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AEROSPACE INFORMATION REPORT

AIR 1569

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Revised

HANDLING & INSTALLATION PRACTICE FOR AEROSPACE HOSE ASSEMBLIES

Preface

This 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.

Purpose

SAE has published this AIR containing information accumulated on civilian and military aerospace fluid systems as a service to all organization, 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.

1. SCOPE

This AIR can be used for the selection, care, handling, installation, and maintenance of hose assemblies for aerospace fluid systems.

2. REFERENCE DOCUMENTS

2.1 Military Specification:

MIL-H-5593 - Hose, Aircraft Low Pressure, Flexible
MIL-H-8788 - Hose, Hydraulic, High Pressure
MIL-H-8794 - Hose, Rubber, Hydraulic, Fuel and Oil Resistant
MIL-H-13444 - Hose, Rubber, Fuel and Oil
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
MIL-H-83797 - Hose, Rubber, Lightweight, Medium Pressure, General Specification for

2.2 Military Standards:

MIL-STD-1523 - Age Control of Age Sensitive Elastomeric Material
MS20756 - Flange, Swivel, Retaining
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

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2.3 Federal Aviation Authority - Technical Standard Orders:

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

2.4 SAE Publications:

ARP 611 - Tetrafluoroethylene Hose Assembly Cleaning Methods
AIR 797 - Hose Characteristics and Selection Chart
ARP 908 - Hose Fitting - Installation and Qualification Test Torque Requirements
ARP 994 - Recommended Practice for the Design of Tubing Installations for Aerospace Fluid Power Systems
AS 1055 - Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings and Similar System Components
AS 1072 - Sleeve, Hose Assembly, Fire Protection
AS 1073 - Sleeve, Hose Assembly, Heat Shrinkable
AS 1291 - Sleeve, Hose Assembly, Chafe Guard, TFE or FEP
AS 1292 - Sleeve, Hose Assembly, Chafe Guard, Butyrate Coil
AS 1293 - Sleeve, Hose Assembly, Chafe Guard, TFE Coil
AS 1294 - Sleeve, Hose Assembly, Chafe Guard, Nylon Coil
AS 1295 - Sleeve, Hose Assembly, Chafe Guard, Neoprene Rubber
AS 1297 - Reducers, Pneumatic Pressure, Missile
AS 1298 - Sleeve, Heavy Wall, Hose Assembly, Chafe Guard, TFE

3. DESIGN INFORMATION

3.1 Selection of Type of Hose:

3.1.1 Innertube Material: The selection of the innertube 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. AIR 797 "Hose Characteristics and Selection Chart" is an excellent reference to aid in hose selection.

3.1.1.1 Elastomeric Tubes: There are many types of elastomers used as innertubes 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.

3.1.1.1.1 Buna N: A synthetic rubber material with excellent resistance to petroleum base oils and solvents.

3.1.1.1.2 Butyl: A synthetic rubber material with excellent resistance to phosphate ester base hydraulic fluids.

3.1.1.1.3 Ethylene Propylene: A synthetic rubber material with excellent resistance to water base and phosphate ester base hydraulic fluids (generally will operate at higher temperatures than butyl).

3.1.1.1.4 Neoprene: A synthetic rubber material with high abrasion resistance, good resistance to petroleum based oil and solvents.

3.1.1.2 Teflon Tubes: (Teflon is a DuPont trademark with a chemical name of polytetrafluoroethylene). With very few exceptions, it has excellent resistance to aerospace fluids over a wide temperature range. Teflon 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 non-conductive, 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 non-conductor of electricity.

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 innertube 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 Teflon* 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.

*Teflon is a DuPont trademark.

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: A common type of connection used on hose assemblies is a coupling or normally a self-sealing coupling whose function is to allow quick connection or disconnection and, while at the same time, sealing both halves of the coupling and thereby preventing fluid loss. The coupling can be part of the hose nipple which will then make one less joint in the system. Various sizes or shapes of coupling joints can be used to prevent interconnection of different lines for different systems.

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 non-standard 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 innertube 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 innertube.

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 innertube. Depending on the amount of differential pressure, it would be highly advisable to use an internal coil for protection against collapsing the hose innertube in this application.

3.3.1.1.3 Kinking Protection: Some hose assemblies, either because of the difficulty of installation or because of the requirements of the installed configuration, are bent to a smaller bend radius than recommended. It may be necessary to use an internal coil to prohibit permanent damage to the hose. Teflon* 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.

*Teflon is a DuPont trademark.

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 AS 1291 through AS 1298 and AS 1073.

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 AS 1072 is sometimes used for this purpose.

3.3.2.1.4 Fire: Hose assemblies meeting TSO-C42, TSO-C53, TSO-C75 or AS 1055 often require firesleeves, such as those supplied to AS 1072, 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 Teflon* 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.

