DOD Initiatives to Rapidly Transition Advanced Coating and Surface Finishing Technologies for Military Turbine Engine Manufacture and Repair

Charles H. Alford, Anteon Corporation
c/o ASC/LPN - PEWG
2145 Monahan Way, Bldg 28,
Wright-Patterson Air Force Base, Ohio 45433-7017
Phone: 937-255-1966 X3309
Email: charles.alford@wpafb.af.mil
**DOD Initiatives to Rapidly Transition Advanced Coating and Surface Finishing Technologies for Military Turbine Engine Manufacture and Repair**

Anteon Corporation, c/o ASC/LPN -PEWG, 2145 Monahan Way, Bldg 28, Wright-Patterson AFB, OH, 45433-7017

Approved for public release; distribution unlimited

25th Replacement of Hard Chrome and Cadmium Plating Program Review Meeting, March 15-17, 2005, Greensboro, NC. Sponsored by SERDP/ESTCP
The PEWG Defined

- The Propulsion Environmental Working Group (PEWG) is an established competency for collaboration within the DOD propulsion community to rapidly transition advanced pollutant free technologies for use in manufacturing, maintenance and rework of gas turbine engines (GTEs).
Principal PEWG Members

• Military
  – acquisition and logistics representatives of Army and Air Force Materiel Commands, Naval Air and Sea Systems Commands.

• Industry
  – environmental executives, product engineers, and repair development engineers from major turbine engine manufacturers and their major vendors.
PEWG Management Office

- Anteon Corporation team
- Experienced professionals
  - Program management
  - Project Direction
  - Meeting Management
    - General PEWG Meetings
    - Technical Working Groups
    - Web site maintenance (www.pewg.com)
PEWG Impact

• Industry is seeing the PEWG collaboration as a way to develop and transfer advanced technologies across military and commercial enterprise boundaries.

• Objectives:
  – Avoid waste in any form
  – Maximize product value
  – Sustain mission readiness
Avoid Waste in Any Form

– Waste is any expenditure of money, talent, or time that does not directly add to product or service value

– Forms of waste
  • Corrosion damage
  • Erosion damage
  • Thermal damage
  • Fatigue losses
  • Noxious air emissions impacts
  • Excessive noise impacts
  • HazMat management costs
  • Workplace hazard response
  • Response to toxic releases
  • Fuel waste
  • Facility energy waste
  • Excess inventory management
  • etc., etc., etc.
Maximize Product Value

– Safety – Consider safety in every aspect
– Sustainment – Keep engines in service
– Improve capability – Transition new technology to both new engines and fielded engines
– Conserve resources
  • Eliminate waste in any form
  • Recover value at end of product life

“Make sure business processes are in place to enable all those other goals to be achieved.”
Readiness

Sustain mission readiness.................
Product Stewardship for DoD Propulsion and Power

Manufacture & field gas turbine engines so that
(1) the parts do not fatigue, corrode, erode, or wear;
(2) engines are manufactured and sustained without reliance on use or generation of toxics;
(3) engine designs minimize noise and air pollutants;
(4) valuable components are reclaimed and reused when engines are retired.
The PEWG serves the PPGM and JPCC by working with other DoD propulsion technology initiatives

- Integrated High Performance Turbine Engine Technology (IHPTET) Program
- Versatile, Affordable, Advanced Turbine Engine (VAATE)
- National High Cycle Fatigue Program (Eliminate HCF problems that account for 50% of engine failures).
- Engine Rotor Life Extension (ERLE)
- Service Life Extension Programs (SLEP)
- Depot Technology Modernization Programs
PEWG Project Methodology

**PEWG Green Engine Project Flow**

1. Introduce Technologies
   - PEWG Conference
2. Lead Engineer Selection
3. JPCC Endorsement
   - (USAF/Navy/Army)
4. Technology Assessment
5. Environmental Assessment & PSOA
6. Performance & Cost Benefit Analysis
7. DoD Funding Application
8. Project Funding Approved
9. Initiate Project – Issue Task Orders
11. Qualification
    - CIP/ Depot Process Change
12. CPP Budget
13. Equipment Funded
14. Equipment Installed
15. Transition Complete
Overview of PEWG Projects Involving Plating, Coating, and Surface Finishing

- Advanced thermal spray coatings (HVOF)
- Electrospark deposition
- Laser cladding
- Non-spray alternatives to chrome and nickel plating
  - Powder coating technology for wear, erosion, and thermal damage resistance (Also potential alternative to aluminum-ceramic coatings with chromium content)
  - Alternatives to chrome plate using nickel-based chemistry
  - Alternative to chrome and nickel plate using nanocrystalline Co-alloy pulse plating
- Kinetic (“cold”) spray technology
- High temperature diffusion coatings
- Thermionic cleaning
Project Fact Sheets
Advanced Thermal Spray Coatings (HVOF)

