

Air Force Materiel Command

Developing, Fielding, and Sustaining America's Aerospace Force

Laser Applications for Maintenance and Sustainment Solutions

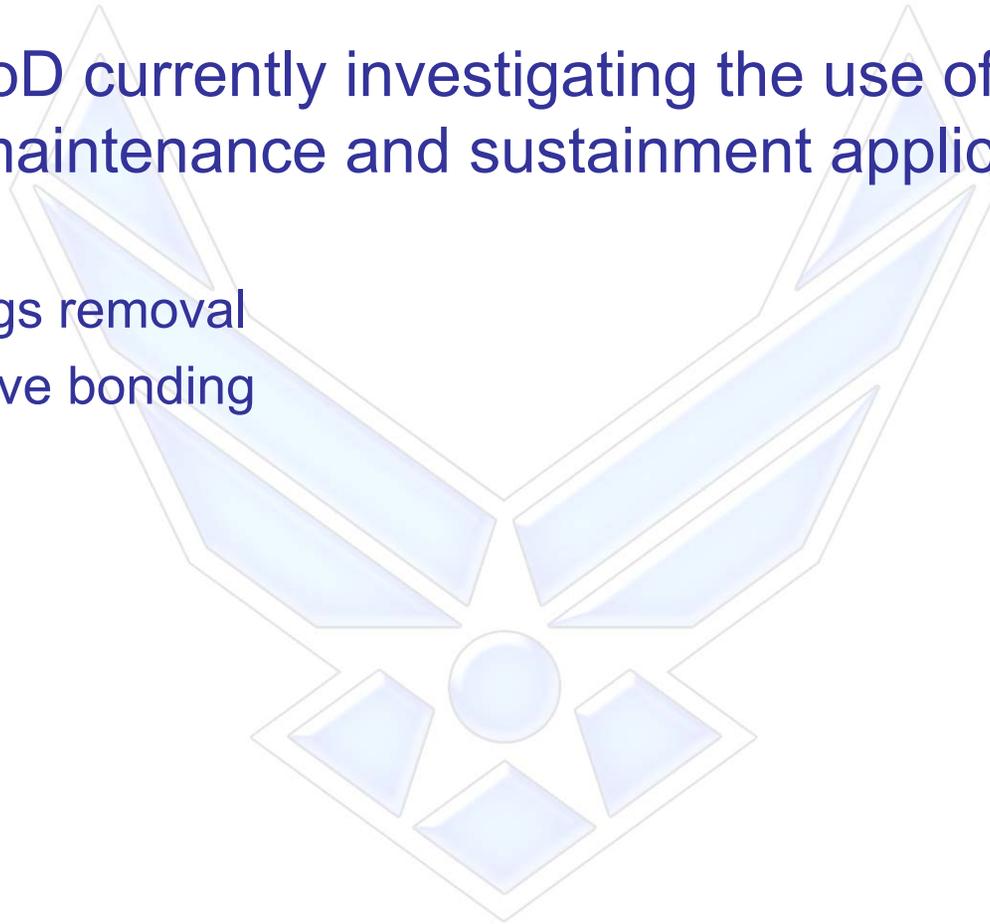


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Background

- USAF/DoD currently investigating the use of lasers for aircraft maintenance and sustainment applications in the areas of:
 - ❖ Coatings removal
 - ❖ Adhesive bonding



