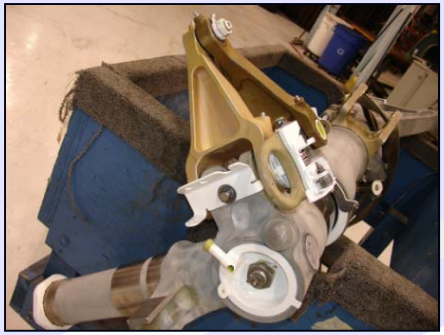
Temperature Effects on Corrosion of Cr^{6+}, Cr^{3+}, and Non-Cr^{6+} Conversion Coatings on AlumiPlate, and AlumiPlate Implementations

Kelly Donaldson, AlumiPlate

ASETSDefense, Feb 2011, New Orleans, LA



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AlumiPlate® Electrodeposited Aluminum

- **Minneapolis, MN, USA**
  - **Established 1995**
  - **Technology developed, tested, qualified & implemented**
  - **100% RoHS / REACH Compliant**
- **Electrodeposited Aluminum Corrosion Protection Coating**
  - **"Green" environmentally friendly replacement for toxic cadmium (Cd) plating (point of app, fly away, MRO)**
  - **Higher performance than present HAZMAT (Cd, Zn, Ni) corrosion protection technologies and any alternatives**
- **Well Established Specifications**
  - **MIL-DTL-83488 & Program / Application Specific**

Temperature Effects on Corrosion of Cr^{6+}, Cr^{3+}, and Non-Cr^{6+} Conversion Coatings on AlumiPlate, and AlumiPlate Implementations

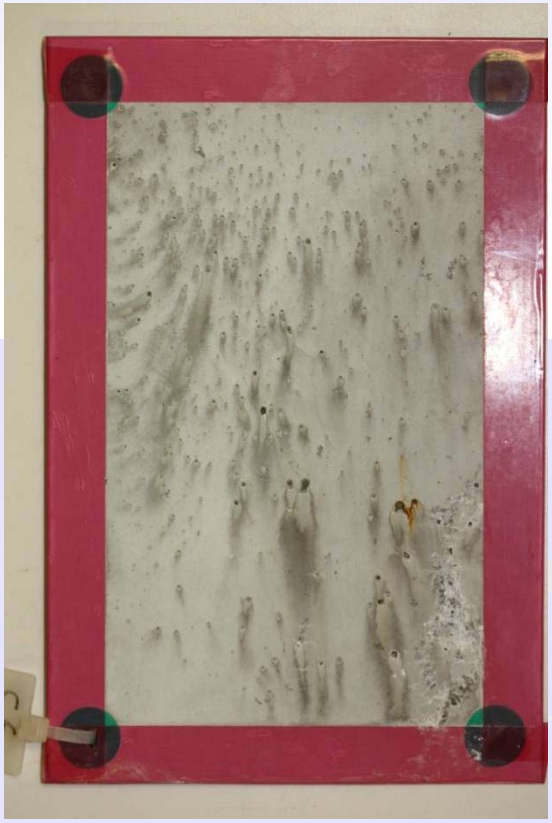
- **Test Conditions**
  - **Aluminum electroplate per MIL-DTL-83488, Class 2 (0.0005”/12.5μ min. thk.) on 4130 steel 3” x 6” coupons**
  - **Conversion coat with Cr^{6+},Cr^{3+}, non Cr^{6+}**
    - **Baseline = NO conv. coat,**
    - **1 type – Cr^{6+} (commercially available)**
    - **3 types -- Cr^{3+} (commercially available)**
    - **3 formulations – CFP non Cr^{6+} -> (provided by NAVAIR under CRADA)**
  - **Temperature exposure: 30C, 250C, 350C**
  - **Corrosion test per ASTM B117**
- **Protocol**
  - **24 hour bake cycle for temperature exposure**
  - **Results are averaged across multiple B117 test runs**

