

Corrosion Monitoring of Non-Common Carrier North Slope Pipelines

Technical Analysis

Of

ConocoPhillips Alaska Inc. – 2002 Commitment to Corrosion Monitoring for Greater Kuparuk Area & Alpine

Submitted by



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EXECUTIVE SUMMARY

Coffman Engineers, Inc. has been charged with reviewing the 2002 corrosion program report submitted by ConocoPhillips Alaska Incorporated (CPAI) to the Alaska Department of Environmental Conservation (ADEC). The report outlines the measures undertaken to mitigate corrosion in CPAI's non-common carrier North Slope pipelines. In addition, Coffman reviewed the presentation materials from the October 2002 and April 2003 Meet & Confer sessions.

Internal corrosion in cross-country lines indicates a clear degree of corrosion inhibition; no leaks and no saves were reported in 2002. Corrosion control, primarily inhibitor injection, has maintained the low leak/save frequency. Corrosion damage increases have been almost eliminated in the cross-country production gathering lines. Coupon pitting rates for three phase pipelines reversed the increasing trend seen during the past 5 years, due primarily to a change in inhibitors late in 2001. The mixed water injection average coupon pitting rates are above the target levels and is mostly attributed to piping at CPF2 locations. The percentage of locations with corrosion damage increases (UT and RT) has increased significantly for water injection service compared to 2001, 22%¹ vs. 0%.

Internal corrosion in well lines is an area that requires CPAI's continued focus; 2 leaks and 17 saves (repairs) were reported in 2002. The number of saves is roughly the same as in 2000, as is the footage of inspected pipe. The percentage of locations with corrosion damage increases (UT and RT) decreased slightly compared to 2001.

A baseline inspection of all weld-packs on cross country off-pad pipelines was completed in 2001. Baseline inspection of on-pad weld-packs (well and cross country lines) is progressing ahead of schedule and average percent of corroded weld-packs is around 3%. There were six repairs (~3% of corroded weld-packs) and more than 800 weld-packs refurbished on above grade piping.

CPAI completed the screening inspections for all Priority 1, below grade piping locations during 2002. Eight below grade locations were excavated and two locations required repair; one location was sleeved and the other location was replaced/upgraded.

There were no failures in 2002 due to structural related issues. An evaluation of the wind induced vibration (WIV) design envelope was completed in 2002 and recommendations implemented. The well subsidence mitigation program continued during 2002.

¹ Manual RT – 4 increases/14 repeats; Manual UT – 1 increases/9 repeats; Total – 5 increases/23 repeats = 22%

CORROSION PROGRAM STATUS

Internal Corrosion Management

Cross Country Pipelines – Monitoring & Inspection

Internal corrosion in cross-country lines indicates a clear degree of corrosion inhibition; no leaks and no saves were reported in 2002. Corrosion control, primarily inhibitor injection, has maintained the low leak/save frequency. Corrosion damage increases have been nearly eliminated in the cross-country production gathering lines. Coupon pitting rates for the three phase and water injection pipelines reversed the increasing trend seen during the past 5 years, due primarily to a change in inhibitors late in 2001

Monitoring data for cross country water injection pipelines shows the average pitting rate exceeds the target. These data are largely dominated by results from CPF2 and work is ongoing in 2003 to determine the cause. The percentage of locations with corrosion damage increases (UT and RT) has increased significantly for water injection service compared to 2001, 22% vs. 0%. The increases are primarily confined to one pipeline, 2EDCWI, and are the first increases identified to date on the water injection system.

CPAI reports that coupon or probe corrosion rates exceeded threshold targets in 20 pipelines and they responded by increasing the corrosion inhibitor concentrations target for all 20 pipelines. Eleven of these pipelines were also reported in 2001 as having exceeded corrosion rate targets and the response was increasing the corrosion inhibitor concentration target. Most of these eleven pipelines show little improvement and in some cases had worse results. Refer to Table 1 for a comparison of these eleven pipelines.

