PREVENTION BETTER THAN CURE

Pipeline inspection, testing and verification play a crucial role in protecting some of the downstream sector's most valuable assets, reports Mark Atkinson

As many GCC countries begin to broaden their focus from upstream activities such as exploration and production to downstream refinery and pipeline processes – and in light of last year's Gulf of Mexico Macondo oil spill – the importance of having sound inspection processes in place has never been greater.

Maintaining pipeline integrity is crucial on many levels. First is to protect what is a considerable financial investment. Second, pipeline failure may not only have serious safety and environmental implications, but there are also the extensive costs of downtime – particularly over an extended period. Third is the issue of prolonging the overall lifespan of the pipeline.

"The risks are that if the material is not inspected properly and frequently at procurement and/or whilst in service, unexpected premature failure is unavoidable," comments Chris Muir, American Society for Non-destructive Testing (ASNT) section chairman. "The cost of such incidents has a domino effect. Rig shuts down, there is a loss of assets, reconfiguration of wells or

Testing in the pre-commissioning phase

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Chris Muir, ASNT-UAE section chairman

even abandonment. At the end of the day, budgets are exceeded and costs go up."

As Ajit Pandey, principle engineer, DNV Abu Dhabi adds, "Pipeline integrity has surely received more attention in the recent years, with the increasing dependence on oil and gas for meeting energy needs." DNV provides 'cradle to grave' pipeline services – from design, manufacture, installation, commissioning, and in-service inspection through to de-commissioning. One of its own recent contributions to pipeline standards is DNV RP F116 – Integrity Management of Submarine Pipeline Systems, 2009.

At the same time, inspection methods in themselves have changed little over the last 30 years. "The recording of information has moved from manual to computerised and digital imaging - however the basic principles of NDT methods such as magnetic particle, electromagnetic and ultrasonic testing have remained the same," observes Muir. "This is not to say that the methods and techniques are left behind…rather they are demanded more frequently by the end users, raising confidence from the outset."

In fabrication

Many of the inspection methods prior to commissioning of the pipeline involve checking the integrity of welding and condition of the pipe. Dye penetrant, or liquefied penetrant testing, detects any cracks in the weld. The area to be inspected is first cleaned then a liquid dye is applied to the material's surface and left for a set time period - usually around half an hour. After washing the liquid from the surface, the defects - or 'indications', that the liquid has penetrated are clearly visible.

Magnetic particle inspection (MPI) involves applying a magnetic field to iron particles placed on the test surface. When the magnetic field is disturbed it forms around the indication and shows the defect. Similarly, magnetic flux leakage detects corrosion and pitting in pipelines and other steel structures. Here, a magnetic field 'leaks' from the steel when corrosion or missing particles are detected.

Like visual inspection, the above methods are valuable within their limitations but cannot detect internal flaws. Conversely radiographic testing (RT) passes X-rays and gamma rays through the weld to produce an image which shows its internal imperfections. Digital radiography is also a common technique to monitor pipe corrosion and wall thickness when insulated.

Ultrasonic testing (UT) also detects internal welding flaws and monitors pipe corrosion/thickness using high frequency sound energy. A handheld device sends high voltage electrical pulses into the material being inspected. These are reflected back when they hit any kind of pit, crack or deformation, showing the location, type and size of the defect.

API 5L Annex E requirements indicate

A drilling mud spill resulting from pipe failure

the type and extent of inspection required for different quality levels," explains Sebastian Fernandes, senior NDE Engineer, Petrofac Engineering & Construction. "PSL quality (the specification for pipes) requires 100 per cent UT, RT of 200mm at each end of the pipe length and MPI of the weld bevel at each pipe end."

The applicable code for field inspection is API 1104, he continues. This involves a check for residual magnetism at each pipe end and MPI of bevel ends before joint fit-up. It also requires UT on a band of a minimum 25mm width all along the circumference to ensure there is no lamination.

There are also some significant differences to consider between onshore and offshore pipelines. "Offshore pipelines are subject to the offshore environment, including the static and dynamic loads imposed by the water body," remarks Pandey. "The design, construction, installation and operation have to take into consideration buoyancy, wind, wave and current loads – as well as other loads such as trawl gear interference or anchor drags, which are typical of the offshore environment. Onshore pipelines have fewer loads and third party damage to consider."

At the same time, offers Dave Torbet, regional technical advisor pipeline and process services, Halliburton, "Onshore lines often face a myriad of internal diameters, as the wall thickness may be increased at road crossings or in high water tables."

In terms of inspection says Fernandes, "In most cases, where the client accepts it, offshore pipelines use some form of automated UT – either conventional or phased array UT (the latter uses a number of small ultrasonic elements that can be pulsed individually and is also used in medical applications such as imaging the heart or womb). Phased array UT is becoming more popular these days because of accuracy, ease of detection and sizing of discontinuities.

> "Incidents such as the Gulf of Mexico spill have placed a far stronger focus on real time data capture"

"UT saves a lot of time and also avoids the [radiation exposure] hazards related to RT," he continues. "For applying UT in lieu of RT, usually an Engineering Critical Assessment (ECA) is required." An ECA is the criteria by which defects are accepted or rejected, based on their location or defects within the weld. Acceptance criteria do not differ between oil and gas as such, observes Fernandes, although they may vary based on the more specific type or composition of the fluid the pipeline is designed for.

