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Cold Gas Systems, Missile or Projectiles Design, Installation, Tests and Requirements For

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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1. PURPOSE:

This aerospace recommended practice covers the design, installation, tests and data requirements of stored cold gas blowdown systems or subsystems for use in guided projectiles and tactical missiles. The term system, hereafter, refers to units which function as aerodynamic surface control devices, valve actuated control devices, reaction control devices and sensing/control devices.

2. SCOPE:

Systems shall be classified in terms of type, category and class.

2.1 Type:

Type defines the ambient temperature range under which the complete system is capable of operating within the performance envelope during the entire service mission.

Type I: Operational temperature range between -54°C (-65°F) and +93°C (+200°F).
Type II: Operational temperature range between -54°C (-65°F) and +149°C (+300°F).
Type III: Operational temperature range between -54°C (-65°F) and +260°C (+500°F).

2.2 Category:

Category defines the use of external thermal energy, above ambient conditions, added to the gas storage reservoir during prelaunch or during the operational missin.

Category A: Gas storage reservoir unheated at all times.
Category B: Gas storage reservoir heated prior to launch.
Category C: Gas storage reservoir continuously heated during the service mission.

2.3 Class:

Class defines the maximum stored gas source pressure when the storage reservoir is stabilized at +21°C (+70°F).

Class 1: Stored gas source pressure of not more than 3000 psia 920.7 MPa).
Class 2: Stored gas source pressure greater than 3000 psia (20.7 MPa) but not more than 5000 psia (34 MPa).
Class 3: Stored gas source pressure greater than 5,000 psia (34 MPa) but not more than 10,000 psia (69 MPa).
Class 4: Stored gas source pressure greater than 10,000 psia (69 MPa)

2.4 Applicable and Reference Documents:

The following documents shall form a part of this Aerospace Recommended Practice (ARP) to the extent specified herein. The applicable issue of each shall be that in effect on the date of this Aerospace Recommended Practice unless otherwise specified in the manufacturer's Model (Detail) Specifications. Supplementary specifications, standards, or the like, which by reference in any of the following publications are indicated to be part thereof, shall not be considered effective except as specifically stated in the manufacturer's Model (Detail) specification or as may be otherwise mutually agreed upon between the vendor and the purchaser.

2.4.1 Specifications and Standards:

2.4.1.1 Specifications:

Military

MIL-G-4343	Lubricating Grease, Pneumatic System
MIL-B-5087	Bonding, Electrical (for Aircraft)
MIL-A-5498	Accumulators, Aircraft Hydropneumatic Pressure
MIL-G-5510	Gasket; Straight Thread Tube Fitting, Boss
MIL-G-5514	Packings, Installation and Gland Design Hydraulic, General Specification for
MIL-V-5523	Valve, Relief, Hydraulic Pressure
MIL-R-8573	Reservoirs, Air, Non-Shatterable Steel
MIL-V-8813	Valves, Aircraft, Hydraulic Pressure Relief, Type II Systems
MIL-P-25732	Packing, Preformed, Petroleum Hydraulic Fluid Resistant 275°F
MS 28775	Packing, Preformed, Hydraulic +275°F (O-ring)
MS 28778	Packing, Preformed, Straight Thread Tube Fitting Boss
MIL-STD-882	System Safety Program Requirements

Aerospace Standard

AS 568	Aerospace Size Standard for O-rings

2.4.1.1 (Continued):

Aerospace Recommended Practice

ARP 1231	Gland Design, Elastomeric O-ring Seals, General Considerations
ARP 1232	Gland Design, Elastomeric O-ring Seals, Static Radial
ARP 1233	Gland Design, Elastomeric O-ring Seals, Dynamic Radial, 1500 PSI Max
ARP 1234	Gland Design, Elastomeric O-ring Seals, Static Axial, Without Backup Rings

3. DESIGN REQUIREMENTS:

3.1 Selection of Specifications and Standards:

Specifications and standards for necessary commodities and services herein shall be selected in accordance with procedures established by the purchaser.

3.2 General System Design:

Systems shall be as simple and foolproof as possible with respect to design, operation, inspection and maintenance. All systems shall require design approval by the purchaser.

3.2.1 System Definition: A complete cold gas system is that group of components and elements installed in a missile to steer, maintain, or determine the magnitude and direction of the velocity vector in a stable manner through all phases of flight.

