PW Green Engine Program

Presented to: CT DEP SIPRAC
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Ray Dimmock
PW Green Engine Manager
**Agenda**

- **Green Engine Elements** (1 slide)
- **Striving for Green Products** (5 slides)
- **UTC Materials of Concern & Technology Plans** (3 slides)
- **Driving MOC Reductions in Engines** (3 slides)
ELEMENTS OF A GREEN ENGINE

**Vision: Pratt & Whitney Sets the Standard for Green**

- Has the lowest possible **Emission Impact** during use
- Has the lowest possible **Noise Impact**
- Manufactured in **Green Factories**
- **Material Efficient** (Metal Buy-to-fly, Propellant Yield)
- **Contains Green Materials**
- **Involves Green Suppliers and Partners**
- **Designed with Human Factors in mind**
- **Energy Efficient** during use (Fuel Burn)
- **Maintained with Green Overhaul and Repair Processes**
- **Designed for Serviceability, Reusability, Recyclability**
Striving for Green Products

- Engines that burn cleaner
- Engines that operate quieter
- Engines with no materials of concern
  - Product
  - Process
  - Original equipment and repair
  - During operation by our customers
  - At end-of-life
- Engines ‘human friendly’ for production and maintenance mechanics
  - In our shops
  - In our customers’ shops
  - On the flight line
Eliminating Materials of Concern

- Identify Materials of Concern
  - Regulatory bans
  - Customer drivers
  - Corporate responsibility

- Identify products containing Materials of Concern
  - Which engine model, which part number
  - Which specifications, which materials

- Develop & validate alternatives
  - Specifications without Materials of Concern
  - Similar or better performance characteristics (weight, strength, durability)

- Insert alternatives into products
  - Validate alternative in target products
  - Release to production
Human Factors Considerations

Product Design Considerations:

- Meant to reduce ergonomic stress
- Added benefit - reduce assembly time
  - *Is a bolt easily accessible?*
  - *Are the part edges too sharp?*
  - *Are handling provisions in place?*
  - *Are there blind assemblies?*

- Human Factors Essential Elements
  - *Accessibility – Ergonomic positioning*
  - *Weight/Center of Gravity*
  - *Fastener Quantity – Standardization*
  - *Force/Torque/Repetition Required*
  - *Assembly considerations – all parts arrive at assembly ready to install*
Environmental Compatibility is a Key Driver for P&W Products

- Engines consume less fuel through higher efficiencies
- Lower emissions address Local Air Quality and Global Warming
  - Less hydrocarbons, nitrous oxides, carbon monoxide, carbon dioxide and smoke
- Lower noise creates opportunity to:
  - Minimize the Noise Footprint around Airports and Communities
- Sustain the Growth of the Aviation Industry through increased capacity
- Enabling Technologies include Advanced Materials and Aerodynamic Design
  - Engine architecture
  - High temperature alloys
  - Low weight composites
Implementation Complexities

Product-related complexities:
- Jet engine part count typically > 10,000 per engine
- Supplier content typically > 50%
- Domestic and international partners
- Suppliers with ‘Design/Make’ status

Material of Concern-related complexities:
- Material Safety Data Sheets
  - Since bans sometimes include trace amounts, MSDS needs to as well
  - Need method to overcome Manufacturer claims of proprietary ingredients
- Product data systems need to be connected to Material of Concern data
UTC Materials of Concern

History:
- UTC Presidents’ Council Approval (’01)
- CEO Public Speech (’03)

Includes:
- Cadmium, Hexavalent Chromium, Lead, Mercury
- Chlorinated Solvents

NOTE: Does NOT include all PW banned/ restricted MOCs

Timing for MOC Elimination:
- Passport Gate 4 after 1/1/07 – “New Designs” – subject to 1/1/07 deadline
- Passport Gate 4 before 1/1/07 - “Legacy Designs” – MOC elimination must be considered when redesign is triggered
  - Products & Spares Production
  - PW Aftermarket Operations

UTC Cooperative Efforts:
- Have developed common process listing
- Participating with UTC Green Products Managers to define risk ranking methodology
Baseline UTC MOC Inventory

