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LABORATORY ACCREDITATION BUREAU
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Certificate # L2267 Testing

Analysis of Hydrotest Methods Used in Valve Preservation

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Project #:11-176-1325(bis)

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Background: Customer is working on a specification for an inhibitor to be added to hydrotest water. VpCI-649 BD is the primary inhibitor under consideration. VpCI-337 and VpCI-609 were also considered as water based inhibitors.

Sample Received: The valves were received on October 10, 2011.

Sample(s) labeled: The valves were labeled with a serial number ending in number 1 through 8.

Method: Humidity chamber (modified ASTM D1748)*
Salt spray chamber (ASTM B117)
*Cortec laboratory is not accredited for the test marked.

Materials: 2 1/16" 5K Valves
VpCI-649 BD batch# 19681
VpCI-337 batch# 26911
VpCI-609
VpCI-322
Shell Tellus S2 V46 Oil
Salt spray chamber (water contains 5% NaCl)
Carbon steel tubing
Carbon steel panels

Procedure:

Hydrotest and Inspection

1. Eight of valves from customer, 2 1/16 inch 5K valves, were hydrotested with various water additives. The table below details the preservation procedure that was performed on each of the valves.

Valve Number	Preserve Product	Application	Performed at Cortec
1	-	Hydrotest in DM Water	-
2	VpCI-649 BD at 1%	Hydrotest w/ VpCI-649BD 1%	-
3	VpCI-649 BD at 1% + VpCI-337 at 1 oz per ft3	Hydrotest w/ VpCI-649BD 1%	-
4	VpCI-649 BD at 1% + VpCI-337 at 1 oz per ft3	Hydrotest w/ VpCI-649BD 1%	-
5	VpCI-649 BD at 1% + (Tellus V46 + VpCI-322 at 5%)	Hydrotest w/ VpCI-649BD 1%	Oil Flush
6	VpCI-649 BD at 1% + Tellus V46	Hydrotest w/ VpCI-649 BD 1%	Oil Flush
7	VpCI-609 at 5%	Hydrotest w/ 609 5%	-
8	VpCI-337 at 1 oz per ft3	NONE	Refog VpCI-337 every 2 weeks

2. The valve bores were capped. Each valve was wrapped individually in VpCI-126 film and packaged in a crate for air shipment to Cortec.
3. Upon arrival the valves were removed from the crate and packaging and initially inspected for any initial rust that may have developed.
4. Valves 5 and 6 were flushed with Shell Tellus S2 V46 oil. The oil used for valve 5 contained VpCI-322 at a concentration of 5%. The two valves were used to compare the possibility of using different oil solutions for pressure testing and subsequent preservation.
5. The valves were placed on to two pallets and put into the humidity chamber set at 100% humidity and 49 °C. (ASTM D1748)
6. The valves were removed every four days to be inspected. After 3 weeks the inspection frequency was reduced to once a week as any corrosion on the valves was developing at a slower pace.
   a. Inspection was performed by removing the six bolts that secure the gate to the body of the valve. The caps used to seal the bores were removed from each side of the valve. The gate and the seated o-rings were removed from the valve to expose the seat pockets. Pictures were taken of the bores, gate, o-rings, and seat pocket.
7. Valve 8 was fogged with VpCI-337 every 2 weeks.

Hydrotest evaluation with steel tubing

1. Steel tubing was cut to six inch lengths and cleaned with methanol.
2. The exterior was wrapped in tape and the interior was treated with VpCI-649BD mixed with water at dilutions of 0%, 0.5%, 1%, and 2% for a period of 8 hours.
3. The steel tubing samples were placed in the salt spray chamber which was set 38 °C and samples were in the chamber for 4 hours.
4. The samples were removed and the interior was evaluated for corrosion.