3.2.2 Category A, Class 1: May be designed to permit operational field tests and gas storage reservoir precharging by the utilization of standard ground or airborne test equipment. Applicable documents defining operatiing gas media requirements shall be specified when field test equipment is utilized.

3.2.3 Remaining Classifications: All other types, categories and classes shall be designed with factory-filled and sealed gas storage reservoirs. The contractor shall certify reservoir compliance to performance and operational requirements without test or servicing prior to its usage.

3.2.4 Materials: Materials used in the manufacturing of pneumatic systems for missiles or guided projectiles shall be of high quality, suitable for the purpose, and shall conform to applicable purchasing source specifications and standards. Materials conforming to the contractor's specifications may be used provided it can be clearly demonstrated that they are at least equivalent to purchasing source specifications with respect to operating characteristics. Contractor's specifications must be satisfactory to the purchaser and contain provisions for adequate tests. The use of contractor's specifications will not constitute waiver of purchaser's inspection.

3.2.5 Gas Fluid Media: Inert gases shall be used in systems for operation and testing, i.e., nitrogen, dehydrated air, helium, argon.

3.2.6 Climate and Environmental Conditions: The system shall be designed to survive the following conditions:

3.2.6.1 Storage Temperature: The system shall be capable of safe storage without impairment of its capabilities from the effect of temperature specified by the purchaser.

3.2.6.2 Preflight, Launching and Flight Temperatures: The system shall be capable of satisfactory performance during preflight testing, launching and flight between the temperatures specified by the purchaser.

3.2.6.3 Shock: The system shall be capable of satisfactory performance following exposure to the shock environment specified by the purchaser.

3.2.6.4 Vibration: The system shall be capable of satisfactory performance following and during exposure to the vibration environment specified by the purchaser.

3.2.6.5 Acceleration: The system shall be capable of satisfactory performance following and during exposure to the acceleration environment specified by the purchaser.

3.2.6.6 Altitude: The system shall be capable of satisfactory performance following and during exposure to the altitude environment specified by the purchaser.

3.2.6.7 Relative Humidity: The system shall be capable of satisfactory performance following and during exposure to the humidity environment specified by the purchaser.

3.2.6.8 Salt Spray: As specified by purchaser.

3.2.6.9 Storage Life: As specified by purchaser.

3.2.6.10 Sand & Dust: As specified by purchaser.

3.2.6.11 Fungus Resistance: As specified by purchaser.

3.2.7 Fire and Explosion Hazard: The system shall be integrated with other missile or guided projectile elements in such a manner as to preclude the possibility of creating a fire or explosion hazard by considering the following:

(a) The pressure and temperature conditions are not inductive to combustion or explosion.

(b) Percentages of lubricant and combustible materials tending to cause or sustain combusion or explosion are controlled and held to a minimum.

(c) Large cavities, in which high energy combustions or explosions could occur, are avoided as much as possible.

3.2.7 (Continued):

(d) Excessively high compression ratios, and resulting temperature peaks, are avoided, particularly in the compressor, if one is used; and pressure or temperature responsive devices are utilized to temporarily suspend the compressor activity whenever there is a danger of approaching dangerous temperatures.

(e) Lubricating oils or greases which are (basically or because of additives) prone to induce combustion or explosion are avoided.

(f) All materials used in the system are chosen after taking into aconsideration their merits in not sustaining combustion or enhancing explosion; and in not wearing out, eroding, or weakening in service in a manner that might cause substantial weakening of any part of the system.

(g) Where the possibility of combustion or explosion cannot be precluded, all steps are taken to minimize the effects of combustion or explosion on personnel and equipment; such steps may include flame arresters and blowout disks. Flame arresters shall be so designed and placed that they will not substantially interfere with fluid flows even after the maximum occlusion foreseeable in service will have occurred. Blowout disks shall be of size proportionate to the volume of the part of the system that they protect; and so placed that their release, in flight and on the ground, will not cause damage to personnel or equipment.

3.2.8 Strength:

3.2.8.1 Additional Loads: All systems and components which are subjected, during operation of the end product to structural or other loads which are not of system origin, shall withstand such loads when applied simultaneously with the appropriate proof pressure as specified in Table I, without exceeding the yield point.

3.2.8.2 Accelerated Loads: Actuation cylinders and other components and their attaching lines and fittings, which in their functional operation are subjected to pressures generated by accelerated loads, shall be designed and tested on the basis of maximum pressure that will be developed without exceeding theh operational envelope of the system performance.

