INCH-POUND

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MILITARY SPECIFICATION

PNEUMATIC SYSTEMS, AIRCRAFT, DESIGN AND INSTALLATION, GENERAL REQUIREMENTS FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the design and installation requirements of aircraft pneumatic systems. This includes systems used in automatic pilots (see 6.4.1), surface control systems (see 6.4.5), and gun chargers (see 6.4.4). The working gas may be air, nitrogen, or similar inert gas.

1.2 Classification. Aircraft pneumatic systems are of the following types and classes:

1.2.1 Types.

1.2.1.1 Charged system.

Type A - Airborne compressor-charged system.

Type B - Ground-charged system.

1.2.1.2 Fluid temperature.

Type I - Maximum fluid operating temperature +160°F (+71°C).

Type II - Maximum fluid operating temperature +275°F (+135°C).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Warfare Center Aircraft Division Lakehurst, Code SR3, Lakehurst, NJ 08733-5100 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 1650

1.2.2 Classes.

Class 1500 - Supply system is charged to a pressure of 1500 pounds per square inch (psi).

Class 3000 - Supply system is charged to a pressure of 3000 psi.

Class 4000 - Supply system is charged to a pressure of 4000 psi.

Class 5000 - Supply system is charged to a pressure of 5000 psi.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

BB-N-411	-	Nitrogen, Technical

MILITARY

MIL-B-5087	-	Bonding, Electrical, and Lighting Protection, For Aerospace Systems
MIL-W-5088	-	Wiring, Aircraft, Selection and Installation Of
MIL-F-5508	-	Fuse, Aircraft, Automatic Quantity, Measuring, Hydraulic
MIL-P-5510	-	Packings and Gaskets, Preformed, Petroleum Hydraulic Fluid Resistant
MIL-J-5513	-	Joints, Hydraulic, Swivel
MIL-G-5514	-	Gland Design, Packing, Hydraulic General Requirements For
MIL-V-5519	-	Valves, Regulating Fluid Pressure
MIL-T-5522	-	Test Procedure for Aircraft Hydraulic and Pneumatic Systems, General Requirement for
MIL-V-5530	-	Valves; Aircraft Hydraulic Shuttle

MIL-V-6164	-	Valve; Aircraft, Air, High Pressure
MIL-C-6591	-	Compressor Unit, Aircraft, Electric Motor Driven, General Specification For
MIL-T-7081	-	Tube, Aluminum Alloy, Seamless Round Drawn, 6061, Aircraft Hydraulic Quality
MIL-M-7969	-	Motor, Alternating Current, 400-Cycle, 115/200 Volt System, Aircraft, General Specification For
MIL-G-8348	-	Gage assemblies, Air Pressure, Dial Indicating Chuck Type, Self-contained
MIL-P-8564	-	Pneumatic System Components, Aeronautical, General Specification for
MIL-R-8573	-	Reservoirs, Air, Nonshatterable Steel
MIL-M-8609	-	Motor, DC, 28 Volt System, General Specification For
MIL-R-8791	-	Retainer, Packing, Hydraulic, and Pneumatic Tetrafluoroethylene Resin
MIL-S-9395	-	Switch Pressure (Absolute Gauge and Differential) General Specification For
MIL-V-19068	-	Valves, Shuttle, Hydraulic, Aircraft, Type II Systems
MIL-C-25427	-	Coupling Assembly, Hydraulic, Self Sealing Quick Disconnect
MIL-H-25579	-	Hose Assembly, Tetrafluoroethylene, High Temperature, Medium Pressure
MIL-P-83461	-	Packing, Preformed, Petroleum Hydraulic, Fluid Resistant, Improved Performance at 275°F
MIL-H-85800	-	Hose Assembly, Polytetrafluoroethylene, Aramid Fiber Reinforced, 5000/8000 psi General Specification For

"(see supplement 1 for list of MS sheet form standards.)"

STANDARDS

MILITARY

MIL-STD-461	-	Electromagnetic, Emission and Susceptibility Requirements For the Control of Electromagnetic Interference
MIL-STD-462	-	Electromagnetic Interference Characteristics Measurement of
MIL-STD-810	-	Environmental Test Methods
MIL-STD-1247	-	Markings, Function and Hazard Designations of Hose, Pipe and Tube Lines for Aircraft, Missile and Space Systems
MIL-STD-1472	-	Human Engineering Design Criteria For Military Systems, Equipment and Facilities
MIL-STD-1568	-	Materials and Processes for Corrosion Resistance and Control in Aerospace Weapons Systems
MIL-STD-1587	-	Materials and Process Requirements for Air Force Systems
MIL-STD-2069	-	Requirements for Aircraft Nonnuclear Survivability Program
MIL-STD-2089	-	Aircraft Nonnuclear Survivability Terms

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the DoDSSP-Customer Service, Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

UNITED STATES GOVERNMENT PRINTING OFFICE

GPO Style Manual

(Copies of the GPO Style Manual are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-0001.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the Dodiss cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the Dodiss are the issues of the documents cited in the solicitation.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

ARP 584 - Coiled Tubing, Corrosion Resistant Steel, Hydraulic Applications

ARP 994 - Recommended Practice for the Design of Tubing Installations for Aerospace Fluid Power Systems

AS 1300 - Boss - Ring Locked Fluid Connection Type, Standard Dimension For

AS 1339 - Hose Assembly, PTFE, Lightweight, 3000 psi, 400°F, Hydraulic

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Report - 1235 - Standard Atmosphere, Tables and Data for Altitudes to 65,800 Feet

(Application for copies should be addressed to the National Aeronautics and Space Administration, 1320 H Street NW, Washington, DC 20361.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. PERFORMANCE REQUIREMENTS

3.1 Systems. For type A systems, the compressor shall be so regulated that it maintains the system air pressure between the cut-in and cut-out pressures specified in Table I. Systems of this type shall also contain provisions for ground charging of the storage reservoirs. For type B systems, the full reservoir charge shall be sufficient to conform to all operating requirements at any temperature throughout the operating range defined in Figure 1.

3.1.1 Class 4000 and Class 5000 supply system. Where Class 4000 and Class 5000 are used, selections of all elements of the 4000 psi and 5000 psi systems, including lines, couplings, hoses, fittings, valves, packings, and seals shall be approved by the contracting activity (see 6.3).

3.2 Air. Unless otherwise specified by the contracting activity, both type A and type B systems shall be designed for operation when ground-charged with filtered and dried air containing not more than 0.25 grains of water vapor per pound of gas or nitrogen in accordance with BB-N-411.

3.2.1 Standard air. Standard air shall be dry air having the properties listed in Table II.

3.3 General system design. The pneumatic systems and components shall be designed to operate satisfactorily under all conditions that the aircraft may encounter within the structural limitations of the aircraft, including forces or conditions caused by acceleration, deceleration, zero gravity, negative g or any flight attitudes obtainable with the aircraft structural, deflection, vibration, or other environmental conditions.

3.3.1 System types. Unless otherwise specified in the aircraft detail specification, the contracting activity shall specify Type A or Type B system for the design based upon performance, reliability, maintainability, and space availability of specific aircraft.

