CORTEC Laboratories, Inc.

4119 White Bear Parkway, St. Paul, MN 55110 USA
Phone: (651) 429-1100, Fax: (651) 429-1122
Toll Free: (800) 4-CORTEC, E-mail: info@cortecvci.com
cortecvci.com • cortexlaboratories.com

LABORATORY ACCREDITATION BUREAU a division of A2LA ACCREDITED ISO/IEC 17025
Certificate # L2267 Testing

Evaluating Rust Preventatives for Customer

To: Customer

From: Cortec Laboratories, Inc.
4119 White Bear Parkway
St. Paul, MN 55110

cc: Boris Miksic
Cliff Cracauer
Robert Kean
Jay Zhang
Mike Gabor

Project #: 18-016-1125.bis

Results reported by:

Ben Voight
Process & Technical Service Engineer

Approved by:

John Wulterkens
Technical Service Engineer

Background:
Customer, manufactures, and services systems and components in the aircraft, vehicle and machinery manufacturers. Customer is manufacturing a new part that is scheduled to be approved in April. Annual volumes are expected to be more than 400,000 parts. The parts are manufactured in the United States and shipped over to China where they are heated and fitted over a crankshaft during assembly. The parts are hardened on the outside edge, but the inner diameter of the part remains softer.

A large portion of the parts will be shipping to China, for which customer currently is using an oil based rust preventative and Zerust film to protect the parts in the shipping process. Parts currently being shipped to China have arrived with corrosion primarily on the inner diameter of the parts. Cortec was asked to test a variety of possible alternatives to customer's current rust preventatives.

Sample Received:
- Yellow Zerust bags, 19" x 15". No visual contamination/damage to bags
- Bottle of Castrol oil, no visual contamination
- 20 gears, packaged in Zerust bags, minor dirt/grease from shipping/manufacturing

Method:
- ASTM D-1735
- VIA Test (CC-027)
- Razor blade Test (CC-004)

Materials:
- Copper panels
- Carbon steel panels
- VIA plugs
- VIA test solution – prepared 2/15/18
- Copper razor blade test solution – prepared 2017
- DI water
- BioCorr Batch #207817
- BioCorr ATF Batch #90248
- VpCI-325 Batch #198017
- VpCI-329 Batch #248317
- VpCI-414 Batch #188717

Procedure:
Metal gears were cleaned in a solution of 5% by weight in water VpCI-414. After cleaning and drying, gears were tested in triplicate. Samples were dipped in Castrol Oil, BioCorr, BioCorr ATF, VpCI-325, and VpCI-329 respectively. One sample was not dipped in any solution and used as a control. After dipping, samples were allowed to "dry" overnight (approximately 16 hours) before being placed into ASTM D-1735 conditions. Samples were checked periodically and any rusting was noted. Samples remained in ASTM D-1735 for 360 hours (15 days).

Both the VIA test and razor blade test were followed per the work instruction.

Results:
Photos of results can be seen on the following pages.

Minor staining appeared on two of the three Zerust samples from the VIA test. No significant rusting was observed in any VIA samples. Following the razorblade test, all of the carbon steel samples failed when using the Zerust film, and two of the three copper panels failed. All VpCI-126 samples in both carbon steel and copper panels passed.

VIA Test

Sample	Plug #1	Plug #2	Plug #3	End Result
Yellow Zerust Film	Grade 3	Grade 3	Grade 2	Pass
VpCI-126	Grade 2	Grade 3	Grade 2	Pass
Control	Grade 0	-	-	Fail

Figure 1. Zerust VIA samples.

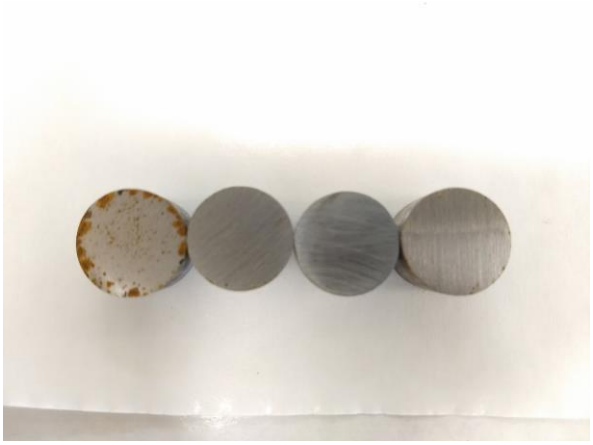

Figure 2. VpCI-126 VIA samples.

Carbon steel Razorblade Test

Sample	Panel 1	Panel 2	Panel 3
Yellow Zerust Film	Fail	Fail	Fail
VpCI-126	Pass	Pass	Pass
Control	Fail	-	-

Copper Razorblade Test

Sample	Panel 1	Panel 2	Panel 3
Yellow Zerust Film	Fail	Pass	Fail
VpCI-126	Pass	Pass	Pass
Control	Fail	-	-

All parts were removed from ASTM D-1735 chamber after 360 hours. Photos can be seen on the following page.

Figure 3. Control after 360 hours

Figure 4. Castrol oil after 360 hours

Figure 5. BioCorr after 360 hours

Figure 6. BioCorr ATF after 360 hours

Figure 7. VpCI-329 after 360 hours

Figure 8. VpCI-325 after 360 hours

Interpretations:
Very minimal rusting was observed on parts coated in VpCI-325, and minimal rusting was observed on parts coated in VpCI-329. BioCorr ATF, VpCI-329, and VpCI-325 appear to perform better than the Castrol oil currently being used, with VpCI-325 performing the best. Heavy rusting was observed on the inner diameter, like customer has reported. Spots of rust appear on the same area of the inside ring due to the gears being stored vertically in the humidity chamber. This caused a pooling of water at the bottom of the inner diameter.

Both Zerust film and VpCI-126 tested comparably in the VIA test. Staining was observed on two samples of the Zerust film. All VpCI-126 samples passed both carbon steel and copper razorblade tests, while only one sample passed copper razorblade from the Zerust film. The yellow film from Zerust does not provide sufficient corrosion protection to pass the carbon steel razorblade test. VpCI-126 film provides excellent corrosion protection for both the contact and vapor phase.