4. CARE IN HANDLING

4.1 Packaging: Many hose assembly specifications call out the packaging requirements. If no special requirements are imposed on the manufacturer, he will use his standard packaging method.

4.1.1 Specified Shipping Packaging: If any special packaging is required because of cleanliness, handling, shipping, storage, or environment, it should be outlined in the order for the hose assemblies.

4.1.2 Precautions for Unpacking: Hose packing cartons should have a warning to the receiver if the assemblies require special care during the unpacking of the carton. In the case of a hose assembly that has special packaging for cleanliness, it can be quickly ruined by an uninformed person. This is also true of the mishandling of the preformed Teflon* hose assemblies.

4.2 Storage: In most cases, hose assemblies require special care in storage. Consideration should be given to the amount of time, the temperature, humidity and location.

4.2.1 Time: Some elastomeric hose assemblies have a "shelf life" limit. A system should be established to insure that the first hose assembly into storage is the first out for a given type assembly.

*Teflon is a DuPont trademark.

4.2.2 Temperature: Elastomeric hose assemblies are sensitive to high temperatures and they tend to harden and stiffen because of increased oxidation at higher temperatures. Therefore, they should be stored at cooler temperatures.

4.2.3 Humidity: High humidity may cause problems of corrosion of the carbon steel reinforcing wire. It is desirable to store at a low humidity or to shorten the storage time.

4.2.4 Location: The preferred location for storage of most hose assemblies would be in a cool, dry, shady area away from ultra-violet light, and with a low ozone atmosphere. It may be necessary in some areas to protect the hose assembly with a special package to overcome the environment.

4.3 Cleaning: The cleanliness of hose assemblies can be very important in many installations. They can be cleaned to special cleanliness conditions by the manufacturer upon request. Many hose assemblies are assembled using a lubricant. If a lubricant or the fluid used for proof testing would be detrimental to the end use of the hose assembly, special instructions should be given to the manufacturer.

4.3.1 After Assembly: For certain levels of cleanliness, it is even necessary to clean the hose and fitting components before making the assembly. In that case, it is necessary for the manufacturer to know the cleanliness level before making the assembly. ARP 611 is a document that describes various cleaning levels for PTFE hose assemblies. Hose assemblies, after cleaning, can be packaged to maintain these cleanliness levels.

4.3.2 Before Installation: The end user many times cleans the hose assembly just before installation to insure the correct level even though it has been previously cleaned. Even then, it may be necessary to provide cleanliness protection up to the time of installation.

5. INSTALLATION

5.1 Planning: It is important to plan the installation of hose assemblies along with the rest of the fluid systems in the vehicle. By proper planning, undesirable hose installation conditions can be avoided. For proper service life, the assemblies should be installed to the manufacturer's instructions and thereby avoid kinking, tight bends, abrasion, twisting, etc., in the aircraft.

5.1.1 Normal Installation Practice:

5.1.1.1 Avoid contact with sharp or abrasive structure.

5.1.1.2 Avoid contact or close proximity with high temperature components without providing proper protection.

5.1.1.3 Avoid hose assemblies that are too long or too short for the application.

5.1.1.4 Make use of elbow fittings where necessary to avoid bending the hose too sharply.

5.1.1.5 Provide protective covers when exposed to abrasive environmental conditions.

5.1.1.6 Provide fire resistant covers when installed in fire zones.

5.1.1.7 Provide adequate support for hoses exposed to high wind or acceleration forces.

5.1.1.8 Avoid installations which result in the hose being twisted during operation.

5.1.1.9 Where hose supports are required, provide clamps which will allow the hose to expand under pressure and will not abrade the hose surface.

5.1.1.10 Where two or more hoses are routed in close proximity, end fitting selection should be made with a view to prevent inadvertent cross connections.

5.1.1.11 Use proper installation torque values recommended in ARP 908 for flared 37° and "MS" flareless fittings or torque values recommended by fitting manufacturer for other style end fittings.

5.1.2 Non-Flexing Applications:

5.1.2.1 Provide adequate length to prevent applying a preload to the hose due to adverse tolerance buildups.

5.1.2.2 Provide a solid connection to either a component or structure at both ends of a hose.

5.1.2.3 Route the hose so that it will allow free movement of isolation mounts where used.

5.1.2.4 Keep hose routing as short as possible.

5.1.2.5 Provide at least one bend in the hose routing in order to accommodate length changes caused by pressure or temperature variations.

5.1.3 Flexing Applications:

5.1.3.1 Provide hoses with adequate length to accommodate the maximum component travel.

5.1.3.2 Avoid installations in which the component motion is such that it tends to twist the hose.

5.1.3.3 Where hose restraint or guidance is required, very careful use of hose clamps may be employed to guard against preventing the hose from completing its flexing operation.

5.1.3.4 Ensure that clearance exists throughout the total hose motion path under all conditions including adverse hose and structural tolerance conditions.