Table 1 - 2000 and 2001 Three-phase CC Production pipelines with corrosion rates exceeding targets

Common Line	2001			2002		
	Coupon Grade	Probe Rate	Inspection Increase	Coupon Grade	Probe Rate	Inspection Increase
1-2Z1QGPO	A	<.5	Yes	A	<.5	Yes
1RPO	F,D	>.5	Yes	C	<.5	
2KPO	D	<.5		C	<.5	
2TAMKHPO	A	<.5	Yes	A	>.5	Yes
2TPO	D	>.5		D	<.5	
2UPO	A	<.5	Yes	A	<.5	Yes
3CPO	D	<.5		D	<.5	
3MIPO	C	<.5		D	<.5	
3RQOPO	D	>.5		C	<.5	

Common Line	2001			2002		
	Coupon Grade	Probe Rate	Inspection Increase	Coupon Grade	Probe Rate	Inspection Increase
XCL/WO at CPF2	F,C	<.5		C	<.5	
XCL/WO at CPF1	D	<.5		B	N/A	Yes

Note: Shaded cells indicate either no change or condition is worse than 2001 result

In addition, inspection showed five lines with inspection increases where the coupons did not exceed the target corrosion rate. The corrosion inhibitor concentrations for all five of these lines were also increased. This helps to illustrate and reinforce the importance of both programs.

An ongoing item of concern is the difficulty of inspecting produced water injection piping with diameters larger than eight inches, which is considered radio-opaque and limits the use of radiographic techniques. CPAI evaluated the feasibility of using inline inspection for these pipelines during 2002, and concluded that while technically feasible it is cost prohibitive. CPAI will continue to rely on “spot UT” measurements for these pipelines.

Well Lines - Monitoring & Inspection

Internal corrosion in well lines is an area that requires CPAI’s continued focus; two leaks and 17 saves (8 injection and 9 production) were reported in 2002. The number of saves is roughly the same as in 2000, as is the footage of inspected pipe.

Production well line coupon data indicate very low general and pitting corrosion rates, however CPAI notes that the inspection data indicates higher rates are being experienced. Injection well line coupon data indicates very low general corrosion rates. Pitting rates for this service are below the action limit; however they are 2-3 times above the historic minimums and have been so for the past three years.

The percentage of locations with corrosion damage increases (UT and RT) decreased slightly compared to 2001. It is unclear if there are specific targets for repeat inspections using manual RT and UT techniques, but the percent repeated for each inspection type and service type vary widely. It is also unclear if there is a target or action limit for the percent increase value.

Internal Corrosion Mitigation

CPAI’s compliance with its own corrosion inhibition targets has improved over time; reporting an average deviation of +0.9% for 2002; a slight over-treatment. CPAI is continuing to move forward with the wellhead inhibitor injection program; with four additional drill sites to be added during 2003. The well lines should benefit greatly from this program. CPAI continues to develop and test new inhibitor formulations with lab and field trials continuing through 2003.

Under deposit corrosion has been identified as a key corrosion mechanism and a test using a chemical surfactant product to promote wetting of oil fouled solids is being put in place at DS1E.

External Corrosion Management

Above Grade Piping

CPAI exceeded their stated external inspection goals in 2002. The baseline inspection for all off-pad weld-packs was completed in 2001 and a program for recurring inspections targeted at “medium wet” weld-packs was begun in 2002. The baseline inspection for on-pad weld-packs was 70% complete overall and is progressing in accordance with CPAI’s stated 2005 completion schedule. The forecasted number of weld-pack inspections for 2003 is roughly 1/3 of 2002 and 2001 inspection levels. It is not clear if this represents a reduction in effort, an increase in physical complexity of the piping system, or a combination of both.

There were zero repairs on off-pad piping, six repairs of piping on-pad and more than 800 weld-packs refurbished. The percent corroded and percent repaired results for 2002 are consistent with the overall average percentages, and likely means there are still ~10 repairs to be made on the remaining ~10,000 weld-packs. Refer to Table 2 for the overall weld-pack baseline inspection status.

Table 2 - Above grade weld-pack baseline inspection status

Service	Total Number (approx.)	Number Inspected During 2002	Number Inspected thru YE2002	% Inspected thru YE2002	Number Remaining	2002 Forecast
X-Country-Off-pad	67,291	0	67,291	100%	0	0
X-Country-On-pad	10,400	2,658	9,568	92%	832	416
Well Lines On-pad	24,000	4,116	14,400	60%	9,600	1,632
Totals	101,691	6,774	91,259	90%	10,432	2,048

Note: This table represents an effort to reconcile numbers presented in previous CPAI reports. There is the possibility for minor discrepancies.

The number of saves is roughly the same as in 2000, as is the footage of inspected pipe (RTR). The percentage of locations with corrosion damage increases (UT and RT) decreased slightly compared to 2001.

Buffer spikes were installed at 76 weld-packs locations as part of a test. The concept is a time-release sodium phosphate salt that serves to increase the pH of the electrolyte in contact with the steel surface, helping to create a passive layer on the steel surface. Little additional information was provided as to the status of this test program.