- **Test Setup – ASTM B117 Salt Fog Test chamber**

- **ASTM B117 – Definition of Failure**

A4 – 30C Cr^{6+}

4032 hrs



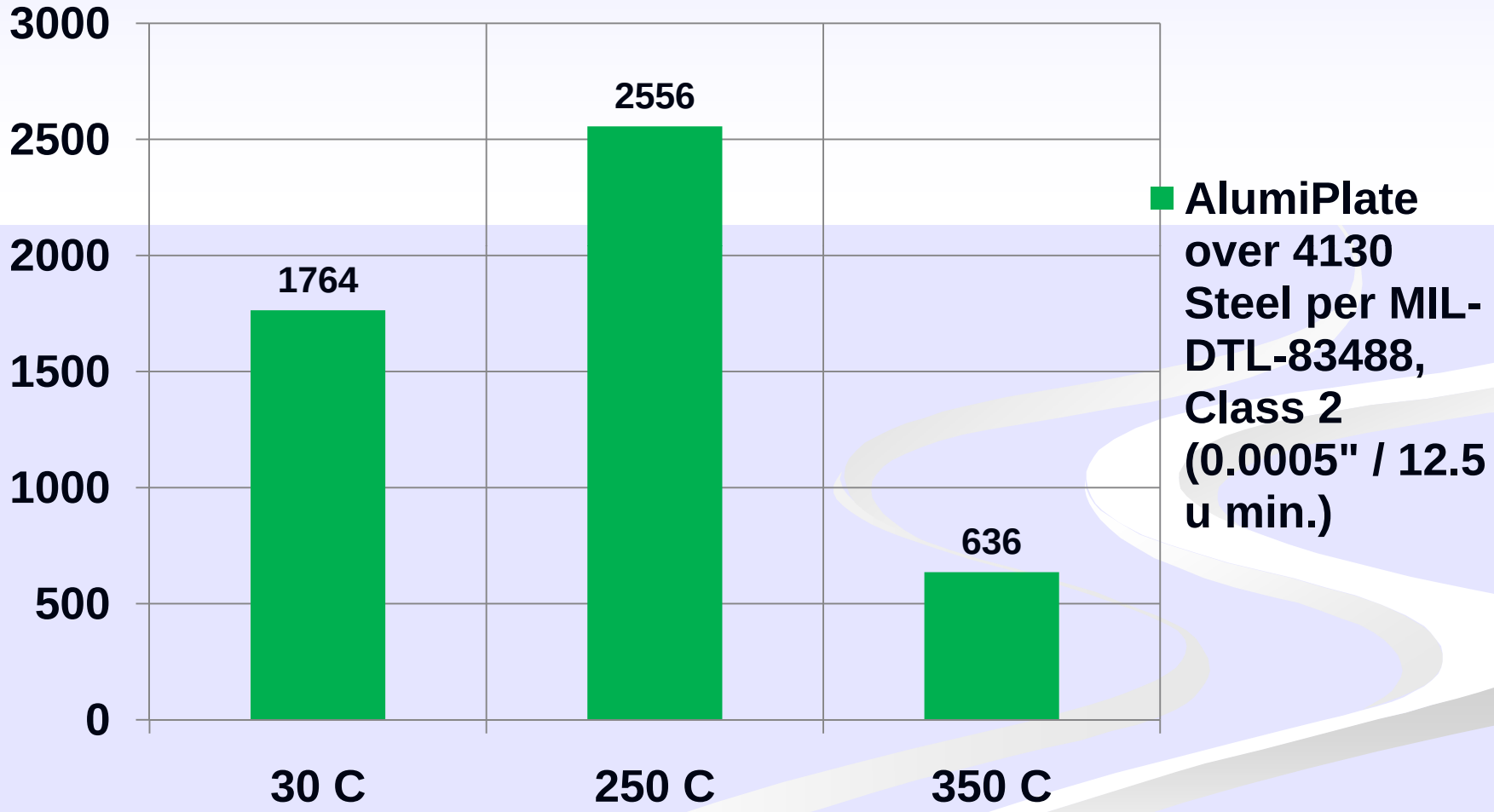
C6 – 250C Cr^{3+}

3456 hrs

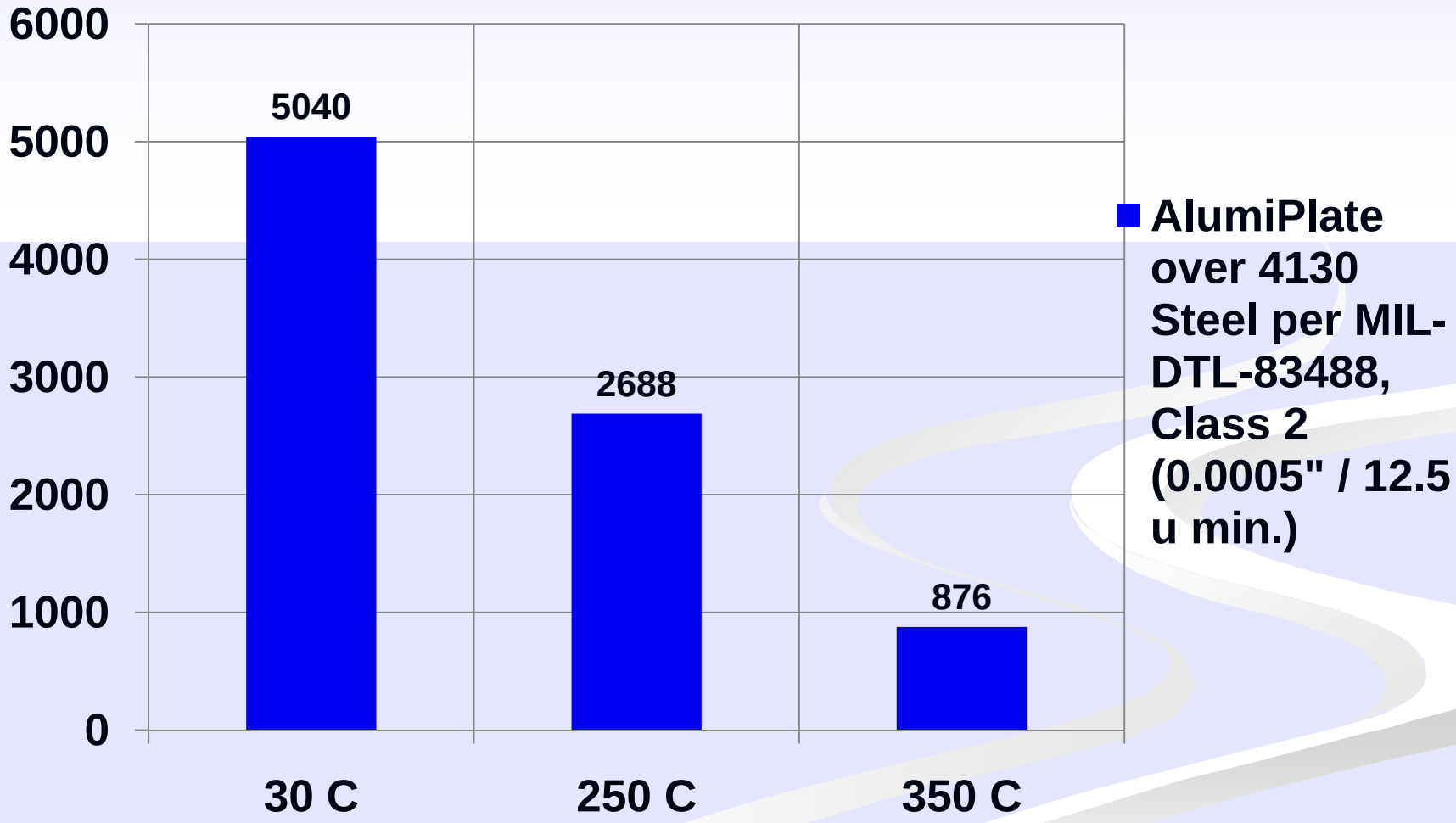