Hydrotest evaluation with panels

1. Steel panels were cut to 4.1 by 11 centimeters and cleaned by submerging them in methanol.
2. Each panel was placed in a different dilution of VpCI-649BD (0%, 0.5%, 1%, and 2%) for a period of 8 hours.
3. The panels were then removed and placed in a large jar with a small beaker containing 15 milliliters of water.
4. The panels were placed in the oven at 40 °C for 5 days
5. After removing the panels they were cleaned and reweighed to determine the level of protection.

Results:

Valve Evaluation

Valve	Preservation	Corrosion Rating of Seat Pocket	Corrosion Rating of Valve Bores
1	-	D	D
2	VpCI-649 BD at 1%	B	C
3	VpCI-649 BD at 1% + VpCI-337 at 1 oz per ft3	B	B
4	VpCI-649 BD at 1% + VpCI-337 at 1 oz per ft3	A to B	B
5	VpCI-649 BD at 1% + (Tellus V46 + VpCI-322 at 5%)	B	C
6	VpCI-649 BD at 1% + Tellus V46	B	C
7	VpCI-609 at 5%	D	D
8	VpCI-337 at 1 oz per ft3	A	A
A = metal is completely clean B = minor surface corrosion C = moderate corrosion D = significant corrosion E = completely corroded			

Steel Tubing Evaluation

Sample	VpCI-649 Treatment (%)	Corrosion Rating
1	0	D
2	0.5	C
3	1	B
4	2	B
A = metal is completely clean B = minor surface corrosion C = moderate corrosion D = significant corrosion E = completely corroded		

Steel Panel Evaluation

Panel	VpCI-649 (%)	Panel weight (g)	Post-test weight (g)	Percent Protection	Corrosion Rate (mpy)
1	0	28.0548	27.9943	N/A	4.91
2	0.5	25.5632	25.5107	13.2	4.69
3	1	25.6123	25.6120	99.5	0.03
4	2	27.5550	27.5550	100	0.00

$$\text{Corrosion Rate} = (K \times W)/(A \times T \times D)$$

$K = 3.45 \times 10^6$
T = exposure in hours
A = area in cm^2
W = mass loss in grams
D = density ($7.85 g/cm^3$)

$$\text{Protection Ability (\%)} = \frac{\text{Corrosion Rate of Control - Corrosion Rate of Sample}}{\text{Corrosion Rate of Control}} \times 100$$

Interpretations:

The objective of this project was to evaluate corrosion development as a result of accelerated corrosion tests on valves and metal samples that were subjected to different corrosion inhibiting treatments. The purpose of evaluating corrosion development was to determine an effective hydrotesting procedure for preserving and shipping valves produced by customer.

The valves were subjected to testing in the humidity chamber for eight weeks between October 19th and December 14th. Each valve was treated differently and compared to an untreated control valve. The primary product for evaluation was VpCI-649 BD as an additive to the hydrotest water. VpCI-609 was also evaluated as an additive to the test water. VpCI-322 was applied as an additive to Tellus oil which was run through two valves. VpCI-337 was another option that was fogged into the three valves; two which were hydrotested with VpCI-649 BD and one valve that was otherwise untreated.

Valve 7 was treated with VpCI-609 at a rate of 5% in the hydrotest water. This valve was the first to develop corrosion on the seat pocket and the corrosion on the bores progressed quickly. This valve was deemed a failure and VpCI-609 was not further evaluated in this project. In order to determine if VpCI-609 would be viable solution for hydrotesting the valves further testing would be necessary.

Valve 2, 3, 4, and 8 were tested with VpCI-649, VpCI-337, or a combination of both inhibitors and were compared to the control, Valve 1. Valve 1, 2, and 3 all developed some small corrosion spots on the seat pocket within 14 days of the beginning of the test. The seat pocket of Valve 4 and 8 both remained clean for the duration of the two month test.

The corrosion on the bores of the valves provides more distinction than the corrosion seen on the seat pockets. The bore of the control valve over the course of two months shows substantial corrosion. As the comparison picture (Figure 4) shows the bore displays a lot of red rust across the surface. Valves 1, 2, and 3 all present some corrosion however it is much less severe than that seen on the control valve. Valve 8, which was periodically fogged with VpCI-337, shows almost no signs of corrosion on the bore. The seat pocket and bore pictures can be seen in below.

