WHITE PAPER

Reduce Downtime by Spending More Time on Hose Maintenance & Safety Procedures

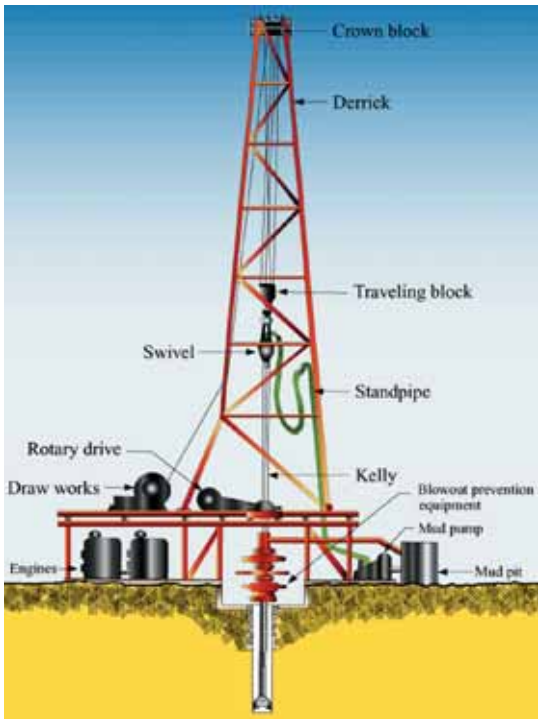
Introduction

Never underestimate the consequences of a failed oilfield hose: downtime, cost overruns, lost production, missed schedules, personal injury, property damage and the failure of associated equipment.

Just installing the best-coupled hoses is not enough to ensure optimal operation on an oil rig. Proper handling, storage, use and maintenance of rotary drilling and vibrator hose assemblies are essential for long-lasting performance and safety.

Plus, external inspection and field pressure testing prior to any continued service of a hose assembly is critical for eliminating serious bodily injury or severe property damage.

To avoid the costly consequences of failed oilfield hoses and hydraulic assemblies, Gates Corporation engineers have developed the following guidelines for rig safety managers, superintendents and drilling contractors.



Maintenance & Safety of Rotary & Vibrator Hoses

Storage

1. Completely drain a hose assembly before placing it in storage.
2. Whenever feasible, store a hose in the original shipping crate. This will provide extra protection against the deteriorating effects of solvents, corrosive liquids, ozone and sunlight. Hose should be stored so coils are in a horizontal plane.
3. Certain rodents and insects can damage hoses. Adequate protection from them should be provided.
4. The ideal temperature for storing hose ranges from 50°F (10°C) to 70°F (21°C) with a maximum limit of 100°F (38°C). If stored below 32°F (0°C), hose will become stiff and will require warming before being placed in service. Hoses should not be stored near sources of heat, such as radiators or base heaters.
5. To avoid adverse affects of high ozone concentrations, hoses should not be stored near electrical equipment that may generate ozone or be stored for any lengthy period in geographical areas with high concentrations of ozone. Exposure to sunlight, direct, reflected or even through windows, should be avoided.
6. Do not stack hoses or place anything heavy on top of them to prevent damage.

Handling

Caution: Care should be exercised to prevent mishandling. Crushing or kinking of hoses can cause severe damage to reinforcement. If this occurs, remove the hose from service.

1. To minimize the chance of kinking, hoses should preferably be removed from crating by hand, laid out in a straight line and then lifted by means of a cat line attached near one end of the hose.
2. Hose assemblies should never be lifted by the safety clamp and chain. The assembly should always be lifted by the lift-eye clamps.
3. To avoid hose kink damage of a heavy rotary hose assembly, always attach a set of lift-eye clamps to the hose end coupling to safely lift and move the assembly.

Recommended Practices

Where applicable, Gates recommends the following practices for rotary drilling and vibrator hose.

A. Overall Hose Length – This includes standard connector and/or special adapters.

B. Rotary Hose Length – To avoid kinking a hose, the hose length and standpipe height should be such that when raising or lowering, as in making mouse-hole connections, the hose will have a normal bend radius at the swivel when it is at its lowest drilling position and at the standpipe when it is at its highest drilling position. Use the following equation to determine the recommended hose length.

