NAVSEA WARFARE CENTERS
Carderock Division

Survivability, Structures, & Materials

Accelerated Corrosion Testing Results for the High Mobility Artillery Rocket System

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Background

- The High Mobility Artillery Rocket System (HIMARS) is a lightweight, C-130 transportable version of the M-270 Multiple Launch Rocket System (MLRS)
- HIMARS was developed for the U.S. Army by Lockheed Martin under the Advanced Concept Technology Demonstration (ACTD)
- In December 2000, Lockheed Martin received a contract to produce HIMARS for the USMC

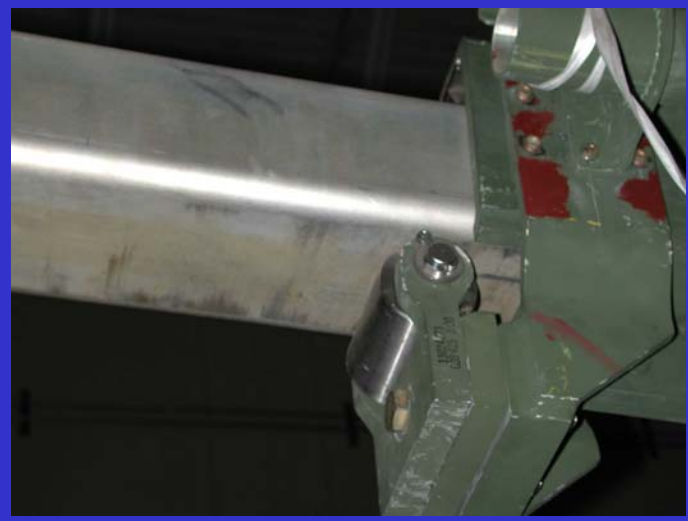
Background (cont.)

- USMC vehicles and weapon systems experience a harsh marine environment and high corrosion rates
- Naval Surface Warfare Center, Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) tasked with investigating corrosion susceptibility and maintenance concerns of HIMARS
- In Dec 01, NSWCCD-SSES conducted a corrosion survey of prototype launchers at Lockheed Martin
- Identified various components that have a high potential for corrosion related damage
- Lockheed Martin corrected many of the problems; however, three items were determined to be too complex to easily correct

Components Susceptible to Premature Corrosion Failure

2024-T851 Aluminum Retractable Beams

- Currently, only protection on the retractable beams is a MIL-C-5541 Class 1A chromate conversion coating



Components Susceptible to Premature Corrosion Failure

Winch Drum

- Consist of a 7075 aluminum drum with nickel-plated 302 CRES wire rope

Components Susceptible to Premature Corrosion Failure

Cadmium-Plated Aluminum Electrical Connectors

- Corrosion Prevention Compounds (CPC) are not currently specified
- Corrosion/seizing problems are expected

Components Susceptible to Premature Corrosion Failure

- NSWCCD-SSES tasked with determining the severity of corrosion damage as well as ways to mitigate potential corrosion damage on these items
- NSWCCD-SSES, in conjunction with Army Aviation and Missile Command (AMCOM) and Lockheed Martin, developed an accelerated corrosion test plan to determine the severity of the problem and to identify corrective actions for any discrepancies
- Testing consisted of performing GM 9540 P accelerated corrosion testing on representative samples with and without Corrosion Prevention Compounds (CPC's) and coatings

