ENGINEERING
TOMORROW

Danfoss

Fluid Power Training

Hydraulics - Routing Hose and Tubing

A 10-point guideline for routing hose and tubing for maximum service life and safety

In hydraulically controlled and actuated machines, the locations of some components are controlled by the structure of the machine and usually cannot be altered. Other components, however, can and should be placed where they are easy to connect, readily accessible and convenient to service.

A system designer should endeavor to eliminate as many fluid conductors as possible by using manifolds to interconnect components. However, in most cases, external piping must be used. The astute designer will try to achieve two objectives: minimize potential leakage points and make maintenance as simple and easy as possible.

When designing the basic machine, the engineer should always remember to:

- Provide adequate space to route hose and tubing
- Coordinate hydraulic system planning and design with other systems on the machine; i.e., electrical, fuel, lube, torque converter, etc.

Parallel routing

Whenever possible, hydraulic lines on a machine should be run parallel within the machine envelope and follow its contours. Smooth, parallel routing can be accomplished with a well planned layout and proper clamping. To help keep lines parallel, study port positions on components. Careful preplanning of the location of valves, filters, heat exchangers and reservoir will also help achieve these objectives.

Parallel routing can often save money by:

- Reducing line lengths and the number of adapters used
- Minimizing the number of sharp bends
- Making the machine more serviceable
- Protecting lines from external damage

Components should be spaced far enough apart to provide enough room for proper installation of adapters and fittings on connecting hoses and/or tubing.

Porting

For most effective leakage control, SAE straight thread, 0- Ring sealed ports are recommended for lines through 34-inch and SAE 4-bolt split flange ports for lines 1-inch and larger.

Avoid use of pipe threads in hydraulic systems. While the pipe thread form is one of the most effective wedges ever invented, it should be used for connecting water systems and other low and sometimes medium pressure circuits.

Pipe threads were not designed for high pressure hydraulic applications. Most hydraulic valves used in high pressure systems are high precision components machined to such close tolerances that lands on spools must be ground optically. Every maintenance technician knows that the wedging action of pipe threads often generates unwanted and potentially dangerous stresses which distort and damage hydraulic components.

When connecting systems which include components with pipe thread ports, the serviceman should install adapters in the port and connect them to SAE 37-degree flared fittings or SAE O-Ring face seal ORS® fittings. The adapter can be used as a separable fitting in the permanent installation, eliminating the need for disconnecting the pipe thread end.

The major reasons for using flanged fittings on lines 1-inch and larger are accessibility and convenience during production and maintenance.

For example, the swivel nut on a 172-inch hose or tube fitting has a hex which measures 2¼ inches across the flats. Lack of space often makes it difficult, if not impossible, to swing such a large wrench to tighten or loosen a connection.

By contrast, a lVz-inch SAE flanged fitting is bolted with four 1/2-inch cap screws, for which sockets and socket-wrench extensions are commonly available.

Flanged fittings equipped with elbows offer a major advantage over elbow adapters connected to pipe thread ports. A flanged elbow fitting can be installed, oriented in the proper direction, then tightened. Often, an elbow pipe thread adapter is not tight enough when in the desired direction, yet too tight if turned another 360 degrees. The extra turn can crack a casting or cause a valve spool to bind.

It is good practice to turn elbow pipe thread adapters in 90-degree increments and adjust the piping to fit. If other positions are used to position an adapter, communicating this information to production and maintenance people may not only be difficult, but downright dangerous. We have seen installations where piping was forced to mate with an adapter which was positioned incorrectly. The results were unfortunate: kinked tubing, hose bent at radii much smaller than recommended and ultimate failure.

Hose and tubing

The system designer must first determine whether hose and/or tubing is best for a particular application. Designers should think of hose and tubing not as separate entities, but as companion items; each offers specific benefits. For example, tubing can:

- Be bent to smaller radii than hose and installed in tighter spaces
- Be routed through areas of higher ambient heat
- Handle hotter fluids than can hose
- Provide superior heat transfer characteristics

On the other hand, tubing can be flattened or damaged when struck, whereas hose is resilient and more apt to absorb a blow and return to its original shape. Tubing may fatigue when connected to high frequency vibrating components; hose will absorb the vibration.