D6 – 350C Cr^{3+}

1344 hrs

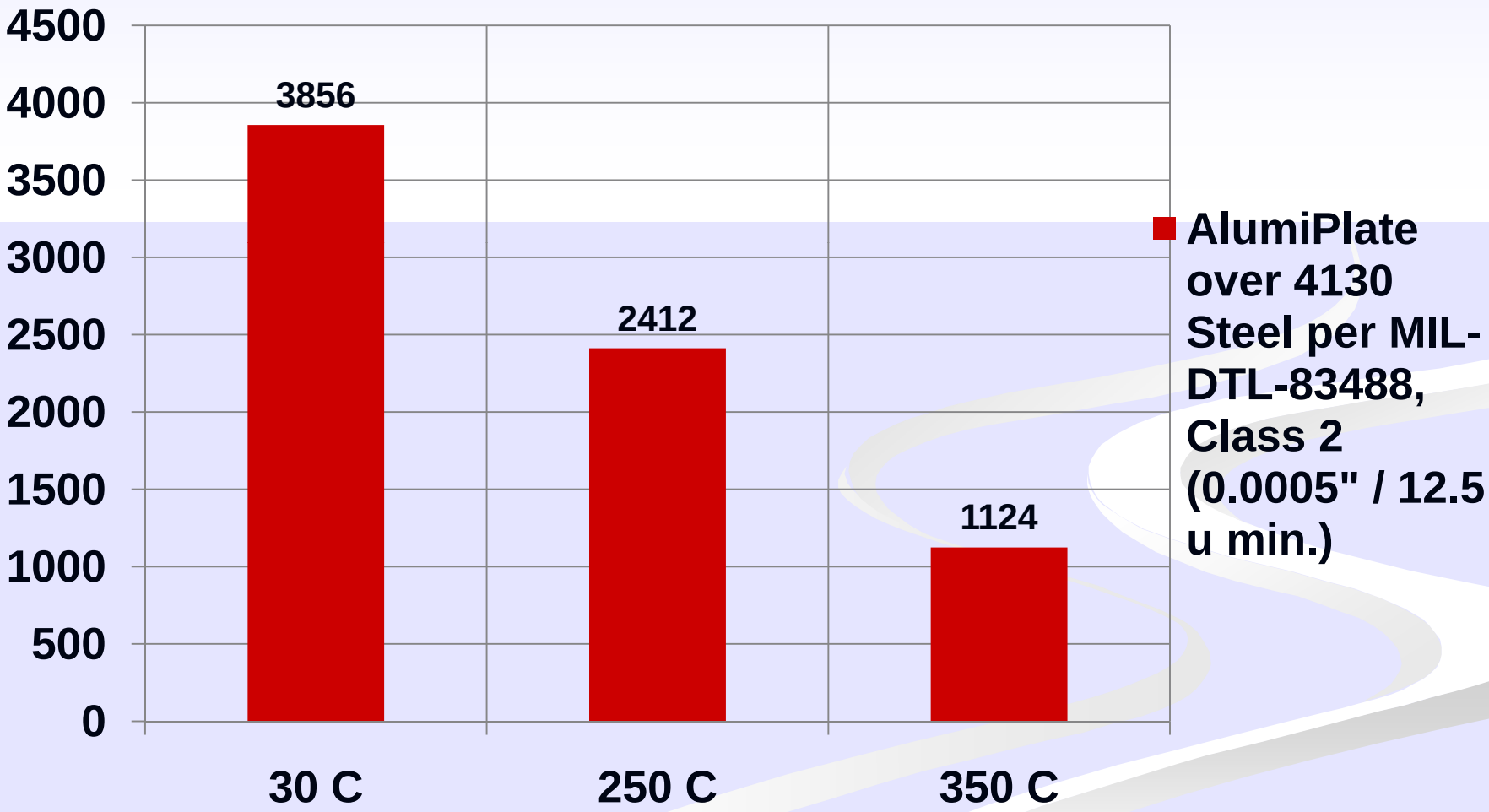
Baseline = No Conversion Coat
ASTM B117 Hours to Red Rust



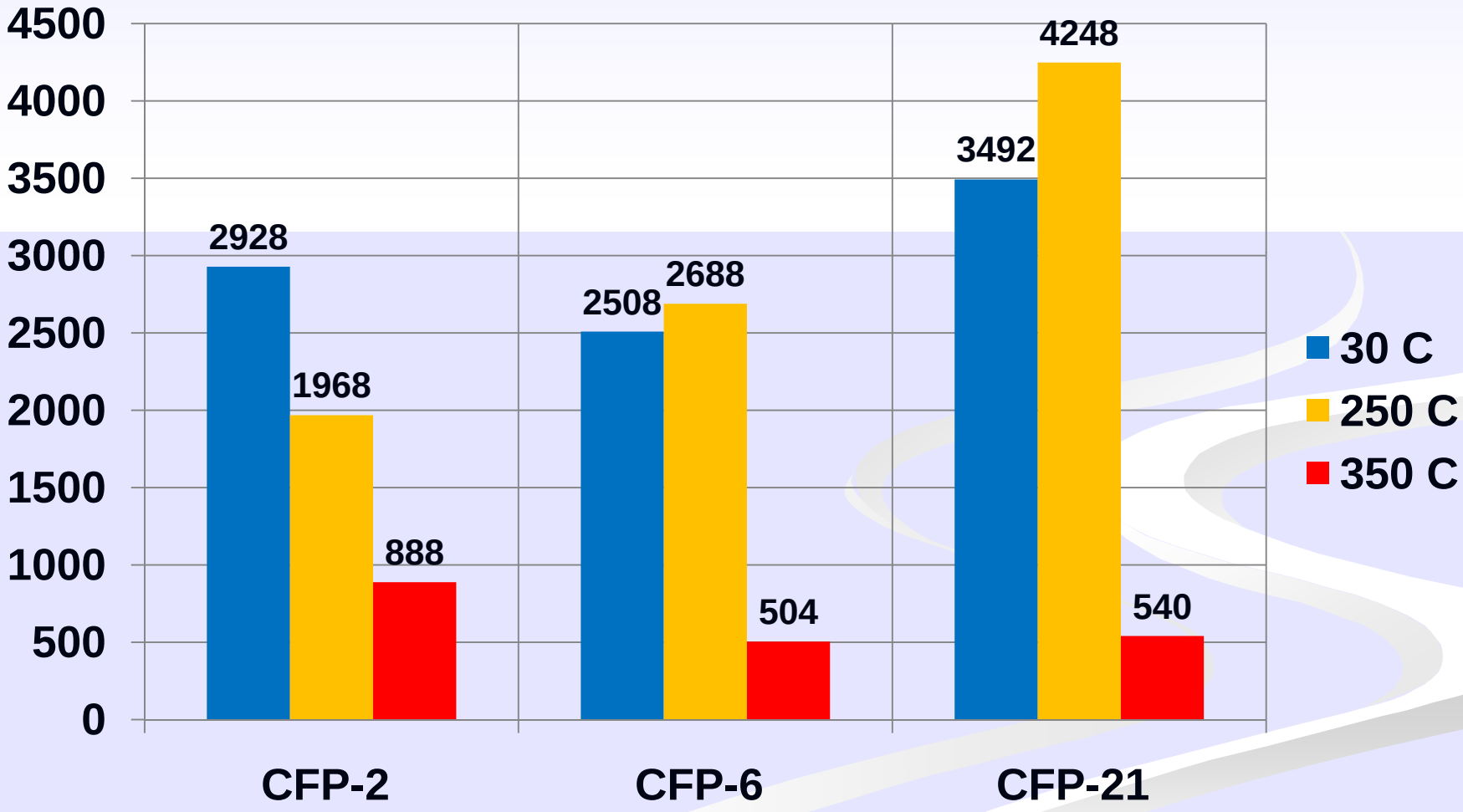
Cr^{6+} Conversion Coat
ASTM B117 Hours to Red Rust