Coatings Removal Background

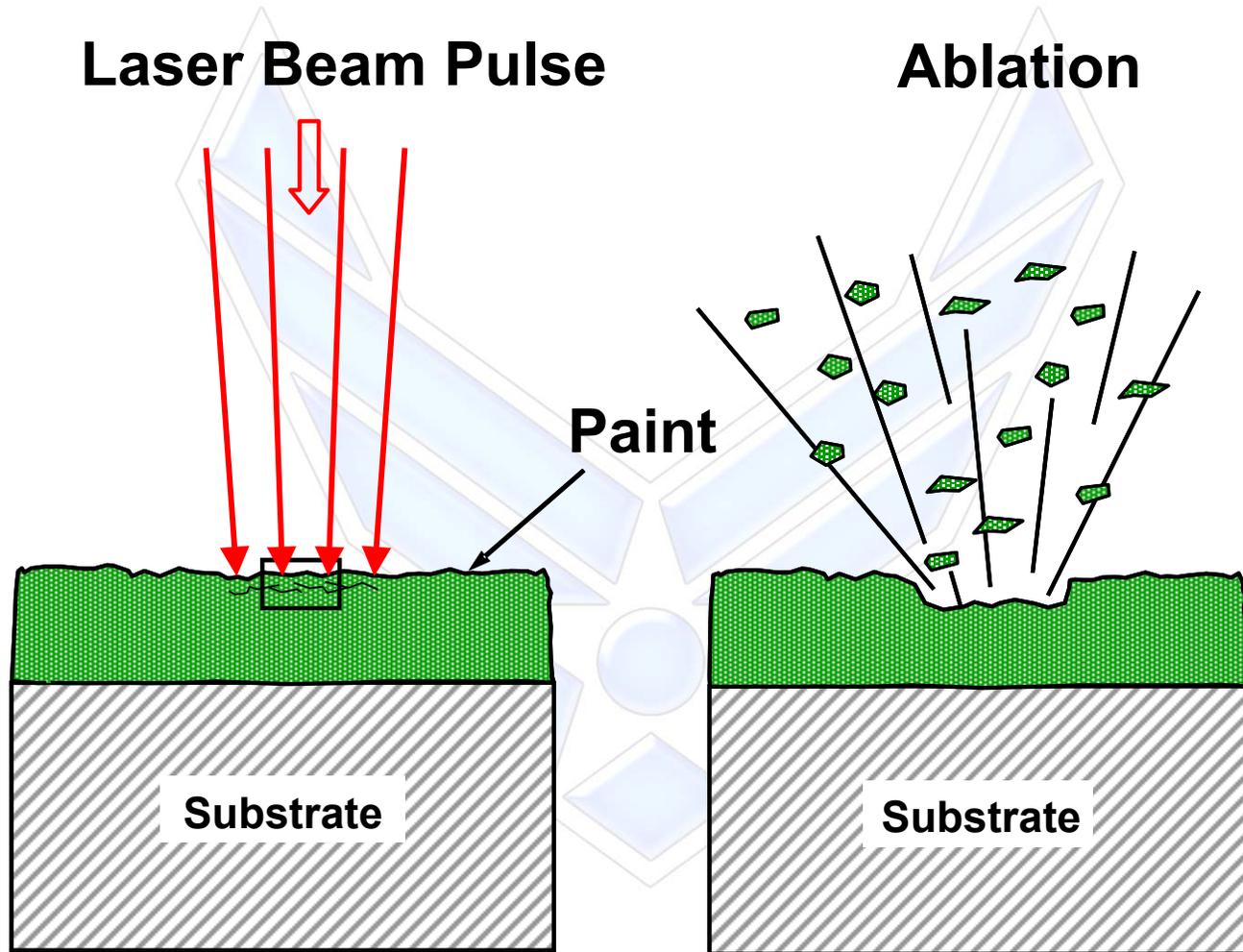
- Laser coatings removal for aerospace applications are currently being utilized at Department of Defense (DoD) and commercial facilities
 - ❖ Ogden Air Logistics Center (ALC)
 - ❖ Raytheon, AF Plant 44 (installation phase)
 - ❖ Airbus (proprietary)
- Commercial off-the-shelf (COTS) laser systems are available for aerospace de-paint applications
 - ❖ In-process of optimizing process parameters for AF coating systems

Coatings Removal Benefits

- ✓ Environmentally Friendly
 - ✓ Cost Effective
 - ✓ Safety Compliant
 - ✓ No Damage to Substrate
 - ✓ Selective Stripping
 - ✓ Reduce Flow Time
 - ✓ Increase Facility Capacity
 - ✓ Portable or Roll-Around System Available
 - ✓ Easy Operation by One Person
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Coatings Removal

Laser Coating Removal



Coatings Removal

Current Laser Projects

- AFMC/AFRL currently performing several projects to evaluate the use of lasers for coating removal during aircraft maintenance and sustainment applications
 - ❖ *Portable Handheld Laser Coating Removal System*
 - Supported by ESTCP and JG-PP
 - ❖ *Specialty Coatings Laser Removal System*
 - ❖ *Glovebox Laser Coatings Removal System*

Portable Handheld Laser Coating Removal System

Description:

- Dem/val low power portable hand held laser systems for coating removal for small area coating removal
- Coatings
 - Conventional aircraft coatings
 - Chemical agent resistant coatings (CARC)
- Substrates
 - Aircraft aluminum
 - Aircraft composites
 - High strength steel
- Lasers
 - CO2 and Nd:YAG

Benefits/Impacts:

- Replace Methylene Chloride, MEK, and PMB uses
 - Reduce hazardous waste generation
 - Reduce handling and storage and worker exposure to known carcinogenic materials



Status:

- Metallic panels stripped and undergoing mechanical testing
 - ECD: Aug 04
- Composite panels stripped and undergoing mechanical testing
 - ECD: Sep 04
- Occupational safety and health assessment in review
 - ECD: Sep 04

POCs:

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- Randy Straw, AFRL/MLSC, DSN 785-5598
 - randall.straw@wpafb.af.mil

Specialty Coating Laser Removal System

Description:

- Dem/val low power portable handheld laser systems for small area coating removal
- Coatings
 - Spray/sheet low observables
 - Sealants/Adhesives
 - Powder coating
 - Applique
- Substrates
 - Aircraft aluminum
 - Aircraft composites
 - High strength steel
 - Magnesium and magnesium-thorium
- Lasers
 - CO2; Nd:YAG; Diode