3.2.9 Design Pressure:

3.2.9.1 System Pressure: Main system operating pressure shall be determined by the contractor and approved by the purchasing source. Peak pressure transients lasting longer than 10 milliseconds and resulting from any phase of the system operation shall not exceed the proof pressure level in any portion of the system.

3.2.9.2 Back Pressure: The system shall be so designed that proper functioning of any unit shall not be adversely affected by the back pressure in the system.

3.2.9.3 Proof Pressure: No part of a system shall fail, take any permanent set, or be damaged in any manner, when subjected to applicable proof pressure. All systems shall satisfy this requirement when subjected to the appropriate proof pressure as listed in Table I.

3.2.9.4 Burst Pressure: No part of a system shall rupture when subjected to applicable burst pressure. All systems shall satisfy this requirement when subjectd to the applicable burst pressure listed in Table I.

3.2.9.5 Command Storage Pressurization: In systems designed to be refillable and require pressurization during storage, the total system shall be recharged to storage pressure after each periodic test or checkout. Atmospheric air other than the gas specified shall not come into the system or any subsystem.

3.2.10 Bonding: The system components and lines shall be bonded in accordance with Specification MIL-B-5087 or equivalent.

3.2.11 Fluid Velocity Limitations: Tubing size and maximum gas velocity for each system shall be determined using at least the following criteria:

(a) Provide minimum required servo response at peak flow with minimum operating temperature.

(b) prevent system pressure surges and over pressure surges in reservoir which exceed the limits defined by Paragraph 3.2.9.1.

3.2.12 Pneumatic Ground Test Provisions: The system shall incorporate a pneumatic interface point at a location in the end product that is readily accessible during ground checkout and prelaunch operation. The location and configuration shall be approved by the purchaser. All configurations shall be in accordance with the applicable documents listed in this specification.

3.2.13 Utility System:

3.2.13.1 Definition: The utility system shall include all systems used for the normal operation of any service on the end product, excluding the flight control system.

3.2.13.2 Power Source for Prelaunch Operations: In order to maintain the missile or guided projectile reliability at the highest possible level, pneumatic operations required only during prelaunch or ground handling operations shall not use the self contained pneumatic power source(s).

3.2.14 Pneumatic Power Source Subsystem:

3.2.14.1 Precautions: In the case of turbine drives (or other devices which can exceed safe operating speed when the unit is unloaded), precautions, such as incorporation of a flow limiter, shall be taken to prevent operating conditions hazardous to personnel.

3.2.14.2 Functional Requirements: The pneumatic power source shall feed the control system designed operating pressure within specified limits and under all flow rates required during flight. If utility services are powered from the same source that feeds the flight control system, operation of these services shall not adversely affect the control system.

3.2.14.3 Long Term Storage: The design of the pneumatic power source shall be such that periodic checkouts are not required. The reservoir shall contain sufficient make-up gas to compensate for normal gas loss.

3.2.14.4 Redundancy: The number of redundant components shall be consistent with the missile requirements. If two separate systems are used, and if practicable, the design shall be such that no single failure will cause loss of more than one system or allow transfer of fluid from one system to another. On dual systems utilizing a switching scheme, switching shall not occur as a result of normal system operation or normal transients. Switching shall be such that a complete switch is normally assured. Redundant systems or components shall be provided with means to permit checkout of each redundant part or subsystem individually.

3.2.14.5 Expended Power Sources: Power sources (integrated packages which are pneumatic within themselves) shall be designed such that they can be installed on and removed without breaking any pneumatic connections. If practical, the electrical connection to the vehicle shall be through a single electrical connector. The number of adjustments required when the system is installed shall be held to a minimum. The package shall contain an accessible provision to replenish the gas supply as required. If dissimilar power sources are used on the same vehicle, they shall be designed to eliminate installation in incorrect locations. Design consideration shall be given to the following guidelines, when applicable, to expended power sources:

(a) Minimize external seals. This includes high and low pressure static and dynamic type.

(b) Wherever practical, high pressure seals shall vent to low pressure cavities.

(c) Means shall be provided to allow instrumentation of the unit to verify performance.

(d) If specifically required by the procuring agency, means shall be provided to allow determination of the reservoir pressure level. The refill level shall be indicated on the unit.

(e) Operating life shall be specified in detail specification.

(f) External test connection design and type shall be such that the possibility of incorrect connection of pressure and return ports is minimized. These ports shall be permanently identified.

(g) Reservoir proof pressure shall be shown on unit nameplate.

