



AEROSPACE INFORMATION REPORT

AIR1569**REV. A**

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Superseding AIR1569

Handling and Installation Practice for Aerospace Hose Assemblies

RATIONALE

AIR1569A has been reaffirmed to comply with the SAE five-year review policy.

FOREWORD

This SAE Aerospace Information Report (AIR) is being issued by the SAE G-3 Committee as a guide for the aerospace industry. It is felt that because of the lack of published information regarding the selection, care, handling, installation, and maintenance of hose assemblies in aerospace installations; a guide of this type is a necessity.

1. SCOPE:

This AIR can be used for the selection, care, handling, installation, and maintenance of hose assemblies for aerospace fluid systems. AIR797 lists characteristics of military and SAE hose, hose assemblies, and sleeves as a selection guide.

1.1 Purpose:

SAE has published this AIR containing information accumulated on civilian and military aerospace fluid systems as a service to all organizations, government agencies, and individuals interested in aviation, as well as to the aircraft designer and maintenance personnel, toward whom the information is specifically directed. This material has been presented in concise indexed form to serve as ready reference material and to provide background information for the designer, and as a guide for the maintenance of hose assemblies on aerospace fluid systems.

2. REFERENCE DOCUMENTS:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

AS604	Hose Assembly, PTFE, 400 °F, 3000 psi, Hydraulic Heavyweight
AS611	Tetrafluoroethylene Hose Assembly Cleaning Methods
AS614	Hose Assembly, PTFE, Heavy Duty, High Temperature, High Pressure, 4000 psi, Hydraulic and Pneumatic

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Documents

Document Sharing Hub

2.1 (Continued):

AS620	High Temperature Hose Assembly, Convolute, PTFE
AIR797	Hose Characteristics and Selection Chart
AS824	Hose Assembly, Flexible Metal, High Pressure, High Temperature
ARP908	Hose Fitting - Installation and Qualification Test Torque Requirements
ARP994	Recommended Practice for the Design of Tubing Installations for Aerospace Fluid Power Systems
AS1055	Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings, and Similar System Components
AS1072	Sleeve, Hose Assembly, Fire Protection
AS1073	Sleeve, Hose Assembly, Heat Shrinkable
AS1291	Sleeve, Hose Assembly, Chafe Guard, TFE or FEP
AS1292	Sleeve, Hose Assembly, Chafe Guard, Butyrate Coil
AS1293	Sleeve, Hose Assembly, Chafe Guard, TFE Coil
AS1294	Sleeve, Hose Assembly, Chafe Guard, Nylon Coil
AS1295	Sleeve, Hose Assembly, Chafe Guard, Neoprene Rubber
AS1297	Reducers, Pneumatic Pressure, Missile
AS1298	Sleeve, Heavy Wall, Hose Assembly, Chafe Guard, TFE
AS1339	Hose Assembly, PTFE, 400 °F, 3000 psi, Hydraulic Lightweight
AS1424	Hose Assembly, Metal, Medium Pressure, High Temperature
ARP1897	Clamp Selection and Installation Guide
AS1933	Age Control for Hose Containing Age-sensitive Elastomeric Material
AS1975	Hose Assembly, PTFE, Aramid Reinforced, 4000 psi, Hydraulic and Pneumatic

2.2 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-5540	Hydraulic Systems, Aircraft, Types I and II, Design and Installation Requirements for
MIL-H-5593	Hose, Aircraft Low Pressure, Flexible
MIL-H-6000	Hose, Rubber (Fuel, Oil, Coolant, Water, and Alcohol)
MIL-H-8790	Hose Assemblies, Rubber, Hydraulic, High Pressure (3000 psi)
MIL-H-8795	Hose Assemblies, Rubber, Hydraulic, Fuel and Oil Resistant
MIL-H-25579	Hose Assembly, Tetrafluoroethylene, High Temperature, Medium Pressure, General Requirements for
MIL-H-38360	Hose Assembly, Tetrafluoroethylene, High Temperature, High Pressure, Hydraulic and Pneumatic (Notice 1 Cancellation, see AS604/AS1339, section 2.4)
MIL-H-83796	Hose Assembly, Rubber, Lightweight, Medium Pressure
MIL-H-85421	Fittings, Tube, Fluid Systems, Separate, Dynamic Beam Seal
MIL-H-85720	Fittings, Tube, Fluid Systems, Separable, High Pressure, Dynamic Beam Seal
MIL-H-85800	Hose Assembly, PTFE, Aramid Fiber Reinforced, 5000 and 8000 psi
MIL-STD-1523	Age Control of Age Sensitive Elastomeric Material
MS20756	Flange, Swivel, Retaining

2.2 (Continued):

MS33514	Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal
MS33515	Fitting End, Standard Dimensions for Bulkhead Flareless Tube Connections
MS33656	Fitting End, Standard Dimensions for Flared Tube Connection and Gasket Seal
MS33657	Fitting End, Standard Dimensions for Bulkhead Flared Tube Connection
MS33786	Fitting Installation, Flared Tube and Hose, Swivel

2.3 Federal Aviation Authority - Technical Standard Orders:

Available from Department of Transportation, Personal Property Operations Branch, Utilization and Storage Section, M-443.2, Washington, DC 20590.

