Regulatory Background

- The National Emission Standards for Hazardous Air Pollutants for Aerospace Manufacturing and Rework Facilities (Aerospace NESHAP) regulates Depainting Operations

  limits methylene chloride usage for coating removal

  **commercial**: 26 gallons/craft/year

  **military**: 50 gallons/craft/year
• Initial Aerospace NESHAP promulgated in September 1995 - subsequent versions exist.
• First substantive compliance date for existing sources is September 1998.
• The Occupational Safety & Health Administration (OSHA) established stringent Permissible Exposure Limits (PEL) effective April 1997.
Partners are:

- EPA
  Emission Standards Division (ESD)

- NASA
  Headquarters, Code JE
  Marshall Space Flight Center (MSFC)

- USAF
  Robins Air Force Base (RAFB)
  Wright Patterson Air Force Base (WPAFB)
Committees are:

- Executive Steering Task Force (ESTF)
  comprised of EPA/HQ, EPA/ESD, NASA/HQ, and NASA/MSFC

- Technical Implementation Committee (TIC)
  comprised of NASA/MSFC

- Technical Advisory Committee (TAC)
  comprised of EPA/ESD, NASA/HQ, NASA/MSFC, USAF/WPAFB, USAF/WRAFB, USCG, General Aviation and Airline Industry
Processes Being Evaluated

- Chemical Stripping
- COLDJET™ (CO$_2$ Blasting)
- TOMCO$_2$ (CO$_2$ Blasting)
- FLASHJET™ Coating Removal
- Laser Stripping
- Plastic Media Blasting
- Sodium Bicarbonate Wet Stripping
- Water Stripping
- Wheat Starch Blasting

* COLDJET™ and TOMCO$_2$ processes deleted from evaluation after 1st stripping.
Initial Parameters of the Study

- Substrates
  - 2024-T3 clad Al, in 64, 32, and 16 mil thicknesses
  - 2024-T3 non-clad Al, in 64, 51, and 16 mil thicknesses

- Paint System
  - primer: MIL-P-23377F, Type 1, Class 2
  - topcoat: MIL-C-83286B, urethane

- Five sequences of panel preparation and stripping.
Current Parameters of the Study

- Substrates - no change

- Paint System (implemented in 2\textsuperscript{nd} sequence)
  - primer: no change
  - topcoat: MIL-C-85285B (high solids, low voc)
    - previous topcoat no longer available from vendor

- Three to five sequences of panel preparation and stripping.
Stages in Each Sequence

- Coating Application
- Measurements - coating thickness
- Aging
- Stripping
- Measurements - substrate thickness, surface roughness
- Specimen Cleaning - WBF surface
- Chromate Conversion
- Measurements - substrate thickness and weight, surface roughness
- Repeat for next sequence
• Cleaning Steps:
  MEK hand clean.
  Vapor degrease with perchlorethylene, 10 min.
  Immerse in Turco 4215, 25 min.
  Hot DI water rinse, 5 min.
  Immerse in Turco Smut-Go #1, 11 min.
  Cold DI water rinse, 5 min.
  WBF test, DI water.
Test Specimens ..... (Continued)

- Aging Steps per ISO/SAE MA4872:
  - Precondition: 12 hours @ 120F, 95%RH
  - Hold at -65 for 1 hour
  - Thermally cycle for -65F to 160F 400x.
  - Return to chamber to ambient temperature.
  - Repeat steps 1-3.
Material Evaluation Testing

- Fatigue and Tensile - *baseline & final stripping*
- Sandwich & Immersion Corrosion - *completed*
- Hydrogen Embrittlement - *completed except for Gage*
- Crack Detectability - *PMB, Wheatstarch, Sodablast, on-going*
- Clad Penetration - *baseline & final stripping*
- Surface Roughness - *on-going*
- Material Loss, Change in Thickness - *on-going*
### Current process status:

<table>
<thead>
<tr>
<th>Process</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Stripping</td>
<td>completed 4 of 5 stripplings</td>
</tr>
<tr>
<td>COLDJET™</td>
<td>dropped from study</td>
</tr>
<tr>
<td>TOMCO₂</td>
<td>dropped from study</td>
</tr>
<tr>
<td>FLASHjet™</td>
<td>completed 3 of 3 stripplings</td>
</tr>
<tr>
<td>Laser Stripping</td>
<td>completed 2 of 3 stripplings</td>
</tr>
<tr>
<td>Plastic Media Blasting</td>
<td>completed 3 of 4 stripplings</td>
</tr>
<tr>
<td>Sodium Bicarb. Wet Stripping</td>
<td>completed 3 of 3 stripplings</td>
</tr>
<tr>
<td>Water Stripping</td>
<td>completed 3 of 3 stripplings</td>
</tr>
<tr>
<td>Wheat Starch Stripping</td>
<td>completed 3 of 3 stripplings</td>
</tr>
</tbody>
</table>
Next Steps