3.3.2 Strength.

3.3.2.1 Additional loads. During operation of the aircraft, all pneumatic systems and components that are subjected to structural or other loads which are not of pneumatic system origin shall withstand the combination of loads that can be applied simultaneously in flight. There shall be no system or component failure or permanent set when the corresponding proof pressure specified in Table I and load combination are applied at the maximum operating temperature.

3.3.2.2 Loads due to aircraft acceleration. All pneumatic system components, their attaching lines, fittings, and couplings subjected to pressure loads resulting from aircraft acceleration, shall withstand a pressure equal to 100 percent of maximum pressure that will be developed without failure or permanent set at the maximum operating temperature.

3.3.3 Pressure limitations.

3.3.3.1 System relief and test pressures. System relief and test pressures shall be in accordance with Table I.

3.3.3.2 Back pressure. The pneumatic system shall be so designed that the functioning of the components shall not be affected by the maximum back pressure in the system. The system or systems shall be designed that malfunction of any component in the system shall not render any other subsystem, emergency system, or alternate system inoperable because of back pressure.

TABLE I. Pneumatic pressure testing and setting.

Component or Characteristic	System Classes (testing and setting pressure in psi)				Remark
	class 1500	class 3000	class 4000	class 5000	
	PRESSURE SETTING				
Compressor pressure range	in - out 1250-1500	in - out 2600-3000	in - out 3400 - 4000	in - out 4400 - 5000	Range of pressure regulator or pressure switch which cuts the the pressure in and out
Main relief valve setting: Reseat (min) Flow (max)	 1650 2025	 3250 3975	 4300 5260	 5500 6250	Valve capacity for flow to be at least equal to compressor delivery
Storage type system reservoir	1500	3000	4000	5000	Reservoir charging pressure
System relief valve (subsystem relief)	125 percent of subsystem pressure reducing valve or regulator setting				Apply to all pressure classes
Actuating cylinders and other components installed in pneumatic system	150 percent of operating pressure or main system relief pressure as applicable Main relief valve cranking pressure applied in the high pressure section of the system Pressure resulting in th low pressure sections of the system with the pressure reducing valves properly set will be considered the proof pressure for these portions of the system				Apply to all pressure classes

TABLE I. Pneumatic pressure testing and setting - Coontinued.

Component or Characteristic	System Classes (testing and setting pressure in psi)				Remark
	class 1500	class 3000	class 4000	class 5000	
	PRESSURE TESTING				
Reservoirs: Proof pressure Burst pressure	To comply with test of MIL-R-8573				For all pressure classes
Proof pressure: (min) Tubing, Hose Fitting, Actuating Cylinders which act as a reservoir	200 percent of operating pressure or main system pressure as applicable				For all pressure classes
Burst pressure: (min) Tubing, Hose Fitting, Actuating cylinders which act as a reservoir	400 percent of operating pressure or main system pressure as applicable				For all pressure classes

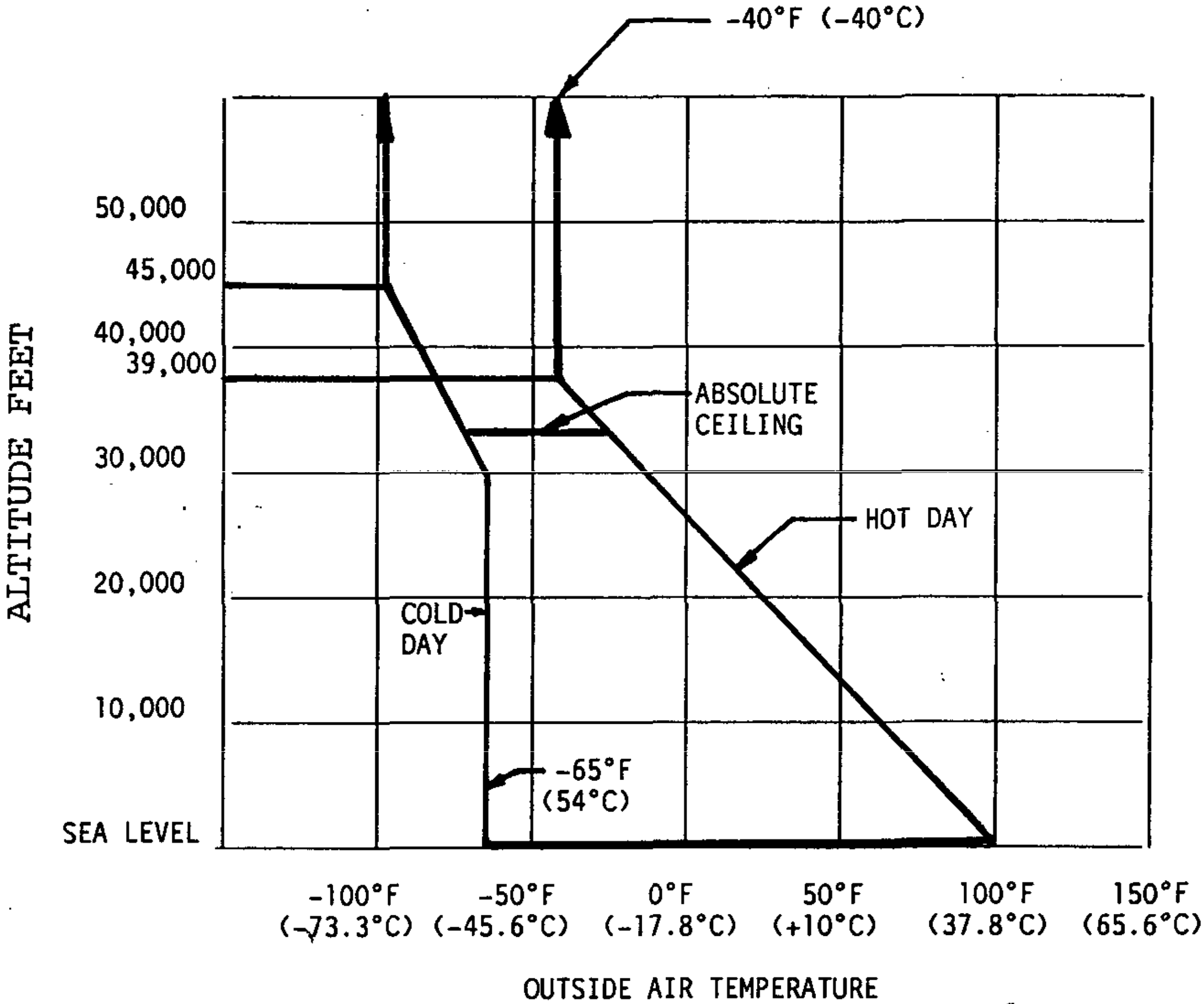

FIGURE 1. Temperature and altitude pneumatic system parameter.

TABLE II. Standard air properties.

Property	Symbol	Values
Temperature 1/	t	59°F (15°C)
Absolute temperature 1/	T	519°R (288°K)
Absolute pressure 1/	P	29.92126 in. Hg
Density 1/	D	0.076475 lb/ft
Gas constant	R	17.165x10 ft/sec/°R
Moisture content	W	0.25 grains/lb

1/ Refer to NASA Report 1235.