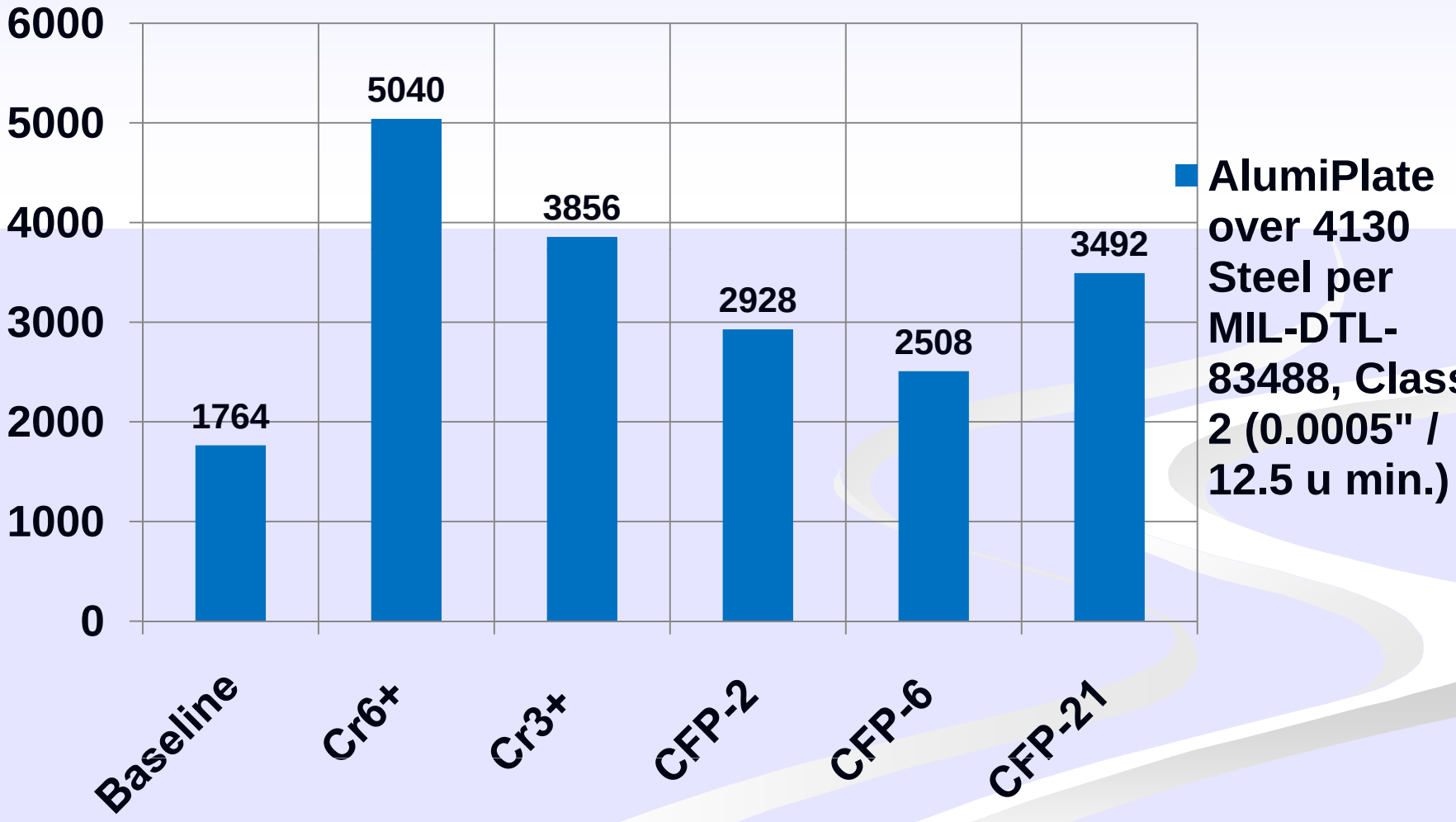
Cr^{3+} Conversion Coat
ASTM B117 Hours to Red Rust



