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Malcolm Baldrige National Quality Award 2007 Award Recipient

ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Title: Corrosion Resistance of Weapon Lubricants

PRESENTATION DATE: 11 February 2010

Presenter Name: Joseph Menke

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
11 FEB 2010		**00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Corrosion Resistance of Weapon Lubricants	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army ARDEC,AMSTA-AR-ESM-H,Rock Island Arsenal,Rock Island,IL,61299**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
2010 U.S. Army Corrosion Summit, Huntsville, AL, 9-11 Feb

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**25**	

OUTLINE

1. INTRODUCTION
2. APPROACH
3. RESULTS
4. CONCLUSIONS
5. RECOMMENDATIONS

INTRODUCTION

- Used animal fat for lubrication as far back as 1400BC
- Oils became available as lubricants in 1859
- Dry lubricant formulations became available in the 1950's

INTRO - CONT'D

WEAPON SYSTEM LUBRICATION CHARACTERISTICS

- LUBRICITY
- VISCOSITY
- CORROSION RESISTANCE

APPROACH

- LUBRICITY – Falex (at various loads) or 4 ball wear testing with variations in loading were the most common
- VISCOSITY – Numbers at -40 are significant as that is where the weapons are required to function
- CORROSION RESISTANCE – Necessary to insure preservation of function and minimize maintenance

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RESULTS

Wear Load Requirements of Specification Lubricants

Specification	Wear/Load
• MIL-PRF-32033	Four Ball – 1mm max. scar
• MIL-PRF-14107	No requirement*
• MIL-L-46000	Four Ball - 4.0 mm max. scar** / Falex - 1500 kg
• MIL-L-46150	Four Ball - 0.5 mm max. scar** / Four Ball - 70 kg
• MIL-PRF-85336	Four Ball - 1.1 mm max. scar / Falex - 2000 kg
• MIL-PRF-63460	Four Ball - 0.8 mm max. scar / Falex - 500 lbs
• MIL-G-21164	Four Ball – Load heat index of 50 minimum***
• MIL-PRF-372	No requirement

* Machine gun firing test shall not reduce cyclic rate by more than 75 rounds per minute

** 250^{O}F vs 167^{O}F, 600 vs 1200 rpm, 50kg vs 40kg load.

***No such requirement in ASTM-D2596

RESULTS

Viscosity Requirements of Specification Lubricants.

Specification	Viscosity
• MIL-PRF-32033	7000 cSt at -40oC
• MIL-PRF-14107	950 cSt at -54oC
• MIL-L-46000	12,000 cSt at -54oC
• MIL-L-46150	120,000 cSt at -54oC
• MIL-PRF-85336	70 Pa-s at -55oC
• MIL-PRF-63460	5000 cSt at -40oC
• MIL-G-21164	-
• MIL-PRF-372	1500 cSt at -29oC

RESULTS

Salt Spray Test Results (ASTM-B117) on Bare Steel – Time to failure in hours

Material Tested	Time to Failure
• MIL-PRF-37215 (Rifle Bore Cleaner)	2
• MIL-L-46000 (LSA)	2
• MIL-L-14107 (LAW)	6
• MIL-PRF-63460 (CLP)	120-160
• VV-L-800 (MIL-PRF-32033)15	3-8
• CLP (Commercial lubricant) (4000 ppm Cl) (C)	2
• CLP (Commercial lubricant/preservative) (S2)	24-48
• CLP (Commercial lubricant/preservative) (1200 ppm Cl) (S2L)	8
• CLP (Commercial cleaner/lube/preservative) (H)	2

SALT SPRAY HOURS

Material Tested

• Commercial Lube (B)	
• MIL-C-16173,Grade 2	192-216
• MIL-L-3150	40-75
• Commercial Rust Preventive Oil (CX)	31-48
• Commercial Rust Preventive Oil (CXHD) (12-16 mils)	2000-3000
• Desert Storm Lube	2
• Iraqi Freedom Lube	2
• Vietnam Lube	20-24

RESULTS

SALT SPRAY HOURS

Material Tested	
• MIL-C-40084 K (10% oil-90% water)	3
• MIL-C-40084 DT (10% oil-90% water)	6
• Commercial F (10% oil-90% water)	4
• Commercial F (20% oil-80% water)	48
• Commercial P (10% oil-90% water)	2
• Commercial P (50% oil-50% water)	48
• Commercial F1 (50% oil-50% solvent)	24
• Commercial F2 (50% oil-50% solvent)	6