5.2 Installation Examples: Flexible hose assembly configurations need to be properly planned and installed for the best results. The following examples are intended to list and illustrate the basic factors for proper installation of flexible hose assemblies.

5.2.1 Proper Length: Hose installations should provide adequate length to provide for adverse tolerance variations and changes in length due to pressure application. The change due to pressure can be as much as 2%, while the allowance for adverse tolerance must be determined by taking into account the end point tolerances plus the hose length tolerances. The preferred installation should provide at least one bend and the hose length should be such that it can accommodate the worst manufacturing and operating tolerance conditions. (See Figs. 1 and 2).

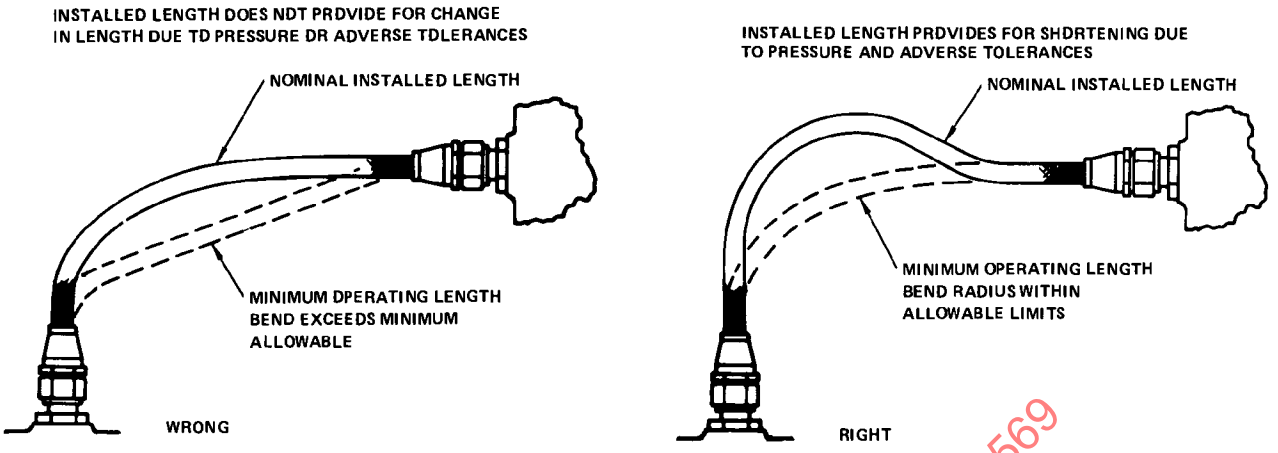
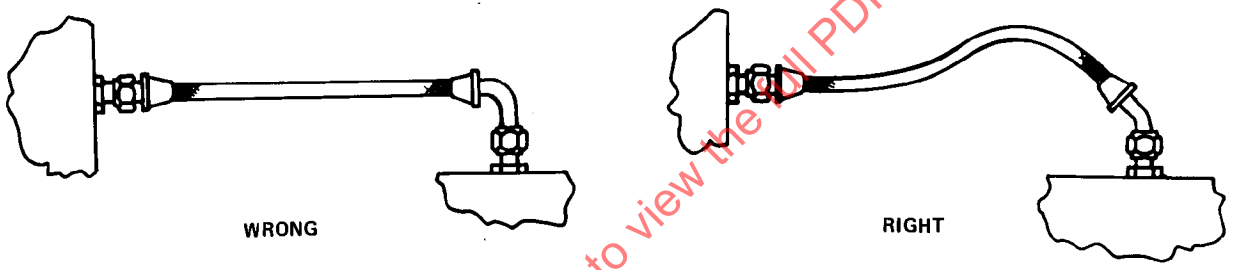


FIGURE 1



GOOD INSTALLATION
PROVIDES LENGTH IN
BENDS TO PROVIDE FOR
TOLERANCE BUILD UP
AND CHANGES IN LENGTH
DUE TO PRESS OR TEMP.

FIGURE 2

5.2.2 Proper Installation: Prior to tightening end fittings and clamping, the assembly end fittings should be assembled hand tight and the hose allowed to take a natural unstressed position. When tightening end fittings, care should be taken to prevent twisting or turning of the hose. Anti-torque hex, if provided, should be utilized and fittings tightened to the recommended torque values.

5.2.3 Twisted Installation: Make certain the hose is not twisted. The printed layline on the hose or the braid pattern, when fittings are tightened down, is an indication of this. When twist is observed, loosen the swivel nut, untwist the hose and retighten the nut while restraining the hose to fitting joint with a suitable anti-torque device.