Where lines are long, tubing may require a series of intricate, close tolerance bends which may complicate installation and ultimately create service problems. The flexing properties of hose, on the other hand, allow it to follow desired contours and make hose installation easier. Hose can absorb some high transient pressureshocks, providing more uniform flow patterns as well as smooth and quieter operation. Where hydraulic rigidity is required, hose is not recommended because of its tendency to act as an accumulator.

GOOD DESIGNS FOSTER GOOD MAINTENANCE

Here are 10 rules of thumbfor correctly routing and properly installing fluid conveying components. This guideline should be most useful during machine prototyping. After all "bugs" have been removed, normal production procedures should be followed.

1. Start with large lines

Because they are the hardest to bend and maneuver, especially in tight spaces, install the largest ID lines first and the toughest part of the job is done.

Smaller lines provide more routing versatility and can be more easily "worked" in tight spaces. Each line should be routed to conserve maximum space. This not only results in a neater looking installation, but makes future modifications or additions of accessories easier, more convenient and more economical.

2. Correct hose length

The appearance and efficient operation of a system often depends on using proper length hoses. Excessive hose footage increases pressure drops and system cost. Hose assemblies are commonly manufactured to specified lengths as well as increments of lengths. This practice helps minimize the size of inventory which must be carried. When computing hose length, remember that hose can shorten up to about 4% when pressurized.

3. Hose flexing

Always remember that a hose assembly is designed to flex or bend, not twist. It has been shown that if a large diameter, high pressure hose is twisted 7 degrees, its service life can be reduced by as much as 90%!

High pressure hose must be routed to flex in only one plane. If plumbing requires that hose be routed through a compound bend, the hose should be "broken" into two or more sections so each will flex through only one plane. Although a spring guard will keep hose from bending beyond the minimum bend radius at the fitting, it will not prevent the hose from twisting.

4. Pivot points

When hose must flex, be sure to route it through the pivot point around which the component is moving, Figure 1. This will result in the best and most efficient flexing of the hose line, use the least amount of hose and keep the hose within the contour of the machine.

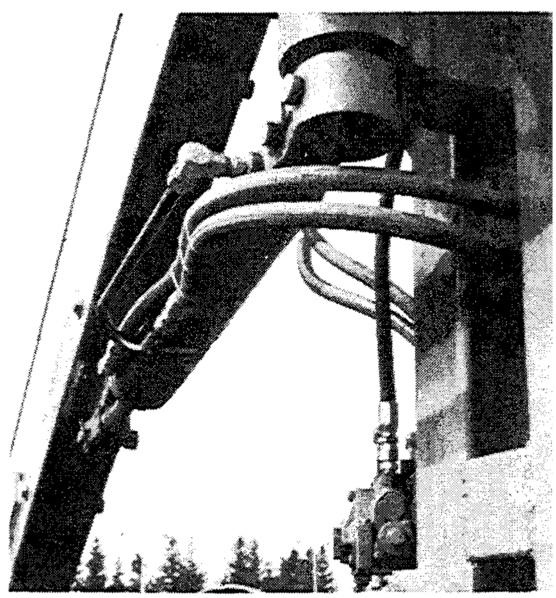

Fig. 1. In flexing applications, the hose assembly should be routed through the pivot point around which the component is moving.

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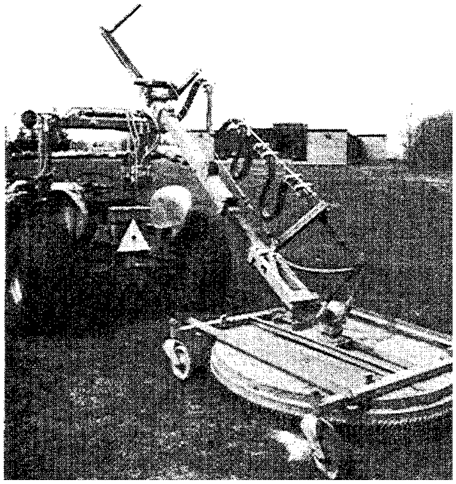

Fig 2. Festooning consists of attaching hose to a steel cable in hanging loops. As one point moves away from the other, the loops open to straighten the hose as needed.

To achieve this, the hose should be positioned to bend like a hinge. Otherwise, the hose may have a tendency to take an S-bend which is most likely to happen when the hose is pushed rather than bent. An S-bend installation results in excessive hose movement and reduced service life.

