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GUIDE FOR QUALIFICATION TESTING OF AIRCRAFT AIR VALVES

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1. **PURPOSE** - The purpose of this document is to provide the aircraft industry with a guide for laboratory qualification testing of aircraft air valves to assure compliance with the valve requirements as set forth in the detail specifications.
2. **SCOPE** - This document defines the tests to be performed on electrically, pneumatically, and mechanically actuated (regulating, modulating, and shutoff) air valves. The valves may be further defined as those which function in response to externally applied forces or in response to variations in upstream and/or downstream duct air conditions to maintain a calibrated duct air condition (i.e., air flow, air pressure, air temperature, air pressure ratio, etc.). The requirements of this document should govern for all qualification tests unless different requirements are established by the detail specifications.
3. **CATEGORIES AND DEFINITIONS** - The valves as referenced in this document are used to regulate, modulate, or shut off the flow of air in aircraft environmental control systems.
 - 3.1 **Categories** - For the purpose of this document the valves will be grouped into three categories:
 - 1) pneumatically actuated valves, 2) electrically actuated valves, and 3) mechanically actuated valves.
 - 3.1.1 **Pneumatically Actuated Valves** - Pneumatically actuated valves are those valves which utilize air for operation. This includes valves which are solenoid controlled but pneumatically actuated.
 - 3.1.2 **Electrically Actuated Valves** - Electrically actuated valves are those valves which rely only on electrical power for actuation. Solenoid controlled pneumatically actuated valves are not considered electrically actuated valves.
 - 3.1.3 **Mechanically Actuated Valves** - Mechanically actuated valves are those valves that are operated by means other than electrical or pneumatic power.
 - 3.2 **Definitions**
 - 3.2.1 **On-Off Valve** - An on-off 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.
 - 3.2.2 **Variable Position Valve** - A variable position valve controls flow by selective throttling of the flow passage. Intermediate areas may be infinitely selectable or incrementally selectable.
 - 3.2.3 **Modulating Valve** - A modulating valve is a variable position valve acting in conjunction with a controller.
 - 3.2.4 **Relief Valve** - A relief valve is a single point modulating valve which limits pressure by dumping from a system or compartment to a lower pressure region.
 - 3.2.5 **Test Article** - A test article is a complete functioning valve of the type to be qualified. It is normally a production article, but may (upon agreement between supplier and customer) be an equivalent prototype unit. The test article should also be marked such that the possibility of inadvertent use on a flying aircraft will be eliminated (paint red).
 - 3.2.6 **Test Failures** - If a failure during the qualification testing is experienced, the corrective action taken by the supplier should be approved by the customer prior to resumption of further testing. Continued testing without customer approval should be at the supplier's risk.
4. **APPLICABLE DOCUMENTS** - The following documents should form part of this recommended practice to the extent specified herein. The applicable issue of each should be that in effect on the date of this ARP unless otherwise specified in the manufacturer's detail specifications. Supplementary specifications, standards, or the like, which by reference in any of the following publications are indicated to be part thereof, should not be considered as effective except as specifically stated in the manufacturer's detail specification or as may be otherwise mutually agreed upon between the vendor and the purchaser.

MIL-STD-810	Military Standard, Environmental Test Methods for Aerospace and Ground Equipment.
MIL-STD-704	Electrical Power, Aircraft, Characteristics of.
MIL-I-6181	Interference Control Requirements Aircraft Equipment.

