Corrosion Monitoring of Non-Common Carrier North Slope Pipelines

Technical Analysis

Of

ConocoPhillips Alaska Inc. – Commitment to Corrosion Monitoring Year 2004 for Greater Kuparuk Area & Western North Slope

Submitted by

COFFMAN ENGINEERS
800 F Street
Anchorage, Alaska 99501
907/276-6664
907/276-5042 Fax
www.coffman.com

ADEC Contract Number – 18-6000-02

Table of Contents

EXECUTIVE SUMMARY

Coffman Engineers, Inc. has been charged with reviewing the 2004 corrosion program report submitted by ConocoPhillips Alaska, Inc. (CPAI) to the Alaska Department of Environmental Conservation (ADEC). The report outlines the measures undertaken to manage corrosion in CPAI non-common carrier North Slope pipelines. In addition, Coffman reviewed the presentation materials from the 2005 Meet & Confer sessions.

The data provided by CPAI supports the conclusion that the corrosion management program is effective and exceeds common industry practice. Sufficient information has been presented to demonstrate that the corrosion control program meets the intent of the Charter Agreement.

The CPAI corrosion program emphasizes the identification of locations where 1) the likelihood of previous damage is greatest, and 2) corrosion rates are likely to be highest. Highest priority is placed on locations where the likelihood of damage and high corrosion rates coincide.

The overall corrosivity of the three phase production system is relatively low, but isolated locations of accelerated corrosion are known to exist. These locations are identified primarily through an extensive inspection program and controlled by chemical corrosion inhibitors.

Although seawater and produced water injection systems are normally considered to have lower susceptibility to corrosion compared to three phase production systems, a leak occurred in 2005. Although information existed on increasing corrosion rates, the lack of previous corrosion in this system did not prompt a major increase in its risk priority. Because of the leak, the injection system priority was elevated and increased mitigation and inspection actions are being taken.

External corrosion of above-ground piping is largely confined to weld packs, and CPAI has made a notable commitment to removing this threat through inspection and repair (where necessary) of all locations.

External corrosion at cased crossings represents a corrosion threat over which CPAI has a difficult challenge. This is because of the difficulty with accessing the pipe surface. In response to this challenge, CPAI has proactively implemented state-of-the-art technologies in further development of long range inspection techniques. CPAI recognizes the current technical limitations of these tools and is working with a vendor to further enhance them.

CORROSION PROGRAM STATUS – GREATER KUPARUK AREA (GKA) & WESTERN NORTH SLOPE (WNS)

The data provided by CPAI supports the conclusion that the corrosion management program is effective and exceeds common industry practice.

The CPAI corrosion program emphasizes the identification of locations where time to failure is shortest. That is, the program seeks to find locations where 1) the likelihood of previous damage is greatest, and 2) corrosion rates are likely to be highest. Highest priority is placed on locations where the likelihood of damage and high corrosion rates coincide. The consequence of a leak in any part of its system is considered to have similar safety or environmental consequences. Risk is therefore controlled by reducing the likelihood of failure.

It is notable that CPAI continues to present data in a transparent way and answers all questions with candor. Information from written reports, presentations, and verbal questions are consistent. In addition, the CPAI corrosion control staff is highly competent and an extensive QA/QC program is in place to monitor the performance of contractors.

Internal Corrosion Management

Three Phase Production System (Well Lines and Flow Lines)

The overall corrosivity of the GKA system is relatively low, but isolated locations of accelerated corrosion are known to exist. Corrosion inhibition appears to be making general corrosion unlikely and appears to be minimizing localized corrosion. Localized corrosion, not mitigated by inhibition, is primarily identified by an expansive inspection program.

Localized corrosion appears to be associated with the presence of solids and/or deposits that create crevices under which corrosion is accelerated and/or delivery of chemical treatment is restricted. The effect of solids on corrosion is reduced by chemical action (i.e., surfactants) that is aided by production velocities sufficient to keep solids mobilized.