3.3.4 Operating temperature and altitude limitations. The pneumatic system shall operate within the range of outside air temperatures and altitudes shown in Figure 1. Pneumatic systems that are started on the ground and operate continuously during flight are not required to start at temperatures below -65°F (-54°C) or altitude above 8000 feet. The air temperature of the system shall not exceed those which the components of the system are capable of withstanding with consideration given to the percentage of expected operating time at various temperatures and conditions.

3.3.5 Subsystem isolation. When two or more subsystems are pressurized by a common pressure source, and one system is essential to safety in flight and the other system is essential to safety in landing, the two systems shall be so isolated by the use of automatic shut off valves, or similar means, that damage to the system or systems necessary for landing operations shall not affect the pneumatic systems essential for flight operations.

3.3.6 Emergency provisions. All pneumatically operated services which are essential to safety in flight or landing shall have provision for emergency actuation (see 3.5 and subparagraphs thereto).

3.3.7 Ground test and charging provisions.

3.3.7.1 Ground testing and charging connection. Provisions shall be made to permit ground charging of the pneumatic system air reservoirs, normal and emergency, in order to eliminate the necessity of operating the pneumatic system compressors on the ground to charge a system prior to takeoff or during ground servicing.

The ground charging connections shall be installed in accordance with AND10071 or MS33740 and shall consist of an air valve designed in accordance with AN6287 for operation pressure 3000 psi and below and in accordance with MS28889 for operation pressure above 3000 psi, provided the temperature shall not exceed +160°F (+71°C) for Type I system and +275°F (+135°C) for Type II system. In type A systems, the connections shall be attached to the pressure line downstream of the moisture removing equipment.

3.3.7.2 Ground test data. The following data shall be written on a plate and attached permanently on the aircraft near the ground test connection and shall be easily visible by the maintenance personal (see 6.3).

Set ground charging compressor relief valve to _____*.

Charge system to _____* psi maximum, at _____*°F (any other precautions necessary).

A pressure-temperature chart shall be installed adjacent to the ground test connection.

Charge system gas ________*.

*Aircraft manufacturer shall enter these values. Pressures shall be given as a function of temperature with an allowance of ±15°F (± 7°C) discrepancy.

3.3.8 Multiple compressors engine-driven. Multiple-engine aircraft pneumatic systems using engine-driven compressors shall have compressors on at least two engines. An engine-driven compressor augmented where necessary by independently driven compressors, shall be provided to maintain stored energy in air reservoirs in order to assure operation of essential flight functions with any minimum combination of engines which will maintain flight and other services needed during taxiing.

3.3.9 Pneumatic system. Pneumatic systems shall include a storage reservoir having volume sufficient to operate the aircraft circuits as required by the aircraft detail specification. When compressors are used, the size of reservoir shall be such that when supplemented by the storage capacity of the system, the required duty cycles of all pneumatic circuits shall be obtained.

3.3.10 Leakage. In type B systems, the total leakage of all components and plumbing in the pneumatic system shall be minimum so that the available stored energy shall not fall below the minimum standby time of the aircraft plus maximum flight time specified in the aircraft detail specification.

3.4 Utility system design.

3.4.1 General. The general design requirements of 3.3 and subparagraphs thereto apply to the utility system (see 6.4.6).

3.4.2 Design of line installation.

3.4.2.1 Hose connections. Where hoses are attached to a pneumatic component in the utility system design, they shall be permanently tagged and marked in accordance with MIL-STD-1247 and arranged to prevent incorrect connection.

3.5 Emergency design for utility systems.

3.5.1 Types. All pneumatically operated services which are essential to safety in flight or landing shall be provided with emergency devices. Where emergency devices are required in pneumatic systems, the emergency systems shall be completely independent of the main systems up to, but not necessarily including, the actuating cylinder or motor. These emergency systems shall utilize only compressed air, direct mechanical connection, electro-mechanical units, and gravity, or combinations thereof. The use of the other types of emergency systems requires specific approval of the contracting activity. On all fighter-type or all carrier-based aircraft, the landing gear emergency extension shall be powered by stored energy released by a control requiring only a single motion on the part of the operating personnel.

3.5.2 Separation of dual lines. Where dual lines are used to provide emergency operation of mechanism, the normal and emergency lines shall be separated from each other as far as it is practicable so that the possibility of both lines being ruptured by a single projectile is reduced to a minimum.

3.5.3 *Emergency line venting. The emergency line from the shuttle valve* shall be vented moisture to atmosphere when the emergency system is not in use.

3.6 Component design. All pneumatic components used in the system shall be designed in accordance with MIL-P-8564.

3.6.1 Component specifications. Where component specifications conflict with MIL-P-8564 requirements, component specification requirements shall take precedence.

3.6.2 Standard components. Standard components shall be used in preference to nonstandard components. Where no applicable AN, MS, or Industry standard exists, a uniquely designed component compatible with the performance, installation, and inspection, and maintenance requirements shall be used.

3.6.3 Air reservoirs. The selection and location of air reservoirs shall maximize the protection of air crew members due to reservoir rupture from projectiles, explosive ordnance or fragments generated by the ordnance. The air bottle mounting brackets shall be strong enough to retain the bottle in its normal mounted position when the bottle is ruptured with a .50-caliber bullet tested in accordance with the gunfire test of MIL-R-8573. The reservoirs shall be rechargeable without being removed from the supporting brackets.

3.6.4 Air reservoir design. Air reservoirs, except for structural members used as reservoirs, shall be in accordance with MIL-R-8573. Where structural members are used as air reservoirs, they shall be tested to determine compliance with the gunfire requirements of MIL-R-8573. A thermal relief valve shall be installed in the down side of reservoir to reduce the high temperature causes by stored energy, to the operating temperature.

3.6.5 Air reservoir location. In systems using air reservoirs, a standard pressure gage made in accordance with MIL-G-8348 shall be located in an area where maintenance personnel can visually check the reservoir pressure. The reservoir shall be so located to produce a minimum length of line between the reservoir and the shuttle valve and shall be located in an area which is relatively sheltered from gunfire. Unless the reservoir has a standpipe, it shall not be mounted with its outlet port at the bottom of the reservoir.

3.6.6 Actuating cylinders. Pneumatic actuating cylinders shall be so installed that they are readily accessible for maintenance and inspection. The cylinder shall be installed in an area safe from external objects or if it is exposed it shall be protected from flying debris during takeoff and landing.

3.6.7 Directional control valves. The location of directional control valves shall be dependent on the valve performance so that the system operation shall not be adversely affected by back pressure, interflow, or pressure surge which might tend to cause the valves to open or move from their setting, or cause them to bypass air in other than the intended manner. Pneumatic control valves shall not be located in the pilot's cockpit or compartment without the approval of the contracting activity.

3.6.7.1 Directional control valve handle location. All directional control valve handles shall be located in accordance with MIL-STD-1472 paragraph 5.10, design of equipment for remote handling. Valve design shall incorporate internal or external stops capable of withstanding limit loads generated by the application of 75 lbs (35 kg) on the handle grip without detrimental effects.

3.6.8 Multiple control valve systems. In systems which incorporate two or more directional control valves, provision shall be made to prevent fluid from being transferred at any valve setting, from the cylinder ports of one valve into the cylinder ports of another valve.