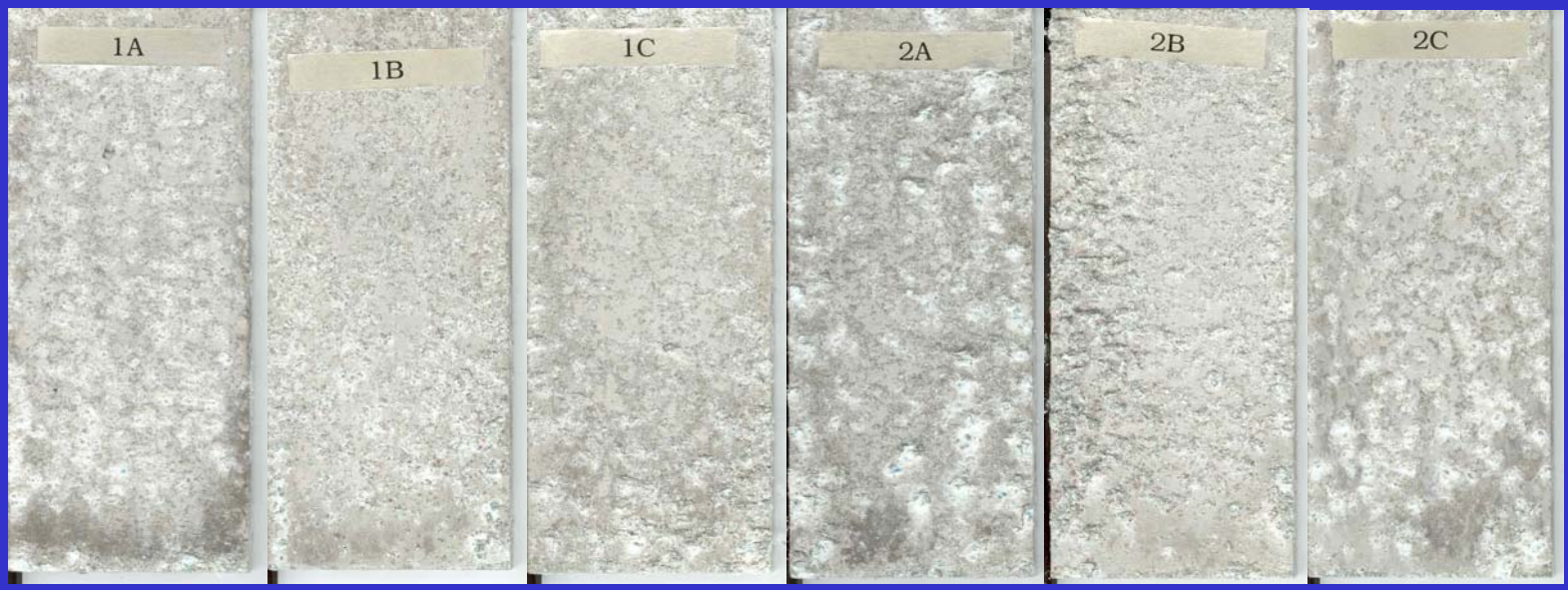
GM 9540 P Accelerated Corrosion Test

- Laboratory based testing chamber
- Cyclic combination of conditions (salt solution, various temperatures, humidity, and ambient environments) to accelerate metallic corrosion
- Complete duration of the testing was 176 cycles (days), nominally equivalent of 22 years
- All preservatives and coatings used for corrosion mitigation were only applied once during the duration of the testing

2024 Aluminum Retractable Beams

Primary Corrosion Protection	Secondary Corrosion Protection
Control	
MIL-C-5541 Class 1A	
Supplemental Coating	
MIL-C-5541 Class 1A	MIL-C-85054 (Amlguard)
MIL-C-5541 Class 1A	MIL-PRF-46147 (Dry Film Lubrication)
Alternative Coating	
MIL-A-8625 Type III	MIL-C-16173 (Cold Application CPC)
MIL-A-8625 Type III	Sodium Dichromate Seal
Commercial Coating A (Water-based inorganic coating)	
Commercial Coating B (Ceramic-based coating)	
Commercial Coating C (Inorganic siloxane coating)	

2024 Findings – MIL-C-5541 Class 1A (Control)



- Severe exfoliation and pitting
- Unacceptable performance for intended use on retractable beams

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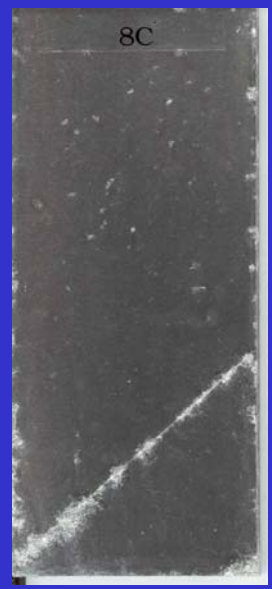
2024 Findings – MIL-C-85054