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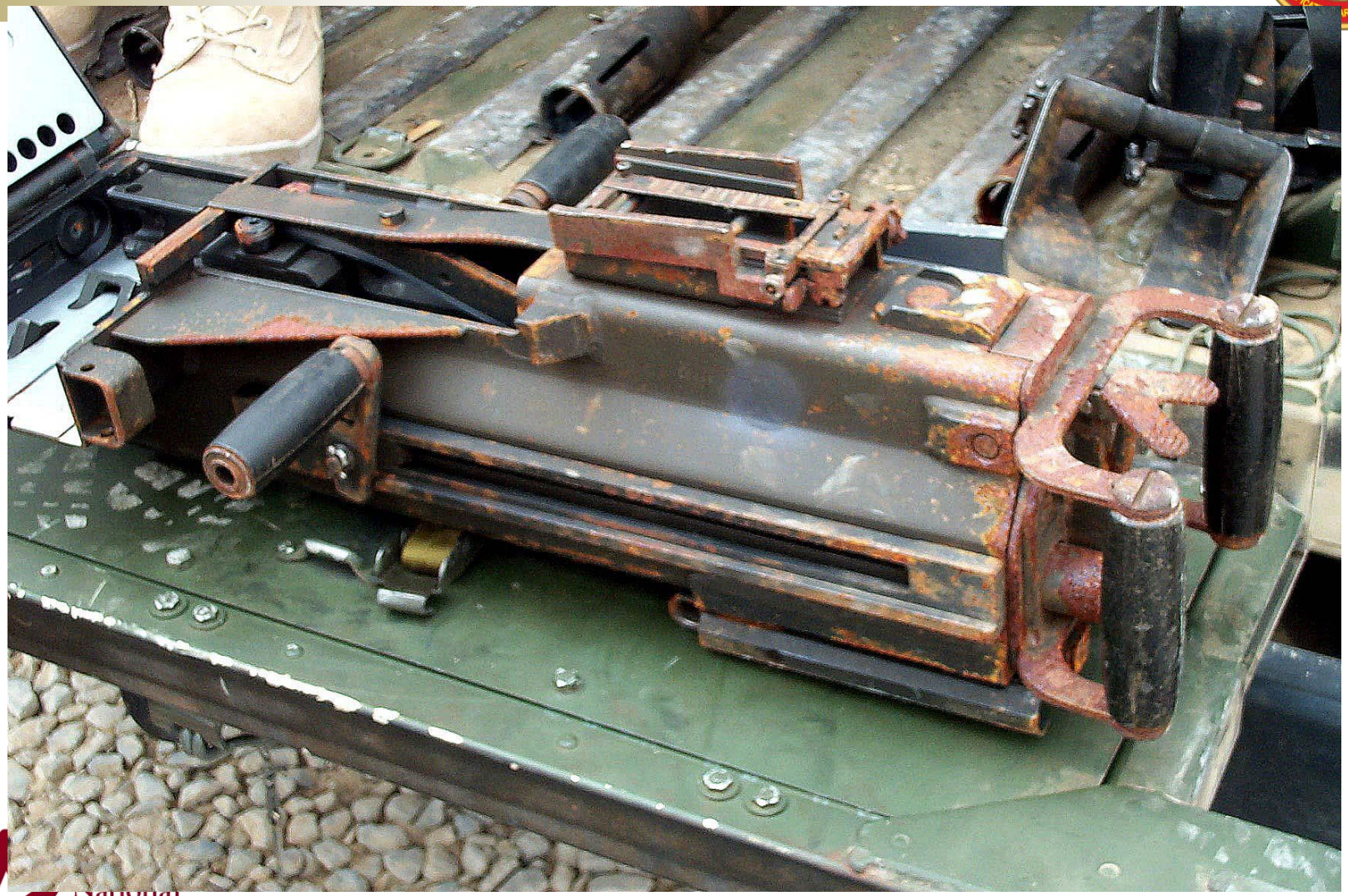

