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
- NASA
- USAF

Emission Standards Division (ESD)
Headquarters, Code JE
Marshall Space Flight Center (MSFC)

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™ (CO₂ Blasting)
- TOMCO₂ (CO₂ Blasting)
- FLASHJET™ Coating Removal
- Laser Stripping
- Plastic Media Blasting
- Sodium Bicarbonate Wet Stripping
- Water Stripping
- Wheat Starch Blasting

* COLDJET™ and TOMCO₂ 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 2nd 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.
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
Status to Date

● Current process status:

   Chemical Stripping          completed 4 of 5 stripplings
   COLDJET™                   dropped from study
   TOMCO₂                     dropped from study
   Flashjet™                  completed 3 of 3 stripplings
   Laser Stripping            completed 2 of 3 stripplings
   Plastic Media Blasting     completed 3 of 4 stripplings
   Sodium Bicarb. Wet Stripping completed 3 of 3 stripplings
   Water Stripping            completed 3 of 3 stripplings
   Wheat Starch Stripping     completed 3 of 3 stripplings
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>
CO$_2$ Blasting

- Two systems: COLDJET$^\text{TM}$ Model 65-250 and TOMCO$_2$ DI-250.
- COLDJET$^\text{TM}$ system caused significant deformation on 16 mil specimens and even 64 mil specimens showed surface damage.
- TOMCO$_2$ 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>
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</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>-----</td>
</tr>
<tr>
<td>51 mils</td>
<td>145 in(^2/)min</td>
</tr>
<tr>
<td>64 mils</td>
<td>167 in(^2/)min</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>
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<tr>
<td>manual</td>
<td>16 mils</td>
<td>76 in²/min</td>
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<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>
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