- Basis for UTC Metrics
- Summarizes MOC uses & replacement status
- P&W/PWC have > 70 MOC identified uses

Example Baseline Inventory Line Item:

<table>
<thead>
<tr>
<th>No.</th>
<th>Material</th>
<th>Process or Usage</th>
<th>Application (Product(s) or Component(s))</th>
<th>Design</th>
<th>Manufacture</th>
<th>Supply</th>
<th>Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cadmium</td>
<td>AMS 2400 plating, SPOP 21 (PS 211)</td>
<td>Threaded parts (nut, plug, screw, stud)</td>
<td>G</td>
<td>G</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>Cadmium</td>
<td>AMS 2400 plating, SPOP 21 (PS 211)</td>
<td>Non-threaded parts (washer, bushing, bracket)</td>
<td>G</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>Cadmium</td>
<td>AMS 2416 plating; QQ-P-416</td>
<td>Threaded parts (Mil. Std. Fastener, tie-rod, bolt)</td>
<td>G</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>Cadmium</td>
<td>AMS 2416 plating, SPOP 25 (PS 301), SPOP 49, SPOP 315</td>
<td>Non threaded parts (Mil. Std. washer, bracket, seal)</td>
<td>G</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

Key:
- **G** Eliminated (Not in use, Usage not allowed)
- **Y** In Process (In use, Action initiated to replace MOC)
- **O** In Use (In use; alternative not cost effective)
- **R** In Use (In use, Action not initiated to replace MOC)
- **U** Uncertain (Insufficient data)
- **E** Approved Exception
- **NR** Not Applicable
Lead Reduction (by Application) from New Designs

2006 – 2009 Technology Development Plan

- Antifretting Replacement
- High Temp Antigallant Replacement

This is a sample ‘waterfall’ chart that will show projects that we expect will get us to the goal

* Assumes Technology Program success
Efficient analysis of affects of potential chemical bans requires:

- All tables above to be complete and accurate
- Appropriate linkage between each table
- Inclusion of partner and supplier information
Implementing Green Alternatives

Key steps to ensure that Green alternatives are driven into products:

- Engineering standard work requires ‘Green’ alternatives when making material or process changes.
- Program chief engineers are presented with target part numbers (those ‘brown’ parts that have green alternatives – see samples on next chart).
- Passport review process ensures appropriate progress.
### Samples of Data for Chief Engineers

<table>
<thead>
<tr>
<th>Spec ID</th>
<th>HMI Percent Contribution</th>
<th>Spec Name</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWA381</td>
<td>12.66%</td>
<td>Shipping Closures</td>
<td>Aluminum caps</td>
</tr>
<tr>
<td>PWA333</td>
<td>8.64%</td>
<td>Tube &amp; Flexhose Product Definition</td>
<td>Tubes</td>
</tr>
<tr>
<td>AMS2400</td>
<td>6.97%</td>
<td>Plating, Cadmium</td>
<td>All Applications</td>
</tr>
<tr>
<td>AMS2416</td>
<td>6.15%</td>
<td>Plating, Nickel-Cadmium Diffused</td>
<td>Major rotating parts (disk, blade, spacer)</td>
</tr>
<tr>
<td>PWA586-3</td>
<td>4.84%</td>
<td>Inactive for new designs - Anti-Gallant Compound and Treatment (Loctite C-200, Kaylube No. 3)</td>
<td>Parts operating below 700°F</td>
</tr>
<tr>
<td>PWA830-1</td>
<td>2.35%</td>
<td>Protective Treatments- AMS 2470 - Anodic Treatment Chromic Acid</td>
<td>All applications except for fatigue sensitive parts and/or parts that may have potential for entrapment)</td>
</tr>
<tr>
<td>AMS3110</td>
<td>1.79%</td>
<td>Inactive per AMS - Primer, Zinc Chromate</td>
<td>All Applications</td>
</tr>
</tbody>
</table>

- **Shows which specs are contributing most to HMI**
- **Shows each part number, the spec, the toxicity value for that spec, and the percent contribution to HMI**
- **Shows effect on HMI of changing each part number to green**