3.6.9 Control valve actuation. Control valve operation shall be direct, such as push-pull rods, cable control, or indirect, such as electrically operated controls. Push-pull rods shall require minor adjustments or no adjustment if possible. Sheathed flexible controls shall not be used without specific approval of the contracting activity. Cable control shall be designed to provide minor adjustment. All controls shall be designed to prevent overtravel or undertravel of the valve control handle by use of external or internal stops. Electrically operated valves shall be provided with mechanical override control mechanisms wherever practicable.

3.6.10 Control valve wiring. Electrically operated control valves shall be wired in accordance with MIL-W-5088.

3.6.11 Pressure regulating valves. Valves that reduce pressure for utility circuits shall be in accordance with MIL-V-5519 for pressure 3000 psi and below and shall be in accordance with MS28889 for pressure above 3000 psi.

3.6.12 Dehydrators. Dehydrators shall be used in Type A systems to remove moisture introduced by the aircraft compressors. The moisture content of the air discharged from the dehydrators shall not exceed 0.12 grains per pound of dry air (specific humidity). The dehydrators shall remove compressor lubricating oil carried into the system by the air.

3.6.13 Filters. Filters shall be installed in the pneumatic system. Foreign particles larger than 15 microns shall be removed from the systems. Reservoir filter shall be of the replaceable element type in refillable or rechargeable systems.

3.6.14 Fittings. Straight thread fittings shall be used in the pneumatic system. Unless specifically approved by the contracting activity no thread lubricants shall be used. All nonstandard fittings (see 6.4.7) use shall require approval from the contracting activity. The use of permanent type fitting connectors employing no screw threads require the contracting activity or procuring activity approval. Aluminum flared fitting shall not be used with steel tubing in size smaller than -8. Aluminum fittings and tubings shall not be installed in designated fire zone and high stress area. Fittings made from free machining steel AISI one thousand series shall not be used in the pneumatic system.

3.6.15 Fuses. Pneumatic fuses shall be provided in the system, as necessary, to isolate ruptured circuits and prevent complete loss of the air pressure in the pneumatic system. Fuses shall be in accordance with MIL-F-5508.

3.6.16 Gages. Pressure gages in accordance with MIL-G-8348 shall be used in pneumatic systems. Gage location shall be chosen to permit operating and maintenance personnel easy access to visually read the displayed data.

3.6.17 Hoses. Unless otherwise indicated in the aircraft detail specification, hoses shall be used where there is relative motion between two connections. When design conditions permit, swivel joints, coiled tubing or flexing steel lines shall be used subject to the conditions specified in 3.6.17.1 through 3.6.17.4. Hose assemblies used in pneumatic systems shall be made up of hose and hose end fittings in accordance with:

(a) MIL-H-5593 for pressure less than 1500 psi
(b) MIL-H-25579 for 1500 psi pressure
(c) AS1339 for 3000 psi pressure
(d) MIL-H-85800 for above 3000 psi pressure

The system design shall not subject the hose to torsion (twisting) or chafing under any operating conditions and there shall be no tendency for their connecting fittings to loosen. Clamp-type hose installations shall not be used in pneumatic systems. Hose(s) under constant pneumatic pressure shall not be used. Polytetrafluoroethylene (PTFE) hose assemblies shall be used for age limitations and high temperature application. Rubber hose shall not be used in such application.

3.6.17.1 Hose support. The support of a flexible hose line shall be such that it shall not tend to cause deflection of the rigid lines under any possible relative motion that shall occur. Flexible hose between two rigid connections shall have excessive motion restrained where necessary, but shall not be rigidly supported, as by a tight rigid clamp around the flexible hose. Installation of hose supports shall be in accordance with ARP 994.

3.6.17.2 Hose bend radii. The minimum bend radius for standard hose assemblies shall be in accordance with MS33790. If nonstandard hose is used where no standard hose is available, minimum bend radii for nonstandard hose shall meet the requirements of MS33790.

3.6.17.3 Hose protection. Hoses shall be protected against chafing when installed in aircraft.

3.6.17.4 Provision for hose elongation and contraction. Hose assemblies shall be so selected and installed that elongation and contraction under pressure, within the hose specification limits, shall not be detrimental to the installation either by causing strains on the end fittings or by binding or chafing of the hose.

3.6.18 Electric-motor-driven compressor. When electric-motor-driven compressors are used, electric motors shall be capable of continuous operation. Test duty cycles, operational temperature range, rated voltage, altitude, explosion proofing and automatic control design requirements shall be in accordance with MIL-M-7969 for Alternating Current (AC) and MIL-M-8609 for Direct Current (DC) systems.

3.6.19 Seals. MIL-G-5514 shall be used for gland design and packing installation. O-ring packing squeeze shall be a minimum of 5 percent or 0.005 inch deflection, whichever is greater for the most adverse tolerance conditions. If necessary, changes to gland dimensions in MIL-G-5514 may be used to accomplish this minimum squeeze. O-ring packings with cross-sectional diameters of 0.070 inch or less, or their equivalent proprietary seals, shall not be used as external seals.

3.6.20 Gland Design. Seal gland dimensions shall be in accordance with MIL-G-5514 except for nonstandard packings (see 6.4.7) use for specialized proprietary application. These nonstandard glands shall be used only with the specific approval of the contracting activity. For system pressure levels above class 3000, the diametral clearance gaps of MIL-G-5514 may be reduced from the minimum of 0.005 inch to the minimum of 0.003 inch to improve seal life and aid in preventing packing extrusion.

Care shall be taken to prevent binding and interference at the most adverse temperature extremes. Standard clearance may be used for system pressure levels greater than 3000 psi if proprietary-type packing shapes and high modulus backup ring materials are used.

3.6.21 Packing. Unless otherwise specify in the contract, o-ring packings shall be in accordance with MIL-P-83461. For MS33649 and AS 1300 port, MS28778 o-rings shall be used. Where packing configurations other than o-ring are used in standard glands they shall be approved by the contracting activity.

3.6.22 Backup rings. Backup rings shall be in accordance with MS27595. MIL-R-8791 backup rings shall be used on dynamic applications where minimum seal friction is required or where access to the gland prevents installation of MS27595. If MS27595 backup rings are used on dynamic piston applications, friction due to pressure entrapment between the backup rings shall be considered in the design of the device. Nonstandard backup rings (see 6.4.7) shall be used for system pressure levels greater than class 3000 subject to the approval of the contracting activity.

3.6.23 Air compressors. Air compressors shall be driven directly by the engine, or an auxiliary gearbox, or by independent motors using hydraulic, electric, air, or any other available power sources. Selection and installation of air compressors shall not be restricted by size, number of stages, or type of mechanism, provided the installation requirements with respect to efficiency, weight, and envelope are complied with. Design and installation requirements of airborne compressor shall be in accordance with MIL-C-6591.

3.6.23.1 Mounting. When driven by independent motors, the compressor assemblies and their motors shall be subject to and shall withstand the environmental conditions to which the airframe is subject as well as vibration conditions induced by the airframe specified in the detailed aircraft specification. The mount shall be designed to withstand vibration and shock at frequencies and forces comparable to the airframe compartment in which installation is made.

