

ASSESSMENT AND MANAGEMENT OF HAZARDS INVOLVING HOSES ON DRILL RIGS AND COMPRESSORS

By Ian Speer

This article is intended to provide a basis for further discussion within the industry at large regarding the types of hazards involving flexible hoses that exist on drills and compressors in our industry.

INTRODUCTION:

All drilling rigs use hoses for a variety of reasons ranging from water transfer at low pressure at the low hazard end of the spectrum, through to the high pressure high temperature hoses filled with compressed air and oil that connect the discharge port of 500 psig oil flooded screw compressors to the separator vessels.

Up until quite recently, hoses have been viewed by many operators as durable items to be replaced in the event of failure, or when a major rebuild of the plant in question was being undertaken.

The advent of boosters and higher pressure oil flooded screw compressors has added a range of new hazards with the potential for catastrophic losses in the event of a serious hose failure.

To date, the industry has embraced a range of restraint measures designed to contain the hose in the event of a failure. In the case of machines operating in hazardous areas such as coal mines and offshore, restraints have been augmented by isolating potential ignition sources such as exhaust manifolds and turbochargers from hoses in such a way, that should a hose carrying flammable material (oil) under pressure fail and the oil be sprayed around the surrounding area it could not impinge on a surface that was hot enough to result in ignition and a subsequent fire.

Such measures may provide comfort to the rig owner but they afford scant protection to personnel working in the vicinity who may well be sprayed with near boiling oil (100-125oC) resulting in serious burns or worse.

DEFINITION OF MANAGEMENT OF RISKS WHEN USING FLEXIBLE HOSES ON COMPRESSORS AND DRILL RIGS:

The safest way to achieve lowest hose costs while minimising the operating risks personnel, plant and the environment.

HAZARDS WITHIN THE HOSE:

High pressures

The pressure of a liquid within a hose represents a hazard as a result of being physically sprayed or hit forcibly by a stream released through a failed hose.

In the case of a gas such as air there is the additional danger of stored energy which is released explosively when a hose fails.

High temperatures

As the working temperature of the fluid or gas being conveyed by the hose increases; the life of the hose is reduced; likewise the danger of burns to people working near a hose carrying hot materials is higher than if the hose was carrying cold water for example.

Flammable fluids

If the fluid being conveyed under pressure is flammable or supports combustion then the potential for injury increases.

Pulsation within fluid/gas being conveyed

If a hose is subjected to continuous variations in pressure the hose life will be reduced. Possibly the best example of this is the percussion feed hose on a drifter rig which operates under amazing loads throughout its life.

EXTERNAL HAZARDS AROUND THE HOSE:

UV light

Almost every type of material used in the construction of flexible hoses is adversely affected by UV light. The notable exception I can think of is the flexible stainless steel hose used on some boosters and compressor discharge lines as well.

Physical damage

This can occur as a result of handling such as dragging a booster connecting hose across stony ground, people driving over or walking on hoses or more subtly the self weight of suspended hoses such as those from a drill head to the mast which must flex almost continuously as well as support their own weight during use.

Ignition sources

Any surface or object capable of igniting a stream of flammable material that escapes as a result of a hose failure.

Ambient temperature

Heat can cause eventual hardening of the elastomers in the walls of hoses. It can also soften the outer layer of a new hose and result in it tearing if it is dragged over rough ground.

Installed position

A hose installed in close proximity to very hot areas, or where it has to support its own weight or where it is bent in a smaller radius than the maker recommends, will not achieve its maximum life.

Vibration and cyclic loading

Hoses installed on equipment which is subject to vibration will chafe and wear through their outer layers leaving the reinforcing braids exposed; which in the case of steel wire reinforcement will start to corrode; leading to premature hose failure.

POSSIBLE CONSEQUENCES OF A HOSE FAILURE:

Fire

The failure of a hose carrying flammable material in close proximity to an ignition source will likely result in a fire and loss of plant as well as a good chance of injuring crew in the area.

Injury to crew

Aside from burns, the threat of physical injury due to explosive release of energy when a hose connected to a source of high pressure air fails is very high. Much has been done in the area of hose restraint to control this risk.

Falling load or object

In some areas of a rig the working fluid in the hydraulics supports considerable loads. Reputable manufacturers fit hard plumbed anti fall devices in jacks and mast raise cylinders as well as spring applied brakes to winches.

The area of greatest risk is the rotation head which must be free to move rapidly up and down the mast to allow the rig to function correctly. Rapid failure of the hose which holds the head up when the control valves are closed will result in the head and any drilling tools

attached thereto free falling down the mast with considerable potential to damage the rig or to injure the crew.

Environmental contamination

Failure of a hose conveying any substance capable of damaging the environment will result in a spill with attendant cleanup costs and potential loss of work.

HOSE RATING AND DERATING:

Effect of temperature

All hose makers provide tables setting out the maximum allowable working temperature of each of their types and sizes of hoses. In general the pressure rating of a hose falls as its operating temperature increases.

Effect of pressure

The life of a hose reduces as the pressure that it is called on to convey increases.

Effect of hose diameter

The larger the diameter of a hose for a given construction, the lower its operating pressure

Effect of hose construction

More layers and different forms of construction within the hose itself measurably alter the working pressure and life expectancy of the hose.

In addition the actual type of elastomers used in the construction of the hose has a significant effect on the durability of the hose.

RISK MANAGEMENT MATRIX:

To simplify the assessment of risks associated with the failure of any particular hose and the unplanned release of its contents; hoses were grouped according to potential damage resulting from a failure.