Based on these results, VpCI-649 BD is effective at reducing the level of corrosion on the valves. VpCI-337 fogged occasionally is also an effective solution.

Valves 5 and 6 were used to evaluate the process of preserving the valves with oil pressure test. Valve 6 was the control as it was flushed with Shell Tellus S2 V46 and valve 5 was flushed with Shell Tellus S2 V46 containing VpCI-322 at 5 percent. The first spots of rust were seen on seat pocket B of valve 5 after 14 days in the chamber. Valve 6 exhibited rust during the following inspection period or after 20 days in the chamber.

The corrosion in the bores of both Valve 5 and 6 developed similarly. Figure 11 below shows a comparison of the bores of Valve 1, 5, and 6 which shows that the corrosion was reduced by both oil treatments. Based on this project there is not a clear benefit of using VpCI-322 in Shell Tellus oil. In order to determine the best procedure for pressure testing with oil additional tests should be conducted.

The salt spray chamber is a very harsh environment so this test provides an accelerated view of the corrosion patterns. After hydrotesting, the steel tubing shows a clear division between using VpCI-649 BD concentrations of 0.5% and 1% or greater. Although sample 2 does show some rust it is clear from Figure 1 that hydrotesting with 0.5% VpCI-649 BD provides some protection as the control exhibits a much greater level of corrosion. Samples 3 and 4 substantially outperformed the control. Sample 4 performed slightly better than sample 3 but both developed light surface corrosion.

The hydrotest with steel panels confirms the results of the steel tubing test. See the comparison picture in Figure 2 below. VpCI-649 BD effectively reduces corrosion when it is applied on the panels at a concentration of one and two percent, the corrosion rates respectively are 0.03 and 0 mpy.

A significant difference between the test panels, the tubing and the valves is that the interior of the valves was isolated from the test chamber. The bore of the valves was sealed with caps when they were in the humidity chamber and although this did not completely prevent water from getting in it did effectively reduce the corrosion by limiting exposure.

Photos:

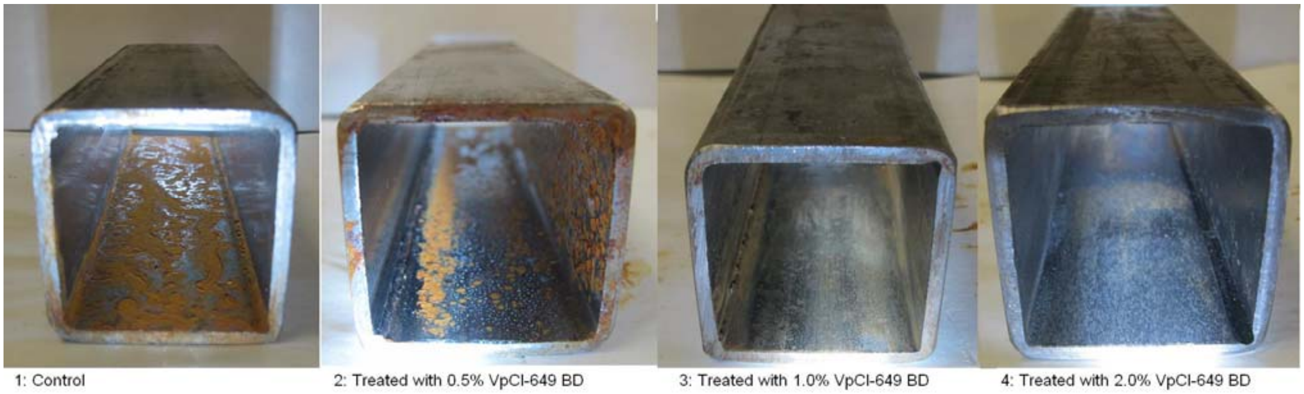


Figure 1: Tubing used to test 0, 0.5, 1, and 2 percent VpCI-649BD solutions for hydrotest