3.6.23.2 Cooling. Compressor units shall be cooled by means independent of the air frame, such as fan or liquid, or shall be blast cooled by ducting ram air supply in the installation.

3.6.23.3 Fan or liquid cooled units. For fan or liquid cooled units, the compressor compartment temperatures shall be maintained at room temperature with vents for air circulation or with cooling reservoir for liquid circulation. Adequate provision shall be made for this heat dissipation without exceeding the safe operating compartment temperatures as specified in the aircraft detailed specification.

3.6.23.4 Blast cooled units. For blast cooled units, the temperatures and quantities of cooling air requirements shall be in accordance with MIL-C-6591.

3.6.23.5 Compressor inlet pressure. Compressor inlet pressures shall be either ambient or regulated engine bleed air pressure. Provision shall be made for precooling for high inlet air temperature. Filter or filters shall be provided in the compressor inlet.

3.6.24 Independent motors. Independent fluid motors deriving their power source from greater pressures and flows shall have speed limiting devices to prevent damage due to surging fluid in the systems. Where electric motors are used they shall be protected from overload by protective devices such as a speed limit switch.

3.6.25 Compressor accessibility. The air compressor shall be located in an accessible area of the aircraft in order to perform periodic servicing and maintenance.

3.6.26 Compressor unloaders. The compressor shall have unloading devices which switches off the load during the period between cut-out and cut-in pressure.

3.6.27 Pressure switches. Switches shall be installed in pneumatic systems where the regulation of pressure is required. Adequate precautions shall be taken to prevent chatter or cutoff. Pressure switches shall be in accordance with the requirements of MIL-S-9395 as applicable.

3.6.28 Pressure reducing valves. Pressure-reducing valves shall be used to automatically reduce operating pressure for each individual subsystem. In cases where conditions make relief of the full subsystem flow necessary, external relief valves shall be provided. These valves shall be installed so that they are accessible for servicing.

3.6.29 System relief valves. System pressure relief valves shall relieve excessive pressure through bypass of fluid from the pressure to the return side. The valves shall have a capacity equal to or greater than the rated flow of the largest pump when two or more pumps have a common pressure line. The systems shall be designed so that the fluid flowing through the system relief valves shall not exceed the temperature of +160°F (+71°C) for Type I systems or +275°F (+135°C) for Type II systems. If the fluid temperature upon relief exceeds the limits, a cockpit temperature warning system shall be used if approved by the contracting activity.

3.6.30 Self-sealing couplings. Self-sealing couplings shall be in accordance with MIL-C-25427. Pneumatic systems shall be provided with self-sealing couplings for each engine compressor and so located that the compressor can be easily removed for servicing. A coupling shall be used in each line connecting to each compressor. Self-sealing couplings shall also be provided at all other points in the pneumatic system which require frequent disassembly or, where convenient, to isolate parts of the system for servicing. If required, provisions for connecting couplings with trapped pressure in the pneumatic system shall be incorporated in the coupling design.

Sufficient clearance shall be provided around the coupling to permit connection and disconnection. Self-sealing couplings installed adjacent to each other shall be of different size or shall be coded with color so that inadvertent cross connection of the lines cannot occur.

3.6.31 Shuttle valves. Class 1500 and class 3000 shuttle valves shall be in accordance with MIL-V-5530 and MIL-V-19068 respectively. For Class 4000 and 5000 systems shuttle valves shall be in accordance with MIL-V-6164. Shuttle valves shall not be used in installations where a force balance can be obtained on both inlet ports simultaneously which may cause the shuttle valve to restrict flow from the outlet port. Where shuttle valves are necessary to connect an actuating cylinder with the normal and emergency systems, the shuttle valve unit shall be built into the appropriate cylinder head using component parts of applicable AN or MS approved shuttle valves in a cartridge. Where the above installation cannot be made, a standard shuttle valve shall be located at the actuator port. In the event neither of the above installations is possible, a length of rigid line is permissible between the cylinder port and the shuttle valve, provided that the rigid line and the shuttle valve shall be firmly attached to the actuating cylinder. Flexible hose shall not be used between the actuating cylinder port and the shuttle valve.

3.6.32 Swivel joints. Swivel joints shall be used in pneumatic systems where relative motion exists between two connections. All swivel joints used shall be approved by the contracting activity prior to installation and shall be designed in accordance with MIL-J-5513 except all pressure-to-atmosphere dynamic seals shall be dual unvented. Life test shall be conducted to all swivel joint prior use. Where lines or fittings are used to drive swivel joints, the swivel joints shall be adequately supported and shall be of sufficient strength to ensure satisfactory installation.

3.6.33 Drain fittings. Drain fittings shall be provided, as necessary, at low points in the system to permit removal of condensed moisture.

3.6.34 Tubing.

3.6.34.1 Materials. Only corrosion resistant steel tubing shall be used in pressure lines and for all tubing mounted on shock struts. Material selections shall be made in accordance with MIL-STD-1587. Aluminum alloy per MIL-T-7081 shall be used in pressure application below 3000 psi. To satisfy special needs such as welding or brazing, other tube materials shall be used if approved by contracting activity.

3.6.34.2 Tube ovally and bends. Bends shall be uniform and shall be in accordance with MS33611. Tubing ovality shall not exceed 3 percent for titanium alloys, 5 percent for corrosion resistant steels, and 10 percent for aluminum alloys. Other ovality limits used shall be approved by the contracting activity.

3.6.34.3 Tubing pre-stress (autofrettage). Tubing flatness shall be in accordance with MS33611. Where flatness greater than as specified in MS33611, tubing pre-stress (autofrettage) shall be used to reduce the flatness.

3.6.34.4 Use of small size tubing. If tubing with outside diameter .375 inch (-6 size) is used for operation at -65°F temperature it shall be approved by the contracting activity.

3.6.34.5 System tubing corrosion protection. Aluminum alloy tubing in exposed areas, such as landing gear wheel wells and missile bays, shall be protected against corrosion, particularly under the sleeve and nut couplings. Protective treatment, material and procedures shall be in accordance with MIL-STD-1568. Any damage to corrosion-preventive coatings during installation, e.g., scratches caused by wrenches or coupling nuts (steel or aluminum), shall be replaced.

3.6.34.6 Tubing flares and assembly. Tubing flares shall be in accordance with MS33583 or MS33584 as applicable and shall be used only in drain or vent lines. When installing tube connections, the wrench torque values to assemble each joint shall be in accordance with MS21344.

3.6.34.7 Designed motion in tubing. Looped or straight aluminum alloy tubing shall not be used between connections where there is relative motion. Relative motion shall be allowed between the ends of steel tubing if the combined calculated stress resulting from burden effect, torsion, tension, and compression is less than 10 percent of the ultimate strength of the tubing, and vibration of the tubing mass shall not have a detrimental effect. Unless otherwise specified by the contracting activity, endurance tests of such tubing shall be required.

3.6.34.8 Straight tube lines. The use of straight tube lines installed between two rigid connections shall be avoided. Where such straight lines are use, provisions shall be made in the mounting of the units or rigid connections to ensure that no strain shall be applied to the tubing and fittings. Semiloops shall be provided in the tubing to ensure proper alignment on installation to protect from damage due to vibration.

