# RUST TRANSFORMERS/RUST COMPATIBLE PRIMERS

**Dario A. Emeric and Christopher E. Miller**
**U.S. Army Belvoir Research, Development**
**& Engineering Center**
**Fort Belvoir, VA 22060-5606**

## ABSTRACT

Proper surface preparation has been the key to obtain good performance by a surface coating. The major obstacle in preparing a corroded or rusted surface is the complete removal of the contaminants and the corrosion products. Sandblasting has been traditionally used to remove the corrosion products before painting. However, sandblasting can be expensive, may be prohibited by local health regulations and is not applicable in every situation. To get around these obstacles, Industry developed rust converters/rust transformers and rust compatible primers (high solids epoxies).

The potential use of these products for military equipment led personnel of the Belvoir Research, Development and Engineering Center (BRDEC) to evaluate the commercially available rust transformers and rust compatible primers. Prior laboratory experience with commercially available rust converters, as well as field studies in Hawaii and Puerto Rico, revealed poor per-formance, several inherent limitations, and lack of reliability. It was obvious from our studies that the performance of rust converting products was more dependent on the amount and type of rust present, as well as the degree of permeability of the coating, than on the product's ability to form an organometallic complex with the rust. Based on these results, it was decided that the Military should develop their own rust converter formulation and specification. The compound described in the specification is for use on a rusted surface before the application of an organic coating (bituminous compounds, primer or topcoat). These coatings should end the need for sandblasting or the removing of the adherent corrosion products. They also will prepare the surface for the application of the organic coating.

Several commercially available rust compatible primers (RCP) were also tested using corroded surfaces. All of the evaluated RCP failed our laboratory tests for primers.

## INTRODUCTION

Proper surface preparation has been the key to obtain good performance by a coating. The major obstacle in preparing a corroded or rusted surface, before the application of an organic coating, has been the complete removal of the contaminants and the corrosion products. Sandblasting has been traditionally used to remove the corrosion products before painting. However, sand-blasting can be expensive, it may be prohibited by local health regulations, and it may not apply in every situation. To get around these obstacles, Industry developed the rust converters /rust transformers, and the rust compatible primers.

The potential use of these products in fielded equipment by the Military, led personnel of the Belvoir Research, Development and Engineering Center (BRDEC) to test the commercially available rust transformers[1] and rust compatible primers[2]. Prior field and laboratory experience with commercially available rust transformers, as well as field studies in Hawaii and Puerto Rico, revealed poor performance and lack of reliability. It was obvious from our studies, that the performance of rust converting products was more dependent on the amount and type of rust present, and on the degree of permeability of the coating, than on the product's ability to form an organometallic complex with the rust. Based on these results, it was decided that the Military should develop their own rust converter formulation (U.S. Patent 4,880,478)[3] and specification (MIL-R-53086)[4]. The compound described in the specification is for use on a rusted surface before the application of an organic coating (bituminous compounds, primer or topcoat). The proper

application of the product should end the need for sandblasting or the removing of the adherent corrosion products. It also will produce the proper surface for the application of an organic coating.

Commercially available rust compatible primers (RCP) that were tested[2] failed our laboratory tests for primers. The Chemical Agent Resistant Coating (CARC)[5] system used by the Department of Defense on tactical equipment performed better on corroded surfaces than the so called rust compatible primers.

## EXPERIMENTAL PROCEDURE

Cold rolled steel panels[1] cleaned in an aqueous non-ionic detergent solution (0.1%Triton-X100) were exposed for 5 minutes to a 5 % salt fog solution according to ASTM B117. These panels were placed outdoors for three weeks[2]. At this point, the panels were ready to be treated and painted. When the corroded surface was treated with a rust converter the following procedure was used:

Step 1. Wet panel with either distilled or demineralized water
Step 2. Allow excess water to run off by tilting panel
Step 3. Apply on first coat (sprayed or brushed) of rust converter
Step 4. Allow panel to dry for not less than 12 hours
Step 5. Rinse in flowing water and repeat steps 2 through 4
Step 6. Spray 5% sodium bicarbonate solution on panels
Step 7. After 3 minutes, rinse solution off panels
Step 8. Allow panels to dry at room temperature for not more than 24 hours

The treated panels were painted with the CARC primer (MIL-P-53022)[6] to a 1.5 mils (38 $\mu$m) dry film thickness (DFT) or with the (MIL-C-62218)[8] bituminous compound to a DFT of 6 mils (152 $\mu$m).

Air assisted spray[3], airless spray, and drawdowns were tried to apply the rust compatible primers in one coat to a DFT of 5-6 mils (127-152 $\mu$m). Two methods for the application of the primers were developed. These methods should prevent the formation of pinholes that could develop during application of the primers. The first method was to spray the initial coat as a mist or flash coat onto the surface of the panels. The second method used the 8 step rust converter procedure described above. Both processes produced a leveled profile (hills and valleys) of the corroded surface. The panels were then coated to a DFT of 3.5 mils (89 $\mu$m) with the rust compatible primers. The paint was allowed to dry for 24 hours, after which, the panels were recoated with 3.5 mils (89 $\mu$m) DFT of the respective products to achieve a final DFT of 7.0 mils. Before having the panels tested, they were allowed to dry at room temperature for one week.[4]

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[1] Q-Panels, R-Type, 0.023" thickness, dull matte finish, 3" x 6" size, Q-Panel Company, 26200 First Street, Cleveland, OH 44145.