$LH = LT/2 + \pi R + S$

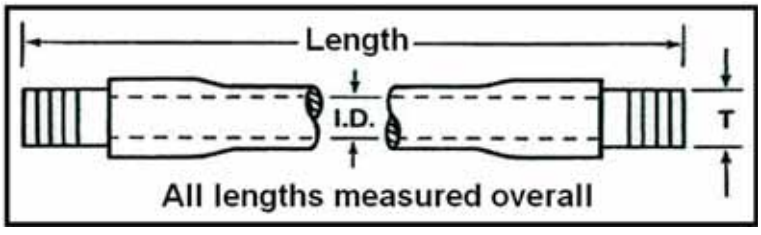
Where:

LH = Length of hose in feet

LT = Length of hose travel in feet

R = Minimum bend radius in feet

= 4 feet for 2-1/2-inch and 3-inch hose



= 4-1/2 feet for 3-1/2-inch and 4-inch hose

S = Allowance for contraction in LH due to maximum recommended working pressure in feet, which is 1-foot for all sizes.

C. Standpipe Height

Use the following equation to determine the recommended standpipe height.

HS = LT/2 + Z

Where:

HS = Vertical height of standpipe in feet.

LT = Length of hose travel in feet.

Z = Height in feet from the top of the derrick floor to end of the hose at the swivel when the swivel is at its lowest drilling position.

NOTE: When the actual hose length is greater than the calculated length, the standpipe height should be increased by half the difference between the actual length and calculated height.

D. Vibrator Hose Length
It's important to choose a vibrator hose having an inside diameter equal to that of the pump discharge fitting and the fluid supply line inside diameters. This is necessary to allow the free flow of fluid and to avoid turbulence or unnecessary abrasion of the hose tube. The length of vibrator hose should be given careful consideration. It should be long enough to prevent kinks near the couplings, yet short enough to prevent kinks in the radius near the middle of the hose.

E. Hose Connections
Line pipe threads should only be used on working pressure of 5,000 psi or less. Threaded-end connections should not be welded to the coupling. This will damage the hose. A hose assembly with a working pressure of 5,000 psi and above should have end connections butt-welded to the coupling. The connections attaching the hose to the swivel and standpipe should be as tangential as possible. The use of a standard connection on the swivel gooseneck will ensure this relationship at the top of hose. It's recommended that a 180° gooseneck should be used on the standpipe connection if the standpipe is vertical. A 160° gooseneck should be used if the standpipe has the same slope as the derrick leg.

F. Vibration and Pulsation
Continuous pressure pulsations and vibrations may shorten the useful life of rotary and vibrator hoses used in high-pressure mud piping systems. Surge chambers or pulsation dampeners of the proper size should be installed in each mud pump discharge line to minimize pulsations and vibrations in the mud lines and hoses. The pre-charge pressure for pulsation dampeners should be set at 10 percent of the maximum

pump pressure. The lines on the suction side of the pump should be pressure charged or operated with a flooded suction to minimize cavitations that can cause pulsations. Pulsation dampeners designed for the pump suction lines should also be installed to minimize pulsation if cavitations occur.

G. Operating Limits
Operating personnel should be advised as to the highest and lowest drilling positions, length of standpipe, etc., for which the hose was selected. Drilling operations should be carried out within such limits.

H. Clearance
Hose installation should allow adequate clearance between hose and derrick or mast.

I. Barge Attended Off-Shore Rigs
When rotary hose is used as a flexible line between barges or offshore drilling rigs, care must be used so hose is in alignment between both end connections. It's recommended that swivel joints be used at both ends. Drilling in rough water and high seas, resulting in excessive flexing and jerking of hose, will cause premature failure.

Hose Operations

Caution: Care should be exercised during operation to prevent crushing or kinking of hose, which can cause severe damage to cable reinforcement. If this occurs, remove the hose from service and test as outlined in the "Field Test Pressure" section.

A. Working Temperature
Working temperature should not exceed 180°F (82°C). Temperatures encountered higher than 180°F (82°C) will shorten the useful life of the hose.

B. After Coolers
Compressors should always be equipped with after coolers to lower the air or gas temperatures within tolerable limits. If after coolers are not used, air or gas entering hose at excessively high temperatures can accelerate the hose aging rate, thus reducing the expected service life.

