THE SOURING

Ian Kinnear, Product Manager, GPT Industries, addresses the impacts of hydrogen sulphide, particularly on corrosion and electrical bridging, and provides solutions to these challenges.

Hydrogen sulphide (H_2S) has become an increasingly concerning issue in oil and gas pipelines around the world. Also known as sour gas, H_2S is highly toxic, explosive, and corrosive, posing significant safety and infrastructure risks.

Where is H_2S coming from?

H_2S naturally occurs in some reservoirs as a component of raw natural gas and crude oil. Additionally, it can be introduced into pipelines through microbial metabolism of sulfur-containing compounds. The oil industry is accessing more challenging reservoirs, with many containing higher levels of H_2S than traditional resources. Operators are also maximising efficiencies by processing and transporting multi-phase mixtures with heightened H_2S concentrations rather than constructing dedicated natural gas pipelines. These factors mean pipelines are transporting more sour gas than ever before.

Impacts on pipeline integrity

Corrosion is the primary threat H_2S introduces to pipeline integrity. When moisture condenses on pipe walls, H_2S reacts with the steel, producing various iron sulphide corrosion products. At higher concentrations, H_2S corrosion can lead to pitting and cracking, which severely undermine pipe strength.

Another emerging issue exacerbated by the presence of H_2S is electrical bridging across pipeline isolation joints. Isolation joints strategically installed at certain points along the pipeline are designed to control electrical current flow from cathodic protection (CP) systems. Stray current leakage reduces CP system effectiveness, wasting power while leaving unprotected pipe segments vulnerable to accelerated corrosion.


OF PIPELINES

Figure 1. An extreme case of iron sulphide or better known as black powder, build up inside of a pipeline.

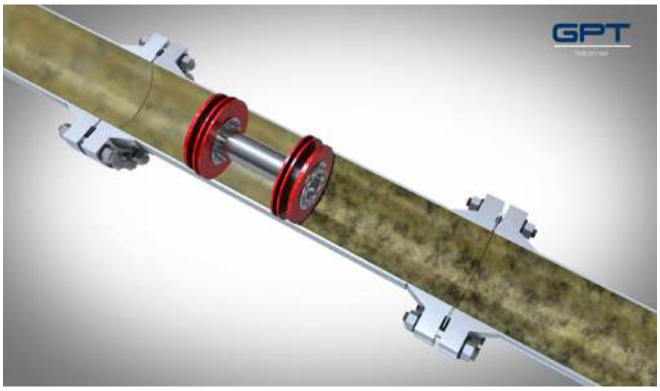

Figure 2. An example of an inline inspection tool running down the pipeline which may push hot tappings or debris across the flange face.

Figure 3. The flange connection, where electrical bridging can take place if built up occurs.

Electrical bridging explained

Electrical bridging occurs when an electrically conductive material, often iron sulphide corrosion products, spans the isolation joint to create a current pathway between pipe segments. This provides an easier path for CP current to flow than the intended circuit through the soil back to the rectifier. When bridging happens, CP systems continue pushing current through now-connected sections rather than forcing it to disperse into the ground. This can often be seen by what are called travelling shorts. Travelling shorts occur as a pipeline cleaning pig goes down the line and deposits this iron sulphide at the flange interfaces. When this occurs, you will see a shorts travel down the line as the pig does, being isolated before but potentially no longer after.

Iron sulphide, known in industry as black powder, readily precipitates from H_2S-tainted condensate within pipelines. Over time, iron sulphide deposition can completely mask isolation joint gaskets. Its extreme conductivity enables sustained electrical connectivity between flanges, bypassing the isolation joint's function. The iron sulphide sludge apparent in Figure 1 illustrates the severity this bridging phenomenon can attain.

Similarly, errant metal shavings from hot tapping or debris from inline inspection tool runs may lodge across isolation joints. Welding spatter can also introduce metallic bridging paths. However, iron sulphide from H_2S-influenced corrosion tends to cause the most persistent, widespread bridging problems over the long term.

Effects of uncontrolled bridging

When designing a piping system, isolation is always put in place for a specific reason. There are several different reasons why isolation would be used, with each of these causing a benefit in terms of corrosion mitigation, safety, protection, cost or a combination of all these. When systems experience electrical bridging, isolation across the bolted flange assembly is no longer maintained, resulting in the opposite effect than what was designed for.

If there is no longer isolation being present between the flanges, a number of direct effects can take place. The first is that there is a significantly higher potential for increased rates of corrosion. Isolation is typically used in conjunction with corrosion prevention methods, and a loss in isolation can mitigate these corrosion preventions. In addition to this, there can be potential large expense losses in capital and operational spend. Wasted cathodic protection current and unnecessary rectifier operation drives up expenses while potentially failing to adequately protect all assets. Large amounts of time and resource also typically then needs to be spent to troubleshoot and provide solutions, which many times comes at the expense of downtime to the system.

In addition to these, isolation can be a means of mitigating stray current. With a loss in isolation, stray current can promote disbondment of protective coatings from pipe surfaces, enabling under film corrosion. If pipe structures are no longer protected as a result of isolation being lost due to electrical bridging, localised corrosion damage can occur, resulting in pitting, cracking, and wall loss in the pipe. Over time, this can cause leaks or ruptures in the pipeline, leading to multitudes of issues in this regard.