[2] After approximately 12 days of exposure, the panels were powerwashed and sprayed with a 5% salt solution. This procedure was followed to obtain uniform, adherent corrosion on the surface of the panel. After the pre-corrosion process, the loose corrosion was removed using a high pressure power-washer.

[3] Binks Spray Gun, Model 2001, Binks Manufacturing Company 4.5 in. (11.4 cm.) Rubber Coated.

[4] The CARC panels used as controls were wash primed with DOD-P-15328[7] to a 0.4 mils (10 um) DFT prior to the application of the primer MIL-P-53022[6].

## WET ADHESION TESTING

The treated panels were tested according to Federal Test Standard No. 141 Method 6301.2[9]. The panels were evaluated according to ASTM D3359[10] (measuring adhesion by tape test).

## SALT SPRAY/WET ADHESION TESTING

After the preparation and curing processes were complete, the panels were placed in the salt spray chamber for periods of 336 hours and 500 hours. The test was run according to ASTM B117[11]. Once removed, the panels were rinsed in tapwater, dried, and tested according to Federal Test Method Standard 6301.2[9]. The panels were then tested according to either ASTM D3359[10] (measuring adhesion by tape test) or ASTM D610[12] (non-impinged area) and ASTM D1654[13] (impinged area).

## SALT SPRAY/GRAVELOMETER TESTING

After the preparation and curing processes were completed, the panels, before testing, were placed in the cold temperature chamber and conditioned for two hours. The panels were tested according to ASTM D3170[14]. After the gravelometer testing was completed, the panels were placed in the salt spray chamber[5] for 336 and 500 hours according to ASTM B117[12]. Upon removal of the samples from the salt spray cabinet, they were rinsed with tapwater, dried, and evaluated according to ASTM D610[12] (non-impinged area) and ASTM D1654[13] (impinged area).

## OUTDOOR EXPOSURE TESTING

Once scribed with a diamond pattern, the panels, treated with the rust converters, were placed outdoors at Fort Belvoir. They were oriented at an angle of 45° from the horizontal facing south for one year. After one year, the panels were removed and tested according to ASTM D610[12] (non-impinged area) and ASTM D1654[13] (impinged area). The rust compatible primers were not tested outdoors because of their failure in the Laboratory.

## RESULTS

The CARC topcoat blistered and delaminated from the panels that had been treated with the phosphoric acid base and tannic acid base rust converters. No signs of blistering or delamination were observed on the panels treated with the BRDEC formulation (Tables 1, 2 & 3).

The MIL-C-62218[8] bituminous coating failed on the edges of the panels when treated with the commercially available rust converters. No signs of failure were observed on the panels treated with the BRDEC formulation.

No problems were found, when the RCP was applied to uncorroded surfaces, but as expected problems were found when the RCP was applied to the corroded test panels. The problems were due to the high profile of the corroded surface that prevented the high viscosity paint to fully wet the surface. Several different application methods were tried but the results were the same. None of these paints could be successfully applied to the proper thickness in one coat. It was decided that once the loose corrosion was removed, that either a mist coat of the RCP or rust converter should be applied to lower the corrosion profile and to improve surface wetting. Final film thickness will be achieved by using a two coat process with 24 hours drying period between first and second coats. No differences were found between the products in this test. All the products performed well in the salt spray tests when there were no chips or cuts in the coating (Tables 5, 6 & 7). There was one rust compatible primer that out-performed the others when a damaged paint film was exposed to 500 hours of salt spray. However, when the same product was applied to

[5] Harshaw Salt Fog Cabinet, Model #22, Harshaw Chemical Company

an uncorroded surface and treated in the same manner, it delaminated three days after testing was completed. The reason for the delamination is not known and it may necessitate further work.

## CONCLUSIONS

The tests and evaluations discussed in this report were under-taken to find out if the commercially available rust converters or rust compatible primers could be used by the Military on corroded surfaces of military equipment without first having to sandblast the surfaces. The decision was that any rust converter to be used by the Military will have to meet the requirements of MIL-R-53086[4] and not to use any rust compatible primer if the CARC[5] system is going to be used.