C. Working Pressure
The recommended maximum working pressure for rotary hose is shown in the table below. Working pressure includes the pressure surges that occur in the system.

Maximum Working Pressures			
Hose I.D. (inches)	**Available Grades**	**Working Pressures (psi)**	
		Grade D	Grade E
2-1/2	D & E	5,000	7,500
3	D & E	5,000	7,500
3-1/2	D & E	5,000	7,500

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Hose I.D. (inches)	**Available Grades**	**Working Pressures (psi)**	
		Grade D	Grade E
4	D & E	5,000	7,500

D. Oil Base Muds
The use of oil base muds having an excessively high aromatic content will cause the hose inner liner to swell, resulting in less abrasion resistance, which can shorten service life. It's recommended that oil base muds be held to a minimum aniline point of 150°F (66°C).

E. Twisting
Hose should not be intentionally back twisted. In order to prevent twisting, it's suggested that a swivel be installed on the gooseneck end of the hose. Each length of hose has a yellow longitudinal stripe. Use this as a guide to ensure hose is installed without any twist.

F. Safety Clamps
All rotary and vibrator hoses 8-feet and longer are marked with the notation "Attach Safety Clamp Here." Safety clamps must be installed prior to placing the hose into service.

For rotary hose – This dimension shall be 6 to 18 inches from the inboard end of the coupling.

For vibrator hose – This dimension shall be 6 to 10 inches from the inboard end of the coupling.

A set of safety clamps can be obtained on special order from hose distributors. The location for attaching these safety clamps is shown by marks at each end of the assembly. Lift-eye clamps are also available. Do not use the safety clamp or chain for lifting. The safety clamp should be tightened securely, but not to such an extent as to damage the hose or reduce the inside-bore diameter. In the case of rotary hose, the safety chain should be attached to a derrick upright at the standpipe end, rather than a transverse support, so the chain will be free to move upward without restricting movement of the hose should the traveling block be raised too high.

Field Test Pressure

Hose assemblies subjected to abnormal abuse such as severe end pull, flattening, crushing, sharp kinking or excessive pressurization must be immediately inspected and hydro-statically tested at 1.25 times the rated working pressure. Follow steps 4 through 9 below.

Field testing of rotary hose, when required for establishing periodic safety levels of continued operation, should be conducted with these factors as a guide:

1. Check and properly attach the safety clamp and chain for complete safety compliance.
2. Avoid all back twist.
3. Suspend the hose in a normal unstressed position from a standpipe to swivel.
4. Visually inspect the hose for any external damage to the hose body, end structure or couplings.
5. Raise the pressure between 1,000 and 10,000 psi per minute.
6. Bleed air when using mud, oil or water as permissible test media.
7. Restrict the duration of test pressure to a maximum of 10 minutes.
8. Do not exceed 1.25 times the maximum rated working pressure when testing.
9. Conduct field testing under full responsibility of end user with safety in mind.

External Inspection

1. Carefully examine hose cover prior to each rig-up or every 30 days, whichever comes first.
2. The hose cover serves the primary function of protecting the cable reinforcement from physical or environmental damage. The cover should be carefully examined to detect areas where cable reinforcement may have been damaged. Inspect the hose cover for cuts, gouges, tears and abrasion.
3. Any cuts, gouges or tears in the cover down to, but not into the cable reinforcement, should be regularly inspected to ensure further deterioration does not occur. If cable reinforcement is exposed and rust or corrosion is evident, remove the hose from service.
4. The cover may show surface cracking due to prolonged exposure to sunlight or ozone. Such deterioration, as long as it does not expose the cable reinforcement, is not usually cause for removal from service.

On-the-Job Welding

On-the-job welding of hose assemblies is not recommended. Excessive heat from welding can cause hose damage.

Maintenance & Safety of Hydraulic Hose Assemblies

The selection and maintenance of hydraulic hose components for oil drilling equipment can spell the difference between productivity and costly downtime, especially when the work site is miles away from the nearest parts distributor or repair shop.