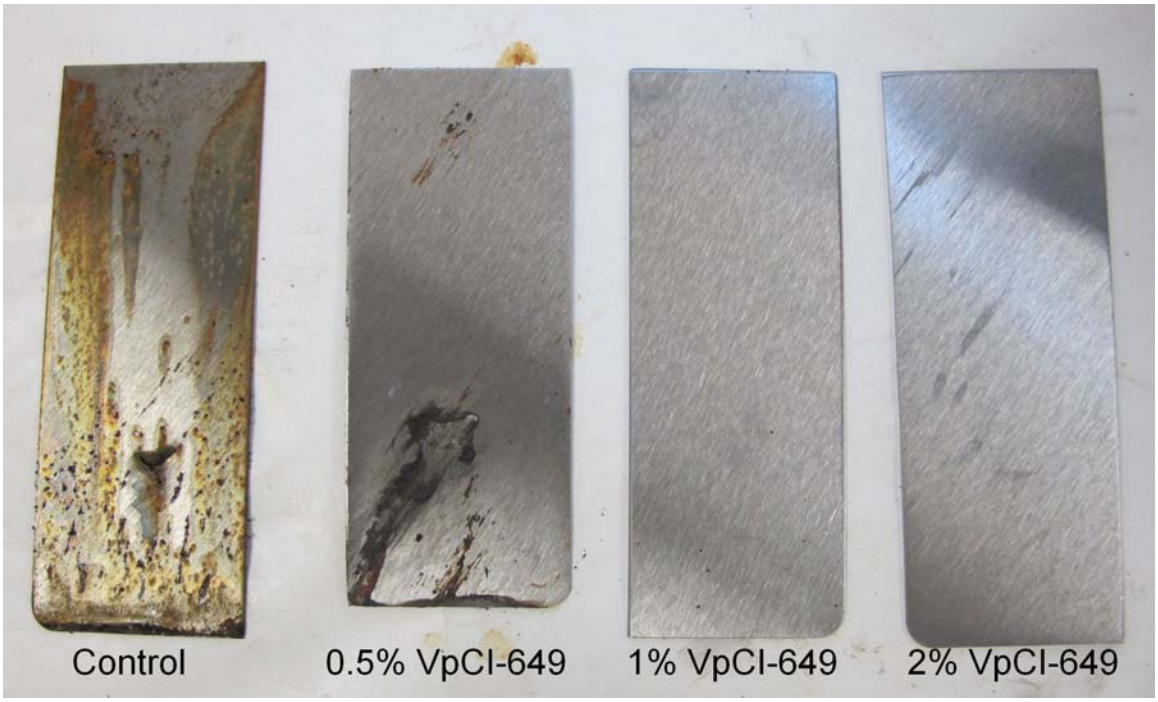


Figure 2: Panels treated with VpCI-649 BD and placed in the oven with 2% salt water at 40 °C for 5 days