Below Grade Piping

CPAI exceeded their stated below grade inspection goals in 2002, inspecting 130 previously un-inspected Priority 1 locations using a combination of electromagnetic pulse and guided wave technologies. One additional screening technology, torsional wave, was evaluated and deemed “not superior” to the incumbent and will not be used at this time. Additionally all cased crossings are visually inspected to ensure they are clear of debris and if found, they are cleaned out.

Eight below grade locations were excavated and two locations required repair; one location was sleeved and the other location was replaced. The remaining six locations were refurbished to prevent further corrosion. Refer to Table 3 for a summary status of this program. The only Priority 1 locations left to inspect are on piping that is less than 10 years old. While age is an important factor, it is unlikely to be the controlling factor for corrosion of the below grade piping. Additional significant factors include: pipeline wall thickness, pipeline operating temperature, location of crossing in relation to drainage, fluid velocities, and fluid corrosivity. It is unclear if these other factors have been considered for the remaining Priority 1 locations.

Table 3 - Below Grade Piping Baseline Inspection Status

Description	Total Number (approx.)	Number Inspected During 2002	Number Inspected thru YE2002	Number Remaining
Priority 1 Oil	375	38	331	44 ²
Priority 1 Non-Oil	243	92	226	17
Priority 2 Oil	19	0	1	18
Priority 2 Non-Oil	98	0	0	98
Priority 3 Oil	22	0	1	21
Priority 3 Non-Oil	15	0	2	13
Totals	772	130	561	211

Notes:

- 1) This table represents an effort to reconcile numbers presented in previous CPAI reports. There is the possibility for minor discrepancies.
- 2) The only un-inspected Priority 1 pipelines are less than 10 years old.

Structural Concerns

Subsidence

There were no leaks attributed to subsidence in 2002. CPAI continues to prioritize and upgrade existing wellhead riser supports and flooring susceptible to subsidence. Thermal siphons are also being installed in near well-bore location to promote re-freezing and stabilization of the soil.

Wind Induced Vibration

There were no leaks attributed to WIV in 2002. An evaluation of the WIV design envelope was completed in 2002 and recommendations implemented

RECOMMENDATIONS

Recommendations for future reports are as follows:

1. In addition to the existing data presentation, consider combining the leaks and saves from the BGPP with the External Leaks and Saves data. Presently it appears the 2001 leak is included, but the two repairs (saves) are not. Refer to CPAI Figure A1.
2. Coupon corrosion rate data is the only specific data presented for Alpine. It is not clear if inspection and mitigation information is commingled or excludes Alpine. Clarification of the treatment of Alpine data in future reports would be beneficial.

CONCLUSIONS

CPAI continues their vigorous corrosion control program and has met or exceeded all of the stated inspection goals during 2002.

Cross-country pipelines inspection data indicates a clear degree of internal corrosion control and the increasing coupon corrosion trend was reversed in 2002. Corrosion control, primarily inhibitor injection, has maintained the low leak/save frequency. Corrosion damage increases have been almost eliminated in the cross-country production gathering lines. The mixed water injection average coupon pitting rates are above the target levels and is mostly attributed to piping at CPF2 locations.

Inline inspection was evaluated for large diameter mixed water cross-country piping and deemed too costly to pursue as a primary inspection method. CPAI proposes to use spot UT measurements for these pipelines; however it is unclear if this will yield an adequate degree of confidence as to the condition of these pipelines. The percentage of locations with corrosion damage increases (UT and RT) has increased significantly for water injection service compared to 2001, 22% vs. 0%.

Well line internal corrosion control appears to be approaching the "top of the curve," but still requires significant focus. There were 2 failures and 17 repairs on well lines during 2002. The percentage of corrosion increases, level of inspections and number of saves were equivalent to 2000 results. The testing of wellhead inhibitor injection began in 2002 and plans are to add four additional well sites during 2003.

The external corrosion control program is progressing and the off-pad piping recur inspection program will begin in earnest during 2003. There are still more than 10,000 on-pad weld-packs requiring baseline inspections and extrapolating the results to date, there are several areas that will require repair. All of the Priority 1 below grade piping, older than 10 years, has had a baseline inspection.

There were no failures in 2002 due to structural related issues. An evaluation of the WIV design envelope was completed in 2002 and recommendations implemented. The well subsidence mitigation program continued during 2002.