3.6.34.9 Tubing supports. Except as otherwise specified in the aircraft detailed specification and provided the temperature does not exceed 500°F, all pneumatic tubing shall be supported by teflon cushion steel tube clamps in accordance with MS21122 attached to adjacent rigid support. Provisions shall be made in clamp location to provide for change in tubing length due to contraction and expansion. Brackets in accordance with AN737 shall be used to support tube clamps. The recommended spacing between supports shall be in accordance with Table III. Where tubing lines are supported by fittings, unions, and tees, spacing shall be reduced by 20 percent from the values shown in Table III. Tubing installation shall be in accordance with ARP 994. Where tubes of different diameters are connected together, an average spacing distance shall be used. If grouping of tubings is necessary, it shall be supported by block-type clamps. Tubes shall not be bundled together. Supports shall be placed as close to bends as practicable to minimize overhang of the tube.

3.6.34.8 Location of pneumatic tubing. Insofar as practicable, pneumatic lines shall not be installed in the cockpit or cabin and shall be remote from personnel stations. All tubing shall be so installed that accumulated moisture shall drain to reservoirs or to specifically provided drain points as indicated in the detailed aircraft specification.

TABLE III. Pneumatic lines support spacing.

Nominal tube OD (inches)		Maximum length, in inches, between support centers (measured along tube)	
fraction	decimals	Aluminum-alloy tubes	Steel tubes
3/16	.063	12	14
1/4	.250	13.50	16
5/16	.313	15	18
3/8	.375	16.50	20
1/2	.500	19	23
5/8	.625	22	25.50
3/4	.750	24	27.50
1.000	1.000	26.50	30
1 1/4	1.250	28.50	31.50
1 1/2	1.500	29.50	32.50

3.6.35 Tubing and fitting identification. All pneumatic fluid lines shall be permanently marked using identification markings which are in accordance with MIL-STD-1247. Hoses shall not have to be marked if the adjacent tubing or component identify the function. Pneumatic lines shall be marked in conspicuous locations throughout the aircraft in order that each run or line shall be traced. These markings shall indicate the unit operated and the direction of flow. These markings shall be repeated particularly on lines entering and emerging from closed compartments in order to facilitate maintenance work. Where fittings are located in air frame members, such as bulkheads and webs, each fitting location shall be identified (placarded) as to system function, using the same terminology as on its connecting line.

3.6.36 Tubing clearance. When tubing is attached to a structure or other rigid members, a minimum clearance of 0.063 inch shall be maintained between the tubing and such members. A minimum clearance of 0.250 inch shall be maintained between the tubing and the adjacent rigid structure or units. In areas where relative motion of adjoining components exists, a minimum clearance of 0.250 inch shall be maintained under the most adverse conditions that will be encountered.

3.6.37 System tubing testing schedule. The system tubing testing schedule for each new model aircraft shall be submitted to the contracting activity for approval (see 6.3).

3.6.38 System tubing location. Tubing location shall be so designed that removal and replacement of tubing shall be accomplished without removal of other pneumatic components.

3.6.39 Mounting of lightweight components. Lightweight components that do not have mounting provisions shall be supported by the tubing installation, provided the component is rigidly installed and shall not result in destructive vibration or cause other adverse conditions to the tubing installation. Clamps or similar devices shall be used to attach such units to structure, provided that nameplates, flow directional arrows, or markings, or other data is not obscured and that the supporting members shall not affect the operation of the unit. If the unit shall not be supported by a clamp, the tubes on each side of the components shall be clamped to structure within two inches of the component.

3.6.40 System protection from damage. Pneumatic lines and components, particularly emergency lines of dual-line systems, shall be so located as to be protected from damage. Armorplates shall be used for protection wherever possible. Actuating cylinders vital to the control of the aircraft shall be protected from battle damage, which causes denting and consequent jamming of the cylinder, by installing auxiliary hoods or barrels over the normal cylinder barrel with clearance between the two, or shall be otherwise protected by armorplate.

3.7 Component location. All pneumatic components shall be located to accommodate the worst dimensional and operational conditions permitted in the component specification or drawing. All components shall be installed and mounted to withstand all maximum accelerated loads, wrench loads, and vibration loads. Where feasible, components shall be installed at high points in the line so that freezing from collected moisture shall not cause malfunction of the component.

3.8 Systems pressures.

3.8.1 Proof pressure. No part of a pneumatic system shall fail, take any permanent set, or be damaged in any manner, when subjected to the applicable proof pressure as indicated in Table I. Tubing shall be tested to proof pressures above the yield point to improve fatigue life.

All pneumatic systems components shall satisfy this requirement when subjected to proof pressure tests as listed in Table I. The proof pressure test shall be scheduled by the contractor and shall be approved by contracting activity (see 6.3).

3.8.2 Burst pressure. No part of the pneumatic system or system components shall rupture when subjected to applicable burst pressure test as specified in Table I. The burst pressure test shall be scheduled by the contractor and shall be approved by contracting activity (see 6.3).

3.9 Electrical bonding, grounding, and lightning protectors. The aircraft pneumatic system components, tubing, and distribution elements shall be bonded to the aircraft in accordance with MIL-B-5087. All electrically conductive components shall have a mounting point to structure not exceeding 2.5 milliohms resistance.

3.10 Vibration. Pneumatic lines, pneumatic components, and their supports shall be installed to be free of destructive vibration throughout the operating engine speeds or critical multiples thereof (see 4.2.3).

3.11 Survivability and vulnerability (s-v). The pneumatic systems shall be configured to accept a single impact by the threats as specified in the detailed aircraft specification without loss of defined mission essential functions. Failure of a backup emergency pneumatic system shall not prevent operation of the normal pneumatic or electric system. Aircraft combat survivability and vulnerability shall be in accordance with the requirements of MIL-STD-2069 and MIL-STD-2089 paragraphs 5.2.2.1 and 5.2.2.2.

3.11.1 Nuclear, biological, and chemical (NBC) protection. The pneumatic system components shall be capable of being operated and maintained in nuclear, biological, or chemical environments. External and internal surfaces shall be resistant to chemical reaction, adherence or absorption of contaminants. The treatment used to protect these environments shall not cause deterioration or corrosion of the system components.

3.12 Environmental condition. The pneumatic system components and equipment shall be capable of withstanding and operating as its were designed without detrimental effect of the performance of the systems under the environmental conditions specified and when tested in accordance with 4.2.3.

3.13 Electromagnetic interference(EMI). All electro-pneumatic components and equipment installed on the aircraft shall be in accordance with MIL-STD-461 to ensure freedom from electromagnetic interference. Pneumatic component resistance to EMI shall be verified by tests conducted in accordance with MIL-STD-462.

3.14 Resistance to gunfire. Pneumatic and gas system pressure vessels shall not rupture from a single impact of gun fire which results in personnel injury or serious damage to the airframe. High pressure vessels shall be capable of sustaining to a single armor-piercing incendiary (API) 50 caliber projectile without fragmentation. For low pressure vessels require resistance to a single API projectile shall be 30 caliber.

