

Improving corrosion inhibition

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Recently developed “spray pig” helps offshore operators gauge the success of their corrosion inhibitor applications.

Top-of-line corrosion (TLC) is an inherent problem in high carbon dioxide, wet and multiphase gas gathering or gas transmission pipelines due to the difficulties of adequately delivering corrosion inhibitors to the uppermost area of the inner pipe wall. Subsea pipelines can be especially susceptible to TLC and thus are at high risk for premature failure if corrosion develops; offshore lines in Southeast Asia have, in some instances, suffered from serious TLC-induced degradation. Millions of dollars have already gone into repairing or even replacing subsea lines compromised by corrosion. Regardless of the line location, unchecked corrosion can easily cause large-scale production losses. Should through-wall failure occur, environmental damage could be severe.

Until recently, the standard response to the threat of line corrosion was batch treatment using a solid chemical slug or column held between two batching pigs. The goal was to keep the chemical intact and contacting all surfaces of the inner pipe – including the upper wall – long enough to deposit a corrosion-detering protective film. In many cases, batch treatment can still be a viable option. However, when you factor in manpower and equipment requirements, chemical expense and production loss, batch treatment is not cheap. Even more worrisome for some operators is the fact that inline inspections have shown that, in many instances, batch treatment is not effective in offshore lines. One reason for this is that it is very difficult to maintain the integrity of a chemical slug

through the vertical drop that results when sending batch treatment from a platform down into a subsea line.

In response to both the TLC phenomenon and the realization that batch treatment is not always effective in combating corrosion, many pipeline operators have sought out other chemical treatment options, such as the patented V-Jet “spray pig” technology developed by Rick D. Pruettt and others of T.D. Williamson, Inc. (TDW), with assistance and support from Yves Gunaltun and his former team at Total (France). Ongoing developments of this tool have included incorporation of a data-logging system, the brainchild of Pruettt’s initiated at the request of consultant Robert

J. Waterhouse. This system has been co-developed with Pruettt by TDW engineers Tyler Lloyd and Robert Strong. As embodied by TDW’s V-Jet Corrosion Inhibitor Pig and the recent Semi-Smart V-Jet (with data-logger) version, spray pig technology relies on a series of nozzles mounted on the front of a pig to disperse chemical inhibitor (introduced into the line in conjunction with the pig) onto the “hard to reach” upper regions of the inner pipe wall.

Spray pig primer

Though the use of spray nozzles to disperse inhibitor upward is innovative, part of what makes the V-Jet pig attractive is its basis in two simple, standard pigging con-



T.D. Williamson’s Semi-Smart V-Jet Pig just prior to an offshore run in Southeast Asia.

Performance data collected by the Semi-Smart V-Jet Pig can be downloaded by a technician following a run.

cepts: differential pressure and bypass flow. A typical pipeline pig is pushed by the flowing pipeline product. As pressure building up behind the pig exceeds the pressure in front of the pig, the pig moves forward. This difference in the pressure from the front to the back of the pig is known as the “differential pressure,” also commonly called Delta P or simply DP. The concept of “bypass flow” is used in many types of pigs to vent pressure from the back to the front of the pig, allowing movement of product (liquid and/or gas) through the pig as it advances downstream. Bypass flow and differential pressure are the only dynamics required for the pig to work.

The special pigging device allows the higher pressure to bypass through its patented body and spray head design. As the pig advances, residual inhibitor fluid, mixed with liquid that has pooled on the pipe bottom, is drawn up and sprayed onto the top area of the inner pipe wall. Bypass acts as the accelerant to transfer and vaporize this fluid by creating a low-pressure area in the spray head as the bypass flows through (due to what’s known in physics as the Venturi Effect). This drop in pressure produces the relative vacuum at the front of the pig that draws up the idle inhibitor fluid to be redeployed. The inhibitor-rich spray is not only directed toward the top of the pipe, but it also creates a dense inhibitor “cloud” that grows out ahead of the pig, extending the contact time and overall effectiveness of the inhibitor. Additionally, the drive cups on the pig tend to “press” the inhibitor against the pipe wall as the pig moves along the line.

A counterweight system is used to ensure proper orientation of the spray head so that the pig projects inhibitor fluid upward at an approximately 45-degree angle from parallel to the centerline of the pipe. The fluid fans out through the top 120 degrees perpendicular to the centerline of the pipe. Multiple nozzles are used on all pig sizes, with the number of nozzles increasing as the pig size goes up in order to increase the delivery and coverage area for larger diameter pipelines. For liquids



with physical properties similar to water, each nozzle typically delivers about two quarts of fluid per minute at 15 psi. Inhibitor delivery rates do vary depending on differential pressure, fluid viscosity and specific gravity. Higher efficiency nozzles are employed on the larger diameter pigs.