TSO-C42	Propeller Feathering Hose Assemblies
TSO-C53a	Fuel and Engine Oil System Hose Assemblies
TSO-C75	Hydraulic Hose Assemblies

3. DESIGN INFORMATION:

3.1 Selection of Type of Hose:

3.1.1 Inner Tube Material: The selection of the inner tube is extremely important since it is the heart of the hose assembly. Items to consider are operating temperature range, fluid compatibility, flexibility, resistance to permeation, resistance to flow (smoothness or friction), electrostatic dissipation, resistance to outgassing in outerspace, and the retention of these characteristics over the desired life of the hose assembly. AIR797 is an excellent reference to aid in hose selection.

3.1.1.1 Elastomeric Tubes: There are many types of elastomers used as inner tubes in addition to many variations of the same basic elastomers which have been compounded to produce the desired characteristics. The following are those most frequently used:

- a. Buna N/NBR: A synthetic rubber material with excellent resistance to petroleum base oils and solvents.
- b. Butyl/IIR: A synthetic rubber material with excellent resistance to phosphate ester base hydraulic fluids.
- c. Ethylene Propylene Diene/EPT or EPDM: A synthetic rubber material with excellent resistance to water base and phosphate ester base hydraulic fluids (generally will operate at higher temperatures than butyl).
- d. Neoprene/CR: A synthetic rubber material with high abrasion resistance, good resistance to low aniline paint, oils and automotive fuels.
- e. Chlorinated Polyethylene/CPE: A synthetic polymer base with excellent high temperature (300 °F) properties, good to excellent resistance to most fluids commonly used in aerospace with essentially nonaging characteristics.

- 3.1.1.2 PTFE Tubes: With very few exceptions, it has excellent resistance to aerospace fluids over a wide temperature range. PTFE tubes are available in smooth bore and convoluted construction for maximum flexibility.
- 3.1.1.3 Convoluted Metal Tubes: A variety of metals can be used as convoluted tubes to withstand higher temperatures than possible with other materials.
- 3.1.2 Reinforcement: The selection of the hose reinforcing material usually is on the basis of the pressure requirements; however, in some cases other requirements dictate the selection of a variety of materials; such applications as nonconductive, high cubical expansion, corrosion resistance, flexibility, etc.
 - 3.1.2.1 Fabric Reinforcement: Many types of fabric yarns are used as reinforcement for the hose. Some of these are cotton, rayon, nylon, and polyester. Often yarns are chosen for lower pressure hoses, but they also offer good characteristics for corrosion resistance or as a nonconductor of electricity. Para-aramid is suitable for high pressure reinforcement. Most fabrics are also temperature limited, 300 °F or less.
 - 3.1.2.2 Wire Reinforcement: The most common types of wire reinforcement are carbon steel and stainless steel wires. The wire reinforcement is used as either a braided configuration or as multiple spiral wraps, or as a combination of both.
- 3.1.3 Cover: The hose cover serves to protect the hose from abrasion or other damage and, in some cases, to protect other components from abrasion. The hose covers can be provided in a number of different materials.
 - 3.1.3.1 Elastomeric Cover: Most hoses having an elastomeric inner tube use a neoprene cover because it offers both excellent abrasion protection and, when properly bonded, good corrosion protection. However, some other elastomers are used when other types of protection are more important.
 - 3.1.3.2 Fabric Cover: A common type of hose cover is a cotton braid bonded and impregnated with neoprene cement. Other fabrics are sometimes used, such as rayon or polyester.
 - 3.1.3.3 Wire Cover: Many hoses and almost all PTFE hoses use the external stainless steel braid as a cover.
- 3.1.4 Size: The internal diameter of the hose as well as the internal diameter of the fittings (as well as elbows) should be taken into account when determining the proper size of the hose.
- 3.1.5 Pressure: The working pressure, peak pressure, and impulse life should all be considered when determining the type of hose from the strength standpoint.