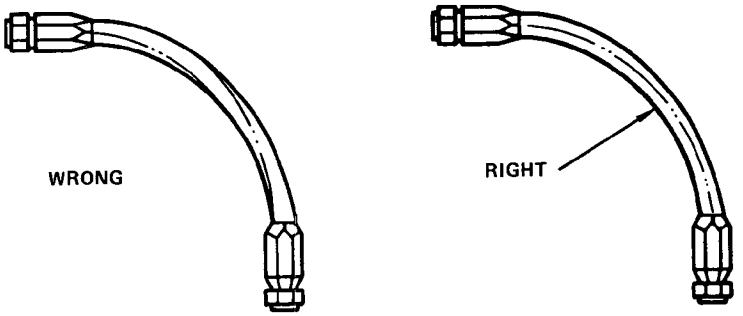
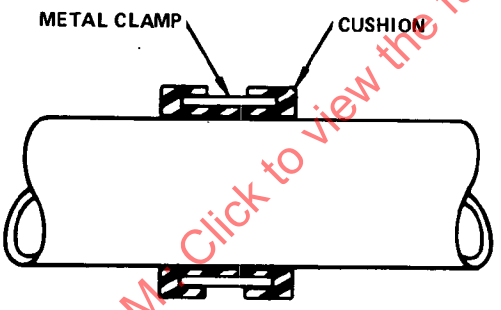


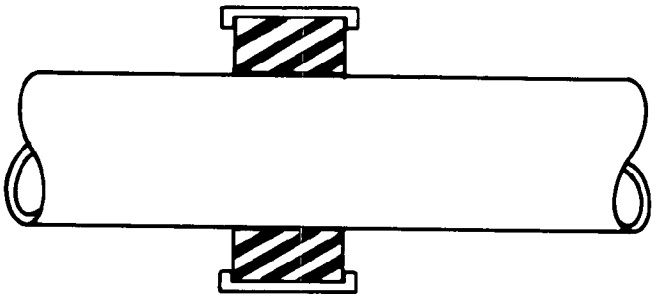
FIGURE 3

5.2.4 Hose Supports: Clamps should be selected based upon the type of hose surface as well as the operating service to which they are to be exposed.

5.2.4.1 Clamp design should allow for hose expansion and flexing without wear to the hose surface. Clamp usage should be kept to a minimum as they will restrict the ability of the hose to flex. Two types of clamps which are commonly used are shown in Fig. 4.



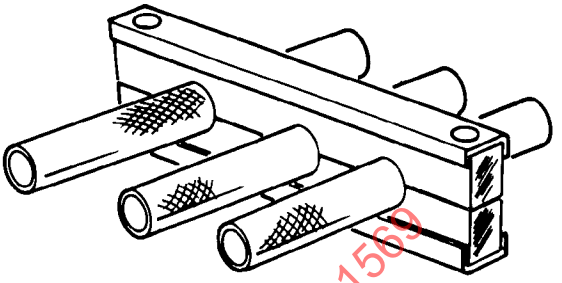
METAL SINGLE OR DOUBLE BOLT
LINED LOOP CLAMP



RESILIENT BLOCK WITH METAL STIFFENER

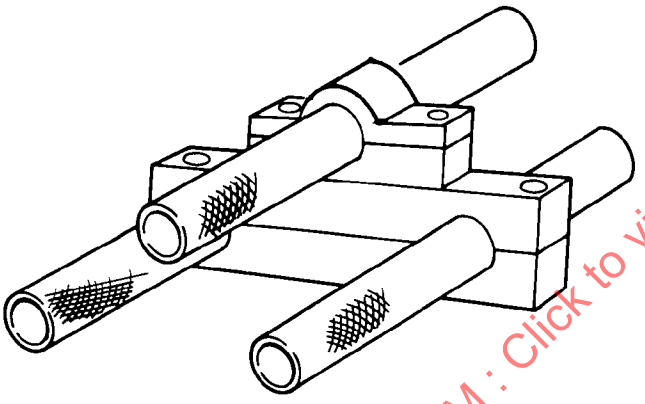
FIGURE 4
TYPICAL HOSE CLAMPS

5.2.4.2 Hoses running parallel can be kept separated by the use of spreader bars as shown in Fig. 5. Spacing should be maintained in order to prevent abrasion between hoses. This is especially critical where hose bundles are subject to air loads such as in the case of landing gear or control actuator installations.

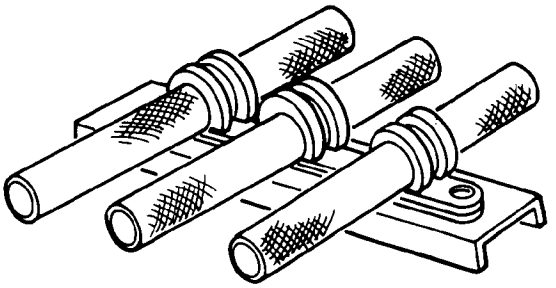


RESILIENT TYPE CLAMP BLOCK FITTED LIGHTLY TO HOSE

HEAVY DUTY SPREADERS



RESILIENT BLOCK-STACKED HOSE RUNS



LINED METAL TUBE CLAMPS FITTED LIGHTLY TO HOSES

LIGHT DUTY SPREADERS

TYPICAL SPREADER BARS

FIGURE 5

5.2.4.3 Where clamping is required in order to maintain clearance with crossing tubing or hose runs, a combination of clamps and brackets is sometimes required. These should be designed so that the clamps are near the tubing crossover point and thus will maintain a positive clearance. (See Fig. 6).