3.15 Pneumatic system schematic diagrams. The contractor shall prepare schematic diagrams which shall include cutaway views of all the standard and nonstandard pneumatic components with data to cover flow directions and component location for the various operating conditions of the unit. High and low pressure lines, flexible hose lines, and valves shall be identified. In addition, the schematic diagrams shall contain the following (see 6.3):

a. Operating pressure of all systems and subsystems.

b. All relief valve and regulator valve pressure settings.

c. Charging pressure of air reservoirs and their nominal capacities.

d. Cut-in and cut-out pressure ranges of all pressure regulating devices and the pressure and flow setting of all pressure reducing valves.

e. Displacement in cubic inches of each actuating cylinder for both extension and retractions.

f. Actuating cylinder piston head diameter, rod diameter, total and working stroke of each cylinder.

g. Type of compressor and output power.

h. Flow path through all components.

i. Compressor inlet supercharge system and operating pressure range.

j. Simple schematic diagram of linkages showing mechanical disconnects, down locks and up locks, and the interconnection of the mechanical system to the pneumatic system.

k. A schematic wiring diagram of the electrical connection to the pneumatic system giving full functional data and current loads. This diagram and data shall be on a separate drawing.

l. Name and part number of each component. For nonstandard components, the name of the manufacturer shall be given.

3.16 Pneumatic system nonstandard components. Where pneumatic system components are not covered by this specification, the contractor shall submit his specifications for approval by the contracting activity. The contractor shall prepare cross-sectional assembly drawings for each nonstandard component and shall submit sufficient technical data so that evaluation of the unit can be made (see 6.3).

3.17 Ignition and explosion hazard. The pneumatic system shall be designed and installed in aircraft such that:

a. The pressure and temperature conditions shall not be conducive to combustion or explosion.

b. Lubricant and combustible materials tending to cause or sustain combustion or explosion shall not be used.

c. Large cavities in the design where high energy combustions or explosions could occur shall not be used.

d. High compression ratios compressor shall not be used.

e. Lubricating oils or greases, which are prone to induce combustions or explosions, shall not be used.

f. All materials used in the system shall be chosen after taking into consideration their merits for not sustaining combustion or enhancing explosion and shall not wearing out, eroding, or weakening in a manner that shall cause malfunction of the system.

g. Where the possibility of combustion or explosion cannot be precluded, all protection devices shall be included in the design to minimize the effects of combustion or explosion on personnel and equipment. Such protection devices shall include flame arresters and blowout disks. Flame arresters shall be not interfere with fluid flows even after the maximum occlusion foreseeable in service occurred. Blowout disks shall be of size proportional to the volume of the part that they protect and so placed that their release, in flight and on the ground, shall not damage the equipment.

3.18 Placards for reversible components. Components, such as one-way restrictors, flow regulators, filters, and check valves shall each have a durable placard on the adjacent structure or equipment, visible with the component installed, to indicate the correct direction of installation. Arrows on connecting lines shall not be considered sufficient for this purpose.

3.19 Cleaning of parts. Prior to and during installation of pneumatic components, care shall be taken that dirt, chips, or other contaminating substances do not enter the system. To assure that the pneumatic system is free of contamination, all parts of the pneumatic system shall be thoroughly cleaned prior to installation, and each new pneumatic system shall be operated in order to ensure filtration of all circulating fluid. Dead-end lines in the system shall be properly connected with jumpers to completely clean such lines. If the filter element in the pneumatic system is used during the cleaning operation, it shall be replaced.

3.20 Workmanship. Workmanship shall be of the quality required to produce pneumatic systems free from defects.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet the requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, and does not commit the Government to accept defective material (see 6.3).

4.2 Inspection. The pneumatic system installation of one of the first complete experimental and production aircraft shall be subject to inspection for conformance to the requirements of this specification by engineering representatives of the contracting activity. It is expected that this inspection shall be performed at the contractor's plant concurrently with similar engineering inspections of other systems of the aircraft.

4.2.1 Ground and flight tests. Ground and flight tests shall be conducted in accordance with MIL-T-5522 (see 6.3).

4.2.2 Functional simulator design test program. A test program describing the general design of the functional simulator and the anticipated test program shall be prepared and approved by the contracting activity prior to beginning construction of the simulator (see 6.3).

4.2.3 Environmental conditions test. MIL-STD-810 shall be used for the environmental test of the pneumatic systems and components. The following are the requirements of tests and test paragraphs (see 6.3).

Environmental conditions test	Requirement paragraphs (MIL-STD-810)
High Temperature	501.2
Low Temperature	502.2

Environmental conditions test	Requirement paragraphs (MIL-STD-810)
Temperature shock	503.2
Solar radiation/sunshine	505.2
Rain	506.2
Humidity	507.2
Fungus	508.3
Salt Fog	509.2
Sand and Dust	510.2
Explosive Atmosphere	511.2
Leakage Immersion Test	512.2
Acceleration	513.2
Vibration	514.3
Acoustic Noise	515.3
Shock	516.3
Gun Fire	519.3
Temperature, Humidity, and Altitude	520.0
Icing and Freezing Rain	521.0
Vibro Acoustic Temperature	523.0

Testing of pneumatic components for humidity and corrosion effects shall include both static and operating conditions.

5. PACKAGING

5.1 Preparation for shipment. All deliverable items shall be prepared for shipment in accordance with the detailed packaging specification or as directed by the contracting activity.

5.2 Shipment of reservoirs. The shipment of pressurized gas reservoirs by common carrier shall be in compliance with the existing regulations of the Department of Transportation (DOT), Hazardous Materials Regulation board.

When stored gas bottles are shipped with electro-explosive devices (EEDs) attached, additional DOT regulations shall apply. It is the responsibility of the prime contractor to ensure that the gas bottle supplier has delivery approvals from the DOT.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The requirements covered by this specification are intended for use in the general design and installation of pneumatic systems such as the utility systems, automatic pilot (AP), surface control systems (SCS), auxiliary power unit (APU), environmental control systems (ECS), and gun chargers with component installation procedures for temperatures from -65°F (-54°C) to +160°F (+71°C) for Type I systems and from -65°F (-54°C) to +275°F (+135°C) for Type II systems.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.

b. Issue of DoDISS to be cited in the solicitation, and if required the specific issue of individual documents referenced (see 2.1.1).

