MILITARY SPECIFICATION

BLEED AIR SYSTEMS, GENERAL SPECIFICATION FOR

This specification has been approved by the Bureau of Naval Weapons, Department of the Navy.

1. SCOPE

1.1 This specification covers bleed air systems for turbo-jet, turbo-prop, and turbo-shaft aircraft.

2. APPLICABLE DOCUMENTS

2.1 Government documents normally furnished - The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-C-5015	Connectors; Electrical, "AN" Type
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for
MIL-C-6021	Castings, Classification and Inspection of
MIL-E-6051	Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapon System
MIL-E-7080	Electric Equipment, Aircraft, Selection and Installation of

SPECIFICATIONS

Military (Continued)

MIL-F-7179	Finishes and Coatings, General Specification for Protection of Aircraft and Aircraft Parts
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-C-27536	Coupling, Clamp, Grooved, V-Band

STANDARDS

Military

MIL-STD-210	Climatic Extremes for Military Equipment
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MS24563	Dimensions, Profile, V-band Coupling Flanges, Design Standard for
MS33586	Metals, Definition of Dissimilar

PUBLICATIONS

Naval Weapons Requirements

WR-62	Specifications and Standards; Use of

(When requesting applicable documents, refer to both title and number. Copies of unclassified documents may be obtained from the Commanding Officer, Naval Supply Depot (Code 1051), 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120. Requests for copies of classified documents should be addressed to the Naval Supply Depot, via the cognizant Government inspector.)

3. REQUIREMENTS

3.1 Precedence - In case of conflict between this specification and a detail specification, the requirements of the detail specification shall take precedence.

3.2 Selection of specifications and standards - Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with WR-62.

3.2.1 Standard parts - MS and AN standard parts shall be used. They shall be identified on the drawings by their part numbers.

3.3 Materials - Materials shall conform to applicable specifications and shall be as specified herein and on applicable drawings.

3.3.1 Metal parts - All metal parts shall be of a corrosion resistant material or treated in a manner to render them adequately resistant to corrosion due to salt spray, or atmospheric conditions likely to be met by aircraft on carrier (shipboard) duty. Parts shall be protected in accordance with MIL-F-7179. Magnesium alloy shall not be used.

3.3.1.1 Dissimilar metals - Unless suitably protected against electrolytic corrosion in accordance with MIL-F-7179, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MS 33586.

3.3.1.2 Castings - All castings shall be Class I in accordance with MIL-C-6021.

3.3.2 Nonmetallic materials - Any nonmetallic material that is adversely affected by salt spray, compressor air, environmental or operating temperatures, and aircraft operating atmospheres shall not be used.

3.4 Design and construction -

3.4.1 Atmospheric design conditions - The system design temperature conditions shall be based on the standard cold and hot atmospheres presented in MIL-STD-210.

3.4.2 Air and pressure source - The engine compressor air shall be used as the air and pressure source for the system.

3.4.3 Engine overheat prevention - Operation of the system shall not cause overheating of the engine or engine exhaust nozzle.

3.4.4 Selection and installation of electrical equipment - Electrical equipment shall be selected and installed in accordance with MIL-W-5088, MIL-E-6051, and MIL-E-7080. Where equipment is subject to removal for inspection and rewiring, AN connectors conforming to MIL-C-5015 shall be used.

3.4.5 Input power requirements - The electrical system shall meet the applicable requirements of MIL-STD-704, and shall be capable of operating satisfactorily throughout the entire variations of voltages and frequencies permitted therein. Installation of all wiring external to the electrical components shall be in accordance with MIL-W-5088.

3.4.6 Insulation - The insulation and heat shielding of the bleed air system components and ducting shall be such that no structural member of the aircraft is raised to a temperature above its designed allowable because of bleed air system operation.

3.4.7 System design - The system shall be as simple and foolproof as possible with respect to design, operation, inspection, and maintenance. The bleed air system and its components shall be designed to operate satisfactorily and maintain structural integrity under all conditions that the aircraft may encounter, including forces or conditions caused by acceleration, launching, deceleration, arresting, zero gravity (g), negative g, flight attitudes obtainable with the aircraft, structural deflection, vibration, or other environmental conditions. The bleed air system shall be so routed that a failure of any duct or component shall not result in the direct impingement of hot air on any of the functional systems in the aircraft which would affect safety of flight.

