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suitability of Prepainted (Coil Coated) Metal
and Adhesive Assembly for Military Application

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Corrosion of vehicles is a major cost to the Army.

Independent Cost Analysis which agrees with our available records indicate a cost per vehicle per year of \$500 to \$1,100.

Much of the fleet has 30 to 40 year old design. In many cases current technology for material selection, component design and manufacturing processes is not incorporated into procurement specifications.

The Automotive and Steel Industries in recent years has done much research in this field of corrosion. We have attended conferences by the Society for Automotive Engineering Automotive Corrosion and Prevention Committee, The American Iron and Steel Institute Task Force on Automotive Corrosion and the Society of Manufacturing Engineers Association for Finishing Process. Our office is also in regular contact with individual automotive company engineers.

The information obtained from all these sources indicates that probably the best cost effective results in corrosion control are achieved by a system consisting of:

- 1.) Galvanized Steel
- 2.) Zinc Phosphate Pre-Treatment
- 3.) Electro-Deposited Cathodic Primer

The Army requirements are different from the automobile market for many reasons, chief of which are:

- More variations and extremes in environment
- Off road use
- Low mileage with high percent non-operating time
- Chemical agent resistance requirements

To evaluate the finding of the automotive industry and determine modifications beneficial to the Army, a study was made of corrosion of Jeep vehicle bodies with different coating systems. These bodies were exposed to a sea coast environment at Cape Canaveral. This site was selected for these characteristics.

- Severe corrosion environment
- High humidity
- Salt laden air
- Frequent rain showers
- Frequent strong ocean winds
- Abundance of solar radiation

After 12 months the following was reported:

"An evaluation of the results of 12 months exposure testing indicate that of the body configurations tested, optimum corrosion protection is achieved by utilization of the following body coating configurations in descending order.

- Galvanized, Two-Sided
- E-Coat Primer (Cathodic Electrodeposition)
- High Solids Enamel Topcoat (PPG-DHT 45323)
- Rust Proofing - Per MIL-R-46164

- Galvanized, Two-Sided
- E-Coat - Primer (Cathodic Electrodeposition)
- High Solids Enamel Topcoat (PPG-DHT 45323)

- Non-Coated Steel
- E-Coat - Primer (Cathodic Electrodeposition)
- High Solids Enamel Topcoat (PPG-DHT 45789)
- Rust Proofing

- Non-Coated Steel
- Alkyd - Primer
- Alkyd - Topcoat
- Rust Proofing

Non-Coated Steel
Alkyd - Primer
Alkyd - Topcoat

"In the writer's opinion, a single component change to offer the most improvement to the standard M151A2 body's corrosion protection system of Alkyd primer, Alkyd topcoat and rust proofing would be two sided galvanized coating on the body in place of non-coated steel. The next most effective single component would be to use E-Coat in lieu of alkyd type primer.

"Only one body had spray CARC primer and topcoat and it rated at the bottom of the eight tests. CARC (Chemical Agent Resistant Coating) is the specified topcoat for new procurements and this one test may be misleading as to CARC's capabilities as the body was non-coated steel, was the only one with epoxy primer and was not rustproofed."

Of particular significance was the fact that on the galvanized bodies the only corrosion showing was at welded areas.

While this project was continuing it was decided to evaluate the potential of coil coated metal for military vehicles with these expectations.

Lower cost/Better paint
Improved environment/No VOC's
No metallurgical changes of steel with
resulting corrosion sites
No damage to zinc coating

The following different constructions were planned for this evaluation:

Group:	Steel:	Construction:	Prime:
Control	C. R. Steel	Welded	Spray CARC
1	C. R. Steel	Welded	E-Coat
2	C. R. Steel	Adhesive	CARC Coil Coat
3	C. R. Steel	Adhesive	Flex Coil Coat
4	Galvanized	Adhesive	Flex Coil Coat
5	Galvanized	Adhesive	E-Coat

The first production of coil coated steel was disappointing in that it was learned that CARC epoxy primer would not take 1T bend as required for the door hem assembly.

The paint manufacturers tried many formulations to develop a more flexible prime paint that would also be resistant to DS2, the solvent used to clean vehicles after a nuclear, chemical or biological attack.

The most suitable was a combination of thin epoxy and polyester.

This more flexible paint was still subject to microfracturing when subjected to a 1T bend.