5. TEST REPORTS - One reproducible copy and two additional copies of the original test report should be furnished to the customer. (It should be the option of the customer to request copies of the test program and to approve the program, or any changes thereto, prior to proceeding with it.)
 - 5.1 The test report should include the results obtained from each test performed on the valve in accordance with this document. The test report should further describe all aberrations, and the action taken to correct any defects that are found during qualification.
 - 5.2 The test report should contain a complete identification of the test article including the supplier's part number, serial number, and part name. If more than one test article is involved, the data should be recorded and referenced to the specific test or tests performed on each individual test article.
 - 5.3 A description of the test set-up should be given, including a schematic with all important dimensions and instrumentation locations noted. It is recommended that sketches and photographs be used wherever possible. The type, model, manufacturer, and names of all principal items of test and control equipment should be included in the test report. A statement as to methods adhered to, to ensure general test equipment accuracy, should be made.
 - 5.4 The test report should clearly state whether or not the test requirements have been met and where failure, if any, has occurred. It should reference the paragraph requirements of the detail specification to facilitate comparison of results with the requirements.
 - 5.5 The test report should be signed by an official or other responsible member of the facility making the test.
 - 5.6 All test reports submitted by a testing organization other than the supplier should have the same requirements as the test report prepared by the supplier and should become a part of the formal test report.
 - 5.7 Reports of those tests which demonstrate compliance of a similar test article with any of the requirements of the detail specification may be submitted to substantiate compliance of the new equipment in areas of similarity. This similarity data should be incorporated in the final test report, with substantiation of the similarity of the two items.
6. TEST FACILITIES - The facilities used to perform the qualification tests should be capable of meeting all of the conditions specified herein.
 - 6.1 The facility should include instrumentation of sufficient accuracy to define the values specified for the units to be tested. The accuracy of the instrumentation should be verified periodically. The instrumentation should also conform to laboratory standards whose calibration is traceable to the prime standards at the U. S. Bureau of Standards.
 - 6.2 The facilities should be capable of simulating the system in which the test article is to operate with sufficient accuracy to insure that the test article will operate under the conditions specified in this document or the detail specification.
 - 6.3 Unless otherwise stated in the detail specification, the allowable tolerances on test parameters should be as follows:

Temperature: Up to 100 ± 5 F
 Up to 250 ± 7 F
 Up to 500 ± 10 F
 Up to 1200 ± 15 F

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

Pressures: $\pm 2\%$ absolute value

Flow: $\pm 3\%$

Humidity: $\pm 10\%$ specific

Vibration Amplitude: $\pm 5\%$

Vibration Frequency: $\pm 2\%$

Voltage: $\pm 2\%$

Frequency: $\pm 1\%$

7. DEFINITION OF COMPLIANCE - Satisfactory compliance with the requirements of this document should be established when the designated number of test articles have been subjected to the tests outlined herein, and upon completion of those tests, have passed the performance record test outlined in paragraph 9. The only exceptions to the above are those tests in which the detail test specification establishes the level of acceptable compliance.
8. SEQUENCE OF TESTS - One or more production or equivalent prototype units should be employed for the qualification test program. When three test articles are used they should be subjected to the following tests, as applicable, approximately as shown:

Test Article Number 1

Performance Record
 High Temperature
 Thermal Shock
 Low Temperature Humidity
 Fluid Resistance
 Acceleration
 Mechanical Shock
 Altitude
 Simulated Service Usage
 Performance Record
 Disassembly and Inspection

Test Article Number 2

Performance Record
 Fungus Resistance
 Salt Fog
 Dielectric
 Explosion Proof
 Performance Record
 Disassembly and Inspection

Test Article Number 3

Performance Record
 Proof Pressure
 Radio Noise
 Leakage A - Internal
 B - External
 Pressure Drop
 Vibration
 Sand and Dust
 Performance Record
 Disassembly and Inspection
 Burst Pressure

If two test articles are selected, the apportionment of tests should be approximately as follows:

Test Article Number 1

Performance Record
Proof Pressure
Low Temperature Humidity
Fluid Resistance
High Temperature
Thermal Shock
Altitude
Vibration
Mechanical Shock
Acceleration
Performance Record
Disassembly and Inspection
Burst Pressure

Test Article Number 2

Performance Record
Radio Noise
Explosion Proof
Leakage A - Internal
B - External
Pressure Drop
Sand and Dust
Fungus Resistance
Salt Fog
Dielectric
Simulated Service Usage
Performance Record
Disassembly and Inspection

Other performance record checks may be included at points mutually agreeable to supplier and customer.