To avoid potential fluid power problems, including environmental complications, Gates engineers offer the following tips from their “Safe Hydraulics” program:

1. Identify Hydraulic Leakage

The first step in any preventive maintenance program involves training equipment operators and maintenance personnel about how to identify and remedy leaky hydraulic hose assemblies. Machine operators need to be aware that although the appearance of dirt on hoses and fittings is an obvious indication of hydraulic leakage, leaks often send fluid onto other equipment surfaces and must be traced to their source.

Tracing the leak to its source may require machine operators to do some detective work. If hoses appear excessively wet around their fittings, check for loose couplings. If the coupling is tight, this is an indication the coupling/hose interface has reached its service life and should be replaced.

2. Look for Abrasions

A frequent cause of leakage in hydraulic hoses for oil drilling equipment is abrasions resulting from cuts, friction caused by other moving parts, or from mechanical impacts. For example, hose-to-hose abrasions are likely to show up where lengths of hose travel through a boom. Hose-to-metal abrasion can occur where hoses travel through a bulkhead. In many cases, abrasion problems will be apparent during an inspection, and replacement can be initiated before failure occurs. Hose covers that are cut, torn or worn through will allow reinforcement wire or textile braids to deteriorate and/or rust. These hose assemblies must be replaced immediately. Hose manufacturers, including Gates, now offer a variety of hose products with abrasion-resistant covers.

3. Follow Proper Assembly Procedures

Another cause of leaks can be the improper assembly of replacement hoses, which can occur when mating surfaces on couplings are incompatible, when couplings are improperly attached to the hose, or when the hose assembly is installed incorrectly.

Assembly problems can be avoided by following the crimp and assembly recommendations of the manufacturer of the products being used. One common cause of failure is incorrect crimping that results when a hose is cut incorrectly, or when the stem of a coupling is not inserted all the way into the hose. Be aware of worn die fingers when using older model crimpers. Die wear is a real concern, especially on dead stop crimpers. When die fingers get worn, the crimp can become loose, and eventually, a hose assembly blowout is inevitable.

Gates engineers say 80 percent of all hydraulic component failures are due to fluid contamination that often results when metal shavings and rubber dust are not thoroughly removed during fabrication of the hose assembly. Preventive measures include blowing air through the hose, flushing the hose with a solvent, or using a cleaning kit with a sponge projectile after the couplings are attached.

4. Allow for a Margin of Safety

When choosing a replacement hose, Gates engineers recommend checking the manufacturer’s specifications for pressure and temperature ratings. Hose dimensions can be critical, as well. It is important to determine the correct inside and outside hose diameters using a precision-engineered caliper. Hose outer diameter is especially important when hose routing clamps are used, or when hoses are routed through bulkheads. Check individual hose specification tables for outer diameters in suppliers’ catalogs.

The inside hose diameter must be capable of handling the required fluid flow rate without generating back-pressure. It is not uncommon for pumps to deliver more than 200 gallons of fluid per minute to hydraulic cylinders and motors in various types of heavy-duty equipment, which is why it is important to know the type

of hose and the working pressure in a system when making replacements. When in doubt about the system pressure, cut the failed hose and determine whether the type of reinforcement is one or two wire braids, or four or six spiral wires.

In situations where equipment has been modified to perform special operations, it is not uncommon to see spikes in hydraulic pressure that the hose and coupling manufacturer did not anticipate. As a general rule, when choosing hose to transmit fluid under pressure, it's best to allow a generous margin of safety.

5. Establish Correct Hose Length

When making a new hose assembly, always make sure it is the same length as the one being removed. Too long an assembly can lead to the hose being severed or pinched in the moving components of the equipment. If the replacement hose assembly is too short, pressure may cause the hose to contract and place excessive stress (tug) at the coupling.

Changes in hose length when pressurized range between plus-two percent to minus-four percent while hydraulic mechanisms are in operation. So, allow for possible shortening of the hose during operation by making the hose lengths slightly longer than the actual distance between the two connections.

6. Consider Temperature Requirements

All hoses are rated with a maximum working temperature ranging from 200°F (93°C) to 350°F (177°C) based on the fluid temperature. Exposure to continuous high temperatures can lead to hoses losing their flexibility. Failure to use hydraulic oil with the proper viscosity to hold up under high temperatures can accelerate this problem.