RETURNS-DESERT STORM

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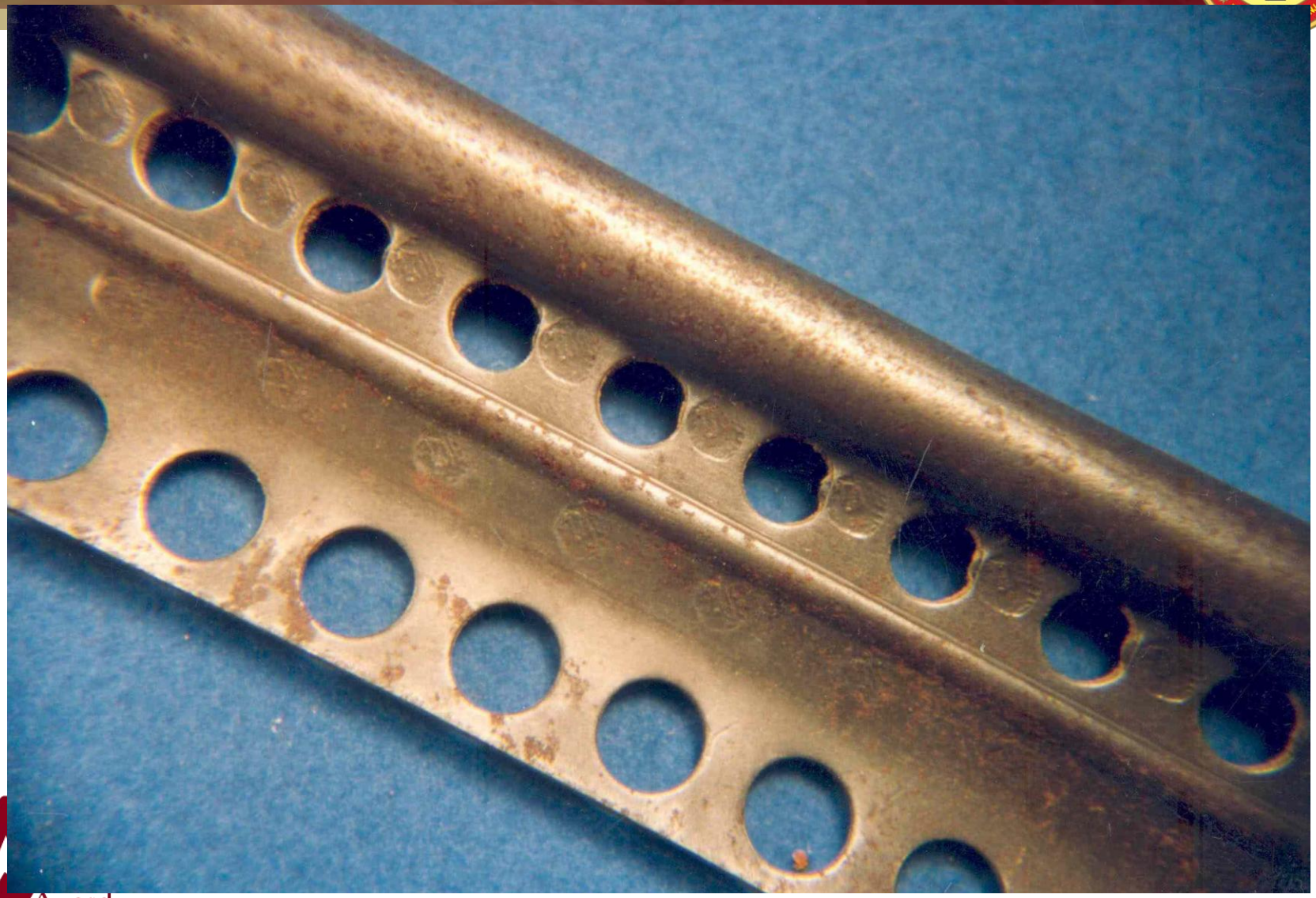