(h) The total system shall be protected by a non-bypass replaceable type filter element.

(i) Ground Test stands shall incorporate non-bypass, replaceable filter elements to protect the system.

3.2.15 Hazard Analysis: Prepare a system safety hazard analysis in accordance with MIL-STD-882.

3.2.16 Special Tools: Systems shall be so designed that special tools will not be required for installation or removal of components, unless it can be shown that use of special tools is unavoidable. In such cases, the contractor shall submit to the purchaser for their approval, reproducible copies of drawings of the tools with substantiating evidence justifying their use.

3.3 General Component Design:

3.3.1 Standard Components: Standard components shall be used whenever they will perform the function required by the system's operating needs.

Unless all qualified sources will operate satisfactory in the application, the applicable drawings shall specify the manufacturer's part number and not the standard part number and the installed component shall not carry the standard part number. Where no applicable AN or MS standard component exists, a minimum size envelope compatible with minimum weight requirements, performance, installation, inspection, and maintenance requirements shall be used. AN or MS standard pneumatic components must be used wherever applicable.

3.3.2 Nonstandard Components: Nonstandard components shall be designed and tested in accordance with the contractor's specifications. The contractor shall determine the number of cycles of operation to which nonstandard components may be subjected including cycles during component and missile checkout and periodic exercises.

3.3.3 Actuators: Actuator design shall be in accordance with detail procurement specifications.

3.3.4 Servovalves: Servovalves design shall be in accordance with detail procurement specifications.

3.3.5 Multiple Control Valve Systems: In systems which incorporate two or more directional control valves, provision shall be made to prevent the medium from being transferred inadvertently, at any possible valve setting, from the cylinder ports of one valve into the cylinder ports of another valve.

3.3.6 Bypass Valves: Bypass valves may be used to bypass fluid around critical components during system purging. Bypass valves shall block off the supply side to the component and shall not block off the return side.

3.3.7 Lock Valves: With the approval of the purchaser, locking systems may be installed in subsystems to mechanically lock the actuating cylinders. When several actuating cylinders are mechanically tied together, only one locking system shall be used to mechanically lock all actuators. Mechanical locks should be used instead of pneumatic shut-off valves in cases where locked position control is required under external loading and/or vibration environments. Such mechanical locks may be electrically, pyrotechnically, pneumatically or otherwise operated to the unlocking position.

3.3.8 Relief Valves:

3.3.8.1 System Relief Valves: Provisions shall be made to insure that pressures in any part of the power system will not exceed a safe limit above the cutout pressure of the pneumatic system. Pressure relief valves as specified herein shall be located in the pneumatic system wherever necessary to accomplish this pressure relief (See Table I). If a reservoir is hermetically sealed, a relief valve is not required.

3.3.8.2 Thermal Expansion: Relief valves, as specified herein, shall be installed in the system wherever necessary to accomplish thermal expansion relief (See Table I).

3.3.9 Manually Actuated Valves for Ground Operations: All mechanically controlled valves shall have a means to insure against accidental switching during flight.

These valves shall be designed so as to prevent partial switching. It shall not be possible to leave a valve in a checkout mode where it would result in a flight failure unless such a condition would be detectable during prelaunch check.

3.3.10 Orifices: All orifices, critical to system operation, shall be protected by a filter element. The filter element screen opening size shall be selected to assure adequate protection of the associated orifice from system contamination. Orifices and filter elements must be strong enough to absorb system design flow and pressure without rupture or excessive deformation.

3.3.11 Filters: Filters shall be provided in all systems. These filters shall be used to filter all of the gas supply in the system. Reservoir filters shall be of the replaceable element type in refillable or rechargeable systems. The total gas supply shall be filtered through a 10-micron (absolute) filter before use in the system. In cases where a finer degree of filtration is required for specific missiles, it shall be so specified in the servicing instructions for that missile and shall be subject to the approval of the purchaser.

3.3.11.1 Filter Locationi: Non-bypass type filters may be provided as necessary in order to protect systems from contamination in the main supply pressure line. This filter shall be so located as to provide protection to all major components in the pressure circuit.

3.3.11.2 Magnetic Filters: Magnetic filters shall be provided when magnetic fields exist in portions of the system such that aggregations of micronic ferromagnetic material may form and impair system operation. In lieu of magnetic filters, fine micronic filters may be used, if test data are available to prove that adequate protection is obtained therewith.