External temperatures become a factor when hoses are exposed to heat from a turbo manifold or some other source. When hoses are exposed to high external and internal temperatures concurrently, there will be a considerable reduction in hose service life.

7. Choose the Right Connections

Permanent and field-attachable couplings are common on oil field equipment. The choice of permanent or field-attachable couplings is often influenced by cost, convenience, the type of hydraulic application, manufacturer's recommendations, the environment in which the assembly will be used and possible regulatory requirements.

Permanent fittings provide greater performance capability and durability, plus the availability of inexpensive crimpers increases their ease of use.

The JIC (Joint Industry Conference) hydraulic seal, which is the most common in use in the United States and the world, is popular among equipment designers because of its performance versatility, availability and low cost. However, metal-to-metal seals found in the traditional JIC 37° couplings can leak when the metal surfaces grind into each other and leave distortions.

Another popular fitting is the flat face O-ring type of coupling which creates a seal by compressing a rubber

O-ring between a sleeve and fitting body. When an O-ring is part of the fitting, it is critical that the seal material is compatible with the type of hydraulic fluid being used. Even when the correct seal is used, circuit heat can deteriorate the seal over time.

Among the most widely used couplings in heavy construction equipment are four-bolt flange type O-ring couplings, often with 45° and 90° elbows that are bolted to the face of bulkheads, tanks and manifolds; JIC 37° male couplings sealing with mating 37° flared tubes; JIC 37° flare female swivel couplings; male O-ring boss couplings for connection to pumps and valves; male NPTF or pipe thread couplings.

8. Don't Mix and Match

Gates engineers recommend against using couplings from one manufacturer and hoses from a different manufacturer interchangeably. Although most American-made hydraulic hoses, and many imported hoses, are built to conform to SAE (Society of Automotive Engineers) specifications, SAE allows a whole range of materials to be used. Different manufacturers use different materials, which can result in a variety of hose styles.

The proliferation of thread ends from around the world in recent years has dramatically increased the possibility of mismatching threads and seats on various couplings. For example, the only differences between a conventional SAE coupling and a foreign coupling are the thread configuration and the seat angle. The ability to correctly identify all of the different types of coupling can help prevent costly mistakes when assembling replacement hoses.

Also keep in mind that rubber O-rings are not interchangeable with all couplings. A common mistake involves the use of JIS (Japanese Industrial Standard) Komatsu flange fittings with the wrong O-ring. In all sizes, the O-ring dimensions are different. When replacing a Komatsu flange with an SAE style flange, an SAE style O-ring must be used. Selection of the wrong O-ring can result in a potential leak. Once an O-ring has been used to make a seal, it is not reusable.

Some manufacturers such as Gates have introduced specially designed fittings that are equal in leak and weep resistance to flat-face O-ring fittings and compatible with JIC fittings.

9. Follow Proper Installation Procedures

Improper installation of replacement assemblies is another prime cause of leaks in hydraulic hose assemblies. One common installation error results from twisting hoses as they are being tightened. Pressure applied to a twisted hose can result in hose failure or loosening of connections, sometimes referred to as detorquing. Always take into account the manufacturer's recommended minimum bend radius and avoid routes that twist the hose or cause it to bend immediately behind the coupling. The use of two wrenches (one on the hex nut and one on the stem nut) while tightening the swivel fittings will help prevent twisting.

When a coupling is leaking, there is a natural tendency to tighten the fitting. However, over torquing couplings can also lead to leakage problems. Proper torquing is especially critical when flared fittings are used. Too much tightening can result in thread stripping, or deflection or scratching of the cone seat and will prevent proper sealing.

10. Be Prepared

In the oil drilling industry, remote job sites are typical. Being miles from the nearest distributor may require keeping an inventory of hydraulic hoses and fittings on hand, along with a crimper, to minimize downtime. Hydraulic parts distributors can provide a selection of hoses, fittings, crimper and training necessary to meet emergency situations. Always remember to replace used inventory for the next emergency hydraulic assembly replacement.

Additional information

For technical assistance from Gates Fluid Power product application engineers, call 303-744-5070 or email pa0000@gates.com.

To learn more about Gates products and services for oil rigs, visit www.gates.com/oilfield.

For additional information about Gates hydraulic maintenance and safety program, visit www.gates.com/safehydraulics.