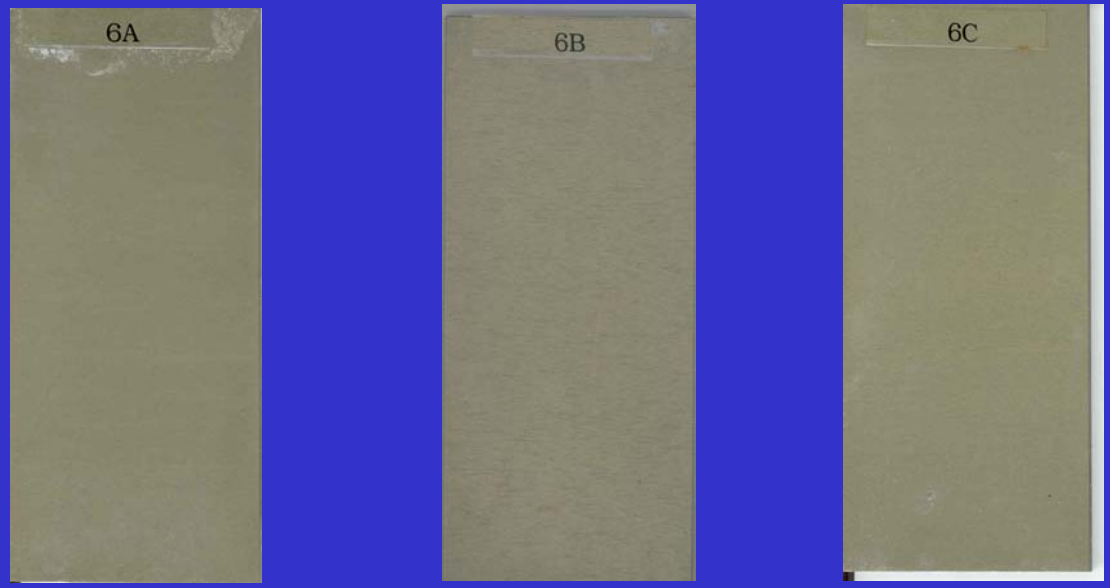
- Significantly reduced surface corrosion
- Majority of corrosion observed at scribe
- Can be applied after production and reapplied periodically

2024 Findings – MIL-PRF-46147 Dry Film Lube



- Corrosion observed primarily at scribe
- Dry film lubricant can be applied after production and reapplied periodically

2024 Findings – MIL-A-8625 Ty III with MIL-C-16173



- Excellent corrosion protection
- Would require major process change to include hard coat anodize during production
- MIL-C-16173 Grade 2 does not completely cure and may embed rocket exhaust and dust

2024 Findings – MIL-A-8625 Sodium Dichromate Seal

- Significant pitting and exfoliation
- Would require major process change to include hardcoat anodize