Benefits/Impacts:

- Replace Methylene Chloride, MEK, and PMB uses
 - Reduce hazardous waste generation
 - Reduce handling and storage and worker exposure to known carcinogenic materials
- Replace hand-scraping
 - Reduce/eliminate repetitive motion stress injuries



Status:

- Formal test protocol developed
- Test panels prepared
- First strip cycle underway

POCs:

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Laser Glovebox Coating Removal System

Description:

- Develop and dem/val laser glovebox coating removal system
 - Modify conventional plastic media glovebox cabinet to make it laser-safe
 - Develop modified laser end effector to allow for use in the glovebox
- Lasers
 - Nd:YAG

Benefits/Impacts:

- Replace PMB uses
 - Reduce hazardous waste generation
 - Reduce handling and storage and worker exposure to known carcinogenic materials



Status:

- FY05 New Start
- ECD: FY05

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Coatings Removal Laser Systems

➤ Evaluating 5 lasers

- ❖ 250 Watt Diode laser (808 & 940 nm wavelengths)
- ❖ 40 Watt Pulsed Nd:YAG laser (1064 nm wavelength)
- ❖ 250 Watt TEA-CO₂ laser (10600 nm wavelength)
- ❖ 120 Watt Q-Switched Nd:YAG laser (1064 nm wavelength)
- ❖ 500 Watt Q-Switched Nd:YAG laser (1064 nm wavelength)

• Diode



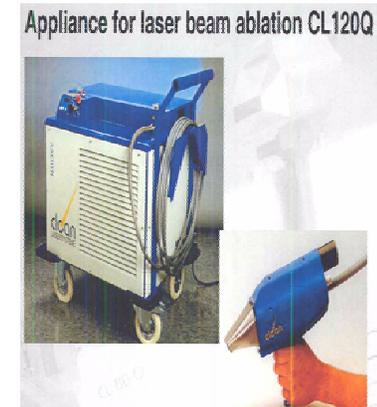
• Nd:YAG



• TEA-CO₂



• Nd:YAG



Coatings Removal Panel Testing

- Lab testing currently being conducted to verify the ability of laser systems to remove various coating systems without causing damage to the substrate.

Metallic Substrate

- Strip rate
- Substrate temperature
- Visual damage
- Clad penetration
- Surface profile
- Hardness
- Fatigue
- Tensile strength
- Conductivity
- Salt fog
- Paint adhesion

Composite Substrate

- Strip rate
- Visual damage
- Substrate temperature
- Ultrasonic
- Tension
- Compression
- Four point flex
- In-plane shear
- Paint adhesion

Coatings Removal Test Coupons

Substrates

- Metallic
 - ❖ 4130 Steel (0.025" Thickness)
 - ❖ 2024 Aluminum (0.025" & 0.032" Thickness)
 - ❖ 7075 Aluminum (0.016", 0.025" & 0.032" Thickness)

- Composite
 - ❖ Graphite epoxy (0.02", 0.04", and 0.08" Thickness)
 - ❖ Fiberglass epoxy (0.14" Thickness)
 - ❖ Metallic honeycomb (0.68" Thickness)
 - ❖ Kevlar (0.08" Thickness)
 - ❖ Bismaleimide (BMI) (0.02" & 0.04" Thickness)
 - ❖ Polyetheretherketone (PEEK) (0.04" Thickness)



Coatings Removal Test Coupons

Panel Coatings to be Tested:

➤ Primer

- MIL-PRF-23377G
- MIL-P-53030
- 10PW 22-2
- Super Koropon 515-K01A
- PR1432GP

➤ Topcoat

- MIL-C-46168, Type IV
- MIL-C-64159, Type I (CARC)
- MIL-PRF-85285, Type I

➤ Specialty Coatings

- Polysulfide Sealant
- Spray RAM (Urethane)
- Spray Low Observable Material (MS-170)
- Fastener Filler (Flex Fair 9794)
- Epoxy Powder Coating
- Non-conductive Gap Filler (PR2200)
- Bond-O