The ultimate apportionment and sequence of conducting the tests should be at the option of the supplier, unless specifically negotiated otherwise.

9. **PERFORMANCE RECORD TEST** - Prior to subjecting each of the test articles to each of the tests outlined herein and, if applicable, at the completion of each test, each test article should be subjected to a performance test point or points specified in the detail specification. Unless essential to the determination of the valve characteristic, the point or points chosen should be maximum sea level operating conditions. Generally, a performance test consists of the following:

- a. Proof Pressure
- b. Leakage (Internal and External)
- c. Minimum Opening Signal (Pressure and/or Voltage)
- d. Opening and Closing Time
- e. Regulation Stability

10. **TEST PROCEDURE** - The following tests should be conducted where applicable. The detail specification should define which of the following tests should be conducted for qualification.

- 10.1 **High Temperature Test** - The test article should be placed within the test chamber and the internal temperature of the chamber raised to and maintained at 160 F or as defined by the detail specification for a period not less than 48 hours. At the completion of the 48-hour period, the valve should be subjected to maximum flow or maximum regulation with air at the maximum temperature and corresponding pressure defined in the detail specification. When the valve temperature has stabilized under the above conditions, the valve should be operated five times.

- 10.2 **Low Temperature Humidity** - The test item should be installed in the test chamber at room temperature in a manner that will simulate the aircraft installation. The chamber temperature should be held at 90 F and the specific humidity of the chamber air held constant at 154 gr/lb of dry air. This condition should be held for three hours. During this three-hour period, the valve should be actuated 10 times while air flow is maintained through the valve as follows:

Temperature: 90 F
Specific Humidity: 154 gr/lb dry air
Air Flow: As specified in detail specification

At the completion of the three-hour period, valve and chamber air flow should be terminated and the chamber temperature should then be lowered to 60 F over a three-hour period. This constitutes one cycle. Ten cycles should be performed for a total time of 60 hours. During the eleventh cycle, rather than lower the chamber temperature to 60 F over a three-hour period, the temperature should be lowered linearly to 0 F

over an eight-hour period with valve inoperative and held one hour. At the completion of the one-hour hold period the valve should be operated and performance compared with initial performance data.

After the performance tests at 0 F, the chamber should be lowered to -65 F and held for two hours. A second performance test should be made at the completion of this two-hour period.

- 10.3 Salt Fog Test - The test article should be subjected to the salt fog test defined in MIL-STD-810.
- 10.4 Vibration Test - The test article should be subjected to the vibration test as defined in MIL-STD-810 for Class I equipment (aircraft) with the following revision:

During the resonance scan of the test article, both internal and external resonance frequencies should be determined. The detail specification should define the vibration frequencies to be expected from the aircraft, and after the test article internal and external resonance frequencies are known, the test article resonance frequency nearest the aircraft frequency should determine the test parameter.

NOTE: Determination of internal resonance frequencies may be expensive, and there is a possibility of changing the valve operating characteristics due to modifications for observation of internal parts.