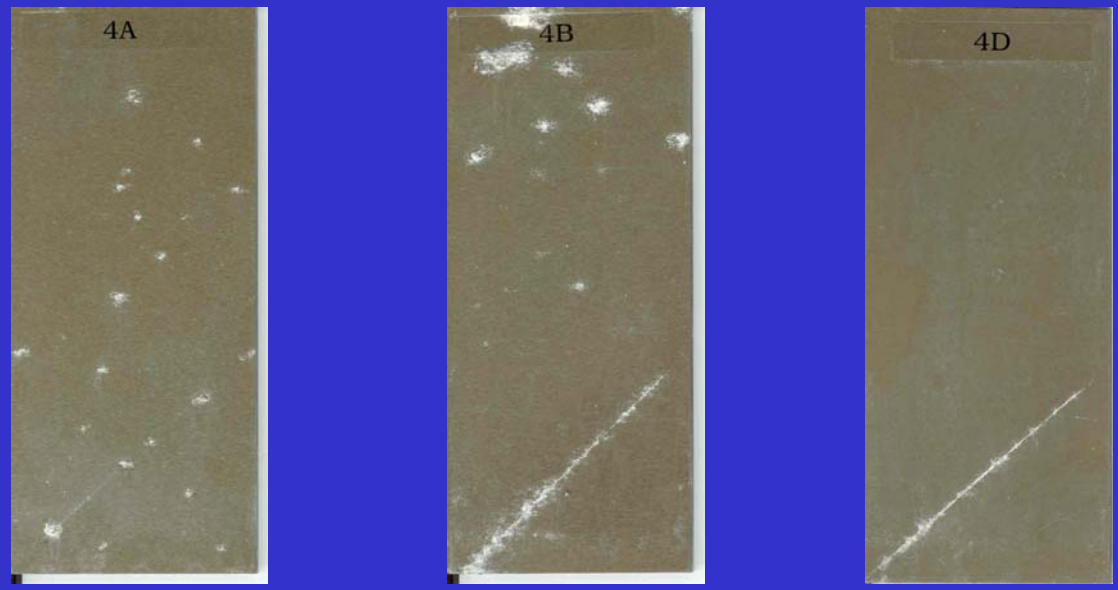
2024 Findings – Commercial Coating A

Water-based inorganic coating

- Excellent corrosion protection
- Would require application of commercial coating

2024 Findings – Commercial Coating B

Ceramic-based coating



- Minor corrosion products observed
- Would require application of commercial coating

2024 Findings – Commercial Coating C

Inorganic siloxane coating

- Severe exfoliation and pitting
- Unacceptable performance for intended use on retractable beams

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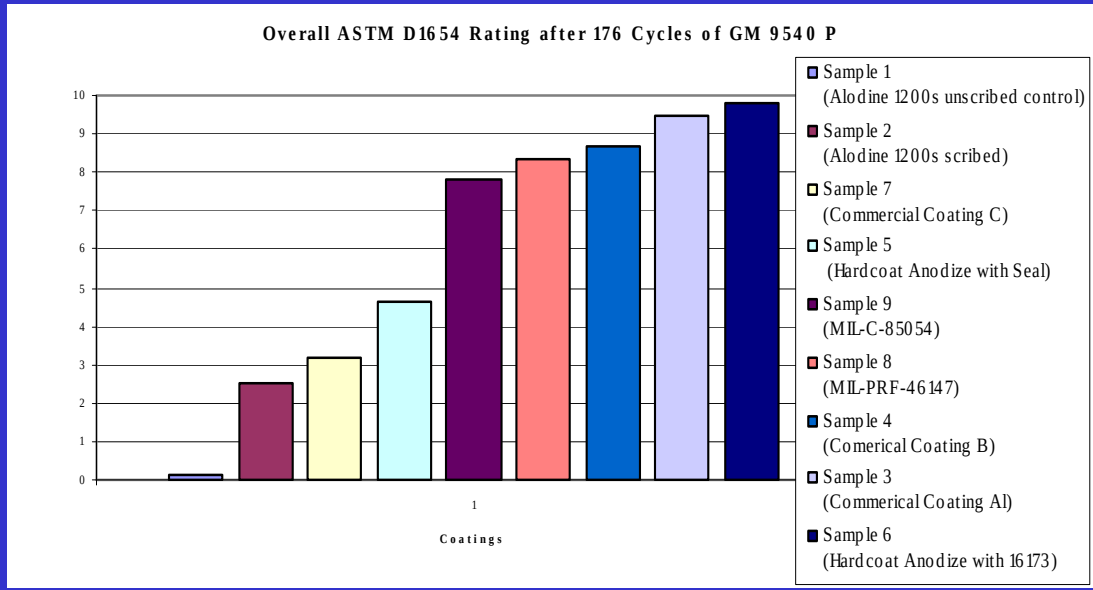
Evaluation of Samples



- Coatings and Preservatives were ranked using ASTM D1654
- Five of the eight coatings tested provided acceptable performance

Conclusions from 2024 Corrosion Testing

- Coatings intended to replace conversion coating process provided the best corrosion protection; however, implementation would require a major process change and associated increased cost
- Supplemental coatings (dry film lube and Amlguard) provided comparable corrosion protection and can be applied without altering the construction process
- Application can be performed during initial production and reapplied by USMC/US Army as part of Preventative Maintenance Checks and Services (PMCS)
- Dry Film Lubrication (DFL) is preferred because retractable beams are moving surfaces and DFL will aid in process