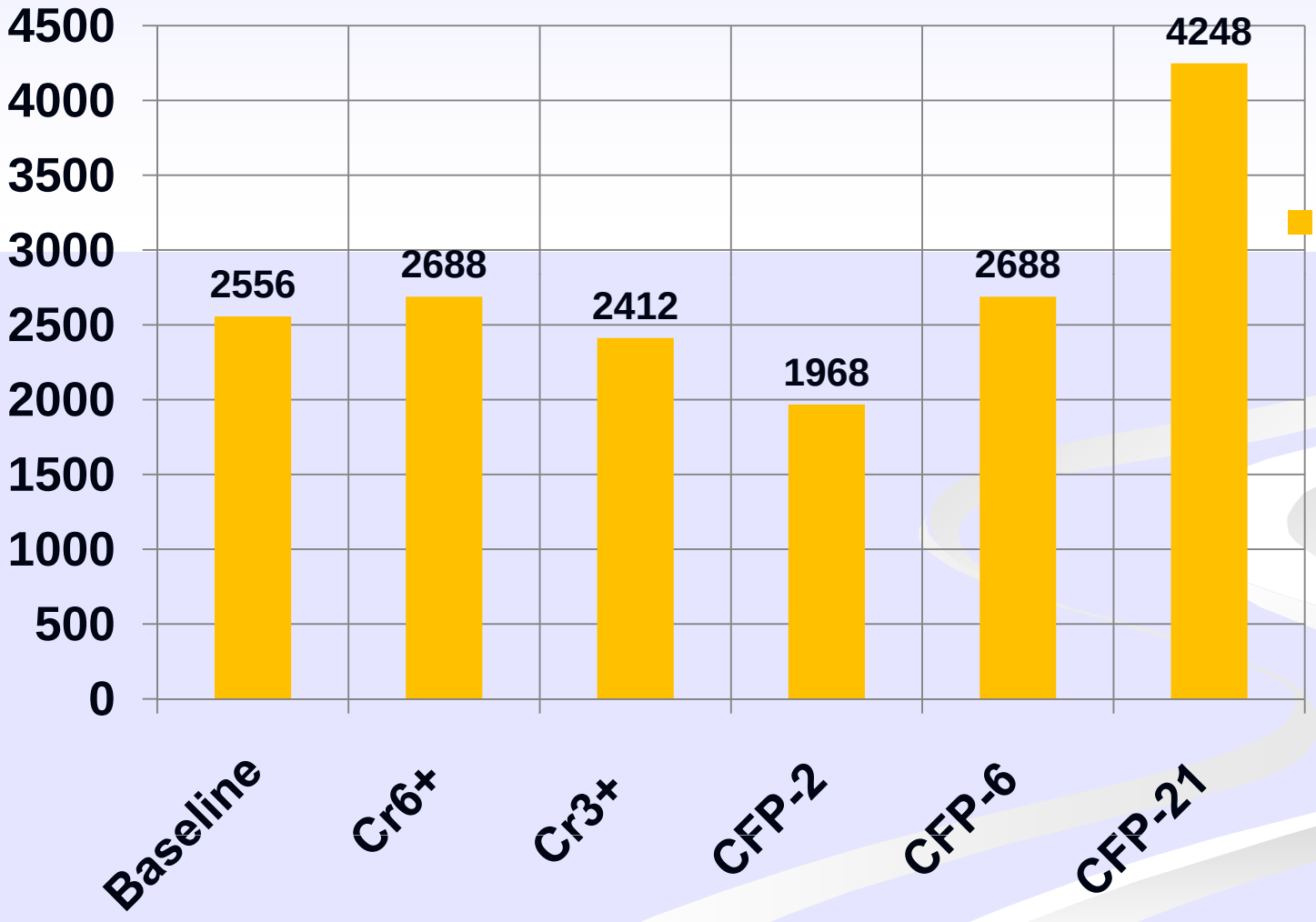
Non-Cr^{6+} Conversion Coat
ASTM B117 Hours to Red Rust



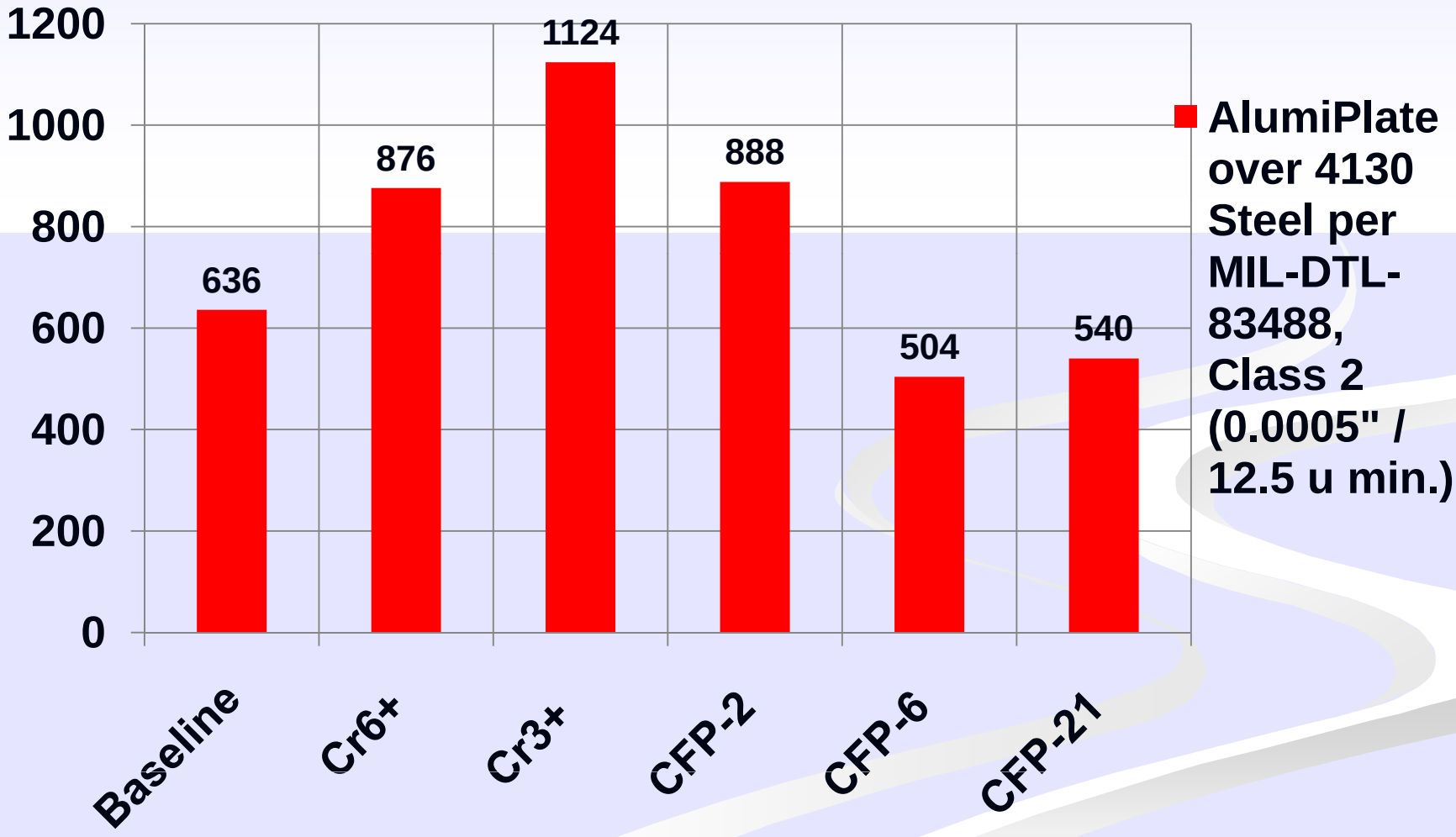
All Conversion Coats at 30 C
ASTM B117 Hours to Red Rust