3.3.12 Fittings: When threaded fittings are used, AN or MS shall be employed. All non-standard fittings shall require approval by the purchaser. Unless specifically approved by the purchaser, no thread lubricants shall be used on straight threaded fittings.

3.3.13 Packings: Specifications MIL-G-5514, ARP 1231, 1232, 1233, 1234, and AS 568 shall be used as guides for packing installations. Lubrication per specification MIL-G-4343 only shall be used on packings in pneumatic systems.

3.3.13.1 Type A and B Systems: Buna N packings and gaskets shall conform to specifications MS 28778 and MS 28775. Other materials compatible with the fluid medium and environment may be used.

3.3.13.2 Type C Systems: Only packings and gaskets approved by the purchaser shall be installed in Type C systems.

3.3.14 Tubing:

3.3.14.1 Materials: Tubing used in Type A and B systems shall be compatible with the fluid medium and capable of performing under the specified environment. Tubing used in Type C systems shall require approval by the purchaser.

3.3.14.2 Tubing Bends: Bends shall be uniform (without kinks or scratches). Radii of bends for non-standard tubing shall be subject to approval of the purchaser.

3.3.14.3 Designed Motion in Tubing: Looped or straight aluminum-alloy tubing shall not be used between two connections where relative motion exists due to cycling of the associated components.

3.3.14.4 Tubing and Fitting Identification: All pneumatic lines greater than 2 feet (610 mm) in length shall be permanently marked. Additionally, markings shall be repeated as ofttен as necessary, particularly on lines entering and emerging from closed compartments, to facilitate maintenance work. Where fittings are located in members such as bulkheads, webs, etc., each fitting location shall be identified (placard) as to system function, using the same terminology as on its connecting line.

3.3.15 Gas Reservoir Design: The gas storage reservoir design shall meet the requirements of MIL-R-8573 except as modified herein and on Table I.

3.3.15.1 Refillable Reservoirs:

3.3.15.1.1 Filtration: Recharging shall be through a 10 micron (absolute) filter located in close proximity to the reservoir.

3.3.15.1.2 Refilling Provisions: The reservoir design shall provide a self-sealing disconnect line separate from the control system operating line except for hermetically sealed reservoirs.

3.3.15.1.3 Markings: Recharging instructions shall be provided immediately adjacent to the reservoir. Adequate information shall be included to indicate the proper gas type and pressure throughout the temperature range for which the reservoir will be serviced. If the data are extensive, the following statement shall be used:

See Filling Procedures * or Service
Information

3.3.15.1.4 Burst Sample Testing: A minimum of one reservoir burst pressure sample test shall be performed on each assembly designated lot. The test sample shall be representative in size, material and fabrication process per detailed drawings used for reference.

3.3.15.1.5 Test Data: A sample test report shall be prepared and include actual pressure data of each test and list any design deviation from applicable drawings and specifications. The test report shall be supplied to the purchaser during development and maintained by the supplier for review.

3.3.15.2 Non-refillable Reservoirs:

3.3.15.2.1 Filling: Non-refillable reservoirs shall be factory-filled and sealed with a gas fluid media in accordance with paragraph 3.2.5.

3.3.15.2.2 Structural Integrity:

(a) The reservoir shall be designed such that a (proof) test pressure of 1.5 times the maximum storage fill (service) pressure does not cause a wall stress that exceeds the 0.2% offset yield strength of the material.

(b) At a pressure of 1.1 times the maximum reservoir service pressure, resulting from ambient temperature effects, the wall stress shall not exceed the 0.2% offset yield strength, or for storage period under the same conditions the stress shall not exceed the 0.2% creep strength.

(c) The reservoir shall be designed such that the hydrostatic burst pressure is greater than 2.36 times the service pressure.

(d) The x-ray requirement in MIL-R-8573 shall be considered optional to the reservoir manufacturer.

3.3.15.2.3 Shipment of Reservoirs: The shipment of pressurized gas reservoirs by common carrier requires compliance with existing regulations of the Department of Transportation, Hazardous Materials Regulations Board. The contractor, therefore, shall either comply with existing regulations or secure non-DOT Specification Exempt Permits as required prior to the delivery of pressurized pneumatic systems to the purchaser.

3.3.15.2.4 Burst Sample Testing: A minimum of one reservoir burst sample test shall be performed on each assembly designated lot. The test sample shall be representative in size, material and fabrication process per detailed drawings used for reference.