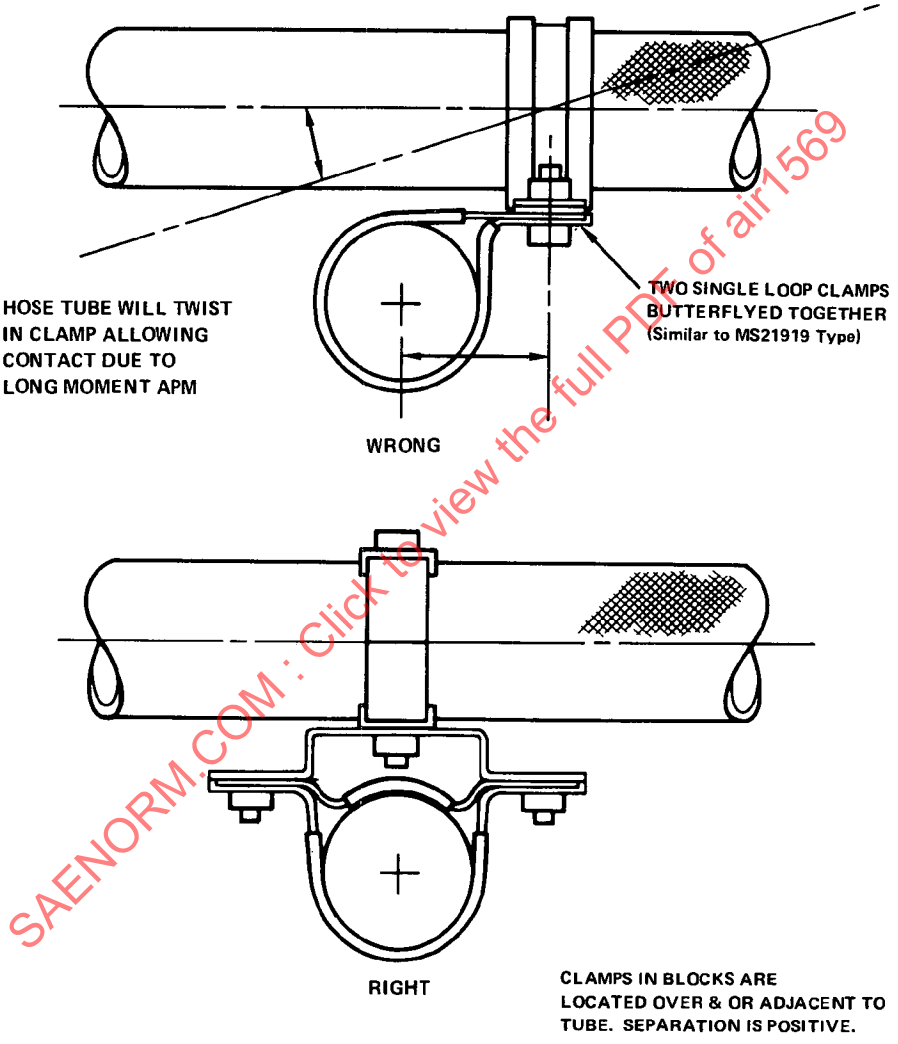


FIGURE 6

5.2.5 Proper Fitting Selection: A solidly-mounted fitting should be provided for attaching both ends of the hose. Two common fitting types available for this purpose are the union screwed directly into the component part and the bulkhead fitting which can be firmly affixed to some form of structure. There are also a number of hose end configurations available, such as straight 90° and various in-between angles, many of which can be obtained with both male and female ends. These should be selected to best suit the needs of each individual installation, taking into account overall weight, cost, pressure drop, and ease of installation as well as the most desirable route for the hose assembly.

5.2.5.1 Bulkhead Fitting: A bulkhead fitting can be firmly attached to a piece of structure or bracket in order to provide a fixed mounting for one or both ends of a hose. The bulkhead fitting can be a straight fitting as shown in Fig. 7, or it can be a more complex shape to allow connecting more than one tube or hose at a single point as shown in Fig. 8.