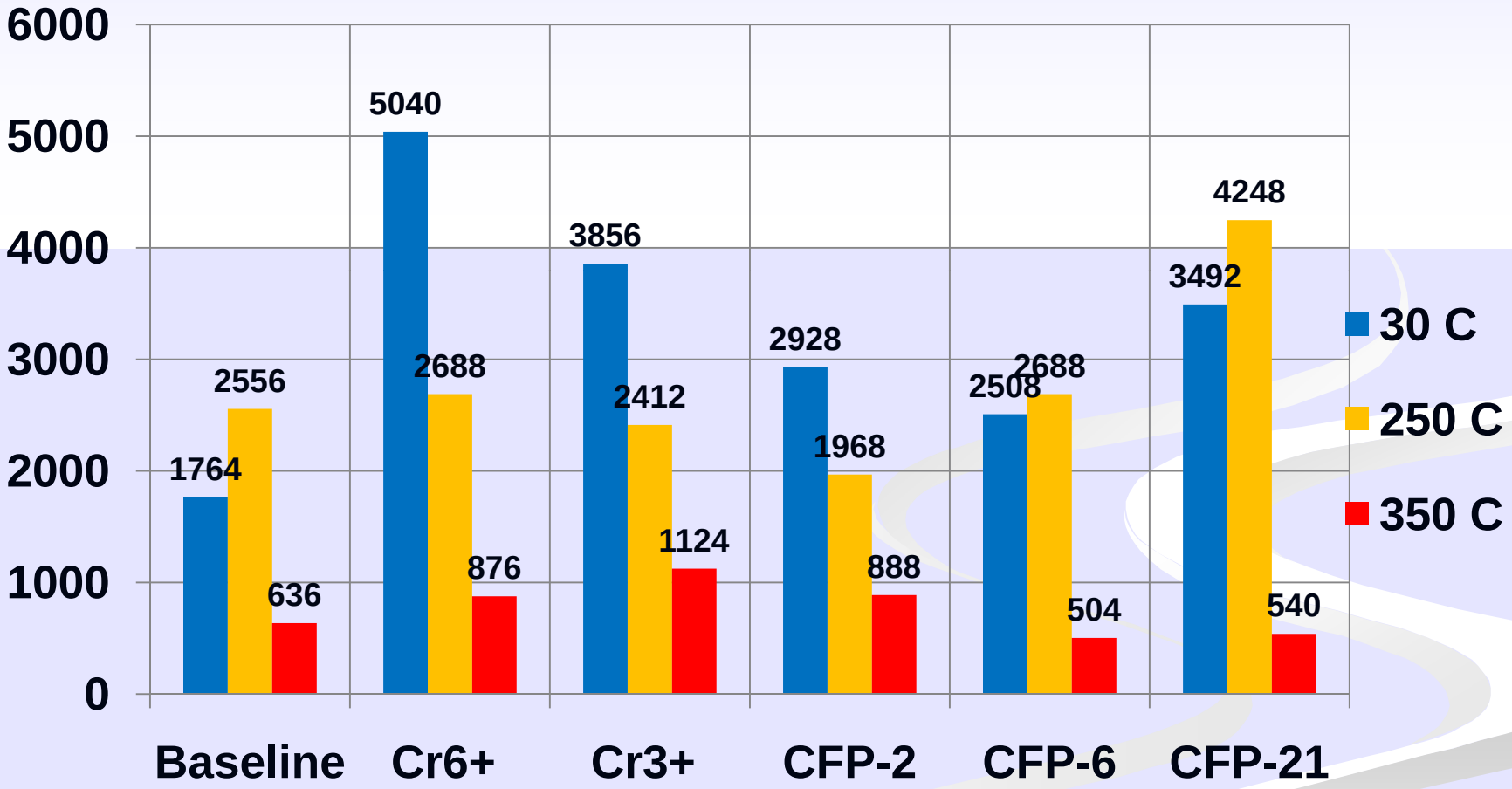
All Conversion Coats at 250 C
ASTM B117 Hours to Red Rust



All Conversion Coats at 350 C - ASTM B117
Hours to Red Rust



All Conversion Coats at All 3 Temperatures
ASTM B117 Hours to Red Rust



Conversion Coat & Temperature Performance Summary

In general, across the conversion coatings tested, corrosion performance decreases as temperature increases (new non-Cr^{6+} CFP generally better)

Cr^{3+} & non-Cr^{6+} CFP provide equivalent or better high temperature corrosion protection compared to Cr^{6+}

The non-Cr^{6+} CFP formulations show promising high temp corrosion protection when compared to Cr^{3+} (WIP)

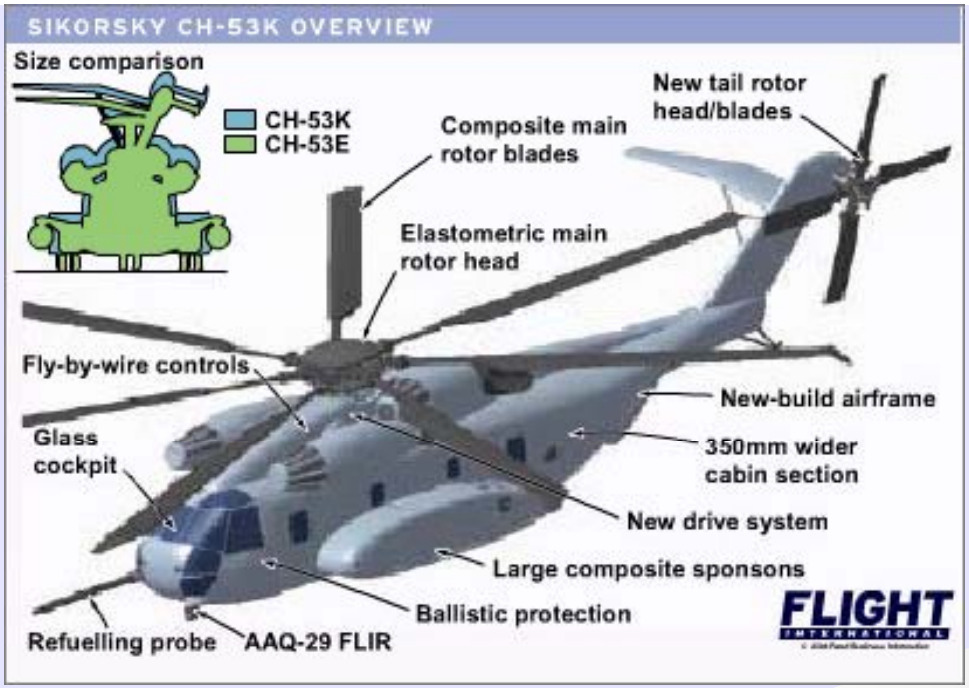
Status Update - Recent AlumiPlate Implementations on Present Programs

PROGRAM	PROGRAM
B-2 Spirit	F-16 Fighting Falcon
BHT 4 Series Model 429	F-18 Hornet
M119A Howitzer	F-22 Raptor
RQ-4 Global Hawk	C-5 Galaxy
CH53K Super Stallion (Landing Gear)	F-35 Lightning II Joint Strike Fighter (Landing Gear, LEFAS, Elec. Conn.)