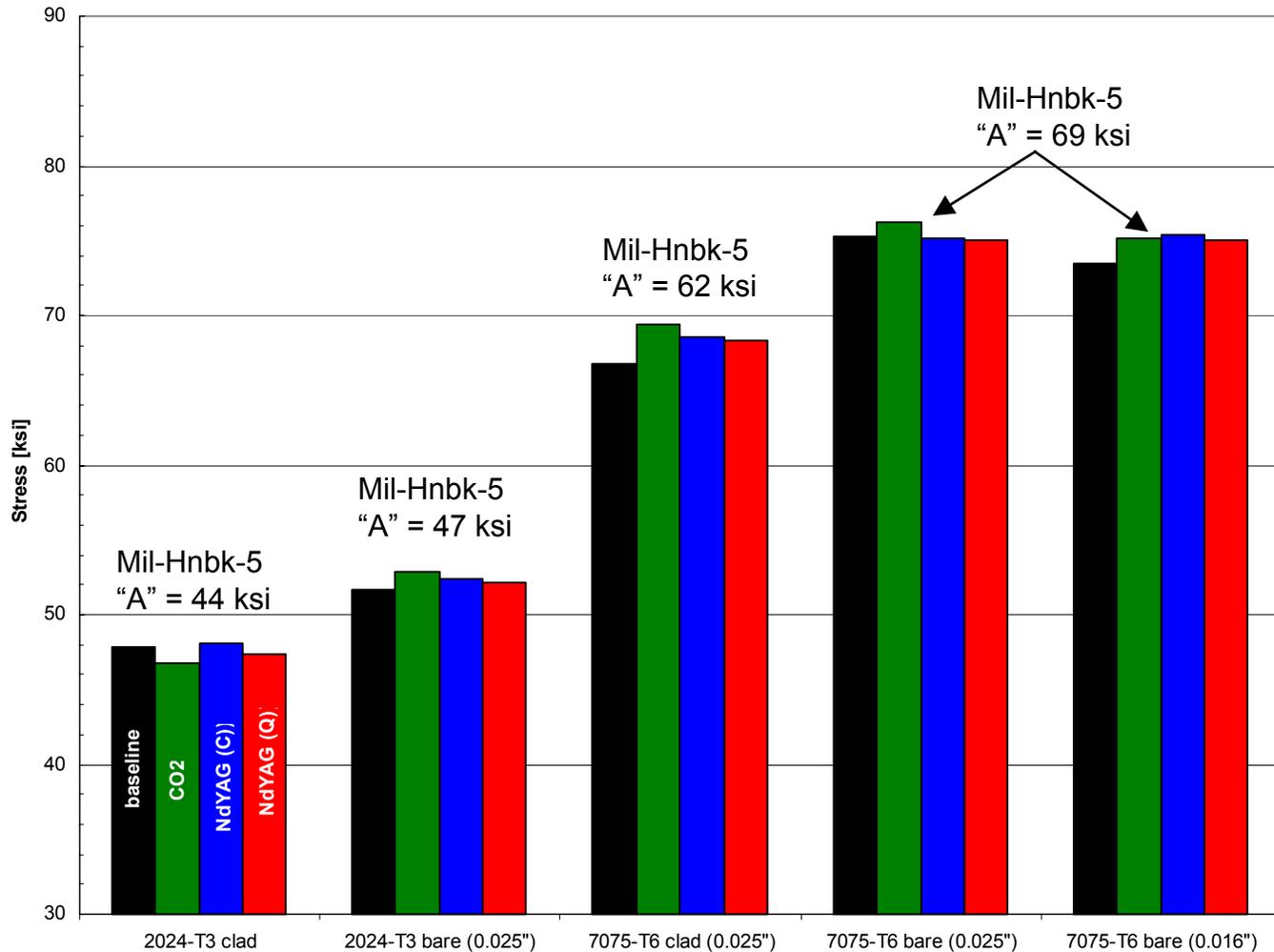
Each coating system has minimum of 18 panels assigned for 4 strip and repaint cycles per laser

Coatings Removal Status

ACTIVITY	STATUS	RESULT
Portable Hand Held Laser Coating Removal System		
Paint Stripping		
Testing of Metallic Panels		
Testing of Composite Panels		
Toxicity Testing		
Safety Plan		
Specialty Coating Laser Removal System		
Panel Stripping		
Laser Glovebox Coating Removal System		
Design		
Field Demonstration	Estimated 2005	