Another feature designed into the pig is its short-term reservoir. Line pressure forces fluid that is immediately behind the pig into this reservoir area, and it is then directly jetted through the nozzles onto the upper pipe wall. As this fluid is jetted forward, the excess gathers in front of the pig, where it is drawn back into the pig and redeployed. This circulation of the inhibitor fluid continues throughout the pig run until the fluid has completely dissipated onto the pipe wall.

Usage methods

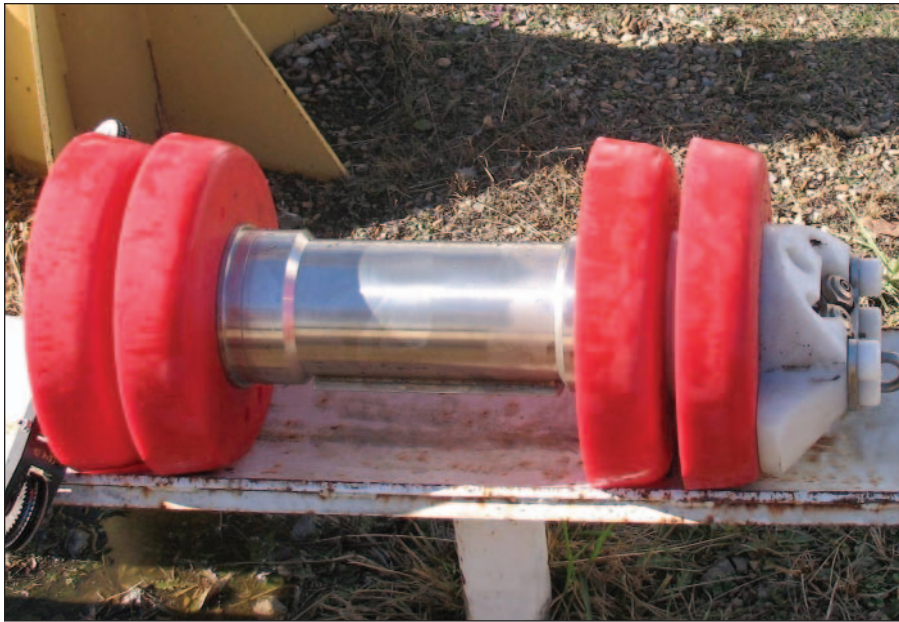
Though it offers simplicity of design, the V-Jet pig can be used in a variety of ways. The simplest method of using the spray pig can be applied when continuous injection is the primary means of introducing corrosion inhibitor fluid into the pipeline. This method is effective on relatively level lines and pipelines with a continuous upgrade, such as those associated with offshore wells. The spray pig has proven to be a very effective dewatering pig while it distributes inhibitor-containing fluids to the top of the pipe. In this manner, a dense vapor cloud is created in front of the pig as it splashes through and jets the liquids from the bottom of the pipe up to the top.

Another method of using the spray pig in a single pig application is what is known

as “lock and load,” so named because the pig is inserted into the launcher, which is then locked. Inhibitor fluid is loaded into the launcher through a fill valve prior to launching of the pig. This technique is particularly useful when applied to relatively short pipeline runs that may not use continuous injection as the primary means of corrosion control. Adding a slug of inhibitor in the launcher behind the spray pig permits a vapor cloud to be formed at the very beginning of the run.

A third option is to run the spray pig in batching mode, which can be useful if no inhibitor fluid is present in the pipeline, if the line is too long to load an adequate supply of inhibitor in the launcher, if there is a long, steep downhill section in the line, or if there’s a need to reduce pig velocities associated with speed excursions. The spray pig is designed to be used as the front pig and/or back pig (preferred) in batching mode. If the spray pig is run behind a standard batching pig with a slug of corrosion inhibitor between them, the spray pig develops a higher differential pressure across the spray nozzles, resulting in higher jetting intensity as the front pig surges ahead.

Also, the bypass flow through the pig at the rear of the slug is normally gas, which does a better job of energizing the spray than liquid bypass, which would be prominent if the spray pig were at the front. Batching may be advantageous in larger diameter applications (to help make sure inhibitor is making it onto the top wall adequately) and on lines with multiple elevation changes. It’s also worth noting that,



when using the spray pig as a batching pig in front, especially, it is not necessary to have a solid slug of inhibitor fluid between the pigs. Rather, a “bow-wave” effect will tend to keep the fluid level well above the suction ports at the bottom of the spray head since gas flow rate (and thus, pig speed) is generally faster than the liquid flow rate.