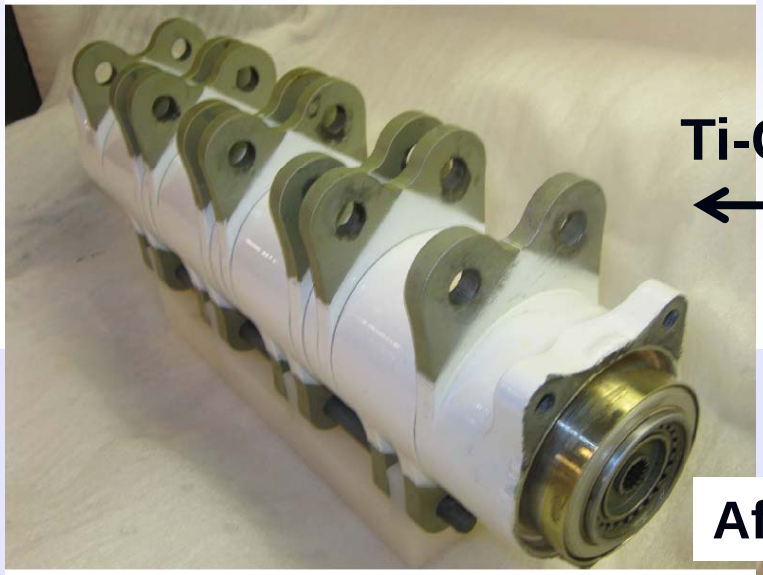
US Army Initiative – High Purity Electrodeposited Aluminum to Replace Cd on Fasteners & Electrical Connectors

Recent Applications – CH53K – Landing Gear

Images of AlumiPlate coated CH53K landing gear not shown for ITAR reasons. Please contact AlumiPlate for details.

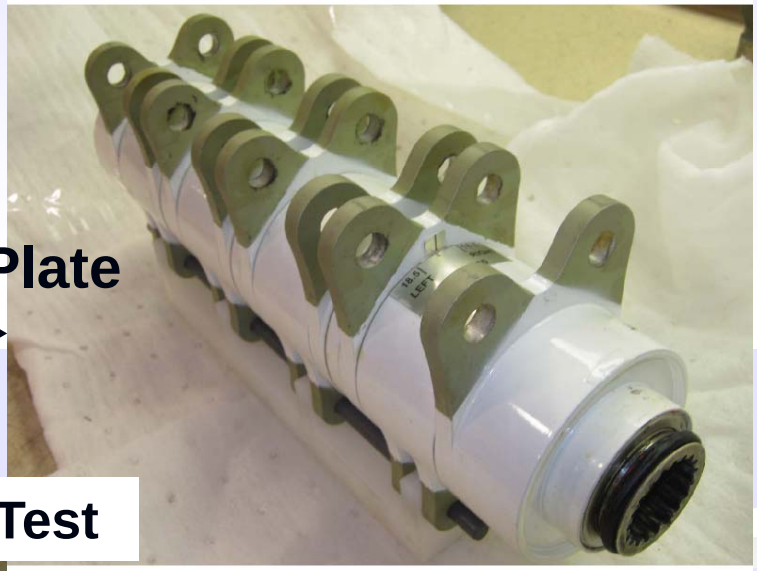


F-35 LEFAS Environmental Qual Tests (in order): Rain (2hr), Icing (168hr), Humidity (250hr), SO_2 Salt Fog (336hr), & Sand & Dust (9hr)