When piping a flexible line through a pivot point, consider the relative positioning of the two end fittings to avoid an S-bend. Follow this procedure:

- Swing the moving component to its farthest point where the hose will experience its widest bend.
- If the fittings are placed in parallel planes at this point, the hose will tend to flex in a hingelike manner when the component is swung back to the opposite end of its travel.

5. Reciprocating motion

In addition to flexing, the ends of the hose may have to reciprocate. There are several design methods:

- *Hose reels* - For use with high pressure hydraulic hose, these reels are equipped with high pressure swivel joints and a spring return to help rewind the hose.
- *Festooning* - Hose is hung in loops from a steel cable, Figure 2. As one point of the loop moves away from the other, the loops open to form almost a straight line.
- *Rolling* - Hose is arranged in an unbalanced U-shape, one leg being stationary and longer than the second, which is free to reciprocate parallel to the first. Hinged tracks carry the hose.

6. Rotary motion

Swivel or rotary joints are commonly used to provide rotating motion. Where rotary movement is a continuous 360 degrees, use a rotary joint; if, however, movement is reversing, a swivel joint would be the better choice.

When used with hose, a swivel joint will avoid hose twisting or bending at the fitting, Figure 3.

7. Controlling oil spray

Where hydraulic lines must be routed near hot, potentially hazardous areas, protection against fire must be used to prevent oil from a broken line from spraying onto any potential source of ignition. Here are some ways to accomplish this:

- Route the line through a tunnel made from steel tubing, channel or angle iron.
- Install a sheet metal baffle between the lines and potential ignition source.
- Route the lines through a large, open-ended hose or sleeve so the oil will flow out of the ends in case of line failure.
- Use fire sleeves that either fit over the hose or are built into the hose cover.
- To guard against a failed hose that might whip and spray hydraulic oil over an ignition source, anchor the hose to the component to which it is hydraulically connected.

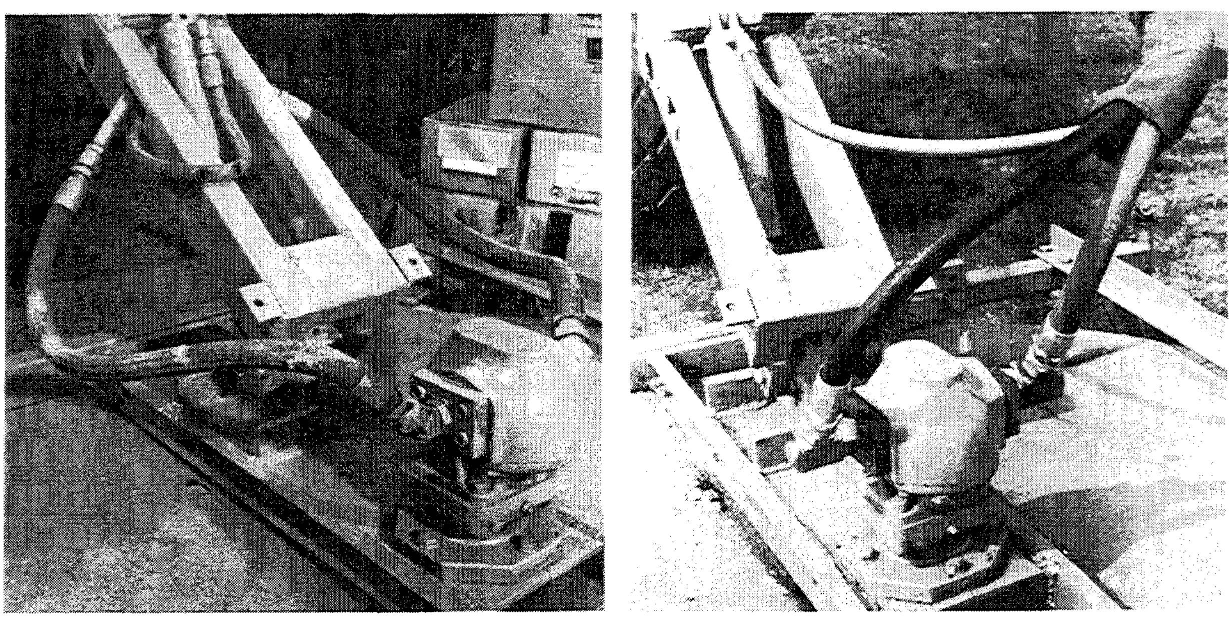

Fig. 3. Swivel joints used on the ends of hose assemblies will eliminate twisting and bending at the fittings. The photo at left shows an installation with fixed fittings and at right is the same application with swivel joints. Notice the neatness provided by a Cordura. (Cordura is a DuPont trademark.)