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VIETNAM GESTURE

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A letter from the PUBLISHER

James R. Shepley

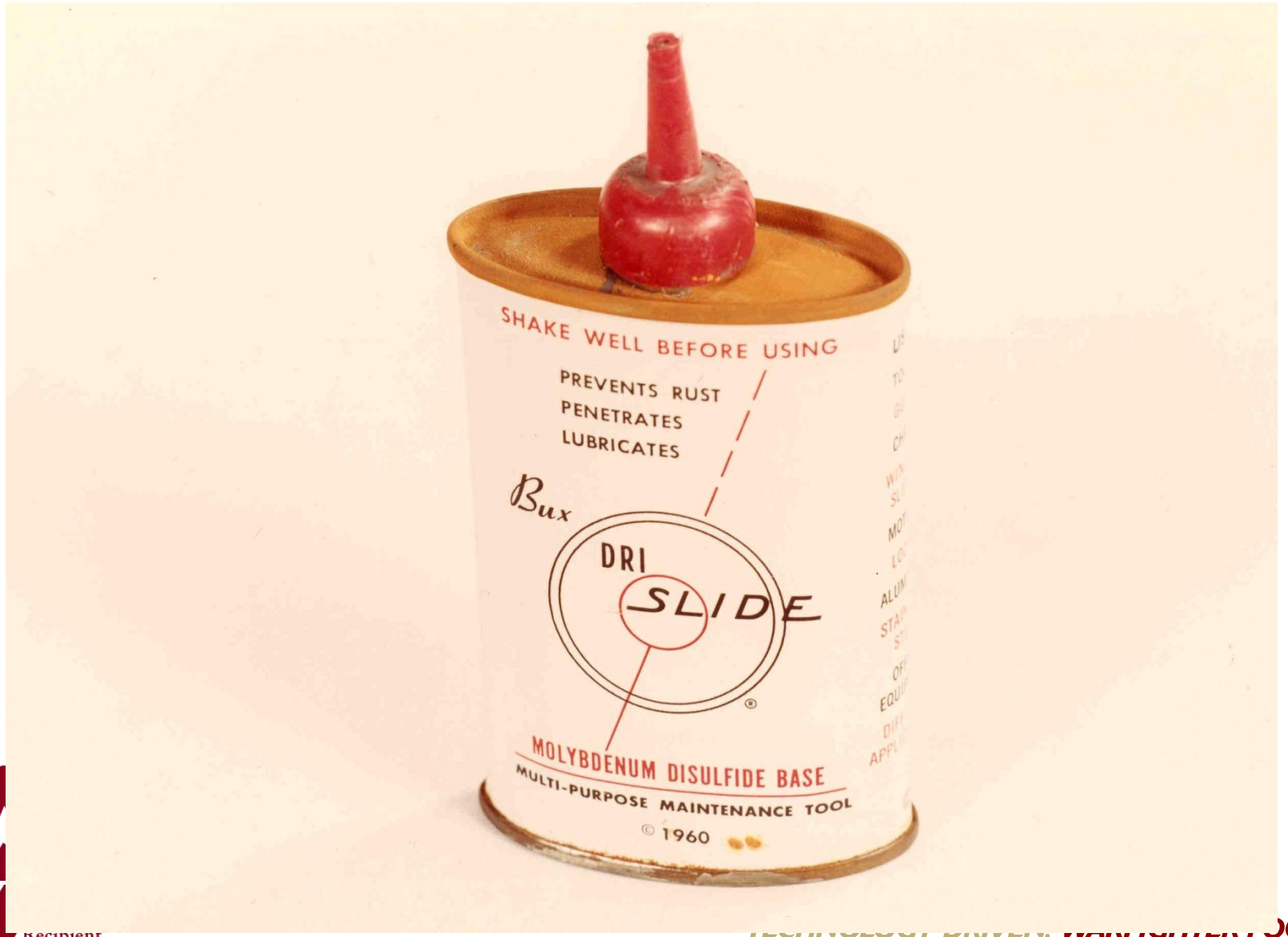
TIME, APRIL 26, 1968

A minute gesture or item, such as the pencil reproduced in actual size on this page, can sometimes acquire great value. That is just what happened when a voluntary organization asked G.I.s in Viet Nam what their most-wanted items were. Those needs were modest—such things as a pair of dry socks and some writing material. TIME provided the tiny pencil, which the Christian Reform Laymen's League included in 200,000 packets to Viet Nam. Surprisingly, the minipencil is serving purposes far beyond postcard writing. Its wooden shaft, wrote one Marine, is being used to clean the hard-to-get-at rifle sights, while the graphite helps sliding parts of the M-16. Hearing

of this, the volunteer group asked TIME for more of them to be included in a second shipment. This week another 200,000 pencils are going to the men.