Category 1

- Hoses conveying hot air/oil mixtures 350-500 psig 100-125oC These are the main discharge hoses from the compressor to the separator vessel.
- Hoses conveying hot oil at 350-500 psig and 100-125oC from the separator vessel to the thermostat or the oil cooler.
- Very high pressure hot air hoses mainly stainless steel construction from booster cylinders to aftercooler 500-2500psig at 200-250oC.

Category 2

- Very high pressure air 500-2500 psig. These are the booster outlet hoses and the air feed up the mast to the rotation head.
- Cool oil hoses 300-450 psig and 70-90oC. These are the hoses from the oil cooler to the air end via the oil filters.
- Medium pressure compressed air hoses 300-500 psig usually from the primary compressor up the mast if boosters are not in use or from the compressor to the booster if a booster is in use.
- Load-carrying hoses such as the feed hose from the side of the feed cylinder that supports the head when the control valves are closed. Failure of these hoses will allow the head to free fall.
- High pressure fuel hoses around engine area

Category 3

- High volume hydraulic hoses such as rotation, non load carrying feed hoses and hydraulic return hoses.

- Small diameter 100 psig air hoses (less than 13mm [1/2"] diameter)
- Fuel and oil transfer hoses high volume and low pressure

Category 4

- Non load carrying small hydraulic hoses.
- Drilling fluid injection hoses rock drill oil foam etc.

PROPOSED RISK MANAGEMENT STRATEGIES:

Category 1

Serious injury or death likely, catastrophic loss of plant and possible environmental damage (\$500k plus loss)

These hoses should, where possible, be replaced with steel pipe and expansion joints. If that is not possible then mechanically isolate the hose from any ignition source and shield any persons near the rig from possible spraying with hot oil. These hoses should also be restrained.

The stainless steel high temperature hoses should be 100% restrained with an external sock and preferably a shield under the sock to prevent shrapnel escaping when this type of hose fails.

Note that covering the ignition source will reduce the fire risk, but not reduce the scalding danger. All category one hoses should be professionally assembled by a trained operator and carry a makers tag with date of manufacture and identifying the person who made the hose. All components of the hose should be traceable.

Category one hoses should be replaced at regular intervals based on machine utilisation hours and type of hose.

Fully guarded and restrained stainless steel air hoses can be used to failure while hoses carrying hot oil/air mixtures should be replaced at 5000 hour intervals

Category 2

Significant injury, major plant damage possible environmental damage (\$200k loss)

The high-pressure air hoses (500+psig) should have sock restraints and where possible full length external restraint with no go area signs around these hoses on the ground.

The air feed up the mast should be steel where possible and the flexible hose to the rotation head should have socks and full length restraints to prevent it breaking free and injuring the driller.

The cooled oil hoses from the compressor should be isolated from ignition sources and shielded to prevent scalding of the crew.

Medium pressure air hoses should have sock restraints on the ends and be in a designated no go area.

Load carrying hoses should be checked for external damage every week and replaced if the outer cover is damaged and corrosion has occurred or if any wire ends are felt through the outer cover. These hoses should be replaced when they become hard with age.

All high pressure fuel hoses should meet the OEM specifications of the engine maker and where possible steel lines should be used.

Category 2 hoses should be traceable as for category 1 hoses. The load carrying, cool oil and fixed medium pressure hoses should be replaced at 7500 hours.

The very high pressure boosted air hoses and rotation head hoses that all move regularly should be inspected weekly and replaced

every 1500 hours. They can be retired to service on a lower pressure area of the system as well if they are in good condition.

Category 3

Low risk of injury, some damage to plant and significant environmental damage

Monitor these hoses monthly for physical damage and leaks. Replace when cracking occurs in the outer cover as a result of age hardening. Replace hoses if there are outer cover areas missing and corrosion of the wire braid is present.

Category 3 hoses should be replaced as required and inspected every six months.

Category 4

Low risk of injury or damage to plant and low risk to the environment

Replace these hoses when damaged to the point they no longer function without leaking or they present a hazard due to broken wires/braid protruding.

Category 4 hoses should be replaced as necessary and inspected annually.

OTHER IDEAS FOR CONSIDERATION:

In addition to the risk management strategies there are a couple of proven methods of improving safety around hoses

Rotate hoses in booster duty

In the case of hoses connecting a compressor to a booster and the booster back to the rig, one can use the simple idea of always using the new hose on the high pressure booster discharge and then after its allocated life, given it has not been damaged, this hose is then used on the lower pressure booster feed application, after

which it is discarded PRIOR to failure.

Perforation of high pressure air hoses

The leading manufacturers of high pressure air hoses perforate the outer elastomeric cover of the hose to allow any air and accompanying moisture that finds its way through the lining then into the metal braids to be released to the atmosphere rather than to form bubbles which result in corrosion of the reinforcing wire and eventual failure of the hose.

CONCLUSION:

Many of the preceding ideas are very simple and can be adopted quickly at modest cost. By focusing on the higher risk areas plant safety can be measurably improved.

Others areas will involve real expenditure and the payback will be slower but no less real coming in the form of lower accident claims thus resulting in lower insurance premiums.

ACKNOWLEDGMENTS:

The majority of the material has been derived from observations of the best practices of many companies over some years. This article will have been successful if a single injury or serious loss is avoided as a result of adoption of one or more of the ideas expounded herein.

This article first appeared in Australasian Drilling, July/August 2004 and is reprinted with permission. Copyright The Australian Drilling Industry Association Limited 2004.