3.3.15.2.5 Design Verification: Non-refillable reservoirs shall be required to undergo 100% hydrostatic (proof) test pressure tests. A burst test shall be conducted on one reservoir of each heat treat lot if heat treated and welded, or one reservoir of each lot of 50 if produced through nonheat treatment/welding process.

3.3.15.2.6 Test Data: A sample test report shall be prepared and include actual pressure data of each test and list any design deviation from applicable drawings and specifications. The test report shall be supplied to the purchase during development and maintained by the supplier for review during production.

4. COMPONENT INSTALLATION REQUIREMENTS:

4.1 Design Practice and Installation:

The component installation requirements stated below are considered to be representative of good design practice. However, it is recognized that variations from these practices will, in many cases, be necessary because of specific installation exigencies. Installation of standard parts or components shall be designed to accommodate the worst dimensional and operational conditions permitted in the applicable specification or standard. All components shall be installed and mounted to withstand all expected internal and external loading effects.

4.2 Reverse Installation:

Components which could inadvertently be installed in reverse shall be avoided. Nonstandard components may be used, if necessary, to conform to this requirement.

4.3 Placards for Reversible Components:

For components which can be inadvertently reversed during installation, a permanent placard shall be installed on adjacent equipment or structures, visible with component installed, to indicate the correct direction of installation. Arrows on connection lines are not sufficient for this purpose.

4.4 Reservoir Accessibility:

In all refillable reservoir installations, space shall be provided around the gas charging valve for use of high pressure, gas testing gage assembly, and for standard fitting connections to charge reservoirs.

4.5 Quantity of Reservoirs:

The number of reservoirs used in the system shall be kept to a minimum.

4.6 Actuating Cylinders:

Pneumatic actuating cylinders shall be installed such that they are readily accessible for maintenance and inspection and do not interfere with the adjacent structure.

4.7 Purging Valves:

Where required, purging valves shall be so located that they can be operated without necessitating removal of other components. Such installations shall permit attachment of a flexible hose so that the total systemmay be purged from a single valve.

4.8 Check Valves:

The direction of flow in the lines leading to and from each check valve shall be clearly indicated on each line. If lines are not visible, a permanent markingn on the structure immediately adjacent to the check valve shall be provided indicating direction of flow through the line for proper installation.

4.9 Directional Control Valves:

The installation of directional control valves shall be compatible with the control valve performance so that the system operation will not be affected by back pressure, interflow, pressure surges, etc., which might tend to cause the valves to open or move from their setting, or cause them to bypass the gas in other than the intended manner.

4.10 Filters:

Line filters located in close proximity to the reservoir shall be installed, if practicable, before the reservoir is installed. Where pressure drop indicator button-type filters are used, they shall be so installed that the indicator is readily visible to servicing personnel.

4.11 Hoses and Coiled Tubing:

To eliminate the tendency for the connecting fittings to loosen, hose assemblies may be installed between two points of relative motion, but shall not be subjected to torsional deflection (twisting) under any condition of operation.

4.12 Motors:

All motors shall be accessible for maintenance and inspection.

4.13 Rechargeable Reservoir Location:

Rechargeable reservoirs shall, if possible, be installed such that the following conditions are met:

(a) All reservoirs shall be accessible for maintenance and service inspection and shall be installed such that ease of removal and replacement does not require complete disassembly and reassembly of the system.

(b) Recharging of the reservoir is possible when the reservoir is installed in the system.

(c) For hermetically sealed reservoirs, (a) and (b) do not apply.

4.14 Tubing:

4.14.1 Straight Tube Lines: The use of straight tube lines installed between two rigid connections shall be avoided wherever possible. Where such straight liines are necessary, provisions shall be made in the mounting of the units or in the rigid conections to insure that no excessive strains will be applied to the tubing and fittings. Semi-loops may be provided in the tubing as necessary, to insure proper alignment on installation and to accommodate vibratory motion.

4.14.2 Tubing Supports: All pneumatic tubing shall be supported from rigid structure by tubing clamps or by suitable multiple block-type clamps to minimize overhang of the tube. Clamps suitable for the temperature involved shall be used as approved by the purchaser. Supports shall be placed as near as practicable to bends to minimize overhang of the tube.

4.15 Component Lines:

Where two or more lines are attached to a pneumatic component and incorrect connection of lines to the component is possible, the two lines shall be sufficiently different, where practicable, to prevent such occurrence.