•

VIETNAM GESTURE



LUBRICANTS-PROPERTIES

Table I. Properties of Common Lubricating Pigments

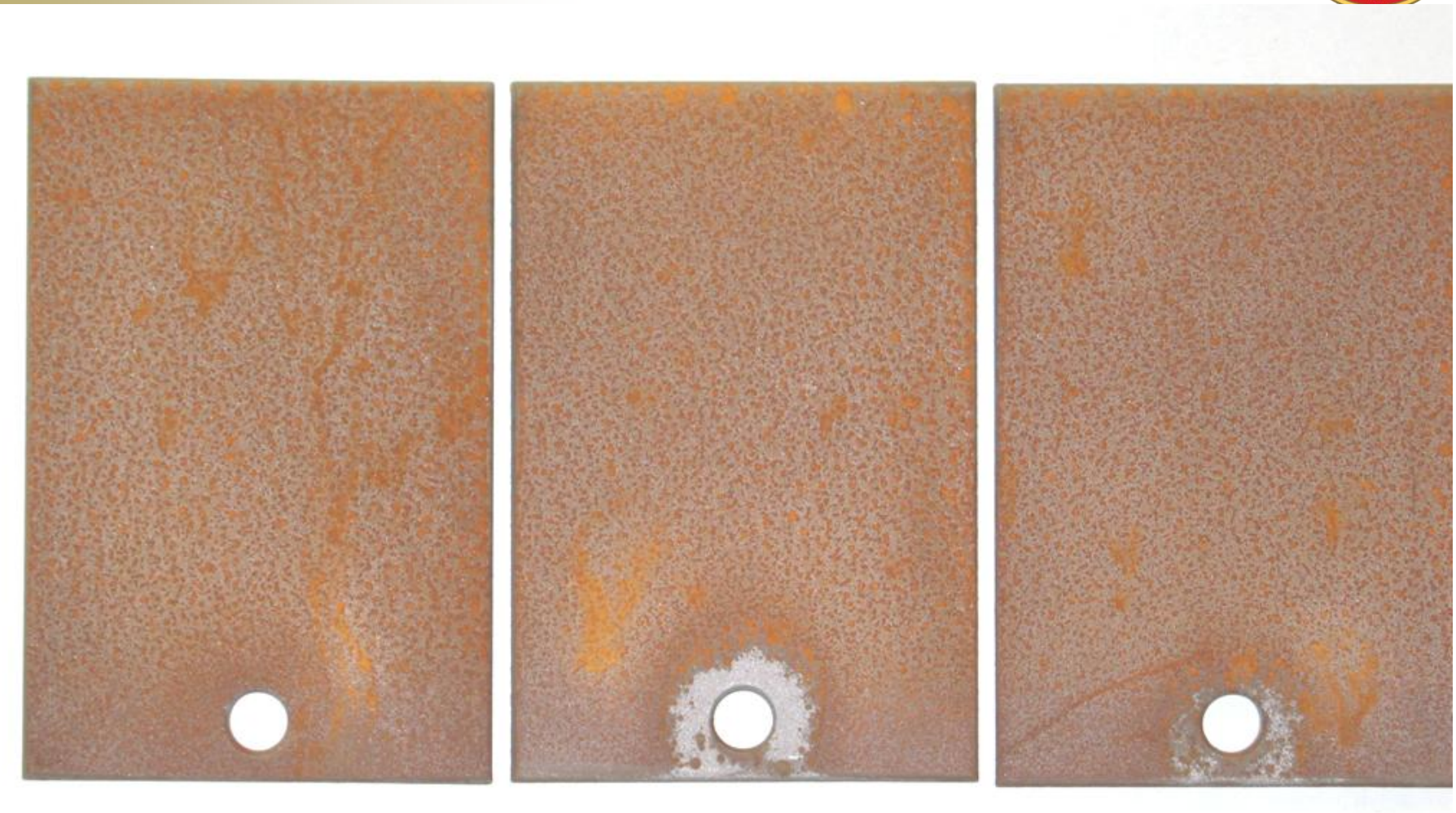
Pigment	*Color*	*Load Carrying Capability (psi)*	*Thermal Stability (°F)*	Corrosion Resistance (0.5–2.0 mil)
Molybdenum disulfide	Gray-black	>100,000	Good (<750)	Very Good
Graphite	Gray-black	<50,000	Excellent (<1200)	Fair/Poor
Polytetrafluoroethylene (PTFE)	White	<6,000 (1500)	Fair (<500)	Good
CLP oil w/ PTFE	light tan	750	150	GOOD

Pigment	*Typical Particle Size (μm)*	*Vacuum Suitability*	*Moisture Sensitivity*	FALEX @1000 lb gage
Molybdenum disulfide	2–6	Yes	Detrimental	>450 minutes
Graphite	2.5–10	No	Necessary	>60 minutes
Polytetrafluoroethylene (PTFE)	Submicron	Yes	No effect	< 1 minute

Table II. The Effect of Pretreatment on Wear Life

Pretreatment	*LFW-1 Test ASTM D-2714 → 72 RPM and 630 lb load ≅ 100,000 psi Cycles to Failure*
None	Failure on loading
Vapor degrease/Sand blast	20,000
Vapor degrease/Sand blast/Phosphate	670,000