<table>
<thead>
<tr>
<th>PROPOLENENT(S)</th>
<th>General Electric Aircraft Engines, Pratt &amp; Whitney, Rolls-Royce</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEWG MANAGER</td>
<td>Chuck Alford, Anteon Corp</td>
</tr>
<tr>
<td>TECHNOLOGY OPPORTUNITY ADVANTAGES:</td>
<td>Advanced thermal spray coatings (WcCCo) have superior wear resistance to hard chrome and is more cost effective on a life cycle basis.</td>
</tr>
<tr>
<td>CURRENT TECHNOLOGY – DISADVANTAGES:</td>
<td>Chrome electroplating currently in use has environmental hazards and is targeted for elimination. Chrome plate has shorter service life.</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Depot repair, New Part Manufacture</td>
</tr>
<tr>
<td>LOCATIONS</td>
<td>OC-ALC, NAVAIR Depots</td>
</tr>
<tr>
<td>PROJECT TEAM MEMBERS</td>
<td>Air Force, Navy, GEAE, P&amp;W, RR, Process Vendors,</td>
</tr>
<tr>
<td>FUNDING SOURCES</td>
<td>Air Force P2, ESTCP, Navy Affordable Readiness Initiative</td>
</tr>
<tr>
<td>STATUS</td>
<td>Funded, Testing complete, Qualification continuing</td>
</tr>
</tbody>
</table>

3/21/2005
Advanced Thermal Spray Coatings (HVOF)

• Accomplishments
  – Joint Materials Testing completed
  – Full production capability at AF and Navy Depots
  – Qualified for GEAE and P&W Engines
    • Functional test
    • Accelerated mission test
    • Flight test
  – Further implementation planned
# Laser Cladding

<table>
<thead>
<tr>
<th>PROPOINENT(S)</th>
<th>General Electric Aircraft Engines (GEAE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEWG MANAGER</td>
<td>Dave Crawford, Anteon Corp</td>
</tr>
<tr>
<td>TECHNOLOGY OPPORTUNITY ADVANTAGES:</td>
<td>Qualify laser additive welding (coating/thin) processes to produce near net shape internal/difficult to access features, Restore wear/damage with parent material. AF depot has equipment on site.</td>
</tr>
<tr>
<td>CURRENT TECHNOLOGY - DISADVANTAGES:</td>
<td>Hex chrome plating is used to restore dimensional tolerances up to 10mil. Greater wear may result in condemnation of part.</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Depot level repair</td>
</tr>
<tr>
<td>LOCATIONS</td>
<td>Oklahoma City Air Logistics Center</td>
</tr>
<tr>
<td>PROJECT TEAM MEMBERS</td>
<td>Air Force; General Electric</td>
</tr>
<tr>
<td>FUNDING SOURCES</td>
<td>AFMC P2 Funding</td>
</tr>
<tr>
<td>STATUS</td>
<td>Approved for FY05</td>
</tr>
</tbody>
</table>

3/21/2005
# Alternatives To Chrome Plate Using Nickel-based Chemistry

<table>
<thead>
<tr>
<th>PROPOsal(S)</th>
<th>Pratt &amp; Whitney Aircraft Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEWG MANAGER</td>
<td>Dave Crawford, Anteon Corp</td>
</tr>
<tr>
<td>TECHNOLOGY OPPORTUNITY ADVANTAGES:</td>
<td>Validate and qualify a commercially available electroless nickel boron coating process to restore dimensional tolerance of worn gas turbine engine parts.</td>
</tr>
<tr>
<td>CURRENT TECHNOLOGY – DISADVANTAGES:</td>
<td>Chrome electroplating currently in use has environmental hazards and is targeted for elimination</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Depot overhaul</td>
</tr>
<tr>
<td>LOCATIONS</td>
<td>OC-ALC; NAVAIR Depots, Corpus Christi AD</td>
</tr>
<tr>
<td>PROJECT TEAM MEMBERS</td>
<td>Air Force, NAVAIR, Army, GEAE, Rolls-Royce, Process Vendor</td>
</tr>
<tr>
<td>FUNDING SOURCES</td>
<td>AFMC P2 Funding, Navy and Army possible</td>
</tr>
<tr>
<td>STATUS</td>
<td>Not currently validated</td>
</tr>
</tbody>
</table>

3/21/2005
# Nanocrystalline Co-alloy Pulse Plating

**PROPOINENT(S)**
Pratt & Whitney Aircraft Engines

**PEWG MANAGER**
Chuck Alford, Anteon Corp

**TECHNOLOGY OPPORTUNITY ADVANTAGES:**
NCo-P coatings, developed under SERDP project #1152, is a promising alternative to chrome and nickel electroplating for IDs, brush plating, and plating of parts with properties not suited to thermal spray. Process can be implemented by retrofitting electroplating tanks.

**CURRENT TECHNOLOGY – DISADVANTAGES:**
Chrome electroplating currently in use has environmental hazards and is targeted for elimination. Nickel plating may also be targeted for more stringent regulation.

