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Corrosion Testing for Our Customer

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Project #: 19-187-1125.bis

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Background: Our customer is a leading producer of mechanical and electric water and oil pumps, electric fans, thermal management systems and highly complex precision machined components. They produce parts for companies such as Caterpillar and John Deere, etc. However, they have experienced corrosion issues using International Chemical Company's Anti-Rust 118H, and Armor VCI bags. They have requested corrosion testing compared to VpCI-126 film, VpCI-325, and VpCI-369.

Samples Received: The following samples were received on 10-17-19 in good condition:

1. one gallon of International Chemical Company's Anti-Rust 118H
2. Armor VCI bags, 4mil
3. 20 highly machined metal parts

Method: Humidity Testing, ASTM D1735
Humidity Testing, CC-018 (based on ASTM D1748)
NACE Standard VIA Test, TM 0208-2018
Razor Blade Test, CC-004*
Nitrite/Nitrate Test*
*The tests marked are not covered under Cortec Laboratories, Inc. ISO 17025 Scope of Accreditation

Materials: Q-fog humidity chamber
Koehler Humidity Chamber
Steel panels for razor blade testing, SAE 1008/1010 (Q-Panel, S-35 DG, 3"x5"x0.032")
Cast Iron panels- G3500, part #101-CI from Metaspec (for Humidity Testing, CC-018)
VpCI-126 film, 4mil (batch #510220)
VpCI-325 (batch #143018)
VpCI-369 (batch #103819)
VpCI-369D 1:3 (batch #131317)
VIA test kit (testing jars/apparatus, steel plugs, 400grit sandpaper)
Glycerol (lot #Q10A018)
Nitrite/Nitrate Test Strips (lot #HC719626)
Methanol, ACS grade (lot #18F066507)
Kimwipes

Procedure: The following procedure was followed for the Humidity Testing, CC-018 (based on ASTM D1748):

1. Clean the panels with methanol and dry with Kimwipes.
2. Dip the panels in the test solutions and hang to drip for 2 hours.
3. Place the panels in the humidity chamber and inspect for corrosion on a daily basis.
4. Record the time it takes for the panels to fail. Failure is determined by visually observing one spec of corrosion larger than 1mm in diameter, or four specs of corrosion of any size.

The following procedure was followed for the Humidity Testing, ASTM D1735:

1. Clean the submitted metal parts with methanol and dry with Kimwipes.
2. Dip one set of parts in the product to be tested, and hang to dry overnight.
3. Another set of parts were sealed in the submitted Armor film and another set of parts in VpCI-126 film.
4. Place all parts in the Q-fog humidity chamber and test until failure.

Procedure:

For VIA testing, the procedure was followed according to the NACE VIA Test, TM0208-2018 option 2 (option 2 uses machine-aided grinding and polishing for the steel plugs).

Note- the VIA tests were conducted using two strips of sample per jar (1" X 6" per strip)

The razor blade testing was followed according to standard procedure.

Results:

The following results were found for the film testing:

Razor Blade Test- Steel Panels

Sample	Panel #1	Panel #2	Panel #3	End Result
Armor Film	Pass	Pass	Pass	Pass
VpCI-126 Film*	Pass	Pass	Pass	Pass
Control	Fail	-	-	Fail

Razor Blade Test- Copper Panels

Sample	Panel #1	Panel #2	Panel #3	End Result
Armor Film	Fail	Fail	Fail	Fail
VpCI-126 Film*	Pass	Pass	Pass	Pass
Control	Fail	-	-	Fail

NACE VIA Test

Sample	Plug #1	Plug #2	Plug #3
Armor Film	Grade 0	Grade 0	Grade 0
VpCI-126 Film*	Grade 3	Grade 3	Grade 2
Control	Grade 0	-	-

*Note- The razor blade and VIA results for VpCI-126 film were previously tested (from 16-083-1125)

Nitrite/Nitrate Test Strips

Sample	Results
Armor Film	Does not contain any nitrite or nitrate

Results:

The following results were found for the Humidity Testing, CC-018 (based on ASTM D1748):

Cast iron panel treated with:	Time to Failure
Control- not treated	<15minutes
International's Anti-Rust 118H	16 hours
VpCI-325	20 hours
VpCI-369D 1:3*	Did not fail

*VpCI-369D was tested for a total of 264 hours (previously tested, from 18-078-1825)

The following results were found for the Humidity Testing, ASTM D1735

Submitted Metal Part Coated With:	Time to first appearance of corrosion
Control- not treated	<15 minutes
International's Anti-Rust 118H	Part #1 = <1 hour
	Part #2 = <1 hour
	Part #3 = <1 hour
VpCI-325	Part #1 = <1 hour
	Part #2 = <1 hour
	Part #3 = <1 hour
VpCI-369	Part #1 = Did not fail
	Part #2 = Did not fail
	Part #3 = Did not fail