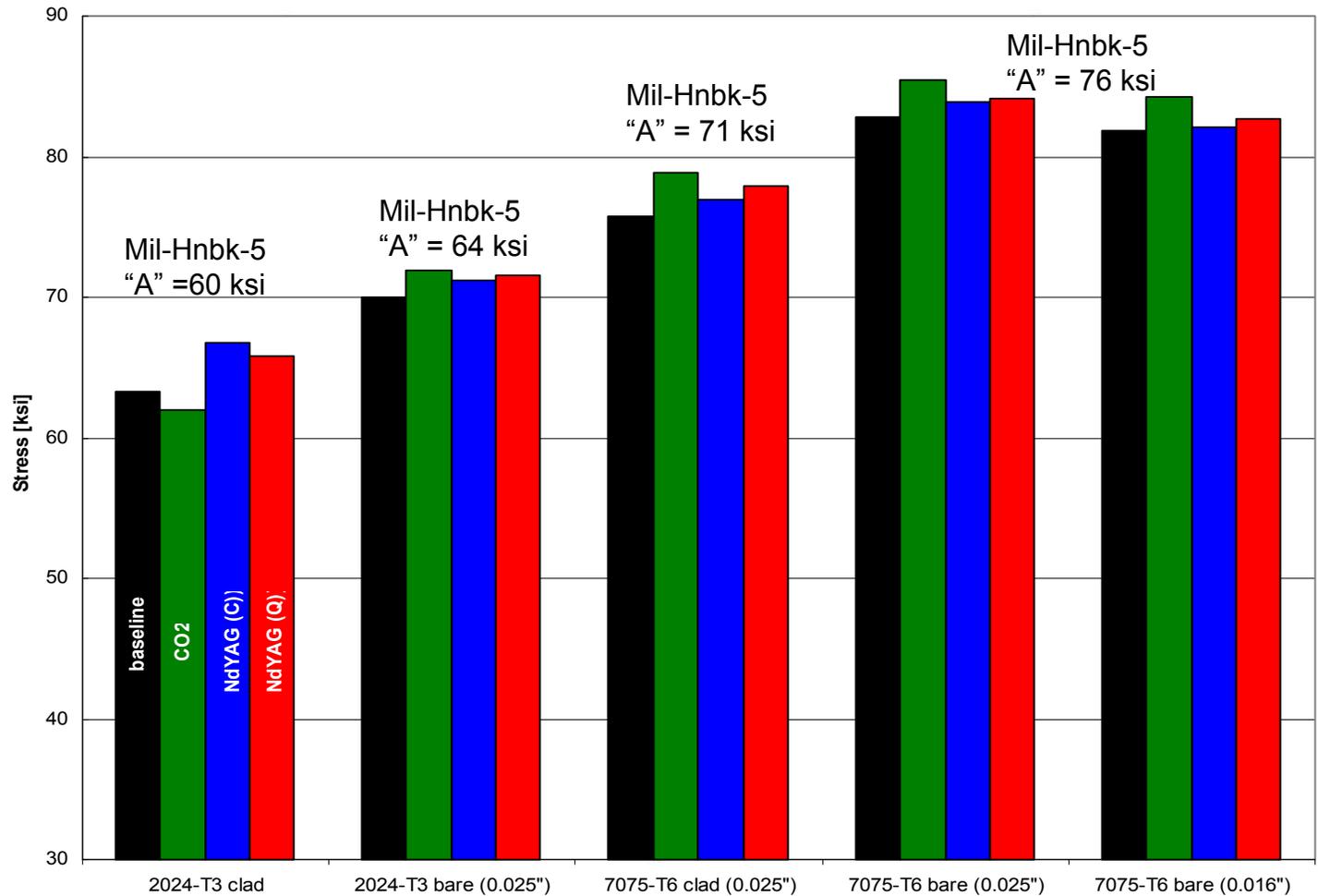
Tensile Results, Yield Strength

Preliminary Data



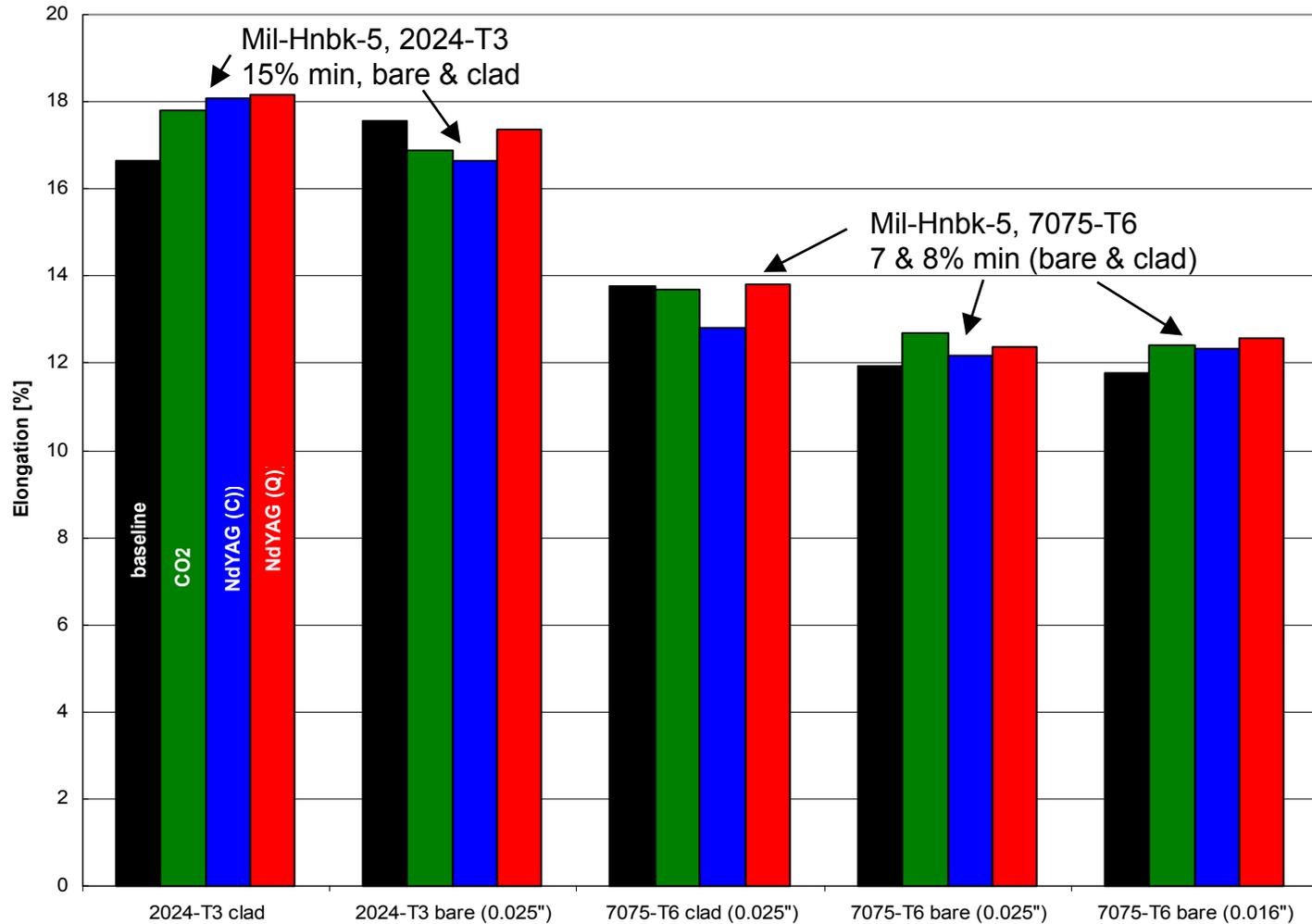
Ultimate Tensile Strength Results

Preliminary Data



Tensile Results, Ductility

Preliminary Data

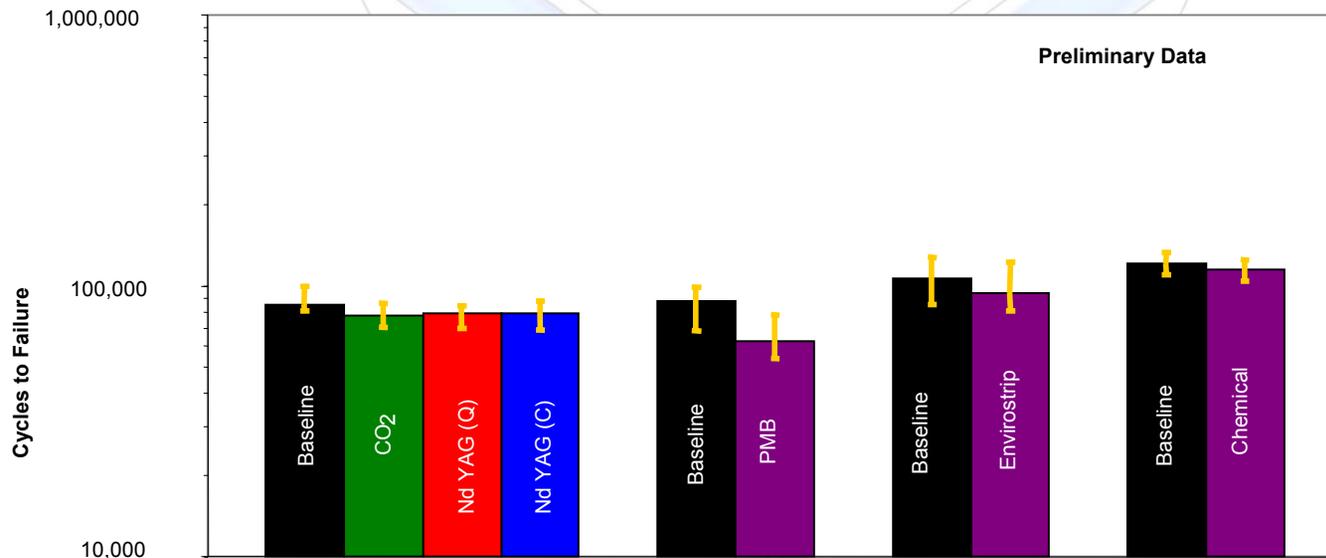


Fatigue Data

Preliminary Data

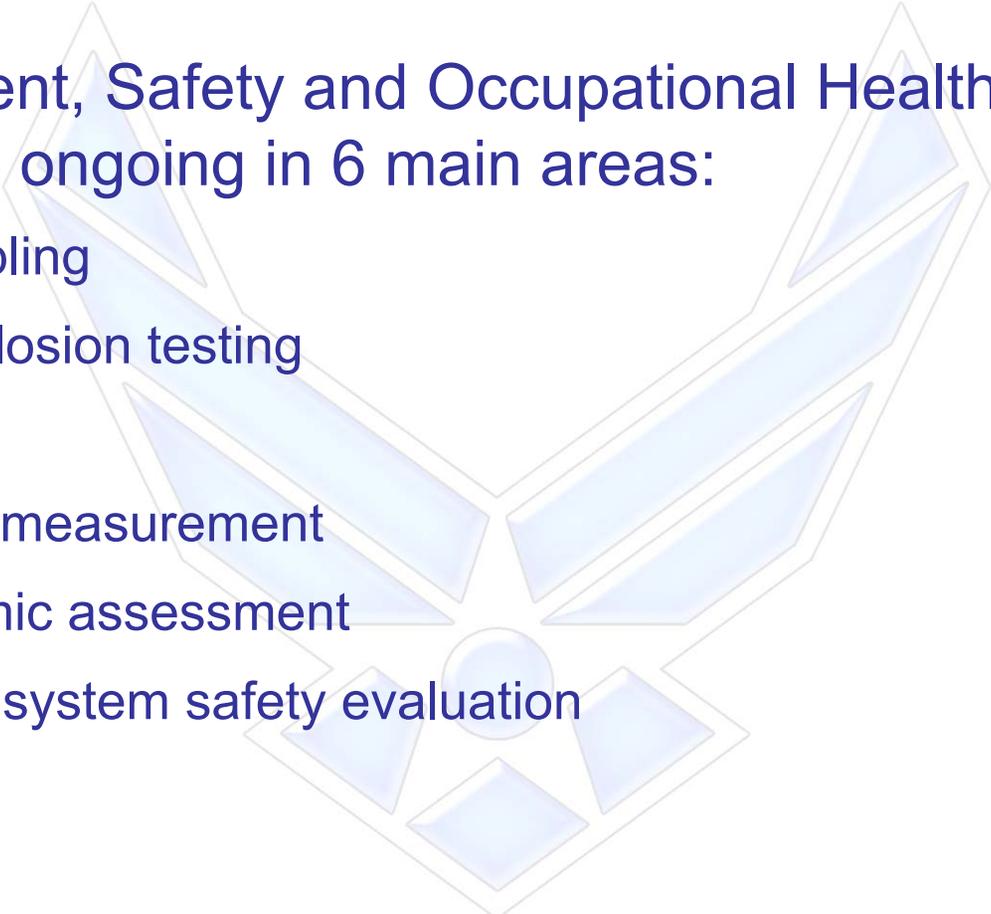
- Comparison of fatigue debit

- Debit from laser stripping equal to chemical stripping
- Debit from laser stripping less than debit from other approved coating removal processes (PMB and Envirostrip)