The doors with the different systems were subjected to the following tests:

- Accelerated corrosion: General Motors 9540P
- Mechanical strength: General Motors Truck Door Slam Durability Test
- Field Test: Trucks at Camp Lejeune Marine Drivers Training School
- Coastal exposure: Cape Canaveral, Florida

Thirty-six sample test doors were subjected to extensive testing to determine the suitability of prepainted metal and adhesively bonded assemblies for military application.

The thirty-six doors consisted of thirteen standard doors and twenty-three adhesively bonded test doors. The thirteen standard doors were of current production methods and techniques. Seven of the doors were cold rolled steel with standard primer and rust proofing. The remaining six were cold rolled steel with E-Coat primer and rust proofing.

The twenty-three adhesively bonded test doors were manufactured using four different material/process systems. Five were cold rolled steel with CARC coil coated primer and no internal paint. Five were cold rolled steel with flex coil coated primer and internal E-Coating.

Ten were galvanized steel with flex coil coated primer and internal E-Coating. The final three doors were adhesively bonded galvanized steel with E-Coat primer.

Four tests were performed. Nine were subjected to an accelerated corrosion test and six were subjected to a durability test. A marine exposure test was performed on twelve doors and nine were installed on vehicles for a military user test. The results of the tests were conclusive in that galvanized cold rolled steel with an E-Coat primer is the best combination of material and processes.

It was concluded that coil coating is not practical for this application. Manufacturing operations such as bending, tool markings, handling, blanking and stamping are detrimental to the prepainted surface. The epoxy CARC precoat could not withstand the 1T bend of the hemming operation. E-Coating was found to be highly superior to coil coating because it is not subjected to these manufacturing processes. The E-Coat application process also assures that all internal parts, cavities, seams and joints received a specific thickness of coating.

Adhesive was determined to be considerably better than spotwelds from a corrosive standpoint. Adhesive is mechanically equal to or better than spotwelding.

Galvanized steel was substantiated as being the door skin. The galvanized covering is very compatible with an E-Coat primer and a zinc phosphate pretreat.

Durability Test (SLAM) - All six sample test doors met GM 0075-A-01-LP1C test specification requirements. No cracking or separation occurred in the bonded areas (both adhesive and spotweld) between the door structure and the sheet metal outer skin. No adhesive failure occurred in any of the six doors even though the test far exceeded the normal life of the doors. Damage, other than adhesive bonded areas, clearly indicates that other parts of the door failed long before the adhesive bonding.

Accelerated Corrosion (SCAB) - Nine sample doors received forty complete cycles of testing in accordance with GM9540-P. The GM test was selected because it best correlates the test with the field life (actual service life) of the door. Three of the nine doors were subjected to an additional forty cycles in order to more nearly approach the normal service life of the door. Galvanize gave the best performance. Evaluation of E-Coating and coil coating did not detect any difference on a flat surface. The coil coat evidenced degradation on surfaces subjected to manufacturing operations. E-Coat performed very well with galvanize but experienced a shorter life when used by itself.

Marine Exposure Test - Twelve doors were tested for 21 months. Results indicate galvanized steel is better than cold rolled steel. E-Coating is the best primer.

Military User Test - Nine test doors were subjected to this 21 month test. Both the military user and the marine exposure tests, have corroborated the results of the accelerated corrosion tests.

Results clearly indicate the two galvanized doors to be better than the cold rolled steel doors.

Our basic conclusions from these studies are:

Cleaning and pretreatment are critical

Zinc phosphate best pretreatment for corrosion resistance

G90 Galvanizing (.75 mil) min. 10-12 year life

E-Coat superior corrosion resistance in both tests
About halfway from spray prime to galvanizing

"Rustproofing" can add up to 20% life to spray paint; but only where applied and if replaced as needed

Most cost effective coating system:

- 1.) Galvanizing
- 2.) Zinc phosphate pretreatment
- 3.) E-Coat prime

This combination provides at least 90% of total corrosion protection.

From the observations this far in our research these correlations have been indicated:

1 Year static coastal exposure = 3-4 years
real life average exposure

10 cycles G.M. 9540P = approximately 1 year
real life average exposure

Support SAE/AISI finding that the GM9540P
accelerated test has .96 correlation to real life

The things we foresee for future work in this area are:

Adhesive assembly of other parts

Further evaluation of potential of a flexible coil
coated prime paint

Non-CARC application of coil coating

More extensive use of galvanizing

More extensive use of E-Coating