4.16 Tubing Clearance:

Where tubing is supported to structure or other rigid members, a minimum clearance of 1/16 inch (1.6 mm) shall be maintained with such member. A minimum clearance of 1/4 inch (6.4 mm) shall be maintained with adjacent rigid structure or units. In areas wehre relative motion of adjoining components exists, a minimum clearance of 1/4 inch (6.4 mm) shall be maintained under the most adverse conditions that will be encountered.

4.17 Mounting Lightweight Components:

Standard lightweight components such as check valves, etc., which are not supplied with mounting holes and which do not require adjustment after installation, may be supported by the tubing, provided a tube clamp is used as close as practicable on each side of the component. Nonstandard components of similar weight and usage may be mounted in the same manner.

Recommended spacings between supports are shown in Table II. Where tubes support fittings, such as unions, tees, etc., spacings should be reduced approximately 20 percent. Where tubes of different diameters are connected together, an average spacing distance may be used. provisions shall be made in support location to accommodate change in tubing length caused by expansion and contraction. In order to facilitate inspection and repair, tubing shall not be bundled together.

Table II. Pneumatic Lines Support Spacings

Nominal tube OD, inches (mm)	Maximum length between support centers (measured along tube) Aluminum Alloy Inches (mm)*	Steel Inches (mm)*
1/8 (3.2)	9 1/2 (240)	11 1/2 (290)
3/16 (4.8)	12 (300)	14 (360)
1/4 (6.4)	13 1/2 (340)	16 (410)
5/16 (7.9)	15 (380)	18 (460)
3/8 (9.5)	16 1/2 (420)	20 (510)
1/2 (12.7)	19 (480)	23 (580)
5/8 (15.9)	22 (560)	25 1/2 (650)
3/4 (19.0)	24 (610)	27 1/2 (700)
1 (25.4)	26 1/2 (670)	30 (760)
1 1/4 (31.8)	28 1/2 (720)	31 1/2 (800)
1 1/2 (38.1)	29 1/2 (750)	32 1/2 (830)

* mm Rounded to nearest 10mm

4.18 Cleaning of Parts and Systems:

All parts of pneumatic system units shall be thoroughly cleaned prior to assembly or installation of the particular unit.

4.19 Interchangeability:

All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable.

5. SYSTEM DESIGN DATA SUBMITTAL AND APPROVAL REQUIREMENTS:

5.1 Purchaser-Contractor Conference:

The contractors shall confer with the project engineers of the purchaser on the proposed systems during the early stages of design, in order to take advantage of exchange of information and to coordinate development programs. The first conference shall take place at the time when the preliminary schematic diagram is established for the missiel or guided projectile. Other conferences shall take place during the appropriate developmentn phases in order to define specific format and time schedule for data submission and testing required by this specification.

5.2 General:

To obtain approval for the system design for each new model, the contractor shall, when specifically directed in the contract, complete the submittal and approval requirements of this specification.

5.2.1 System Studies Data: The following data shall be submmitted for evaluation to the purchaser during the program studies period:

(a) Description of the proposed system.
(b) System schematic diagram.
(c) Peak pneumatic flows for typical missions.

5.2.2 Prototype Design Selection Data: The following data shall be submitted for purposes of selecting a preliminary system design for continuation into the Engineering Development phase:

(a) Descriptionof the system, including a discussion of those areas that will present problems and will require considerable development effort.

(b) System schematic diagram.

(c) Peak flow for each major component for worst case mission.

(d) Fluid peak temperature versus time curves only when considered critical to design.

(e) A report that presents a simplified analysis verifying system compliance to application requirements.

(f) An estimate of system weight and envelope requirements.

5.2.3 Schematic Diagram: Schematic diagram arrangement shall be such as to present the system in a clear and easily read form, with complete subsystems grouped and labeled accordingly. Emphasis shall be placed on simplicity and clarity of presentation, with locationin the missile being of secondary importance. 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, including prelaunch auxiliary systems used on the launcher or in the missile.

(b) Initial gas pressure of reservoirs and their nominal capacities.

(c) Pressure settings of pressure regulators and sequence valves.

(d) Total and reserve fluid capacities of reservoir(s) and valves.

(e) Motor displacement per cycle of operation, operating time and the torque load required for each unit.

(f) Indicated flow of gas through all pneumatic lines.

5.2.3 (Continued):

(g) Reservoir pressurizing system source, operatingn pressure, and schematic diagram of plumbing.

(h) Indicated connections for testing with auxiliary or ground test power systems.

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

(j) Valve types (solenoid, servo, squib-operated, thruster, etc.) and rated flow.