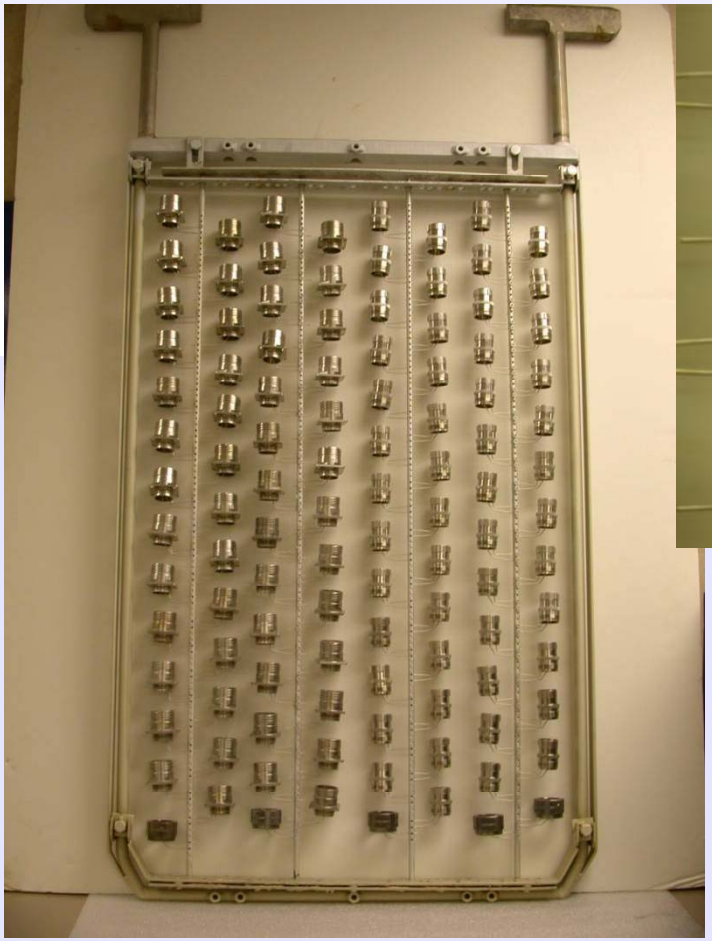
Ti-Cad ←

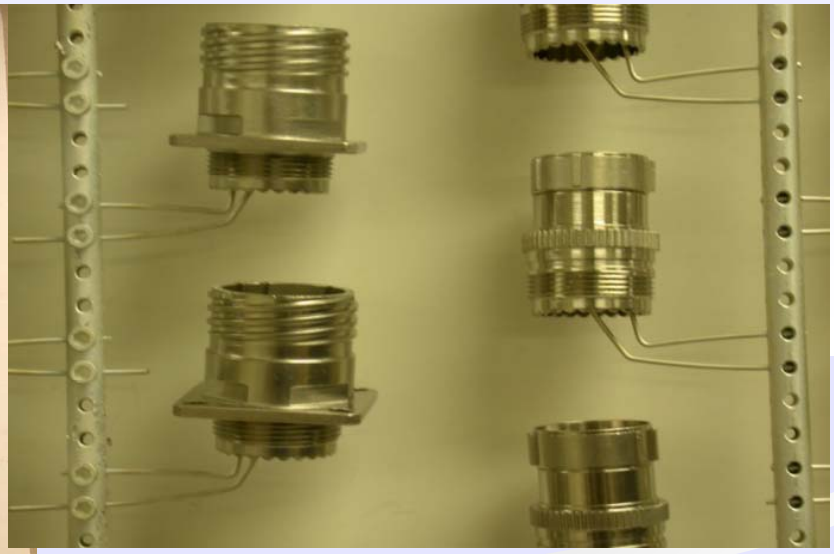
AlumiPlate →

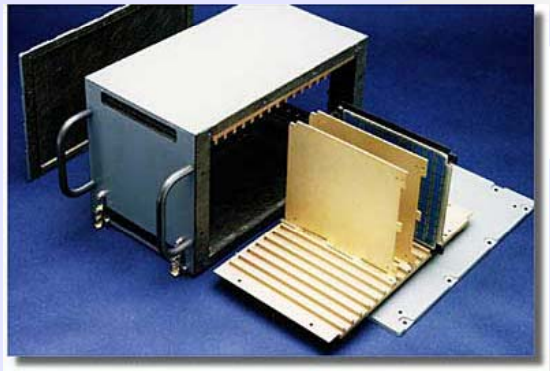


After 4+ Week Test

Recent Applications – Elec Conn







LMA PH010
MIL-DTL-83488

AlumiPlate finish on selected F-35 JSF electronic components (Honeywell TMC)

Recent Applications – Elec Conn

ELECTRICAL CONNECTOR SPECIFICATIONS

Electrical Connector Specifications that include "Class P" for Pure Dense Electrodeposited Aluminum as a Cadmium Alternative

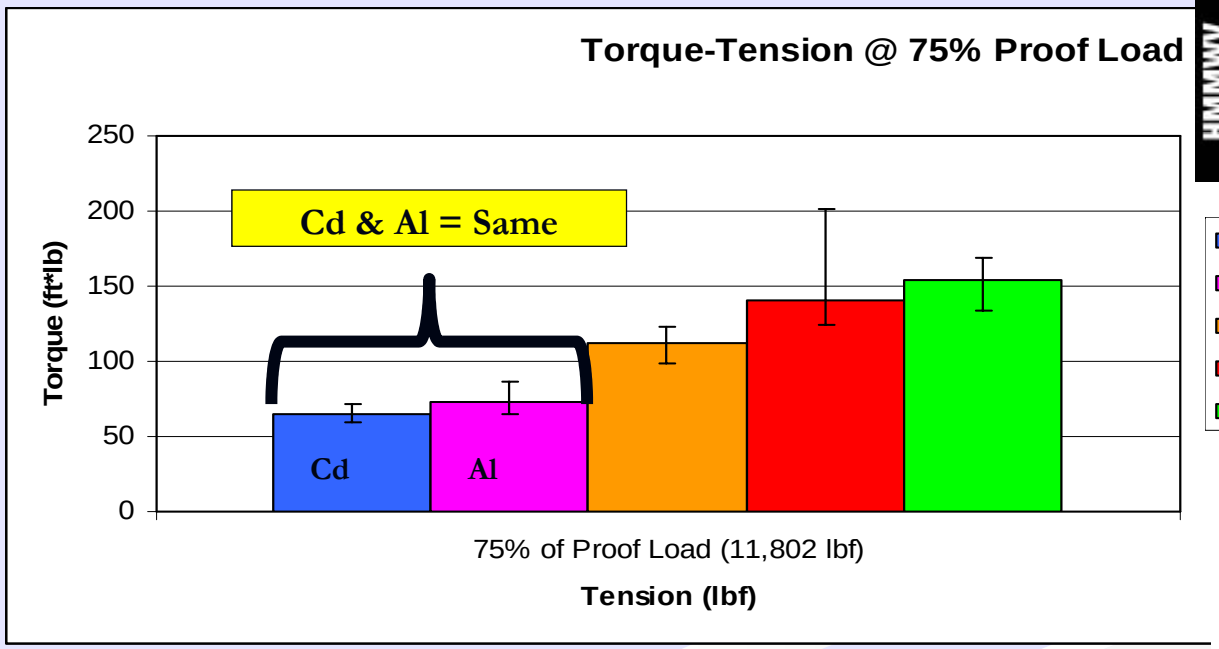
MIL-DTL-24308G	MIL-DTL-32139A	MIL-DTL-83513G
MIL-DTL-38999	MIL-DTL-28840	MIL-DTL-26482
MIL-DTL-83723	MIL-DTL-22992G	MIL-DTL-3607C
	AS85049	

Recent Applications – Fasteners

STRYKER Wheel Bolts – Field Trial

Zn Plate with Cr^{6+} + CARC Topcoat

AlumiPlate with Cr^{3+} NO Topcoat



- Cadmium w/ 30 Weight Oil (K=.14)
- Aluminum w/ Everlube 9002 (K=.16)
- Cadmium - Dry (K=.24)
- Aluminum w/ Magni B18 Silver (K=.30)
- Aluminum w/ 30 Weight Oil (K=.33)

Grade 10.9
M12 x 50mm
All from same heat lot
30 samples each test condition
T n T & GM9540P & etc.

Electrodeposited Aluminum

Performance Status

- Proven performance vs. Cd Cr^{6+}
  - (CH_3CO_2K ground runway deicers)
- High temperature performance with Cr^{3+} & non-Cr^{6+}
- Potential lower lifetime costs (lower corrosion costs)
- ESOH Friendly (at point of application & coating on product)
- Commercially available (TRL 7+, MRL 8)

Implementation Status

- Slow but steady adoption program by program (part by part)
- Supply chain availability a challenge but being addressed thru DPA Title III Project Request working with a S.E. Michigan metal finishing company partner
  - New large capacity plating line targeted for late 2012

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