- Conclude stripping sequences.
- Initiate final material testing to compare to baselines.
- Evaluate process performance.
- Provide conclusions to EPA.
- Targeted conclusion of study is December 1998.
Process Comparisons

- Unable to recommend one process over another due to following:
  
  manual vs. automatic
  ease of use, operability
  capital investment costs
  no final fatigue data at present
Chemical Stripping

- Data taken from three sequences.
- Approximately 40 candidates - downselected to 10 chemical strippers (5 alkalines & 5 acids)

<table>
<thead>
<tr>
<th>Chemical Type</th>
<th>Dwell Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baselines</td>
<td>12 minutes</td>
</tr>
<tr>
<td>Alkalines/Neutrals</td>
<td>5.3 hours</td>
</tr>
<tr>
<td>Acids</td>
<td>5 hours</td>
</tr>
</tbody>
</table>
CO₂ Blasting

- Two systems: COLDJET™ Model 65-250 and TOMCO₂ DI-250.
- COLDJET™ system caused significant deformation on 16 mil specimens and even 64 mil specimens showed surface damage.
- TOMCO₂ system was capable of some coating removal but allowable pressure was too low for efficient stripping.
Flashjet™ Coating Removal

- Generous time and effort donated by McDonnell Douglas in St. Louis, MO.
- Data taken from two sequences.

<table>
<thead>
<tr>
<th>Substrate Thickness</th>
<th>Strip Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 mils</td>
<td>109 in²/min</td>
</tr>
<tr>
<td>51 mils</td>
<td>136 in²/min</td>
</tr>
<tr>
<td>64 mils</td>
<td>128 in²/min</td>
</tr>
</tbody>
</table>
Plastic Media Blasting

- Data taken from two sequences.
- Media: type V Plastic Media, 20/30 & 16/20 mesh
- Nozzle diameters: 0.25” @ throat, 0.50” @ exit

<table>
<thead>
<tr>
<th>Substrate Thickness</th>
<th>Blast Pressure</th>
<th>Strip Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 mils</td>
<td>30 psi</td>
<td>17 in²/min</td>
</tr>
<tr>
<td>51 mils</td>
<td>35 psi</td>
<td>20 in²/min</td>
</tr>
<tr>
<td>64 mils</td>
<td>40 psi</td>
<td>18 in²/min</td>
</tr>
</tbody>
</table>
Sodium Bicarbonate Wet Stripping

- Data taken from two sequences.
- First sequence was manual with great variance in strip rate.

<table>
<thead>
<tr>
<th>Substrate Thickness</th>
<th>Strip Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 mils</td>
<td>145 in²/min</td>
</tr>
<tr>
<td>51 mils</td>
<td>167 in²/min</td>
</tr>
<tr>
<td>64 mils</td>
<td></td>
</tr>
</tbody>
</table>
Water Stripping

- Data taken from two sequences.
- Stripped using a customized system of robotics and spray equipment.

<table>
<thead>
<tr>
<th>Substrate Thickness</th>
<th>Strip Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 mils</td>
<td>139 in²/min</td>
</tr>
<tr>
<td>51 mils</td>
<td>408 in²/min</td>
</tr>
<tr>
<td>64 mils</td>
<td>390 in²/min</td>
</tr>
</tbody>
</table>
Chemical Stripping

- Maintain environment at an rH of 34% and a temperature between 80 & 86 F.
- Apply fine mist of stripper over panel.
- Apply heavier mist 30 minutes later.
- Check at 2 hour intervals.

  if any paint is released, brush panel and reapply stripper as before.
Wheat Starch Stripping

- Generous time and effort donated by CAE Electronics, Montreal Canada.
- Data taken from two sequences.

<table>
<thead>
<tr>
<th>Process</th>
<th>Substrate Thickness</th>
<th>Strip Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>semi-automated</td>
<td>16 mils</td>
<td>249 in²/min</td>
</tr>
<tr>
<td>semi-automated</td>
<td>51 mils</td>
<td>459 in²/min</td>
</tr>
<tr>
<td>semi-automated</td>
<td>64 mils</td>
<td>459 in²/min</td>
</tr>
<tr>
<td>manual</td>
<td>16 mils</td>
<td>76 in²/min</td>
</tr>
<tr>
<td>manual</td>
<td>51 mils</td>
<td>96 in²/min</td>
</tr>
<tr>
<td>manual</td>
<td>64 mils</td>
<td>76 in²/min</td>
</tr>
</tbody>
</table>