3.2 Selection of Type of Fitting:

- 3.2.1 Construction: The selection of the fittings to be used with the hose requires not only information about the application, but some knowledge about the wide variety of fittings that are available. Items to consider are the maximum operating temperature, fluid compatibility, corrosion resistance, weight limitations, the overall configuration of the hose assembly; that is, the requirement for elbow type ends, and the methods of sealing the hose, fitting, and the port.
- 3.2.1.1 Crimp Fitting: This type is sometimes called a "permanent type" end fitting. Generally, this type of fitting cannot be removed from the hose without destroying at least one component part of the fitting. The rest of the fitting can sometimes be salvaged.
- 3.2.1.2 Swage Fitting: This type is also called a "permanent type" end fitting. It is distinguished from the crimp fitting by the method of attachment to the hose.
- 3.2.1.3 Reusable Fitting: This type is sometimes referred to as "detachable reusable" or "screw together" end fittings. As the name implies, this type of fitting can be removed from an old hose and, if in good condition, it can be reassembled on a new hose.
- 3.2.1.4 Field Attachable Fittings: At times, the names "field attachable" and "reusable fitting" are used interchangeably; however, they are not always the same. In some instances, a fitting may be called "field attachable" but it may not be completely reusable. Also, a permanent type fitting may be called "field attachable" because it can be assembled in the field with simple equipment.
- 3.2.1.5 Method of Sealing: Various methods of sealing the hose to the end fitting are in use today. The most common type is to use various shapes of circumferential lands and grooves in the nipple portion of the fitting. Other methods are in use also so the user may evaluate the many different designs.
- 3.2.1.6 Method of Gripping: The best method of gripping the hose with the fitting is to hold the hose reinforcement with the fitting. This is especially important in high temperature or impulsing applications.
- 3.2.2 Material: The considerations for the type of fitting material should include corrosion resistance, weight, strength, operating temperature range, and fluid compatibility.
- 3.2.2.1 Corrosion Resistance: The environment in which the hose fitting will be operating should be considered in the selection of the metals used in construction. Both the external and internal conditions should be examined. The most popular metals used are aluminum, stainless steel, carbon steel, and titanium. Corrosion protection is added as needed.
- 3.2.2.2 Weight: One of the primary design characteristics in aircraft is low weight, and this should be of prime importance in the fitting design also. Where possible, the lighter-weight materials should be selected if they will satisfy the other requirements of strength, temperature, corrosion resistance, and fluid compatibility.

- 3.2.2.3 Fluid Compatibility: Fitting material selection for use with system fluids should be chosen by consulting the fluid manufacturers for recommendations. Items to be considered also are other fluids that may come in contact with the external surfaces of the fitting.
- 3.2.3 End Connection: A wide variety of end connections are available to meet system requirements for connecting and sealing.
- 3.2.3.1 Type of Seal: Generally, there are two types of seals used in fluid systems: an elastomeric seal and the metal-to-metal seal. These are each used in a variety of connecting devices. The elastomeric seal has temperature range limitations depending on the characteristics of the elastomer. The metal-to-metal seal is used extensively since it has a very wide temperature range of operation. It depends upon deformation of the metal to effect a seal and is very sensitive to surface finish or contamination. Historically the two most popular metal-to-metal seals are the 37° flare and the flareless type which are both detailed in military and industry specifications. More recently metallic pressure assist lip seals have been introduced extensively on both military and commercial aircraft.
- 3.2.3.2 Swivel Nut: The 37° flare (mates with MS33656 and MS33657) and the flareless (mates with MS33514 and MS33515) both make their connections with a swivel nut that allows for the positioning of the hose assembly and the connecting port.
- 3.2.3.3 Flange: The flange type of connection requires an O-ring or gasket to effect a seal. This connection is generally used for low to medium pressures and is not normally used in hydraulic systems. A military number for this flange is MS20756 and installed per MS33786.
- 3.2.3.4 Coupling: Using a self-sealing coupling which is part of the hose nipple allows for one less joint and a lighter design; however, if the cost of the coupling is great compared to the cost of the hose, it may make sense to have two separate assemblies. If the hose is damaged, it alone must be replaced instead of both it and the self-sealing coupling.
- 3.2.3.5 Swivel: Integral swivels are sometimes used in the end fitting in hose assemblies. These are used where the motion in the hose assembly is such that a rigid connection could cause damage to the hose.
- 3.2.3.6 Elbows: Integral elbows are an efficient method of reducing weight, number of sealing points, and improving flow patterns when incorporated into the end fitting. Normally 45 and 90° elbows are standard, but other angles may be used.
- 3.2.3.7 Formed Tubes: These are similar to the elbows mentioned in 3.2.3.6 except they are nonstandard and may have more than one bend in the tube. The primary reasons for using the formed tube as part of the end fitting are to decrease weight and reduce the number of joints in the system and reduce pressure drop.