**APPLICATION**
Depot overhaul, New part manufacture

**LOCATIONS**
OC-ALC; NAVAIR Depots, Corpus Christi AD

**PROJECT TEAM MEMBERS**
Air Force, DoD HCAT, NAVAIR, Army, GEAE, Rolls-Royce, Process Vendor

**FUNDING SOURCES**
ESTCP, AFMC P2 Funding, Navy and Army possible

**STATUS**
ESTCP appr FY04-5 req FY06, AF Budgeted for FY06
Kinetic ("Cold") Spray Technology

<table>
<thead>
<tr>
<th>PROPOINENT(S)</th>
<th>Pratt &amp; Whitney Aircraft Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEWG MANAGER</td>
<td>Chuck Alford, Anteon Corp</td>
</tr>
<tr>
<td>TECHNOLOGY OPPORTUNITY ADVANTAGES:</td>
<td>Kinetic spray technologies deposit thick coatings with a metallurgical quality bond in applications where high temperature spray processes, such as HVOF thermal spray cannot be used. Process also has potential for spray forming on titanium components.</td>
</tr>
<tr>
<td>CURRENT TECHNOLOGY – DISADVANTAGES:</td>
<td>Chrome electroplating currently in use has environmental hazards and is targeted for elimination. Thermal spray is not suitable for parts with very low heat tolerance</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Depot repair and new part manufacture</td>
</tr>
<tr>
<td>LOCATIONS</td>
<td>Engine depots and part manufacturing facilities</td>
</tr>
<tr>
<td>PROJECT TEAM MEMBERS</td>
<td>Air Force, NAVAIR, Army, GEAE, Sandia National Lab, Process Vendors</td>
</tr>
<tr>
<td>FUNDING SOURCES</td>
<td>AFMC P2 Funding, Navy and Army possible</td>
</tr>
<tr>
<td>STATUS</td>
<td>AF Budgeted for FY06 – ESTCP Funds applied for</td>
</tr>
</tbody>
</table>
# High Temperature Diffusion Coatings

<table>
<thead>
<tr>
<th><strong>PROPOLENT(S)</strong></th>
<th>HITEMCO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PEWG MANAGER</strong></td>
<td>Tom Pagnard, Anteon Corp</td>
</tr>
<tr>
<td><strong>TECHNOLOGY OPPORTUNITY ADVANTAGES:</strong></td>
<td>Replace current silicide coating on F100 augmenter components with a longer life coating.</td>
</tr>
<tr>
<td><strong>CURRENT TECHNOLOGY – DISADVANTAGES:</strong></td>
<td>Current coating (PWA 295) is shorter life (2400 hrs versus desired 4000 hrs) which requires more frequent teardown, cleaning, and use of HazMats at engine depot.</td>
</tr>
<tr>
<td><strong>APPLICATION</strong></td>
<td>New Part Manufacture</td>
</tr>
<tr>
<td><strong>LOCATIONS</strong></td>
<td>Vendor’s facility</td>
</tr>
<tr>
<td><strong>PROJECT TEAM MEMBERS</strong></td>
<td>Air Force, Process Vendor, Pratt &amp; Whitney</td>
</tr>
<tr>
<td><strong>FUNDING SOURCES</strong></td>
<td>RTOC</td>
</tr>
<tr>
<td><strong>STATUS</strong></td>
<td>Project in work</td>
</tr>
</tbody>
</table>
## Thermionic Cleaning

<table>
<thead>
<tr>
<th>PROPONET(S)</th>
<th>Edison Welding Institute, GEAE, P&amp;W</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEWG MANAGER</td>
<td>Tom Pagnard, Anteon Corp</td>
</tr>
<tr>
<td>TECHNOLOGY OPPORTUNITY ADVANTAGES:</td>
<td>Identify applications of a commercially available cleaning technology which uses a reverse polarity welding process to vaporize surface contaminants on turbine engine parts (AKA Cathodic Arc Cleaning). Process does not use water or chemical solvents and apparently generates no toxics.</td>
</tr>
<tr>
<td>CURRENT TECHNOLOGY – DISADVANTAGES:</td>
<td>Current cleaning methods generate waste effluents that require management and create potential for uncontrolled releases of hazardous materials.</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Depot and intermediate level repair operations</td>
</tr>
<tr>
<td>LOCATIONS</td>
<td>OC-ALC, NAVAIR and Army Depots and repair operations</td>
</tr>
<tr>
<td>PROJECT TEAM MEMBERS</td>
<td>EWI, GEAE, P&amp;W, Rolls-Royce</td>
</tr>
<tr>
<td>FUNDING SOURCES</td>
<td>RTOC</td>
</tr>
<tr>
<td>STATUS</td>
<td>OC-ALC request for FY06 Funding</td>
</tr>
</tbody>
</table>
Other Technologies

- **Electrospark Deposition for Repair Applications**
- **Powder Coating Technology For Wear, Erosion, And Thermal Damage Resistance**
In Conclusion

• The PEWG is a trendsetter for collaborative technology transition enterprise within the Department of Defense.

• Technical societies like the AESF are sources for advanced technology discovery and a way to share successes.

• Details on these projects will be available to authorized persons by accessing the project workspace being created on www.pewg.com. Interested parties may apply to the author for password access.