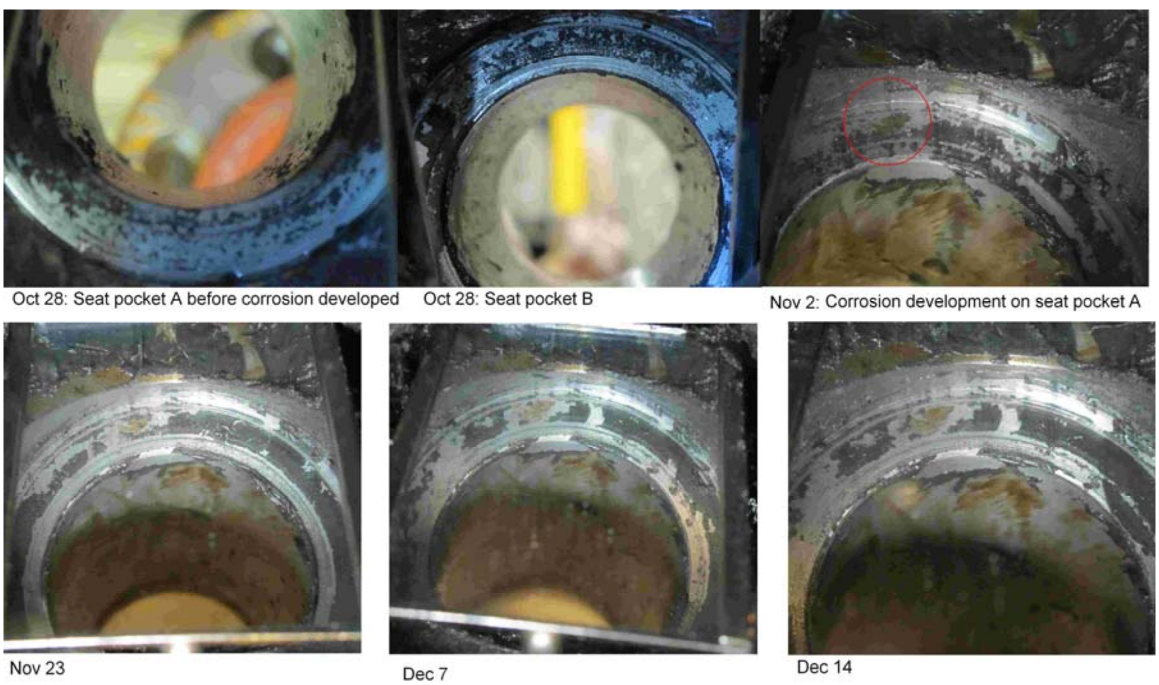


Figure 3: Pictures of the Valve 1 seat pocket over the course of the test. Seat pocket B didn't develop corrosion during the test.

Figure 4: Pictures of Valve 2 seat pocket B. Corrosion did not develop on seat pocket A during the test.

Figure 5: Pictures of Valve 3 seat pocket B, side A did not develop corrosion.