- 3.2.3.8 Interconnection Protection: The design stage of the fluid systems is the proper time to give consideration to the possibility of reversing connections during the construction or maintenance of the aircraft. Jump size connections, either to a smaller or larger size, can be incorporated into some of the end fittings or, as mentioned in 3.2.3.4, couplings of varying size or shapes can be used on some of the hose ends to prevent interconnection of different fluid systems.
- 3.2.3.9 Other End Connections: Many other types of connections are available to meet special requirements. The preceding paragraphs cover the most common types, but consideration should be given to the best end configuration that will meet all requirements.
- 3.3 Hose Assembly Protection:
- 3.3.1 Internal: Under some conditions, a hose assembly requires additional protection for the internal surface of the hose if it is to remain the same shape and size.
- 3.3.1.1 Internal Metal Coil: A wire coil spring installed in the hose will resist forces that may cause hose kinking or inner tube collapse.
- 3.3.1.1.1 Vacuum Protection: When an application involves sustained or pulsing vacuum, the user must give consideration to the difference between the requirements of the application and the test parameters of the hose qualification program. The qualification program, of necessity, defines tests of relatively short duration to prove hose acceptability for the majority of applications rather than for the most severe applications. When service requirements exceed the qualification test requirements for vacuum, it is recommended that the hose be provided with vacuum support springs to prevent collapse of the inner tube.
- 3.3.1.1.2 External Pressure: An unusual condition occurs, for example, when a hose assembly is submerged in a fuel tank and the tank is pressurized. Possibly, at the same time, the hose assembly is also subjected to a vacuum. The net effect is a differential pressure on the hose assembly which can create an even greater force to collapse the inner tube. Depending on the amount of differential pressure, it would be highly advisable to use an internal coil for protection against collapsing the hose inner tube in this application.
- 3.3.1.1.3 Kinking Protection: Hose assemblies, particularly PTFE, shall not be bent to less than the specified minimum bend radius during installation, such bending could kink the hose leading to premature failure. For sleeved hose (assemblies) such damage may be impossible to detect before failure occurs. It may be necessary to use an internal coil to prohibit permanent damage to the hose. PTFE extruded hose assemblies may be preformed to accommodate these tight bends, or convoluted hoses may be used as is if other operating criteria are met.

- 3.3.2 External: To prohibit damage to the external surfaces of the hose assembly, auxiliary devices are sometimes used.
- 3.3.2.1 Hose Cover Protection: Supplementary sleeves can be used on hose assemblies for protection against a variety of damaging situations.
- 3.3.2.1.1 Abrasion: The best method for protection of the hose assembly from abrasion is to make the proper use of clamps that will prohibit the hose from touching anything else. Where this is not possible, various sleeves can be used on the hose that are of the tubular spiral (telephone cord type) or shrinkable tubular type. Materials used are PTFE, FEP, nylon, neoprene, EPDM, vinyl, and polyolefins. The sleeve material is chosen for fluid and temperature compatibility. Some standard sleeves are given in AS1291 through AS1298 and AS1073.
- 3.3.2.1.2 Fluids: At times, fluid from another system may come in contact with a hose with which it is not compatible and it is necessary to use a tubular sleeve to protect the hose from the fluid. Sleeves such as mentioned in 3.3.2.1.1 may be used, provided they are arranged to prevent entrapment of the foreign fluid.
- 3.3.2.1.3 Insulation: In installations where a hose assembly is close to a high temperature device, protection by an insulating sleeve may be used. A typical fire sleeve as shown in AS1072 is sometimes used for this purpose or extruded silicone integrally bonded to the hose outer braid (similar to AS1723).
- 3.3.2.1.4 Fire: Hose assemblies meeting TSO-C42, TSO-C53, TSO-C75, or AS1055 often require firesleeves, such as those supplied to AS1072, to meet the fire protection requirements. Various other types of fire protective sleeves are available; some are suitable for field installation and for replacement of damaged sleeves.
- 3.3.2.2 Sealing Surface Protection: The sealing surfaces at each end of the hose assembly require protection against damage or dirt during shipping and storage. Caps or plugs made from plastic or metal are the popular types used for this purpose and should remain in place until immediately prior to installation. The design of these caps and plugs should be such that the hose assembly cannot be installed without removing the cap or plug.
- 3.3.2.3 Restraining Devices: Special protective devices are sometimes employed for PTFE hose assemblies. Special preformed assemblies normally have a restraining device that holds the assembly in its preformed position. This device should not be removed during incoming inspection or during the proof testing. If possible, it should be left intact during installation, but always removed after installation.
- 3.3.2.4 Blow-Off Protection: Some high pressure gas systems require the use of a blow-off protection device installed such that the fitting and hose have an additional external connector that will prohibit a complete fitting blow-off. This device holds onto the hose, thus preventing the hose from whipping and endangering personnel.