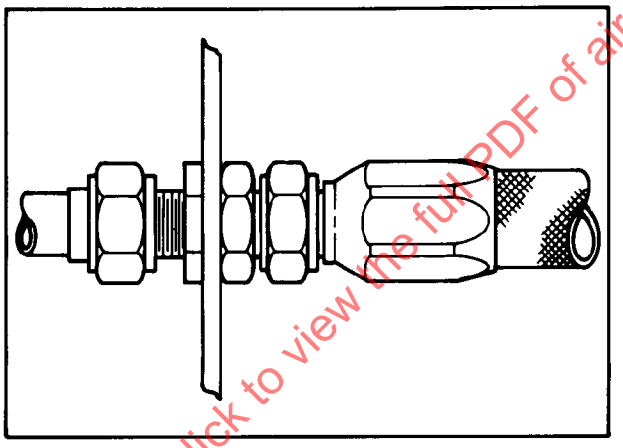


FIGURE 7

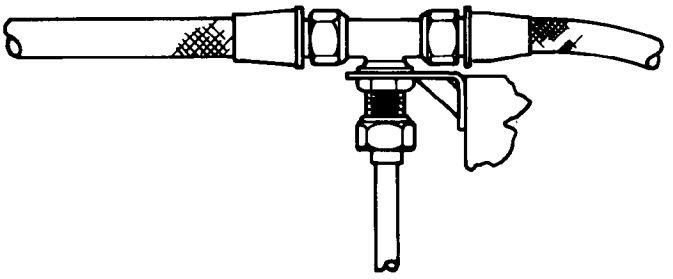


FIGURE 8

5.2.5.2 End Fitting Selection: Hose end fittings should be selected in order to provide an installation with the minimum hose length, the maximum clearance from adjacent objects, and, at the same time, maintain a neat appearance.

5.2.6 Service Disconnect Hoses: Hoses to equipment that require frequent removal should be installed in a manner to give maximum protection from damage during this operation. The shape of the hose should allow for non-operating motions involved in removal or installation of the units. A hanger can be installed to prevent kinking the hose when pulling it out of the way. (See Fig. 9).

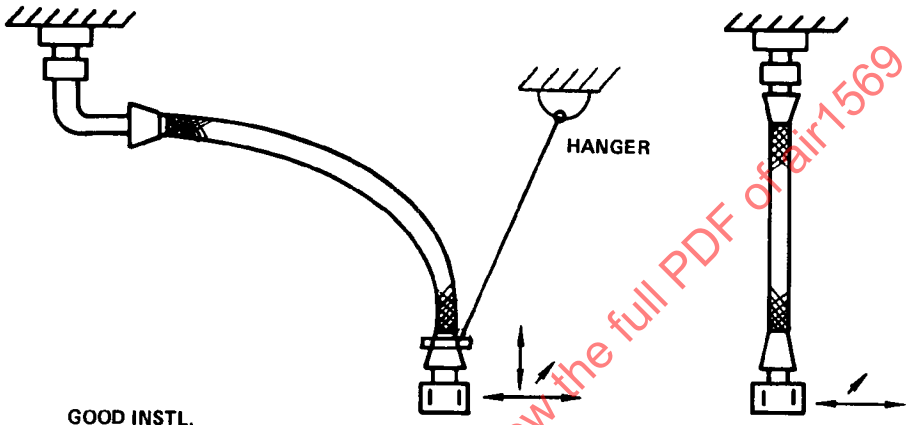


FIGURE 9

5.2.7 Bend Radius: Do not bend the hose to a radius smaller than the minimum bend radius during handling, storage or installation. If the bend radius is too small, the hose will tend to flatten and kink.

For information on hose bend radii, consult related industry specifications and manufacturers' catalogs. AIR 797 gives a good summary of minimum bend radii for various hose constructions.

5.2.7.1 Measurement of Bend Radius: Measure the bend radius from the inside of the bend. Allow at least one inch straight run out of the fitting. (See Fig. 10).

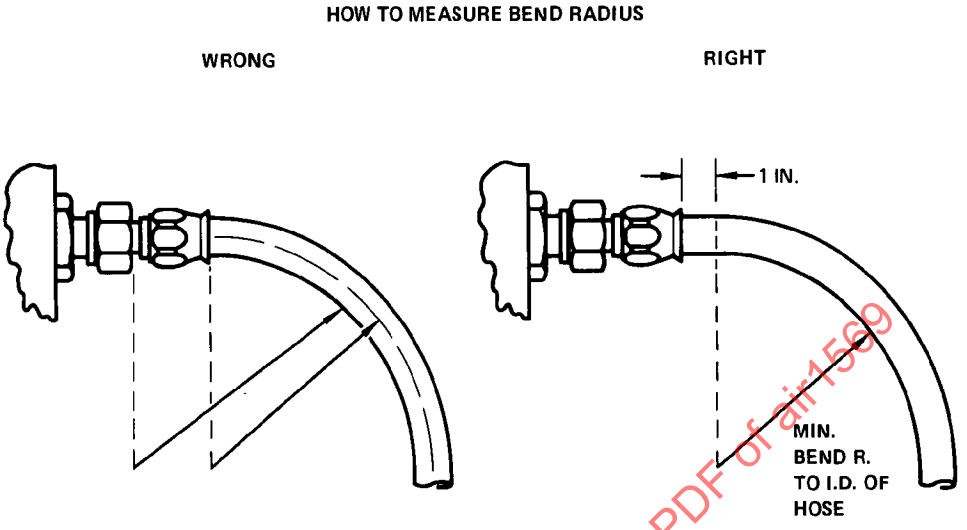


FIGURE 10

5.2.8 Proper Routing:

5.2.8.1 Direct Routing: Excessive slack in hose lines is one of the most common causes of poor appearance, and many times contributes to abrasion. (See Fig. 11).