Quality control

In order for a spray pig run to be truly successful, several conditions must be met. First and foremost, the pipeline must be piggable, meaning valves are open, obstructions are removed, and bend radii are adequate (at least three times the pipe diameter in most cases). Assuming these prerequisites are met, the line should also be clean, both to prevent debris from building up in front of the pig and disrupting nozzle operation and to make sure that the inhibitor fluid is actually contacting the pipe wall (rather than simply coating scale, black powder or other compounds attached to the wall). Paraffin buildup, for example, can affect a tool's orientation, the amount of inhibitor-to-wall contact, pig speed and jetting action. Finally, a corrosion inhibitor compatible with product and other constituents in the pipeline must be utilized.

Assuming an adequately prepared pipeline and proper inhibitor and spray pig usage, the challenge then becomes how best to gauge the effectiveness of the

run(s). To gauge effectiveness, it is necessary to know if inhibitor fluid is being successfully delivered to the desired pipe surface and at the desired film thickness. Further, there is a need to verify that this delivery is happening at the right frequency to maintain the chemical film intended to inhibit corrosion and thus preserve the pipe wall's integrity.

Attempts to gauge effectiveness are hindered by a number of variables at play in any inhibitor application program, including chemical performance, changes in fluid composition and changes in operating conditions (such as temperature, pressure and flow rate). All of these variables need to be considered when planning a spray pig regimen and when attempting to gauge a regimen's success. For onshore pipelines, use of top-line corrosion coupons and frequent, regular monitoring (perhaps monthly) is a good way to validate success. Due to the lack of access to offshore pipelines, the best method for gauging inhibitor application effectiveness has been through the use of inline inspection (ILI) tools. Though they are capable of mapping the total length of a line and providing detailed information on wall defects, these tools are costly and, therefore, infrequently run (typically bi-annually). This inherent time gap between when a chemical treatment plan is undertaken and when the inspection tools can map changes creates a potential delay in detecting problems in inhibitor application.

Development of the Semi-Smart V-Jet Pig was prompted by needs to verify tool performance required for successful application of corrosion inhibitor fluids inside pipelines.

Data acquisition

To eliminate this gap and provide more immediate feedback on the performance of a spray pig in any given application, engineers at TDW have developed a “Semi-Smart V-Jet Pig,” so named for its incorporation of some, but not all, existing inline inspection technologies into the body of the pig itself as an on-board datalogger. It is, essentially, a spray pig with a brain. Capable of operating under normal spray pig conditions, this pig is equipped to collect a variety of information during every run. This includes data on differential pressure, which is helpful because, as previously noted, Delta P is of key importance to achieving proper jetting action. The semi-smart spray pig gauges pressure at both the front and back of the pig.

In order to be effective, a spray pig must deliver inhibitor to the top of the pipe. To verify that this is indeed happening, the semi-smart design also monitors rotation/orientation of the pig. The data acquired by the device offers a complete three-dimensional profile of how the pig moved throughout the run, including tool rotation, spray nozzle orientation and port orientation. Should an improper orientation occur, the pig's sensors can tell whether this was temporary or permanent, and where it took place in the pipeline (for example, relative to known corrosion areas).

To be optimally effective, a spray pig should stay within speed limits that allow for proper contact time between the inhibitor and the pipe wall. The semi-smart design includes an odometer to generate a speed profile on the run, as well as accurate location of events recorded during the run. It may be possible to calculate the minimum inhibitor contact time for specific pipe segments within the run and cross-check this with vendor suggestions. Contact time is generally longer than what

would be calculated due to the extended cloud of inhibitor that forms in front of the pig. This information can also be used to help guide increases and decreases in the frequency of spray pig usage.

The semi-smart spray pig design is also capable of measuring temperature. Gauging temperature is helpful because it is believed that TLC occurs in specific temperature ranges; accurately gauging line temperature throughout a run can spotlight areas that may be most susceptible to corrosion. Or, when used in conjunction with other inline inspection devices, this temperature data may offer insights into the conditions that are most conducive to corrosion development.

Last but not least, the semi-smart design allows for acceleration logging. In other words, for the measuring of speed excursions during a pig run. Speed excursions are typical when running in gas pipelines but are not conducive to consistent, manageable corrosion inhibitor application. Monitoring these excursions, and matching them to specific line locations based on odometer readings, can offer further valuable insight into overall jetting performance during a given run.

Looking ahead

The Semi-Smart V-Jet pig is but one example of newly emerging tools that seek to accurately gauge and treat top-of-line corrosion in hopes of avoiding or at least minimizing the instances of pipeline failure due to this phenomenon. Certainly more work remains to be done before the corrosion mechanisms are fully understood or fully controllable. While devices such as the semi-smart spray pig are significant steps forward, it is anticipated that future developments may include stand-alone sensor and data logging devices capable of being attached to, or delivered by, pigging tools rather than sensor combinations built into the body of a specific pig. The versatility of such stand-alone sensor devices would facilitate even wider use of this technology and a consequent broader understanding of corrosion development and mitigation in a variety of environments. ■

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