3.4.7.1 Drainage provisions - Drainage provisions shall be incorporated in the system and its components to prevent the accumulation of rain or washing water.

3.4.8 Component design - The bleed air system may consist of the following components - compressor bleed air fittings, distribution ducts, auxiliary duct units, brackets, hinges, fittings, unions, clamps, gaskets, bellows, coupling assemblies, expansion joints, nozzles, spacers, insulation, heat shields, shut-off valves including linkages and drives, pressure and temperature gages, and check valves.

3.4.8.1 Selection of components - Any component included in the bleed air system shall have been tested to indicate suitability of design. These tests

shall be in accordance with the suppliers approved equipment specifications and shall include life and performance tests plus the following applicable environmental tests in accordance with MIL-E-5272.

(a) High temperature, Procedure II

(b) Low temperature, Procedure II

(c) Humidity, Procedure I

(d) Altitude, Procedure VI, Condition in accordance with operating altitude

(e) Salt spray, Procedure II

(f) Shock, Procedure V

(g) Vibration, Procedure XIV

(h) Sand and dust, Procedure I

(i) Fungus resistance, Procedure I

3.4.8.2 Reverse installation - Components whose proper operation is subject to direction of flow shall be so designed that they cannot be installed reversed.

3.4.8.3 Duct design - The ducting shall be constructed of corrosion resistant metal.

3.4.8.3.1 Duct wall thickness - Minimum wall thickness may be dictated by damage occurring during fabrication or handling. The following minimum wall thickness shall be adhered to.

Duct diameter (inches)	Min. wall thickness (inches)
Under 1.00	0.010
over 1.00 to 2.00	0.012
over 2.00 to 3.50	0.016
over 3.50 to 5.00	0.020
over 5.00 to 6.00	0.025
Over 6.00	as required by design

3.4.8.3.2 Standard sizes - The duct shall be designed and fabricated to the diameters shown below:

Outside diameter(inches)	Size increments (inches)
0.75 to 4.00	0.25
over 4.00	0.50

3.4.8.4 Couplings - Couplings shall conform to MIL-C-27536 and MS24563. The selection of other types shall be subject to the approval of the procuring agency. Nuts used for couplings shall be of a torque limiting type, approved by the procuring activity.

3.4.8.5 Expansion devices - Suitable devices to absorb deflection shall be installed in the duct installation as required. Supports shall be provided on each side of the device as close as practicable to the device. Only one support may be fixed. With the system operating at the most adverse combination of temperature, pressure, and airframe deflections, there shall be no misalignment or deformation of these devices or components that will adversely affect the performance of the system.

3.4.8.6 Shut-off valve - Valves shall be provided to control the air flow of the bleed air system. The valves shall be incorporated as near as practicable to the air source and shall be mounted by means that will prevent malfunction due to vibration.

3.4.8.7 Branch duct joints - Flat areas inherent in the design of Y's and T's shall be kept to an absolute minimum. Areas that are normally flat shall be crowned as much as is practicable. The crotch area of "Y" sections shall be reinforced when subjected to adverse mechanical and thermal loads.

3.4.8.8 Brackets - Brackets which are assembled to ducts by welding shall not be welded directly to the duct walls. The bracket shall be welded to a doubler, and the doubler shall be welded to the duct wall.

3.4.8.9 Screw threads - Screw threads shall conform to MIL-S-7742 or MIL-S-8879.

3.5 Performance - The bleed air system shall meet the following performance requirements and any additional requirements specified in the detail specification.

3.5.1 Proof pressure - The bleed air system components shall withstand, at operating temperature, a pressure equal to twice the operating pressure without evidence of permanent deformation, malfunction, or leakage.

3.5.2 Endurance - The bleed air system ducting shall withstand, at operating temperature, a minimum of 15,000 cycles between the operating pressure and a pressure within 10 percent of the specified minimum operating pressure with a duration of impulse not longer than 0.05 second at a rate of pressure rise between 12,000 and 15,000 psi per second without evidence of leakage, permanent deformation, or structural failure.