6.2.1 Acquisition requirements optional. Unless otherwise specified by the contracting activity, the following are the options which should be specified for pneumatic systems or subsystems design:

a. General system design. For Navy use only, see Navy department publications SD-24, Volume I and II for the general design and construction requirements of aircraft weapon systems. Detail design requirements for environmental control systems (ECS) and auxiliary power units (APU) systems are specified in MIL-E-18927 and MIL-P-85573 respectively.

b. Operating temperature and altitude limitation. Most of the pneumatic components specified herein are intended for use in maximum operating temperatures of +160°F (+71°C) for Type I systems and +275°F (+135°C) for Type II systems. In the pneumatic systems where operating temperatures must exceed the above limits, use of special components or design techniques may be required. Such special components or techniques should be approved by the contracting activity prior to incorporation into the system design.

c. Reliability. The pneumatic system reliability is an integral part of the reliability requirements of the total air vehicle. The overall system reliability program shall be in accordance with MIL-STD-785. Component or subsystem performance reliability is impacted by basic design, material selection, production processing, installed environment, subsystem or component interfaces and maintenance. All modes of failure should be anticipated and analyzed.

d. Maintainability. The pneumatic system maintainability requirements should be integrated with the overall system maintainability programs and should comply with the requirements of MIL-STD-470. For details relating to component and subsystem performance maintainability programs demonstration should be in accordance with MIL-STD-471. Pneumatic system components should be designed for adjustment and repair at the lowest level of maintenance as far as practicable.

e. Pneumatic system design submittal and approval. In order to obtain approval for the pneumatic system design of each new aircraft, the contractor should submit the following for design study:

1. Schematic diagram of the pneumatic system or systems.

2. All pneumatic system component cross-sectional assembly drawings.

3. Pneumatic system ground and flight test data conducted in accordance with MIL-T-5522.

4. Pneumatic system design analyses of ignition and explosion dangers.

f. Ignition and explosion hazard report. The contractor should prepare an ignition and explosion hazard report during the early stages of the system development. In the ground and flight test reports, the contractor should prepare an actual tests conducted in accordance with MIL-T-5522, to prove that his design and installation provisions are effective in preventing damaging combustions and explosions. Whenever the contractor modifies the system covered by said reports, he should submit supplementary analyses and reports to cover the modifications.

g. Developmental and preproduction aircraft submittal data. The following data should be prepared and submitted to the contracting activity for approval.

1. Schematic diagram of the pneumatic system or systems.

2. Pneumatic system design report.

3. Plan and profile or isometric diagram detail of the pneumatic system installation which indicates separation of dual pneumatic systems, and emergency systems from normal systems.

4. Pneumatic system nonstandard component cross-sectional drawings.

5. Pneumatic systems nonstandard component test reports, or such data as may be required by the contracting activity for approval of each component.

6. Complete list of all pneumatic system components.

7. Pneumatic system flight and ground test in accordance with MIL-T-5522.

8. Explosion hazard report.

9. Corrosion protective treatment, material and procedures for tubing in exposed areas.

h. Complete list of pneumatic components. The list of pneumatic components should be in chart form and should contain the following items:

1. Component description.

2. Number of item required per aircraft.

3. Military specification part no.

4. Manufacturer's part no. or standard part no.

5. Name of manufacturer.

6. Test specifications used.

7. Design submission with two subtitles: Manufacturer's letter, and contracting activity approval.

8. Component test data submitted to the qualifying activity and approved by the contracting activity. Preliminary copies may be submitted at any time and the final corrected copy is submitted after the system design is frozen.

i. Production data. Where changes have been made in the pneumatic system over the developmental system, the developmental data should be submitted before production of aircraft.

j. Pneumatic system design report. The pneumatic system design detail report should be submitted with the final schematic diagram. The report should incorporate sufficient design calculations and data to verify that the pneumatic system design complies with all design requirements. A pneumatic system temperature survey (minimum through maximum) should be included considering the location of the pneumatic system in the aircraft. The time of flight at maximum system temperature and conditions under which this temperature occurs should be included. Compartment temperatures should be estimated. For primary flight control systems, peak and average flow rates, duration of peak flow rates, and the power spectrum should be indicated. The minimum temperature at which full performance occurs should be determined by the contractor.

k. Certification of test reports. The test reports should include the following:

1. Upon completion of validating tests, the contractor should certify that the pneumatic component conforms to the applicable military or contractor prepared specifications approved by the contracting activity and is satisfactory for use in the particular aircraft weapon system and pneumatic system.

2. The contractor should list those components that are contractor certified for data availability and compliance with the applicable Government approved specifications.

6.3 Data requirements. The following Data Item Descriptions (DID's) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this specification is applied on a contract, in order to obtain the data, except where DOD FAR Supplement 277.405-70 exempts the requirement for a DD Form 1423. For the Department of the Navy the Contract Data Requirements are shown in SD8706..

Reference Paragraphs	DID Number	DID Title	Suggested Tailoring
3.1.1, 4.2, 4.2.1,	DI-NDTI-80809A	Test/Inspection Reports	Use contractor format
3.6.37 3.8.1, 3.8.2	DI-MISC-80761A	Test Scheduling Report	Use contractor format
3.15	DI-DRPR-81002	Developmental Design Drawings And Associated List	Use contractor format
3.16	DI-MISC-81058	Nonstandard parts test data report	Use contractor format
4.1.1	DI-NDTI-80809A	Test/Inspection Reports	10.2.7
4.2.1, 4.2.2	DI-QCTC-80774	Demonstration Test Report	Use contractor format
4.2.3	DI-ENVR-80863	Environmental Test Report	Use contractor format

(The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.)

(Copies of the DOD Federal Acquisition Regulation Supplement and Forms are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-0001 and the DoDSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

6.4 Definitions.

6.4.1 Automatic pilot. Equipment which automatically controls the altitude of the aircraft about its pitch, roll, and yaw axes and maintains a pre-determined heading.

6.4.2 Auxiliary power unit. Auxiliary power unit (APU) supplies compressed air for aircraft pneumatic starting and environmental cooling systems. It is a power source to drive hydraulic pumps, generators, and other aircraft accessories.

6.4.3 Environmental control systems. Environmental control systems include pressurization, heating, cooling, pressure and anti-G suit systems, defogging, defrosting, anti-icing, rain removal, electronic/electrical equipment environment, and boundary layer control and related systems.

6.4.4 Gun charger. A member of a gun on an aircraft which operates to retract the bridge mechanism bolt to the rear and to insert a charge into the chamber.

6.4.5 Surface control systems. Systems which provide control of the pitch, roll, and yaw of an aircraft and provide secondary control of the flappers, leading edges, trailing edges, and speed brakes.

6.4.6 Utility system. The utility system includes all systems used for the normal operation of any services on the aircraft excluding those used for the operation of the aircraft primary control surfaces.

6.4.7 Nonstandard components. Nonstandard components such as couplings, hoses, fittings, packing, o-rings are defined as components designed and manufactured for a specific application where there are no government, Industry, or military standard components available.

6.5 Weather consideration. MIl-STD-210 should be used as a general guide lines for designing pneumatic systems and subsystems for various weather conditions.

6.6 Subject term (key words) listing.

Air system design
Airborne-charged compressor
Ground-charged compressor
Inert gas
Nitrogen
Operating pressure 1500 to 5000 psi
Power control system
Type I and Type II systems

6.7 Identification of changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue because of the extensiveness of the changes.

Custodians:
Army - AV
Navy - AS

Review activities:
DLA-CS
Marine Corps-MC

Preparing activity:
Navy - AS

(Project No. 1650-0452)

ALPHABETICAL INDEX

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-P-5518D	2. DOCUMENT DATE *(YYMMDD)* 930630

3. DOCUMENT TITLE PNEUMATIC SYSTEMS, AIRCRAFT, DESIGN AND INSTALLATION, GENERAL REQUIREMENTS FOR

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME COMMANDING OFFICER, NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION LAKEHURST SYSTEMS REQUIREMENTS DEPARTMENT	b. TELEPHONE *(Include Area Code)* (1) Commercial (908) 323-7488 (2) AUTOVON 624-7488
c. ADDRESS *(Include Zip Code)* CODE SR3 LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340