Coatings Removal

ESOH Evaluation

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- Environment, Safety and Occupational Health (ESOH) evaluation ongoing in 6 main areas:
 - ❖ Air sampling
 - ❖ Fire-explosion testing
 - ❖ Noise
 - ❖ UV light measurement
 - ❖ Ergonomic assessment
 - ❖ General system safety evaluation

Coatings Removal Fire & Explosion Testing

Artificial Cavity Testing

Fluids Tested

- JP-8+100 Engine Fuel
- Engine Lubricating Oil MIL-L-23699
- Engine Lubricating Oil MIL-PRF-7808
- Hydraulic Fluid MIL-PRF-83282
- Hydraulic fluid MIL-H-5606-
- Skydrol LD-4 (fire resistant hydraulic fluid)



- ✓ Observations: No flames/explosions under any test conditions.

Coatings Removal Fire & Explosion Testing

Surface Contamination Testing

Fluids Tested

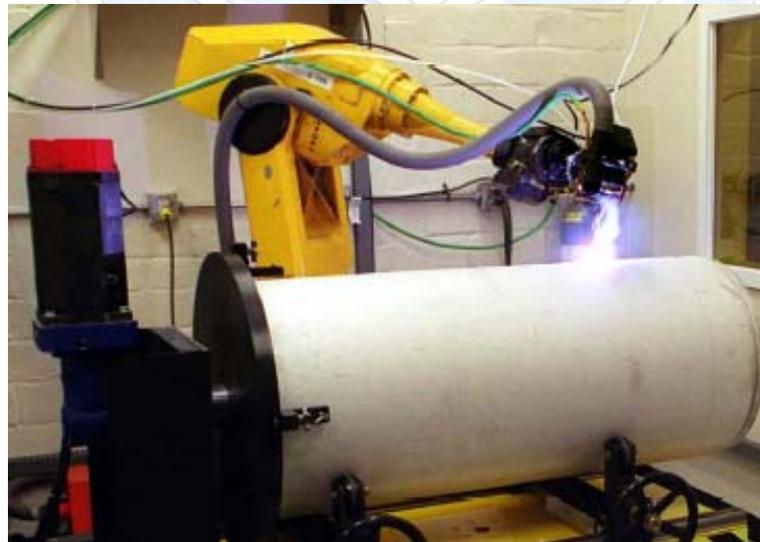
- JP-8+100 Engine Fuel
- Engine Lubricating Oil MIL-L-23699
- Engine Lubricating Oil MIL-PRF-7808
- Hydraulic Fluid MIL-PRF-83282
- Hydraulic fluid MIL-H-5606
- Skydrol LD-4 (fire resistant hydraulic fluid)



- ✓ Observations: No flames/explosions under any test conditions.