The following supporting data, where applicable, shall be supplid in chart and/or block diagram form and shall be cross-referenced to the schematic:

(k) All relief valve cracking and full flow pressure.

(l) Diameter, wall thickness, and material of tubing.

(m) Displacement of gas in cubic inches of each actuating cylinder for both extension and retraction.

(n) Actuating cylinder piston head diameter, rod diameter, effective piston area, and total and working stroke of each cylinder.

(o) Type of power source and displacement, including gas usage rate curve showing consumption rates, for all phases of flight such as launch, climb, ballistic or cruise and terminal time.

(p) Simple schematic diagram of linkages showing mechanical disconnects, downlocks, and uplocks, and other data to tie the mechanical system to the pneumatic system for analysis. This shall include mechanical feedback devices and mechanical instrumentation elements (such as filter element P indicators).

(q) A simple schematic wiring diagram of the electrical portion of the pneumatic system giving current loads and describing functions. (This diagram and data may be on a separate drawing). Electrical feedback elements and electrical instrumentation elements shall be shown on this schematic including reference to direction of operation (i.e., piston extend, increasing pressure, etc.).

(r) Suitable name and/or part number of all units for cross-referencing to supporting documents. Standard part numbers shall be indicated, where applicable.

(s) Tubing and hose lines shall be identified.

5.2.3 (Continued):

(t) Normal system temperature (estimated).

(u) Maximum system temperature (estimated).

(v) Length of time in minutes and in percentage of total flight time that the pneumatic system will be at or near maximum temperature.

(w) Compartment temperatures (estimate).

5.2.4 Nonstandard Component Drawings: A cross-sectional assembly drawing for each nonstandrd pneumatic component shall be prepared and contain sufficient information in order that an evaluation of the unit can be made.

Such information shall include the applicable specification, the material, protective finish of each part, and bearing data. This information may appear as a written addition to the drawing.

5.2.5 System Design Report: A system design report shall be submitted as agreed to by the paragraph 5.2.1 conference. The final report shall be submitted prior to the first missile or guided projectile flight with the final schematic diagram and shall incorporate sufficient design calculations and data to demonstrate that the design requirements have been met. A system temperature survey shall be included considering the location of the system within the end product, and estimated hotspot temperatures shall be noted. Minor changes made during the development and production phases may be documented as addenda to the final system design report.

5.2.6 Engineering Development Data:

5.2.6.1 Preferred Data Submittal: The following system data shall be submitted during the Engineering Development program and shall be suitable for use as production procurement data:

(a) If it is determined by the preliminary design review conference that this specification is not adequate for a specific missile application, the contractor shall prepare and submit for approval a system specification similar to this specification.

(b) A system schematic diagram in accordance with paragraph 5.2.3 shall be submitted for approval.

(c) A system design report in accordance with paragraph 5.2.5 shall be submitted for approval.

(d) A system ground and flight test report shall be submitted for approval.

5.2.6.1 (Continued):

(e) Detail specifications and test reports for the following components and such other components determined critical by the contractor shall be submitted for review and approval:

(1) Gas reservoirs.
(2) Flight control actuators, thrusters, or other controllers as applicable.
(3) Flexible connectors, including hoses (if nonstandard).
(4) Packings and packing installations (if nonstandard).
(5) Lubricants (if nonstandard).
(6) Fittings (if nonstandard).

(f) Cross-sectional assembly drawings, in accordance with paragraph 5.2.4 of all nonstandard system components shall be submitted for information.

The following data need not be submitted for technical review and approval:

(a) Component specifications and test reports other than those specified in paragraph 5.2.6.1(e).
(b) System and component detail installation drawings.

5.2.6.2 Alternate Data Submittal: The following procedure shall be adopted by the contractor in lieu of submitting the data specified in paragraph 5.2.6.1:

(a) The contractor shall certify, upon completion of validating tests, that the pneumatic component conforms to the applicable military, or contractor-prepared specifications approved by the purchaser and is satisfactory for use in the intended application.

(b) The test reports as well as the specifications and other applicable engineering data covering the system components, other than those specified in paragraph 5.2.6.1(e) and (f) shall be retained by the contractor and shall be available to the purchaser upon request.

(c) The contractor shall provide in a status of equipment list those components that are contractor-certified for data availability and compliance with the applicable Government-approved specifications.

5.2.7 Production Data:

5.2.7.1 Test Specification: A specification defining the necessary functional tests of production systems shall be prepared and submitted to the purchaser for approval.