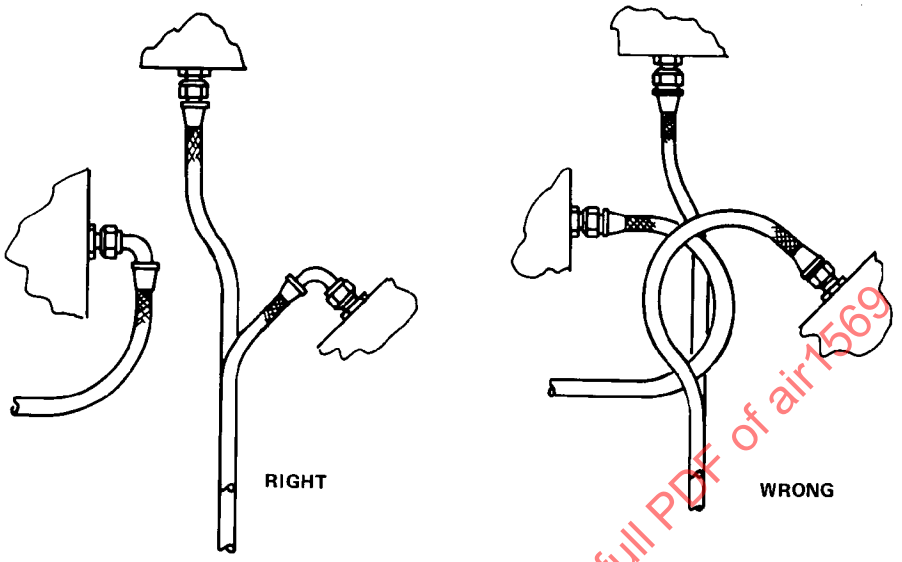


FIGURE 11

Use 45° and 90° elbow adapters or elbow hose fittings to provide direct routing.

5.2.8.2 Shield from Temperature: Exposure to unusually high temperature can drastically shorten hose life. Route hose assemblies away from hot manifolds or other high outside temperatures wherever possible. If this is not possible, a protective sleeve or baffle plate should be installed to protect the hose. (See Fig. 12).

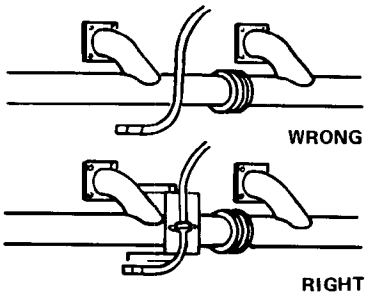


FIGURE 12

5.2.8.3 Abrasion: Constant abrasion at the same point may wear through the outer cover eventually and weaken or allow corrosion of the reinforcement. Therefore, route the hose to prevent it from coming in contact with abrasion points. Avoid contact with sharp edges. (See Fig. 13).