Finally, a geometry and caliper inspection is conducted in order to detect any deformations such as bulges, dents or ovations, also checking construction elements such as bends and joints.

Pre-commissioning

The last step before commissioning is hydrostatic testing or 'hydrotesting', to determine the overall integrity and likelihood of leakage within the pipeline. This includes flaws in the material, stress corrosion cracking or localised spots that may cause failure in operation. Hydrotesting involves running water through a pipeline to assess whether its structure is able to withstand the maximum operating pressure of the material it has been designed for. Unlike the non-destructive testing methods described above however, it cannot detect material flaws.

"Hydrotesting is normally carried out as part of pre-commissioning, coupled with the line cleaning and gauging," explains Torbet. "This is carried out with treated seawater in offshore situations."

For onshore pipelines, it is common for the pre-cleaning and gauging to be carried out with air and the line hydrotested in sections typically not exceeding 25km, due to the higher thermal effects compared with offshore. "This results in difficulty establishing pressure loss due to variance in depth, groundwater and resultant thermal impact," Torbet concedes.

Hydrotesting presents its own environmental issues however. "In an area like the Middle East where natural water supply from lakes/rivers is limited, water has to be tankered to the site or water wells drilled," he continues. "Conservation of this water is critical, and is moved on from section to section by dewatering after each hydrotest. Hydrotesting may also be required after line repair. This may result in waste-handling issues or if the line requires dewatering."

In operation

Monitoring the integrity and efficiency of the pipeline continues throughout its operational life. Further emphasising the importance of pre-commissioning checks, any failure during operation itself is much more complex to resolve.

"Proven leakage can be hard to find," says Torbet. "A seep from a buried land line may not reach the surface for visual identification, and the concrete coating and currents on a subsea system may mask the discharge of any dye."

One technology used to check the integrity of a pipeline during operation is pigging. Here, automated gauges, or 'pigs', run through the pipeline carrying out cleaning, maintenance or inspection tasks without interrupting production. As it moves and collects data along the line, it records its position, so after its run, positional data can be combined with its evaluation.

UT and multi-flux leakages (MFL) pigs are typically run to check the line after it has been in service for a while, as these are used to look for cracks and corrosion (both inside and out). They also pick up ovality and some other deformations - although not to the same degree as the calliper inspections. "There is a tendency for these IPs (intelligent pigs) to be run either in the pre-commissioning phase, or with the product shortly after commissioning, as a base line survey," says Torbet. "Thus future runs can be compared with the new-pipe condition, so as to identify problem areas and assist in estimating pipeline life."

New developments

While it falls into the drilling rather than pipeline category, the Gulf of Mexico Macondo spill last year was a wake-up call for many and may cause those in both upstream and downstream operations to revisit their inspection processes. Not only did the spill cause catastrophic damage to the environment, but also to the livelihoods of entire fishing communities.

Assigned by the joint investigation team of the US Departments of the Interior and Homeland Security, DNV conducted a forensic examination of the blowout preventer and lower marine riser package fitted to the Macondo well.

After the investigation, DNV launched a new recommended practice for recertifying drilling equipment, DNV-RP-E102 - Recertification of Blowout Preventers (BOPs) and Well Control Equipment for the US Outer Continental Shelf June 2010. As a result, the US Department of the Interior issued a document, Increased Safety Measures for Energy Development on the Outer Continental Shelf May 27 2010. Key recommendations include mandatory inspection and overhaul of BOPs across a whole new range of criteria, new safety features and requirements for back-up equipment. While the titles of these documents suggest an emphasis towards the US market, their implications are equal if not more relevant to the GCC's oil-producing countries.

As Richard Kluth remarks in a report on pulse structural monitoring, incidents such as the Gulf of Mexico spill have placed a far stronger focus on real time data capture. One of these has been strain measurement, using sensors mounted on the outer surface of a drilling riser.

Back to pipelines, "UT/MFL (pigging techniques) are being favoured as the latest processes for base line survey, as well as regular checks throughout (the pipeline's) lifetime," says Torbet. "This is in order to determine potential problems such as premature corrosion in certain zones - before some catastrophic event takes place."

Another more recent but now widely-used technology is guided-wave testing, where mechnical stress waves are sent down the length of a pipeline to perform a number of ultrasonic tests.

In the meantime, many tried and tested inspection methods remain standard practice. But as the aspect of inspection, verification and testing takes on increasing importance, new methods and technologies will evolve.

Inspection helps prevent such corrosion, often caused by fluid flow

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>
> **Sebastian Fernandes, senior NDE Engineer, Petrofac**

SHARING INFORMATION

The Pipeline Performance Tracking System (PPTS) was first initiated by the American Petroleum Institute (API) in 1998 to gather a collective database about safety and environmental performance within the oil pipeline industry.

Its members comprise firms within the industry that enter incident and infrastructure surveys into the PPTS. These are used to evaluate the industry's overall performance, gain a better understanding of the issues and identify trends that other members can utilities within their own organisations.

The aim of PPTS is to continuously improve industry performance and move toward the eventual goal of error-free and spill-free operations. There is no fee for participation.

Source: www.api.org