OIL-2 HOUR SALT SPRAY



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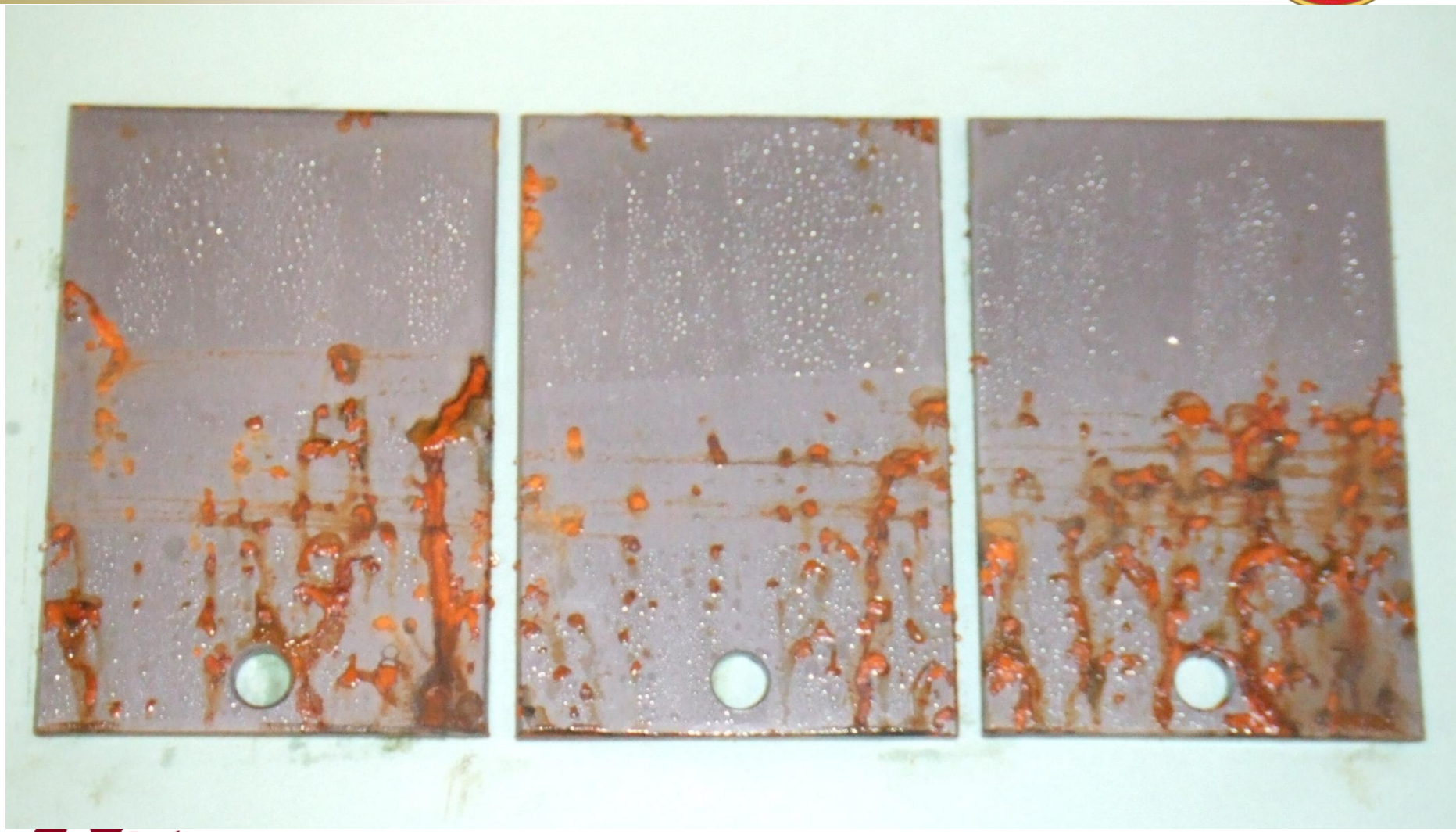