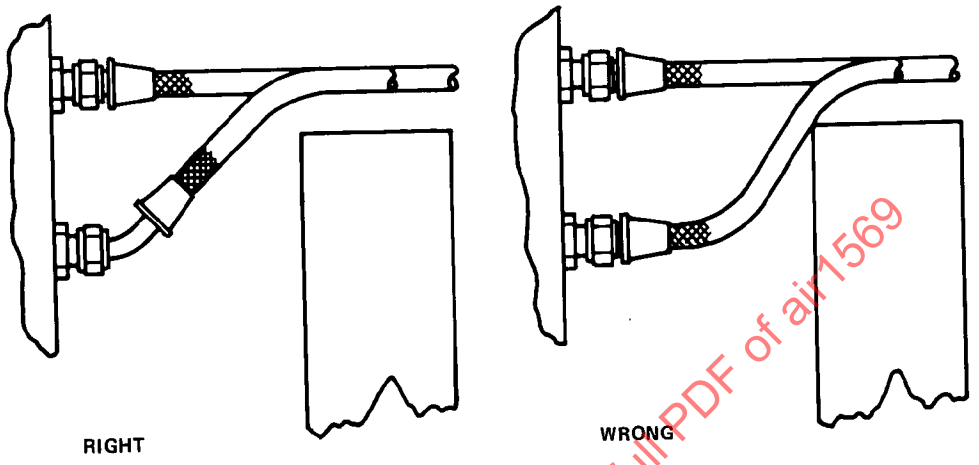
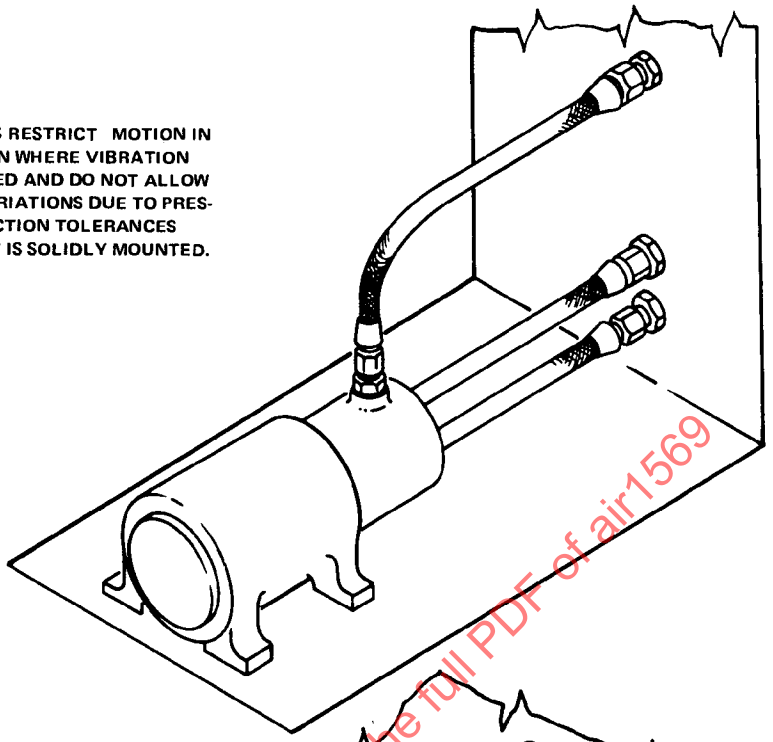


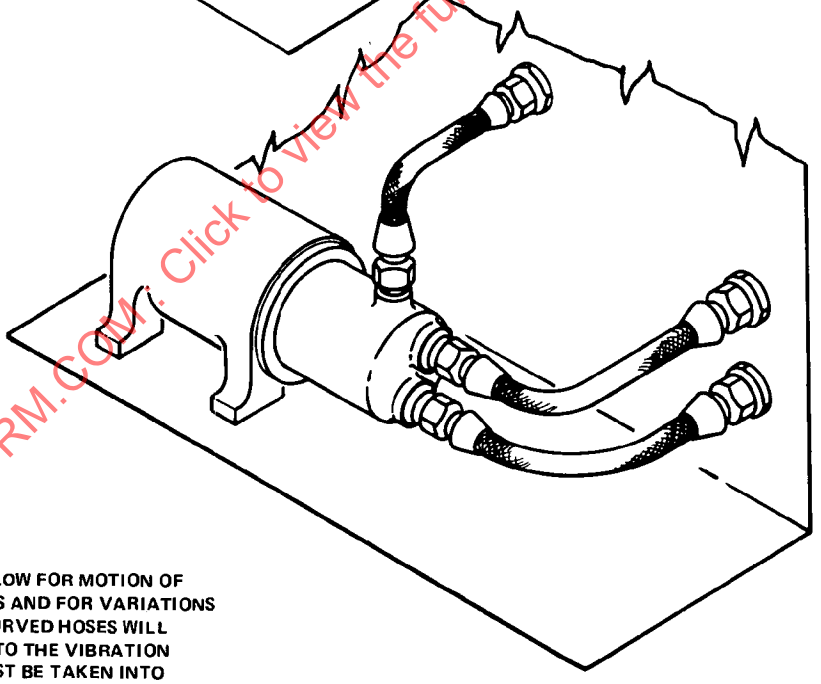
FIGURE 13

5.2.8.4 Shock Mounted Equipment: Hoses routed between structure and equipment mounted on shock or vibration mounts should be routed in such a manner that they will neither preload the mounts or restrain the component motion in any direction. (See Fig. 14).

STRAIGHT HOSES RESTRICT MOTION IN AXIAL DIRECTION WHERE VIBRATION MOUNTS ARE USED AND DO NOT ALLOW FOR LENGTH VARIATIONS DUE TO PRESSURE OR PRODUCTION TOLERANCES WHERE THE UNIT IS SOLIDLY MOUNTED.

WRONG





RIGHT

CURVED HOSES ALLOW FOR MOTION OF VIBRATION MOUNTS AND FOR VARIATIONS IN LENGTH. THE CURVED HOSES WILL APPLY A PRELOAD TO THE VIBRATION MOUNTS WHICH MUST BE TAKEN INTO ACCOUNT DURING DESIGN.

FIGURE 14