3.5.3 Vibration - The bleed air system bellows, valves, and ducting incorporating welded brackets for support shall withstand vibration in accordance with the frequency - amplitude profile of vibration test Procedure XIV of MIL-E-5272 without evidence of cracking, permanent deformation, or structural failure.

3.5.4 Flow resonance - The bleed air system flex sections shall withstand resonant or chattering conditions due to flow for a total of 100 hours at the operating pressure and temperature without evidence of leakage, permanent deformation, or structural failure.

3.5.5 Burst pressure - The bleed air system components shall withstand, at operating temperature, a pressure equal to four times the operating pressure without evidence of leakage or rupture. Permanent deformation shall be permitted.

3.6 Weight - The weight of the system shall be as low as practicable reflecting the existing stage of technological development and current industrial practice.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Inspection methods -

4.2.1 Examination - The system shall be thoroughly examined to

determine conformance with this specification and applicable drawings with respect to all the requirements not covered by tests specified herein.

4.2.2 Proof pressure - The equivalent proof pressure which will result in stresses equal to those applied by the combined pressure and temperature at operating conditions may be approximated by $P_T = 2P_O\left(\frac{S_T}{S_O}\right)$ where:

P_O = working pressure at operating temperature, pounds per square inch

P_T = proof pressure at test temperature, pounds per square inch

S_O = maximum allowable tensile yield stress value at the operating temperature, pounds per square inch

S_T = maximum allowable tensile yield stress value at the test temperature, pounds per square inch

Each system component shall be tested with water at room temperature. After bleeding all air from the component and plugging all outlets, a proof pressure (P_T) shall be applied twice, at a rate not exceeding 25,000 psi per minute, and shall be held for a period of two minutes for each application. The pressure shall be reduced to zero between applications. Each component shall meet the proof pressure requirements specified in 3.5.1.

4.2.3 Endurance test - The ducting (including expansion devices and branch duct joints) shall be subjected to a pressure cycling test at room temperature with the test pressure adjusted to compensate for the reduction in allowable stress that would occur at the operating temperature ($P_E = P_O\left(\frac{S_T}{S_O}\right)$ (see 4.3.2)).

P_E = endurance pressure at test temperature, pounds per square inch

The ducting shall be cycled for 15,000 cycles between the adjusted test pressure (P_E) and a pressure within 10 percent of the minimum operating pressure. The duration of impulse shall be no longer than 0.05 second and the rate of pressure rise shall be between 12,000 and 15,000 psi per second. The ducting shall meet the endurance requirements specified in 3.5.2.

4.2.4 Vibration - Bellows, valves, and ducting incorporating welded brackets for support shall be vibration tested at room temperature in accordance with MIL-E-5272, Procedure XIV. The components shall be surveyed for resonance between 5 and 2,000 cps. The components shall be vibrated at each resonant frequency for one hour. If no resonance is encountered, the vibration frequency shall be 2,000 cps for one hour at an acceleration of 20g in each plane. The bellows, valves, and ducting shall meet the vibration requirements specified in 3.5.3.

4.2.5 Flow resonance - This test shall be conducted on one sample of each flex section assembled into a test duct. The assembly shall be subjected to a range of flows at the pressure and temperature specified on the applicable drawing. The flow at all resonance or chattering conditions shall be noted. Air flow through the test duct shall be maintained at each resonant flow point for equal lengths of time totaling 100 hours. Each test section shall meet the flow resonance requirements specified in 3.5.4.

4.2.6 Burst pressure - The equivalent burst pressure which will result in stresses equal to those applied by the combined pressure and temperature at operating conditions may be approximated by $P_{TB} = 4P_O\left(\frac{S_{TB}}{S_{OB}}\right)$ where:

P_O = working pressure at operating temperature, pounds per square inch

P_{TB} = burst pressure at test temperature, pounds per square inch

S_{OB} = maximum allowable tensile ultimate stress value at operating temperature, pounds per square inch

S_{TB} = maximum allowable tensile ultimate stress value at test temperature, pounds per square inch

Each system component shall be tested with water at room temperature. After bleeding all air from the component and plugging all outlets, a burst pressure (P_{TB}) shall be applied twice, at a rate not exceeding 25,000 psi per minute, and shall be held for a period of two minutes for each application. The pressure shall be reduced to zero between applications. Each component shall meet the burst pressure requirements specified in 3.5.5. After completion of burst pressure tests the pressure shall be increased at the same rate until the component ruptures, and this pressure value shall be recorded and retained.