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7075 Aluminum Winch Drum

Primary Corrosion Protection	Secondary Corrosion Preservative
Control	
MIL-C-8625 Type III	
Supplemental Coating	
MIL-C-8625 Type III	MIL-C-16173 (Cold Application CPC)
MIL-C-8625 Type III	MIL-C-40084 (Water Displacing Oil)
MIL-C-8625 Type III	Sodium Dichromate Seal
Alternative Coating	
MIL-A-8625 Type II	Sodium Dichromate Seal
Commercial Coating A (Water-based inorganic coating)	
Commercial Coating B (Ceramic-based coating)	

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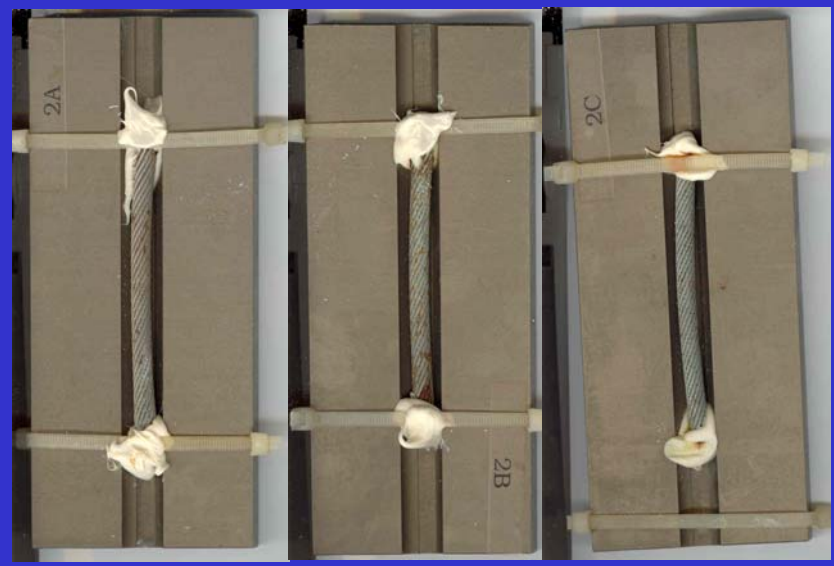
7075 Findings

MIL-C-8625 Type III Hardcoat Anodize - **Control**



Hardcoat Anodize with MIL-C-16173

No major corrosion observed

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7075 Findings

Hardcoat Anodize with MIL-C-40084

Hardcoat Anodize with Sodium Dichromate Seal

No major corrosion observed

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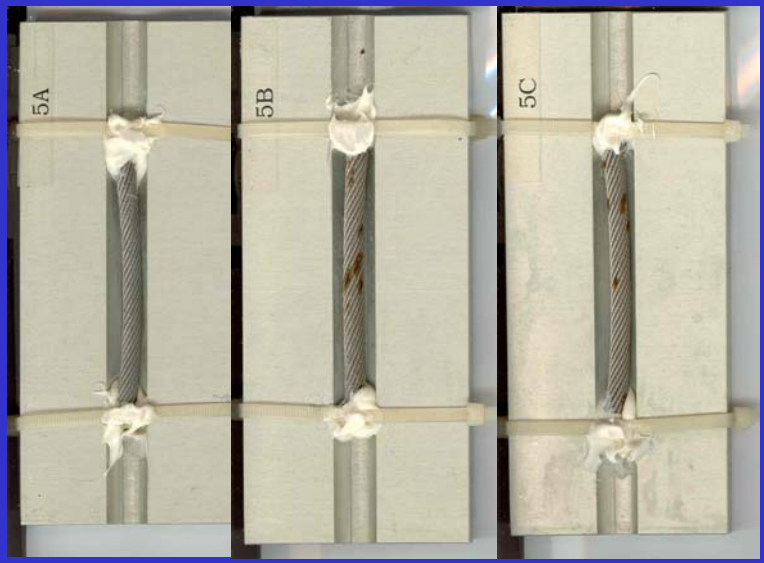
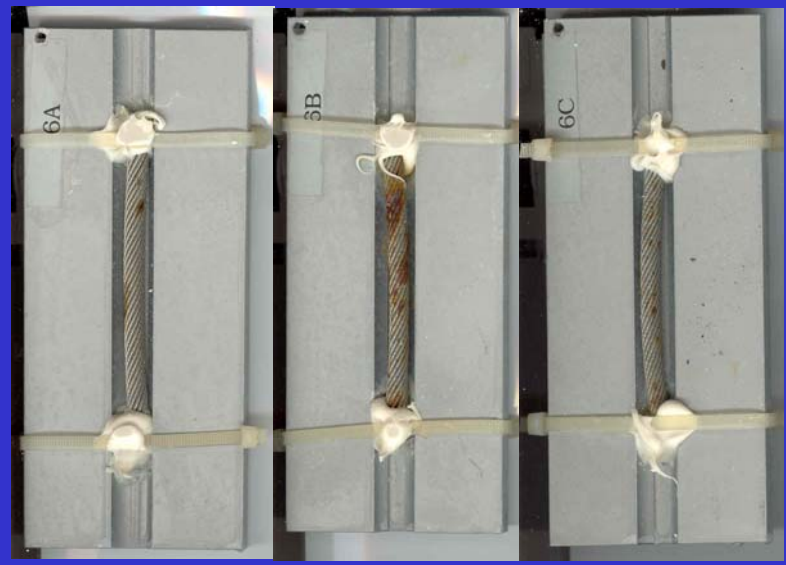
7075 Findings



