2/2012

Hydrogen Sulfide — Standard Cables

Hydrogen Sulfide (H2S), is lethal to breathe, very corrosive, and it can embrittle the standard GIPS (Galvanized Improved Plow Steel) armor wire used on oilfield electromechanical cables. When water is present and galvanized steel armor wires come in contact with H2S there is a chemical reaction. The first and fastest reaction is with the Zinc resulting in the formation of Zinc Sulfide, which is black, in addition to the release of nascent or atomic Hydrogen (H). The second and ongoing reaction is with Iron forming Iron Sulfide and again atomic Hydrogen.

The more stable state of Hydrogen is H2. However the reaction we are discussing results in a large percentage of atomic hydrogen which is extremely small. The molecules are so small they can diffuse and accumulate within the crystal structure of steel. As the accumulation continues the atomic Hydrogen seeks a more stable state and combines with another H forming H2, which is twice as large as H. In this larger state it does not diffuse back out of the structure as easily as it went in. This packing of Hydrogen in the steel crystal structure generates an internal stress and in time can lead to micro-stress cracks in the steel. Even before there is advanced stress cracking, the accumulation of Hydrogen in the steel crystals results in the crystals' elements being unable to move internally, causing the steel to become extremely brittle. A strand of GIPS wire exposed to sufficient Hydrogen Sulfide can result in the steel wire breaking like a glass rod when bent.

After the Zinc has been used up in the chemical reaction the H2S continues to react with the Iron. This action can take place faster in the presence of water. If the well fluid is mostly oil, then the reaction of dissolved H2S on the cable is slower but there are no safe or unsafe standards.

The presence of CO2 where there is water present results in the formation of carbonic acid. This acid environment seems to accelerate the action of H2S on iron, but again the published data is not complete enough for any standard guidelines to be complete. Another catalyst occurs when the carbonic acid etches the steel surface providing additional surface area exposed to the effects of H2S. Field experience has shown that when CO2 and H2S are both present in bore hole fluids that include water, the embrittlement of steel is much faster and more severe. In addition to CO2 the well pressure, temperature and the total time of exposure are factors that can radically affect the degree of embrittlement.

The above guidelines are very general and what is safe depends on a number of other factors. The nature of H2S embrittlement is that up to a point the embrittlement is reversible without permanent damage to the cable. Over time the H2 will diffuse out of the wires and the cable will return to normal.

If a standard cable has been exposed to H2S and has successfully come out of the hole, you need to make a quick check of the armor wire by bending a wire around a rod (2 to 3 times the wire diameter) 5 complete wraps. Unwrap the wire; if it does not break then it is likely there has been no permanent damage by micro-fracture, and the cable can be saved. The H2 in the cable armor will ultimately diffuse out of the armor. If a wire breaks in this wrap test but there were no outer armor wires broken coming out of the hole, then it is best to let the cable sit for a few days to allow the H2 to diffuse out of the wires. Do not use this cable in an H2S well again until it has made several trips in normal wells and the wrap test has passed.

Although not recommended, if you are considering running a standard, plow steel, cable in a well containing H2S, then here are several pointers:

- Run an older cable, less Zinc
- Use plenty of the pressure control grease, Liquid "O" Ring 4-I, (or equal)
- Use larger diameter sheave wheels
- No hydraulic pack off pressure
- Use more flow tubes with greater clearance, 0.004"
- Get in and out of the hole as quickly as possible, within correct operating speeds

If your operating conditions do not fall within these guidelines, then an alloy cable should be used. H2S and alloy armored, MP35 and stainless steel cables will be covered in another technical bulletin.