- 10.4.1 After the completion of the vibration test, the test article should be visually examined for evidence of damage or undue wear, and photographs should be taken of any such evidence noted. The test specimen should then be operated and the results compared with those obtained in paragraph 9.
- 10.5 Fungus Resistance Test - The fungus resistance test should be conducted only on those test articles employing materials or finishes which may be considered to be fungus nutrients.
- 10.5.1 The test article should be subjected to the fungus test described in MIL-STD-810.
- 10.6 Explosive Atmosphere Test - The test article should be subjected to the explosive atmosphere test defined in MIL-STD-810.
- 10.7 Simulated Service Test - The test article should be installed in a test set-up duplicating the aircraft installation and thermal conditions as closely as possible and subjected to the following tests in sequence:
- 10.7.1 The test article, while in the full open or full regulation position, should be subjected to the following conditions simultaneously for a period of four hours.
- 10.7.1.1 Voltage maximum as defined in the specification.
- 10.7.1.2 Air flow conditions:
- (a) Maximum temperature as defined in the specification.
 - (b) Corresponding flow rate as defined in the specification.
 - (c) Corresponding pressure as defined in the specification.
 - (d) Specific humidity 100 gr/lb dry air.
 - (e) A mixture of sand and dust per MIL-STD-810 should be injected into the valve inlet air at a rate of 0.10 gr/lb air flow.
 - (f) MIL-L-7808 oil should also be injected into the valve air flow at a rate of 2 cc/100 lb of air flow.
- 10.7.2 At the completion of the four-hour period, items 10.7.1.2(d), 10.7.1.2(e) and 10.7.1.2(f) should be terminated and the valve cycled 4000 times.
- 10.7.3 At the completion of the 4000 cycles, a performance test should be conducted.

- 10.7.4 Tests 10.7.1, 10.7.2, and 10.7.3 should then be repeated with the following exception: test conditions should be reduced to the normal flow rate, temperature, pressure, and voltage as defined in the specification.
- 10.7.5 Tests 10.7.1, 10.7.2, and 10.7.3 should be repeated with the following exception: test conditions should be reduced to a minimum flow rate, temperature, pressure, and voltage as defined in the specification.

NOTE: During all testing under 10.7, valve electrical position indicators (internal) should be electrically loaded to simulate the aircraft installation. If an altitude compensating device is incorporated in the valve design, altitude testing should also be included in the valve performance test at the end of each phase.

- 10.8 Proof Pressure - With the test article in the open position, the test article should be subjected to air flow at the maximum specified operational temperature until the test article temperature is stabilized. Ambient air should be at room temperature and pressure, unless otherwise covered by the detail specification. The test article should then be closed and subjected to a proof pressure of 1-1/2 times maximum operating pressure. This pressure should be held for a minimum of one minute.
- 10.8.1 Repeat 10.8 with the test article open.
- 10.8.2 After completion of the proof pressure test, the test unit should be visually examined for evidence of damage or permanent deformation. The test article then should be subjected to a final performance test and the results compared with the results obtained in paragraph 9.
- 10.9 Burst Pressure Test - The test article should be mounted in the test set-up and be supported and confined no further than may be expected in its normal functional installation. The outlet should be sealed. The inlet side should be connected to a source of high pressure air.
- 10.9.1 With the valve open and the valve temperature stabilized at a maximum operating temperature, the burst pressure, as specified by the detail specification, should be applied to the valve.
- The valve need not operate after the test, but structural integrity must be maintained.
- In general, burst test pressures should not be less than 2-1/2 times the maximum pressure to which the valve could be subjected as a result of a single failure of an upstream flow or pressure limiting valve when maximum possible pressure conditions exist.
- 10.9.2 After completion of the burst pressure test, the test article should be visually examined for evidence of rupture, and photographs taken of any such evidence discovered.
- 10.10 Dielectric Test
- 10.10.1 Equipment designed to operate on 28 volts d-c should be subjected to test voltage of 1000 volts (rms) at commercial frequency of approximately 60 cycles for one second applied between connector pins or terminals and the actuator frame. If a radio noise filter is integral with this unit, it may be disconnected before the test. If the electrical design is such that a short will result, individual components may be subjected to the test prior to assembly.
- 10.10.2 Equipment designed to operate on 400 cycles 115 volts a-c should be subjected to a test voltage of 1250 volts (rms) at commercial frequency applied both between connector pins or terminals and frame and between each connector pin or terminal and frame. Each connection should be tested a minimum of one second.
- 10.10.2.1 Capacitors should withstand, for one second, a d-c voltage of twice the maximum peak voltage in service or a minimum of 500 volts, whichever is greater.
- 10.10.2.2 Electrical wiring insulation should also be tested. Any breakdown or leakage in excess of 10 milliamps should constitute a failure.