MIL-A-8625 Type II Thincoat Anodize with Sodium Dichromate Seal



Commercial Coating A
Water-based inorganic coating

No major corrosion observed

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7075 Findings

Commercial Coating B
Ceramic-based coating

No major corrosion observed

Conclusions from 7075 Corrosion Testing

- No major corrosion was observed on any sample
- While testing did not simulate wear damage, it did test aluminum alloy 7075 susceptibility to general corrosion, crevice corrosion and galvanic corrosion with CRES rope
- Not enough evidence to warrant further corrosion protection

Electrical Connectors

- Control – No Additional Treatment
- MIL-C-81309 Type III –Ultra Thin Film Coating
- MIL-C-85054 – Amlguard
- MIL-C-11796 Class III – Thin Film Preservative
- MIL-L-3150 – Corrosion Prevention Compound
- MIL-A-46156 – Room Temperature Vulcanizing Compound (RTV)
- Commercial Coating A - Inorganic Siloxane Coating

Electrical Connectors – Control (No Treatment)

- Severe corrosion and cracking observed on backshell of connectors

Electrical Connectors – MIL-C-81309 Type III

- Severe overall corrosion and cracking observed on backshell of connectors

Electrical Connectors – MIL-C-85054

- Significant overall corrosion observed
- Cracking was not observed

Electrical Connectors – MIL-C-11796 Class III

- Significantly decreased amount of corrosion damage when compared to control
- Cracking was not observed

Electrical Connectors – MIL-L-3150

- Severe corrosion and pitting observed

Electrical Connectors – MIL-A-46156

- No corrosion observed after removal of RTV
- RTV application and removal is a labor intensive process

Electrical Connectors – Commercial Coating A

Inorganic siloxane coating

- Significant overall corrosion and cracking observed
- Would require application of commercial coating

Conclusions from Electrical Connector Testing

- RTV had best corrosion protection; however, application and removal is a very labor intensive process
- RTV is best suited for electrical connectors that are infrequently removed
- For connectors that are frequently removed, a brushable / sprayable preservative should be used
- The brushable/sprayable preservatives that provided the best protection were MIL-C-85054 and MIL-C-11796
- Application can be performed during initial production and reapplied by USMC/US Army as part of Preventative Maintenance Checks and Services (PMCS)

Conclusions

- Accelerated corrosion testing predicted the severity of corrosion on the three components
- Corrosion Prevention Compounds (CPC's) are available for improved component protection/performance
- Remedial actions are low cost when performed as preventative maintenance
- Applying CPC's during vehicle construction will provide effective protection of these components at delivery
- Periodic inspection and reapplication can be performed as part of Preventive Maintenance Checks and Services (PMCS)