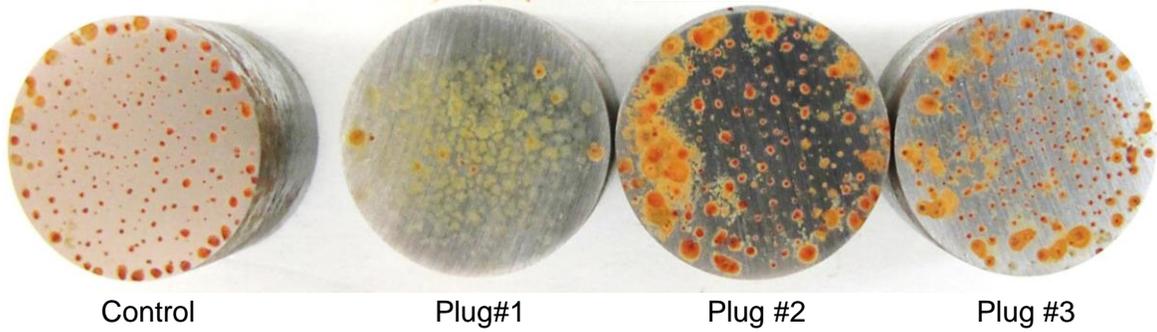
Parts were tested for 24 hours

Submitted Metal Sealed in:	Time to first appearance of corrosion
VpCI-126 Film	Part #1 = 200 hours
	Part #2 = 264 hours
	Part #3 = 264 hours
Armor Film	Part #1 = 120 hours
	Part #2 = 120 hours
	Part #3 = 264 hours

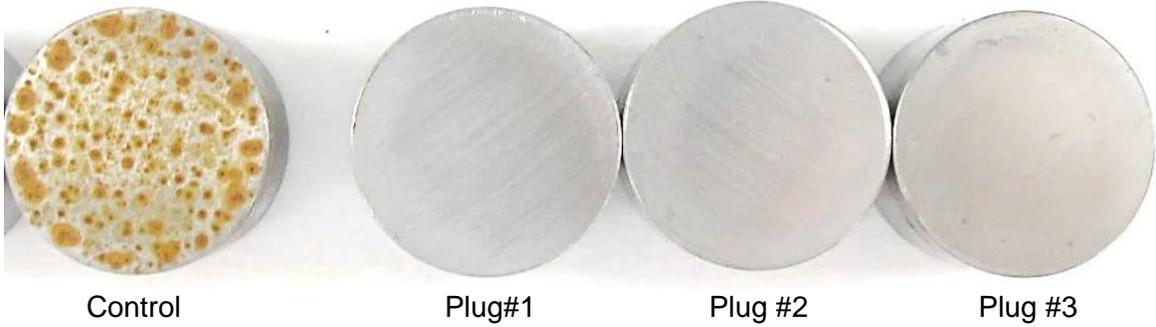
****Results apply only to items tested***

Photos from the NACE VIA test:

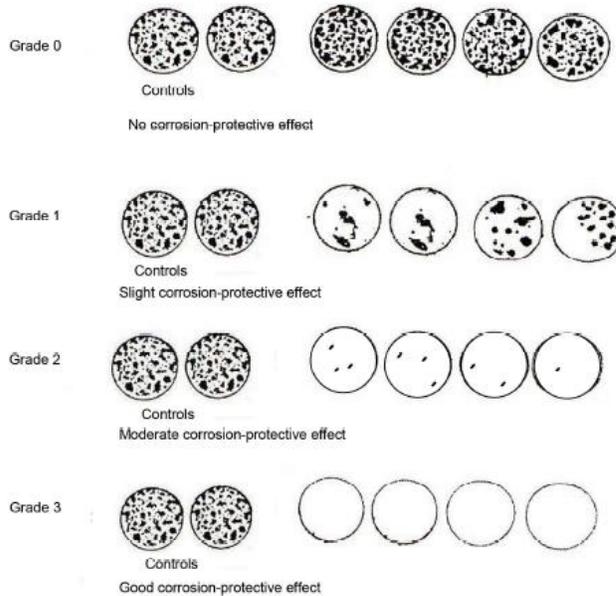
Armor Film



VpCl-126 film

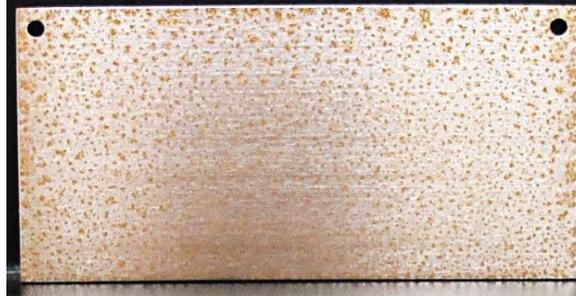


VIA Test Grades



Photos from Humidity Testing, CC-018 (based on ASTM D1748):