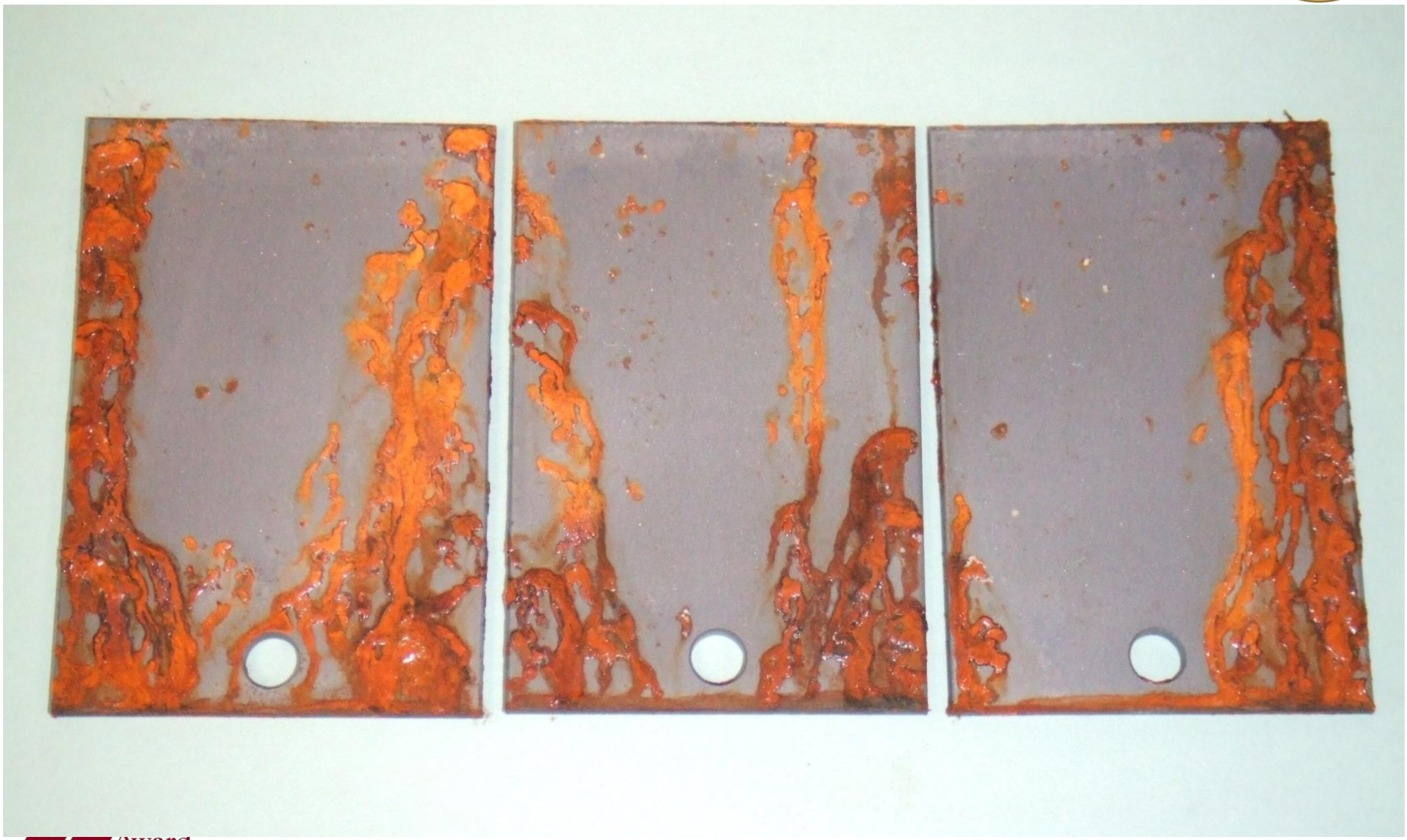
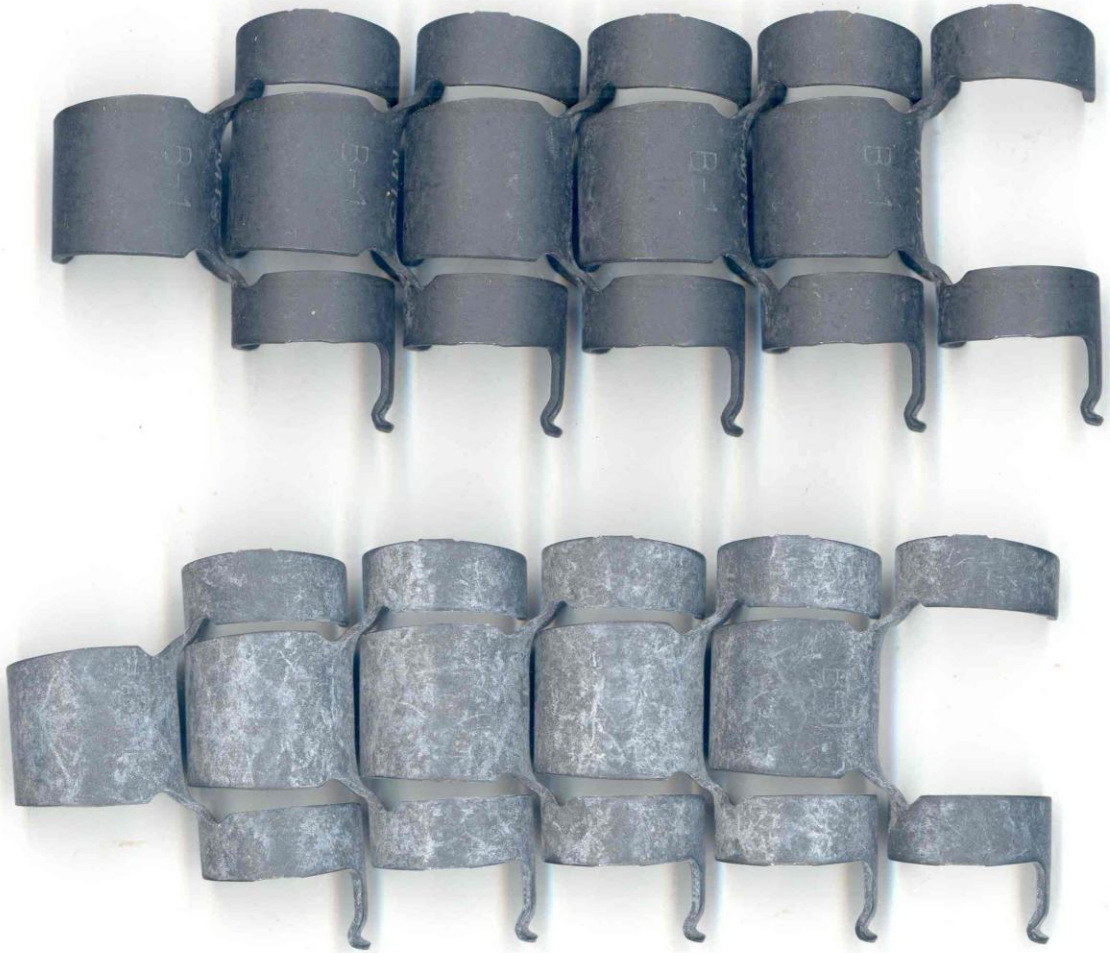
OIL-24 HOUR SALT SPRAY