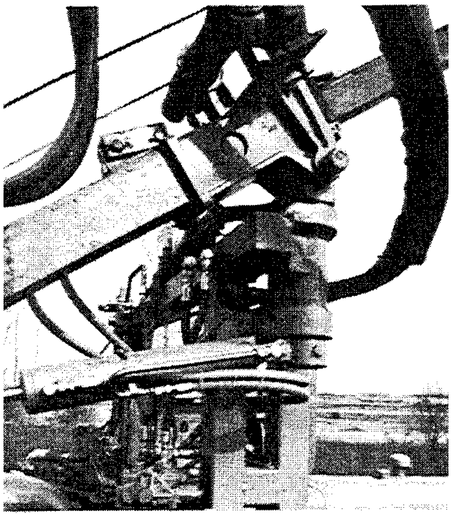

Fig. 4. The tough outer cover of a hose assembly will abrade if exposed to continuous rubbing in the same spot. To avoid this problem, route and damp to keep hose dear from interfering objects.

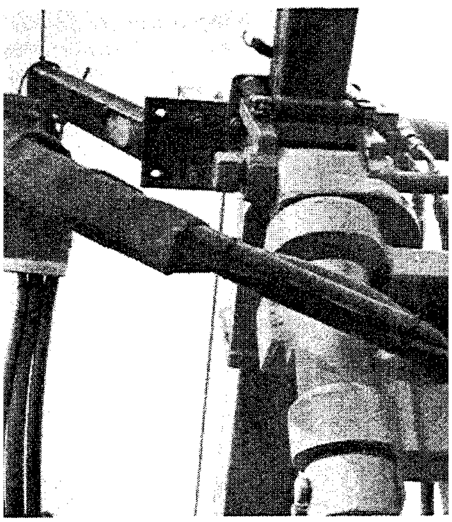

Fig. 5. The choice of sheathing and damping bundles of hose assemblies must be studied carefully. Hose should be routed to provide proper damping, yet allow for flexing when pressurized.

8. Minimum bend radii

SAE specifications and fitting manufacturers' catalogs list the minimum bend radii for various size hose. The figures usually refer to the minimum bend radius at maximum operating pressure for a static line. When a line is flexed, the minimum radius increases in relation to the number of degrees through which the hose line flexes. The designer should plan to increase the minimum bend radius when the hose is flexing, by applying an N factor to the normal, recommended bend radius.

For example, the minimum bend radius for -12 high pressure hose is 9½ inches (measured from the inside bend of the hose) at 3000 psi. If the hose line flexes through 140 degrees, the N factor is 1.4. Multiplying 9.5 by 1.4 gives a new bend radius of 13.3 inches for this -12 hose at a pressure of 3000 psi.

9. Avoid abrasion

Most hydraulic hose is built with a tough outer cover to protect the hose reinforcement from abrasion and/or moisture damage. Constant abrasion at one point will eventually puncture the outer cover and weaken the reinforcement. For this reason, route and clamp the hose so it will not abrade, Figure 4, or use a protective cover.

Choose from a variety of protective coverings:

- Coiled springs
- Coiled strap steel
- Spiraled plastic
- Nylon sleeves

10. Clamping

A piping installation is not complete until it has been properly clamped. Clamp choice is very important; often it can be critical, Figure 5. Common sheet metal clamps will not hold a large, high pressure hose.

Good clamps can be inexpensive, yet highly effective for high pressure surge lines. Anticipate and plan for a possible length change ranging from +2 to -4% for high pressure lines. Proper routing and clamping should be planned to avoid areas of vibration. Never clamp hose on a bend.

Good routing avoids crossed lines. Where unavoidable, clamp the two crossing lines together at the junction point. However, NEVER clamp together high and low pressure hoses which run parallel. The differential in respective length changes is likely to result in a seesaw action which will damage the hoses.

Properly sized clamps should grip hose in a positive manner. To keep the clamp from abrading the hose, the ID of the clamp should be about 1/32-inch smaller than the OD of the hose.

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