Cast Iron Panels



Control panel after 15 minutes of humidity testing

After 24 hours of Humidity Testing



VpCI-325



International's Anti-Rust 118H

After 264 hours of Humidity Testing

Previously tested (from 18-078-1825)



VpCI-369D 1:3

****Results apply only to items tested***

Photos after 24 hours of Humidity Testing, ASTM D1735:



Control- not treated



Coated with International's Anti-Rust 118H

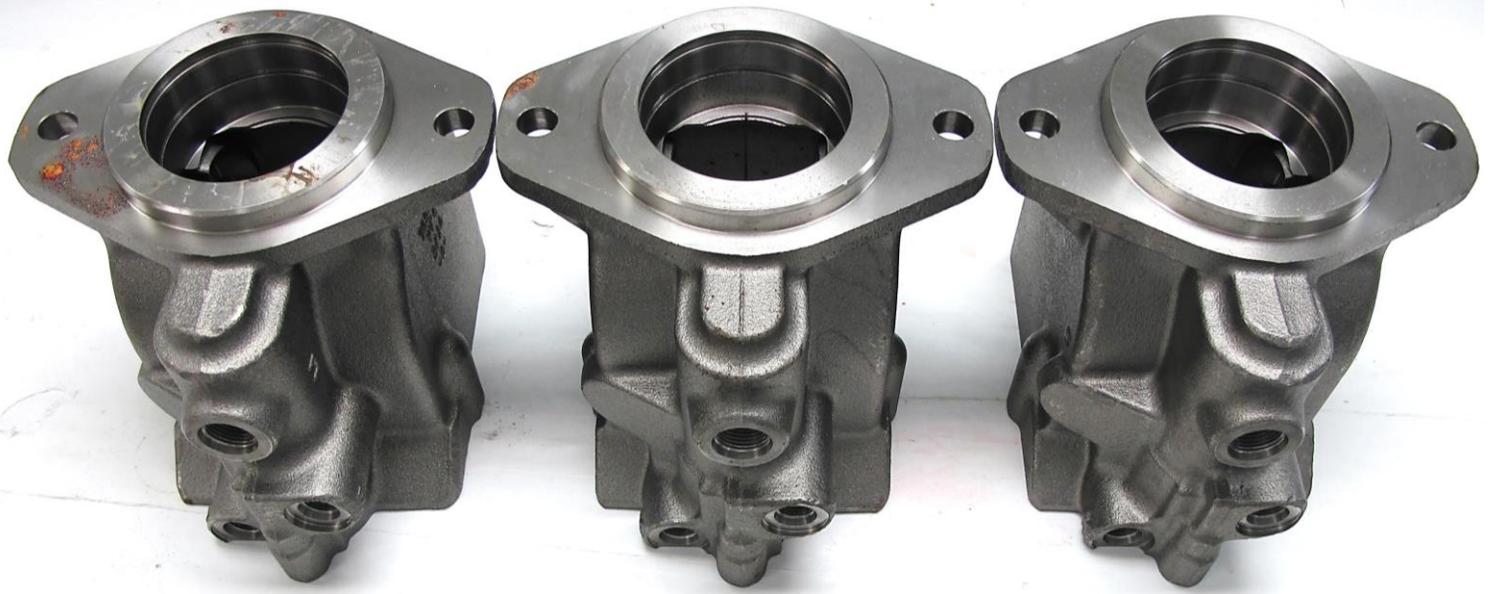


Coated with VpCI-325



Coated with VpCI-369

Photos after 264 hours of Humidity Testing, ASTM D1735:



Sealed in VpCI-126 Film (tested for 264 hours)



Sealed in Armor Film (tested for 264 hours)

****Results apply only to items tested***

Interpretations:

VIA and Razor blade testing demonstrates that while the Armor film submitted by our customer does provide contact protection to steel (as demonstrated in the steel razorblade test), it does not provide sufficient vapor corrosion protection to steel and cannot provide contact protect to copper (as demonstrated by the VIA and copper razorblade tests, respectively). Cortec's VpCI-126 film provides good protection in all three tests.

Results from humidity testing (ASTM D1748 conditions) on standard test panels demonstrates that both VpCI-325 and VpCI-369 D provide better corrosion protection than the International Anti-Rust 118H rust preventative. VpCI-369 D is designed to form a more robust, oily film on metal surfaces, and therefore provides better corrosion protection than the VpCI-325.

These results are confirmed in testing in ASTM D1735 conditions on parts submitted by our customer. International Anti-Rust 118H provides the worst protection, followed by VpCI-325, and VpCI-369 D provides the best protection in this testing.

Packaging testing in ASTM D1735 conditions shows that VpCI-126 film provided better corrosion protection to the parts submitted by our customer compared to Armor VCI film.