Seeking solutions

Left unaddressed, electrical bridging will over time lead to the challenges discussed above, which can be incredibly costly for the system. Fortunately, improved isolation joint technologies can help combat bridging.

Monolithic isolation joints (MIJs) with internal coatings substantially extend the effective isolating distance, impeding electrical bridging. Instead of using a bolted flange assembly with a flange isolation kit, a monolithic isolation joint welds directly into the pipeline and provides the same electrical isolation capabilities. When the MIJ is internally coated, the effective isolating distance becomes that of the joint itself, as opposed to being the width of the isolation gasket in a flange isolation kit. The coating increases the amount of distance that bridging would have to span in order for isolation to be lost. However, not every system can utilise the MIJ design. In these cases, flange isolation kits will still need to be used.

When utilising a gasket in these applications, the first consideration that must be taken is ensuring that the gasket ID at least matches the pipe bore. The reason for this is because if the gasket ID is larger than the pipe bore, this will allow for there to be a gap between the flanges. This gap creates a perfect place for conductive media to build up between the flange faces and create an electrical bridge. In the most challenging cases, a slight protrusion of the gasket ID into the pipe bore has also been successful, to again effectively increase the isolation distance where build up can occur.

Gasket enhancements have also been made specific to overcoming challenges that come from electrical bridging. Utilising a gasket with a PTFE inner diameter seal has proven to provide benefits in terms of electrical bridging. The ID seal allows for the only material to come in contact with the media to be PTFE, which creates a non-stick surface to prevent build up at the gasket and flange face, where isolation could be lost. The ID seal also ensures that the metal core of the isolation gasket is no longer exposed, as it typically would be in higher pressure models. This increases isolation efficiency by again increasing the effective isolating distance, whereas previously the metal core exposed made this distance short. Strategically recessing or protruding the gasket ID relative to the pipe inner wall controls the potential for deposit accumulation at flange faces.

The example above illustrates how a PTFE-sealed Evolution gasket successfully maintained electrical isolation where previous metallic cored gaskets had repeatedly failed. Its non-stick PTFE ID seal prevented bridging deposit adhesion even with highly conductive produced water.

You can't manage what you don't measure

In addition to providing solutions that can help mitigate electrical bridging from taking place, remote monitoring can provide solutions towards ensuring the isolation is being

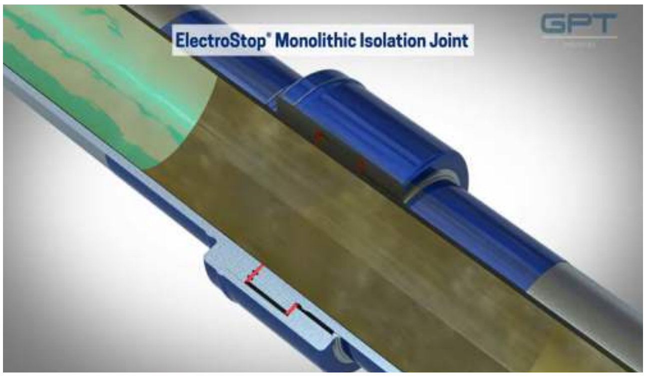

Figure 4. An internally coated GPT monolithic isolation joint, which provides the longest effective isolating distance.

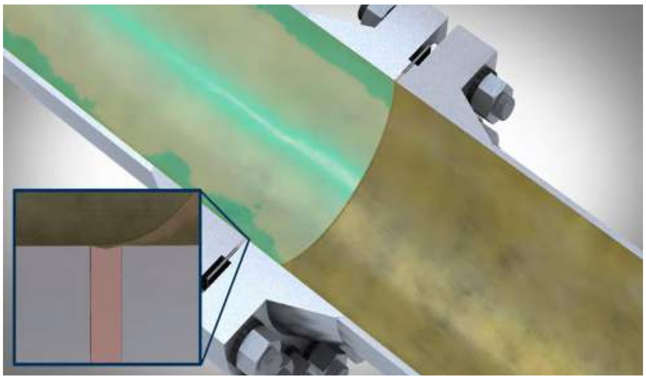

Figure 5. GPT Evolution gasket, utilising a reinforced PTFE ID seal, used specifically to combat electrical bridging challenges.

maintained where it is designed to be. When electrical bridging takes place, the isolation flange will pass isolation tests when installed, but likely fail isolation at some time when in service. Without monitoring, there is no way for operators to know exactly when this isolation failure occurs and on what flanges it is taking place. By using remote monitoring, there can be a constant view to ensure that the flange is indeed isolating or be able to track any changes that may occur. If isolation is lost, an alarm will be sent highlighting this so the operator is aware to proceed. This remote monitoring of isolation will keep the health of the pipeline where it needs to be, instead of simply assuming the system is working as intended.

Looking ahead

Specification of properly configured, bridging-resistant isolation products plus accurate remote monitoring of the system will become increasingly necessary to manage growing H_2S-related pipeline integrity risks. As reservoirs sour and throughputs rise, H_2S is fast transforming from an occasional nuisance into a pervasive, potent pipeline threat, and along with this comes the challenges with electrical bridging as well. Adopting the latest isolation technologies, monitoring technologies and corrosion prevention strategies will prove essential to safely transport production, protect infrastructure investments, and avoid catastrophic failures.