Future Coatings Removal Projects

- USAF/DoD planning a project to evaluate the use of robotic laser system for large area coating removal
 - ❖ *Robotic Laser Coating Removal System*
 - Integrated package of laser system, non-contact contour-following control system, vacuum system and associated control software that can be mounted onto different styles of robots



Robotic Laser Coating Removal System

Description:

- Dem/val robotic laser coating removal system to replace current chemical/mechanical coating removal methods used on large off-equipment components
 - Target components are flight controls, wing leading edges, landing gear doors, engine cowl doors, etc.
 - Will use non-contact automatic contour-following control system to eliminate complicated computer programming
- Lasers
 - CO₂

Benefits/Impacts:

- Replace chemical strippers, MEK, PMB and wheat starch
- Potential reductions at one depot alone include:
 - 13,200 gallons paint stripper
 - 341,260 pounds of solid waste
 - 4003 pounds of VOCs
 - 1,815,000 gallons contaminated waste water
- Reduce stripping time – increased production



Status:

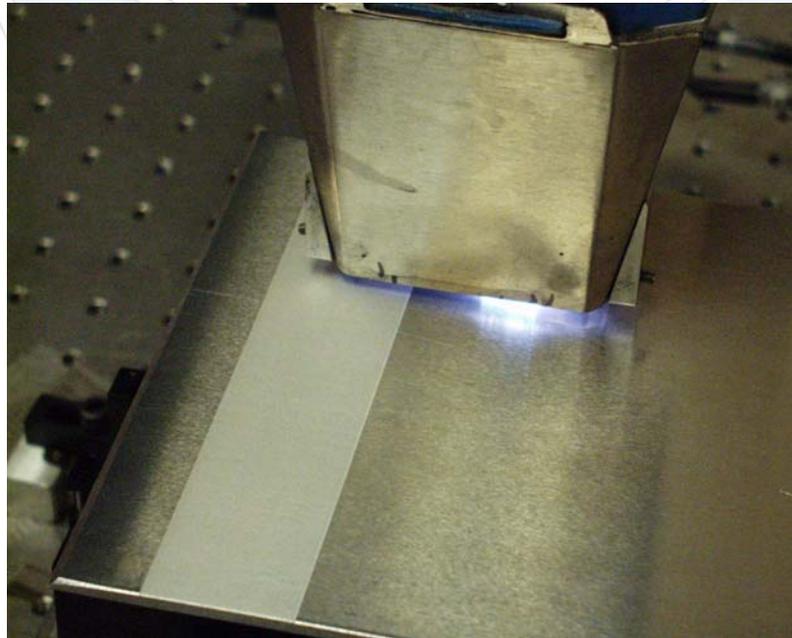
- FY05 New Start
- ECD: FY08

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Adhesive Bonding

- USAF is currently investigating the use of hand held lasers for surface preparation for adhesive bonding
 - ❖ *Laser Surface Preparation for Adhesive Bonding*



Laser Surface Preparation for Adhesive Bonding

Description:

- Evaluate the ability of low power portable hand held laser systems to prepare surfaces for adhesive bonding
 - Phase I covers aluminum while employing sol-gel technology for pretreatment instead of the current acid containing and chromated products
 - Phase II will cover titanium and composites
- Lasers
 - Nd:YAG and Diode
 - Using same lasers as Portable Handheld and Specialty Coatings projects to increase usefulness

Benefits/Impacts:

- Eliminate polluting, laborious, time-consuming surface preparation activities
- Eliminate use of Methylene Chloride coating stripper and MEK/MPK cleaner/ surface preparation solvents
- Eliminate hand-sanding and grit blasting that can release hazardous air pollutants
- Minimize generation of hazardous waste
- Minimize worker exposure to hazardous materials



Status:

- Phase I (aluminum surfaces) underway
 - ECD: Sep 04

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Laser Surface Preparation for Adhesive Bonding Status

ACTIVITY	STATUS	RESULT
Panel Pretreatment	Ongoing (estimated completion 31 December 04)	
Panel Bonding	Ongoing (estimated completion 31 December 04)	
Mechanical Testing	Ongoing (estimated completion 31 December 04)	

Summary

- Laser technology is proven and available
- Air Force Laser Program includes 2 main areas
 - ❖ Coatings Removal
 - ❖ Surface Preparation for Adhesive Bonding
- Preliminary results achieved during the laboratory testing conducted in both areas are positive
- Results of laser safety testing and evaluation are positive
- The combination of laser technology with robotics will be evaluated in a planned Air Force project

Additional information available on the Air Force Laser Library

<http://laser.ctcnet.net>

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