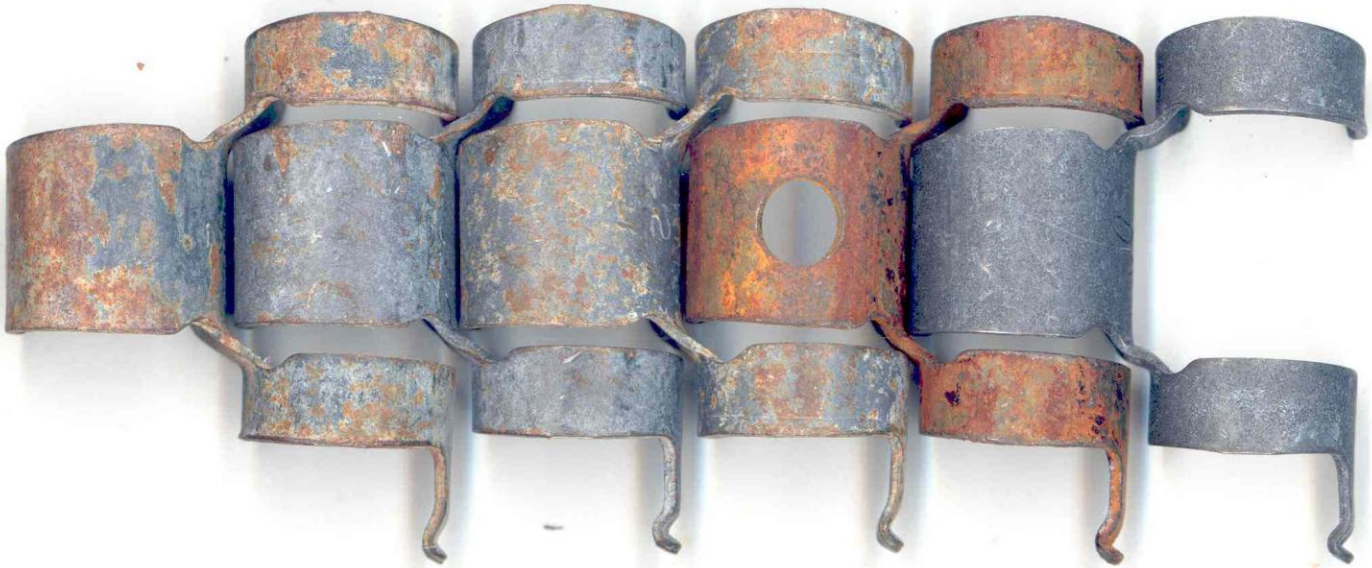
OIL-72 HOUR SALT SPRAY



BELT LINKS-OILED VS DRY



BELT LINKS FROM FIELD



CONCLUSIONS

- CURRENT WEAPON LUBRICANT (MIL-PRF-63460) MEETS THE BEST COMBINATION OF LUBRICITY, VISCOSITY AND CORROSION RESISTANCE
- PREVIOUS WEAPON LUBRICANTS NEEDED A VARIETY OF MATERIALS TO MEET OPERATIONAL REQUIREMENTS
- LUBRICANT EVALUATION STILL INCLUDES GUN FIRING TESTS WHICH HAVE BECOME INCREASINGLY EXPENSIVE
- CURRENT FIELD LUBRICANT HAS SUFFICIENT CORROSION RESISTANCE TO MINIMIZE MAINTENANCE PROBLEMS

RECOMMENDATIONS

- ARMY NEEDS A LUBRICITY TEST THAT BETTER SIMULATES WEAPON OPERATION AND USE THE TEST TO EVALUATE ALL WEAPON LUBRICANTS
- CONTINUE TO USE THE CORROSION RESISTANCE AND LOW TEMPERATURE VISCOSITY REQUIREMENTS FOR FUTURE LUBRICANTS
- ALWAYS, ALWAYS USE THE LUBRICANT RECOMMENDED IN THE FIELD MANUAL

LATEST DEFINITION OF CORROSION

DOD'S WEAPON OF MASS DESTRUCTION