All inspection, monitoring, mitigation, and inspection data support the conclusion that the GKA assets are being adequately preserved. Corrosion control efforts exceed standard oilfield industry practice. The average corrosion rates of coupons and probes are near zero and the average pitting rate is low.

The corrosion inspection and monitoring program has several components:

- Real-time radiography (RTR) is performed system-wide at approximately 5-year intervals. This inspection covers long continuous lengths of pipe selected to serve at least two purposes. The first is that defects that could result in leaks are identified and repaired. The second is that locations of corrosion damage that are not near-term integrity threats are identified as known-damage-recurs (KDR's) so that a growth rate can be determined. KDR's are scheduled for ultrasonic inspection at a time sooner than the next RTR survey. KDR's are also identified by conventional factors to prioritize susceptibility to corrosion (e.g., dead-legs, high velocity flow).

- KDR's are measured ultrasonically at less than 3-year intervals (2 month minimum), and the results are used for 1) determining if the location becomes an integrity threat in need of repair, and 2) determining corrosion growth rate for feedback to mitigation. The rate of KDR inspections is approximately 5% of the system every 5 years. All lines with internal corrosion damage are monitored by KDR inspections. The number of KDR locations on each line is determined by the severity and amount of damage. Guidelines specify there should be three to ten KDR locations per damaged line unless there is a good reason for fewer or more locations.
- Corrosion monitoring consists of corrosion coupons and probes. Their purpose is primarily to identify changes in corrosivity over time. It is recognized that coupons are not typically placed in the most susceptible location and that the rates do not necessary represent what is occurring on the pipe wall. This limitation in the coupon program is compensated by the KDR program. An increase in coupon corrosion rate therefore serves as an indication of a possible problem triggering further action. It is recognized that a coupon without corrosion does not necessarily indicate the lack of corrosion in a line.

In the 2003 report, a concern was raised that data reported by CPAI did not reflect the significance of isolated corrosion. This was because 1) corrosion coupons and probes are not typically located where the corrosion is considered most likely, and 2) presenting coupon data in an averaged form does not reflect the isolated high corrosion rate coupons. This issue was resolved by further communication from CPAI regarding the use of KDR's at locations considered most susceptible to corrosion. Since CPAI does not rely on coupons to identify locations most susceptible to corrosion, the importance of the coupon corrosion rates and their distribution of corrosion rates are of lesser importance than what is found by inspections.

Seawater and Mixed Water Injection

In general, seawater and produced water injection systems have lower susceptibility to corrosion compared to three phase production systems. The gas phase containing CO_2 and H_2S has been removed, and the presence of only one phase (i.e., water) simplifies delivery of chemical treatment. Corrosion caused by bacteria or oxygen are the most likely corrosion mechanisms. Corrosion of the CPAI seawater system is mitigated by removing oxygen and injecting biocides. Corrosion of the mixed produced/sea-water injection system is mitigated by carryover inhibition from the production system (and the upstream treatment of seawater) and increased line velocities to help reduce under-deposit corrosion. Additionally, cleaning pigs and a biocide are being used to remove deposits and kill bacteria. These actions are consistent with good corrosion control practices.

In 2005, a leak occurred in the water injection system at 2H pad, which was attributed to microbiologically induced corrosion (MIC). It is noteworthy that coupon corrosion rates have been high since 2002, and pitting rates exceeded 25 mpy in 2004. In hindsight, the high coupon rates are consistent with the leak, but it should be recognized that corrosion management programs (including that of CPAI) typically prioritize locations where likelihood of previous damage and high existing corrosion rates coincide. In this case, information existed that corrosion rates had increased, but the likelihood of previous corrosion damage was considered low. On that basis, other locations within the system were given higher priority. Because of the leak, the future risk priority of the water injection system has been raised and additional mitigation, monitoring, and inspection has been implemented.