4.2.7 Ground test - Ground testing of the system shall be conducted with the aircraft at rest using full operating pressure to demonstrate general security, structural integrity, and safety of the system for flight. The bleed air system shall show no evidence of leakage or conditions affecting safety of flight.

5. PREPARATION FOR DELIVERY (Not applicable)

6. NOTES

6.1 Intended use - The bleed air system is intended for use in turbo-jet, turbo-prop, and turbo-shaft aircraft to supply heated air for cabin air, windshield de-icing and de-fogging, boundary layer control, rain removal, etc.

6.2 Data -

6.2.1 Drawings - Drawings shall include the following and shall be in accordance with MIL-D-70327.

6.2.1.1 Schematic diagram - The arrangement of the schematic diagram shall be such as to present the bleed air system in a clear reduced scale, easily readable form, with complete subsystems grouped and labeled accordingly. Nomenclature of each unit shall be made adjacent to or in the vicinity of each unit. In addition, the schematic diagram shall contain the following information:

(a) Operating pressure of all systems and subsystems

(b) Operating temperature of all systems and subsystems

(c) Diameter, wall thickness, and material of ducting

(d) Maximum velocity, mass, and direction of airflow through ducts and nozzles

(e) A simple schematic diagram of shut-off valve linkages

(f) A simple schematic wiring diagram of the electrical portion of the bleed air system giving current loads and voltage drops, and describing functions

(g) Name and part number of all units. Standard part numbers shall be indicated where applicable. Non-standard units shall also include name of manufacturer and the manufacturer's part number.

(h) Connections for testing with auxiliary ground test power systems shall be indicated.

(i) All components shall be shown in schematic, typical cutaway views with adequate data to show flow directions for the various operating conditions for the unit.

6.2.1.2 Final assembly drawing - The final assembly drawing shall have sufficient detail to completely identify each interface connection.

6.2.1.3 Installation drawing - The installation drawing shall include the following information:

(a) Complete location of bolt-down holes

(b) Minimum size of area for installation and maintenance

6.2.1.4 Nonstandard component cross-section assembly drawings - The cross-section assembly drawings for each nonstandard system component shall contain information in order that an evaluation of the unit can be made. Such information shall include the applicable specification, material, and protective finish of each part. This information may appear as a written addition to the drawing. Reason for the use of a nonstandard component shall be submitted with the component drawing.

6.2.2 Design analysis report - The design analysis report shall incorporate design calculations, a weight breakdown for the complete system, and data to verify that the system complies with all design requirements. A system temperature survey (minimum through maximum) shall be included considering the location of the system in the aircraft.

6.2.3 General - The contract will specify the tests and design data that will be required, will amplify or modify the tests and design data, and may specify other tests and design data under the appropriate section of this specification.

6.2.3.1 Addition of tests and design data - If the tests and design data required by the contract are inadequate to prove that the bleed air system and the bleed air system installation incorporate the specified requirements, the contractor should propose amendments to the contract to include tests and design data which will prove adequately that the bleed air system and the bleed air system installation incorporate the specified characteristics.

6.2.3.2 Deletion of tests and design data - If applicable test and design data are available, the contractor should, in lieu of repeating tests and submitting design data, propose amendments to the contract to require the submittal of these data supplemented by sufficient information to substantiate their applicability.

6.2.3.3 Test witnesses - Before conducting a required test, the contractor should notify the Bureau of Naval Weapons Representative in sufficient time so that he or his representative may witness the test and certify results and observations contained in the test report. When the BuWeps Rep is notified, he should be informed whether the test is such that interpretation of the behavior of the test article is likely to require engineering knowledge and experience - in which case he will provide a qualified engineer who will witness the test and certify the results and observations of the test.