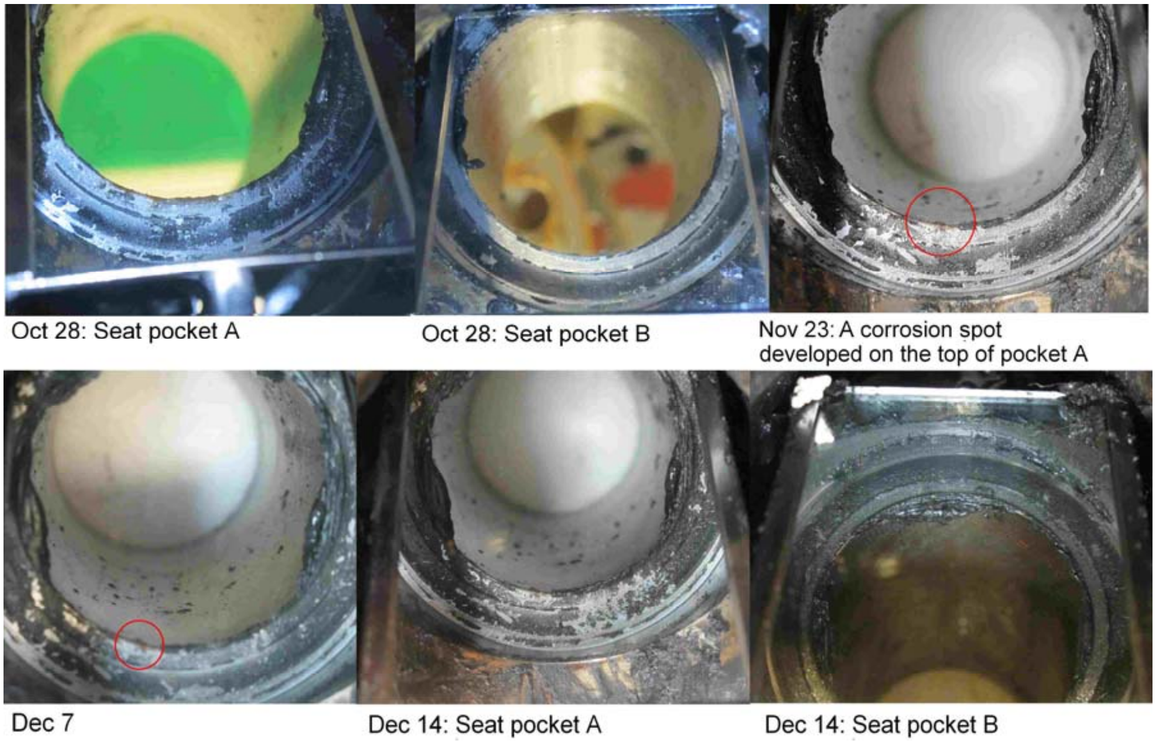


Figure 6: Valve 4 with only a small spot of corrosion developing on seat pocket A.

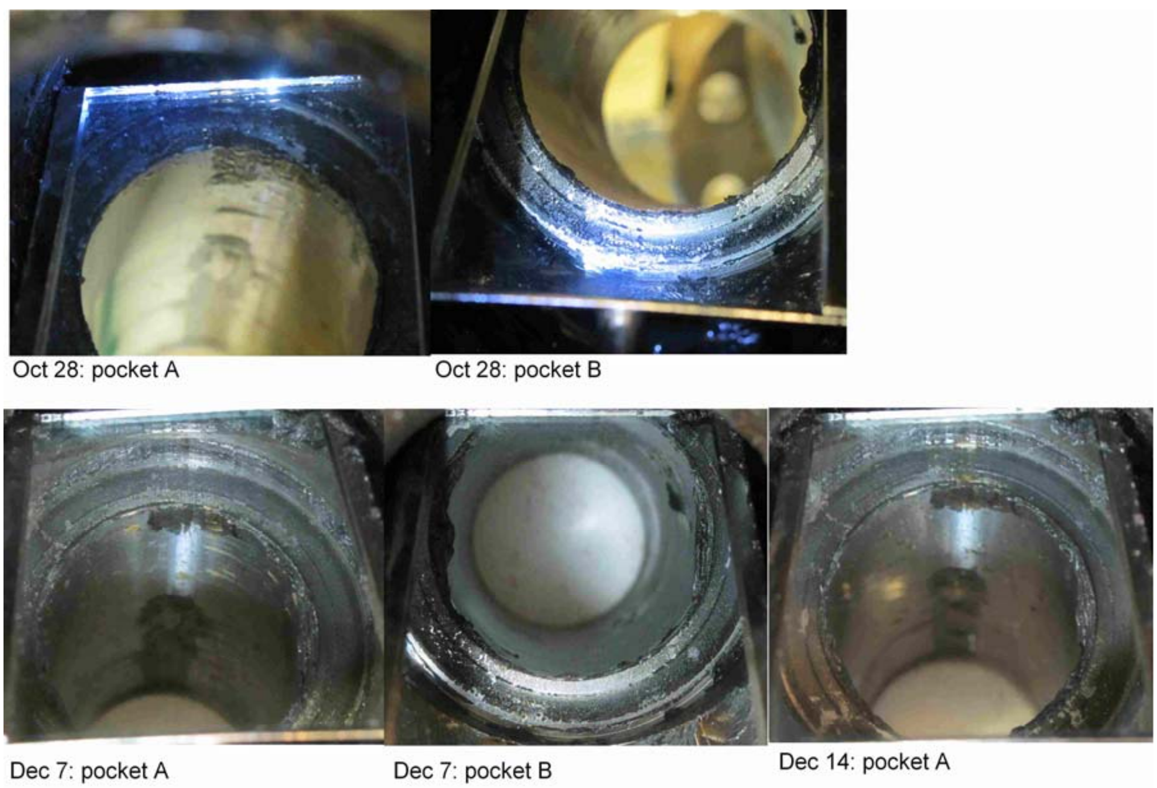
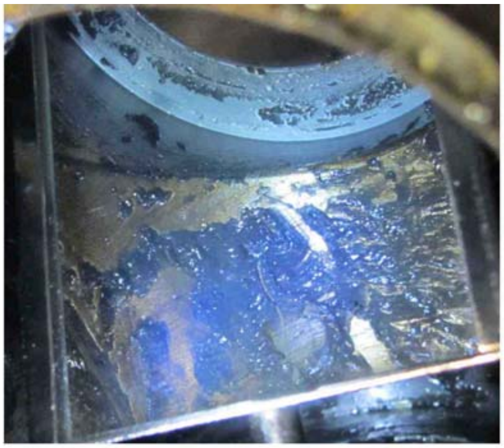