External Corrosion Management

Above Grade Piping

CPAI is committed to removing corrosion under weld-pack insulation as an integrity threat. No leaks were caused by external corrosion in 2004. CPAI completed tangential radiography testing (TRT) on all cross country lines and well lines. Two locations of severe damage were identified and repaired. A new weld pack design is intended to prevent future water ingress and corrosion at these field-applied insulation locations. To check the performance of the new design, at least 100 of the refurbished weld packs were inspected for water ingress. No corrosion under insulation was found in any of the areas inspected.

Below Grade Piping

External corrosion at cased crossings represents a corrosion threat over which CPAI has a difficult challenge. This is because of the difficulty with accessing the pipe surface. In response to this challenge, CPAI has proactively implemented state-of-the-art technologies in further development of long range inspection techniques. CPAI recognizes the current technical limitations of these tools and is working with a vendor to further enhance them.

In 2004, all casings were visually inspected (i.e., at the ends), and identified problems were remediated (e.g., pipe insulation in contact with casing, debris). Nine casing locations were excavated, inspected refurbished and repaired (as required). Additionally, 63 cased crossings were assessed using long-range ultrasonic inspection.

CPAI reports that 764 cased crossings are located in GKA. Because the pipe cannot be accessed without excavation and removal of the casing and insulation, inspection from outside of the pipe is not considered practical. The inspection program at GKA is heavily based on radiography of above ground insulated pipe, resulting in limited capability for inline inspection. The remaining alternative is long-range ultrasonic inspection, but the resolution of this method is less than other inspection methods used at GKA.

The primary reason for inspecting casings is for external pipeline corrosion because water and debris may enter the annular space and support corrosion. Although some differences in internal corrosion susceptibility might exist at the crossings because of elevation changes, the pipe upstream and downstream of the casing is considered representative. On that basis, it is reasonable to conclude that the absence of internal corrosion surrounding the crossing indicates low likelihood of internal corrosion within the crossing.

RECOMMENDATIONS

Recommendations for areas that warrant further review or information that should be included in future reports are as follows:

1. Further clarification regarding the mechanism of under-deposit corrosion in the three-phase oil production system.
2. Continue improvements to the mixed water injection systems until corrosion rates are below established threshold limits.
3. Continue the commitment to develop and enhance long range inspection techniques used at cased crossings. Supplement this commitment with direct assessments and/or inline inspections (where possible).
4. Continue commitment to aggressively address corrosion under insulation at weld pack areas.
5. Provide additional information confirming that WNS corrosion management has equal or equivalent rigor to GKA programs.

CONCLUSIONS

The data provided by CPAI supports the conclusion that the corrosion management program is effective and exceeds common industry practice. Sufficient information has been presented to demonstrate that the corrosion control program meets the intent of the Charter Agreement.

It is notable that CPAI continues to present data in a transparent way and answers all questions with candor. Information from written reports, presentations, and verbal questions are consistent. In addition, the CPAI corrosion control staff is very competent and an extensive QA/QC program is in place to monitor the performance of contractors.

The CPAI corrosion program emphasizes the identification of locations where 1) the likelihood of previous damage is greatest, and 2) corrosion rates are likely to be highest. Highest priority is placed on locations where the likelihood of damage and high corrosion rates coincide.

Internal corrosion of the three phase production and water injection systems are effectively managed, but a leak occurred in a water injection system considered to have low susceptibility to corrosion. CPAI has increased the risk priority of this system and has increased mitigation and inspection activity.

External corrosion of above-ground piping is largely confined to weld packs, and CPAI continues to make notable progress on removing this threat through inspection and repair (where necessary) of all locations.

External corrosion at cased crossings represents a corrosion threat over which CPAI has a difficult challenge. This is because of the difficulty with accessing the pipe surface. In response to this challenge, CPAI has proactively implemented state-of-the-art technologies in further development of long range inspection techniques. CPAI recognizes the current technical limitations of these tools and is working with a vendor to further enhance them.