require that "There shall be no permanent deformation following application of proof pressure". The test procedure should specify the locations and dimensions of the valve to be measured and recorded for comparison with the allowable changes in those dimensions following application of proof pressure. All raw data recorded during the testing should be retained for Customer review for the duration defined in the test procedure, but at least until Customer acceptance of the test report.

4.3.1.1.1 Tolerances

Tolerances on test conditions shall be specified in the test procedure. They should be specified no more tightly than necessary for the purpose of the testing. The following tolerances are typical, but not assured of what can be provided by most test facilities:

a. Fluid Temperature:

1. < 59 °F: ± 10 °F (< 15 °C: ± 5.5 °C)
2. > 59 °F and < 250 °F: ± 15 °F (> 15 °C and < 121 °C: ± 8 °C)
3. > 250 °F and < 500 °F: ± 25 °F (> 121 °C and < 260 °C: ± 14 °C)
4. > 500 °F and < 1200 °F: ± 50 °F (> 260 °C and < 650 °C: ± 28 °C)

b. Controlled Ambient Temperature: ± 5.4 °F (± 3.0 °C)

c. Altitude: $\pm 5\%$ of the absolute barometric pressure

d. Pressures: $\pm 5\%$ absolute value

e. Flow: $\pm 3\%$

f. Humidity: $\pm 5\%$ absolute value

g. Acceleration: $\pm 10\%$

h. Vibration Amplitude:

1. Sinusoidal: $\pm 10\%$
2. Random: see MIL-STD-810 method 514 or RTCA/DO-160 Section 8

i. Vibration Frequency: $\pm 2\%$

j. Voltage: $\pm 2\%$

Refer also to RTCA/DO-160, Section 3 for additional recommendations for ambient and test condition tolerances.