Figure 7: Pictures of the Valve 8 seat pockets. The mark on the seat pocket in the December 14 picture is from VpCI-337 buildup and not corrosion.

Figure 8: Pictures of the bore of each valve protected with water based inhibitor after the test was completed December 14th.



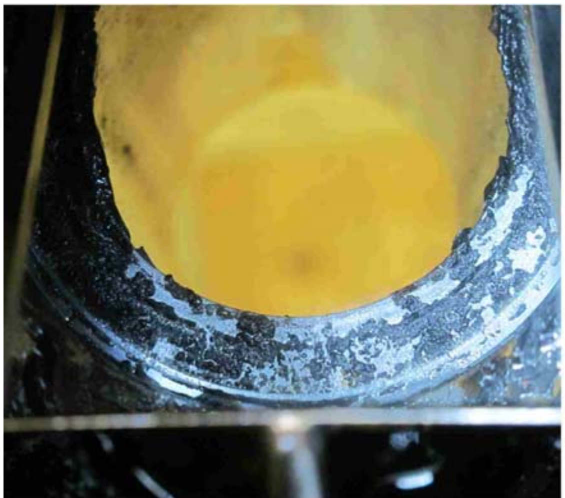
Nov 2: When the rust mark developed

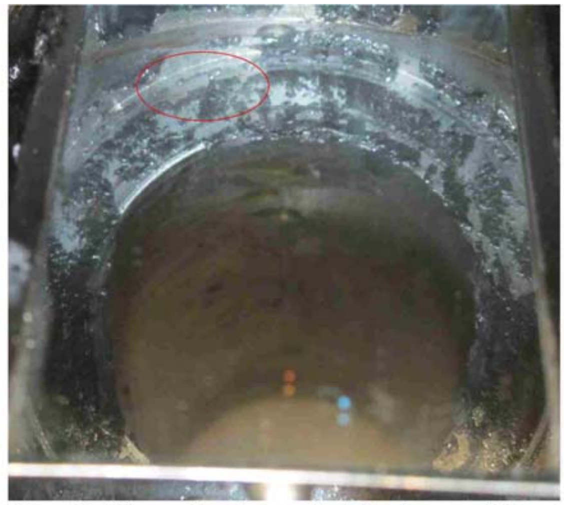
Nov 16: Corrosion on the seat pocket

Nov 30: The corrosion can be seen developing at the top of the picture. (the bottom of the seat pocket)

Dec 14

Figure 9: Pictures of the seat pocket of Valve 5.





Nov 2: The seat pocket of valve 6 at the time corrosion began in valve 5.

Nov 11: Corrosion formed at the base of the seat pocket. (top of the picture)

Nov 30

Dec 14

Figure 10: Pictures of the seat pocket of Valve 6.

Control

Valve 5: Treated with Tellus and 5% VpCI-322

Valve 6: Treated with Tellus

Figure 11: Comparison of the bores from the control and valves treated with Tellus oil.

References:

ASTM D 1748 "Standard Test Method for Rust Protection by Metal Preservatives in the Humidity Chamber" West Conshohocken, PA: ASTM International, 2008.

ASTM G 31 "Standard Practice for Laboratory Immersion Corrosion Testing of Metals" West Conshohocken, PA: ASTM International, 2004