## REFERENCES


1. D.A. Emeric, B. Westich, R.C. McNeil, Rust Converters, BRDEC Report 2457, November 1987.
2. C. Miller, B. Westich, Evaluation of High Solids Paint, BRDEC Report 2492, May 1990.
3. D.A. Emeric et al, Protective Coatings for Steel Surfaces and Method Application, U.S. Patent No. 4,880,478 November 14, 1989.
4. MIL-R-53086, Rust Converter, Metric
5. MIL-C-46168, Coating, Aliphatic Polyurethane, Chemical Agent Resistant
6. MIL-P-53022, Primer, Epoxy Coating, Corrosion Inhibiting, Lead & Chromate Free
7. DOD-P-15328, Primer (Wash), Pretreatment (Formula No. 117 for Metals)
8. MIL-C-62218, Corrosion Preventive Compounds, Cold Application (For New & Fielded Motor Vehicles & Trailers)
9. Federal Test Method Standard (FTMS) 141, method 6301.2, "Adhesion (wet) tape test"
10. ASTM D3359, "Measuring Adhesion by Tape Test"
11. ASTM B117, "Standard method of salt spray (fog) testing"
12. ASTM D610, "Standard method of evaluating degree of rusting of painted steel surfaces"
13. ASTM D1654, "Standard method for evaluation of painted or coated specimens subjected to corrosive environments"
14. ASTM D3170, "Chip Resistance of Coatings"

## TABLES

Table 1
Wet Adhesion
of Corroded Panels
ASTM D3359

| Panel | In the Laboratory | In the Field |
|---|---|---|
| BRDEC formulation | 5B | 4B |
| Phosphoric Acid | 4B | 2B |
| Tannic Acid | 4B | 1B |
| RCP | 3B | 3B |

Key: RCP - rust compatible primer - high solids epoxy

Table 2
Salt Spray/Wet Adhesion
of Corroded Panels

| Panel | ASTM D610 (Rusting) | ASTM D3359 (Adhesion) |
|---|---|---|
| BRDEC formulation | 7 | 4B |
| Phosphoric Acid | 7 | 4B |
| Tannic Acid | 9 | 1B |
| RCP | 7 | 2B |

Key: RCP - rust compatible primer - high solids epoxy

Table 3
Outdoor Exposure Testing
of Corroded Panels

| Panel | ASTM D610 (Rusting) | ASTM D1654 (Scribe) |
|---|---|---|
| BRDEC formulation | 6 | 3 |
| Phosphoric Acid | 5 | 3 |
| Tannic Acid | 2 | 2 |
| RCP | 4 | 3 |

Key: RCP - rust compatible primer - high solids epoxy

Table 4

Visual Analysis before Testing

| Panel | No Rust Converter Comment | With Rust Converter Comment |
|---|---|---|
| Control | ok | |
| 53022 | ok | |
| Tannic acid | | ok |
| Phosphoric Acid | | ok |
| BRDEC Formulation | | ok |
| RCP | pinholes throughout | ok |
| | | ok |

Key: Control -- Cold rolled steel panels + 0.4 mils (10.2 $\mu$m) of DOD-P-15328 wash primer + 1.0 mil (25.4 $\mu$m) MIL-P-53022.
RCP - rust compatible primer - high solids epoxy
53022 - epoxy primer as per MIL-P-53022

Table 5
Wet Adhesion Results

| Panel | No Rust Converter ASTM D3359 Rating (Adhesion) | With Rust Converter ASTM D3359 Rating (Adhesion) |
|---|---|---|
| Control | 5B | |
| 53022 | 3B | |
| Tannic Acid | | 4B |
| Phosphoric Acid | | 4B |
| BRDEC Formulation | | 4B |
| RCP | 3B | 3B |
| | | 4B |

Key: Control -- Cold rolled steel panels + 0.4 mils (10.2 $\mu$m) of DOD-P-15328 wash primer + 1.0 mil (25.4 $\mu$m) MIL-P-53022

Table 6
Salt Spray/Gravelometer Results (336 hours)

| Panel | No rust converter | | With Rust Converter | |
|---|---|---|---|---|
| | ASTM D610 (Rusting) | ASTM D1654 (Scribe) | ASTM D610 (Rusting) | ASTM D1654 (Scribe) |
| Control | 10 | 7 | | |
| 53022 | 10 | 8 | | |
| Tannic Acid | | | 10 | 9 |
| Phosphoric Acid | | | 10 | 9 |
| BRDEC Formulation | | | 10 | 9 |
| RCP | | | 10 | 8 |
| | 10 | 7 | 10 | 9 |

Key: Control -- Cold rolled steel panels + 0.4 mils (10.2 $\mu$m) of DOD-P-15328 wash primer + 1.0 mil (25.4 $\mu$m) MIL-P-53022
RCP - rust compatible primer - high solids epoxy
53022 - epoxy primer as per MIL-P-53022

Table 7
Salt Spray/Gravelometer Results (500 hours)

| Panel | No Rust Converter | | With Rust Converter | |
|---|---|---|---|---|
| | ASTM D610 (Rusting) | ASTM D1654 (Scribe) | ASTM D610 (Rusting) | ASTM D1654 (Scribe) |
| Control | 10 | 10 | | |
| 53022 | 10 | 9 | 10 | 9 |
| Tannic Acid | | | 10 | 9 |
| Phosphoric Acid | | | 10 | 7 |
| BRDEC Formulation | | | 10 | 7 |
| RCP | 10 | 6 | 10 | 8 |

Key: Control -- Cold rolled steel panels + 0.4 mils (10.2 $\mu$m) of DOD-P-15328 wash primer + 1.0 mil (25.4 $\mu$m) MIL-P-53022
RCP - rust compatible primer - high solids epoxy
53022 - epoxy primer as per MIL-P-53022