ABSTRACT
PROCESS DEVELOPMENT IN AQUEOUS CLEANING

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8 DECEMBER 1992

Process development in aqueous cleaning is taking place at the Aerojet Advanced Solid Rocket Motor (ASRM) Division under a NASA Marshall Space and Flight Center contract for design, development, test and evaluation of the ASRM including new production facilities. Lockheed Missiles and Space Company and Aerojet have formed a team partnership. Lockheed, as prime contractor, is providing systems engineering and integration and facility construction with overall responsibility and accountability for the project. Aerojet, as a subcontractor, is heading the propulsion design, development, and manufacturing of the new booster. The ASRM will utilize aqueous cleaning in several manufacturing process steps to clean case segments, nozzle metal components, and igniter closures. ASRM manufacturing process development is underway, including agent selection, agent characterization, subscale process optimization, bonding verification, and scale-up validation.

After a literature search and screening demonstrations of 11 aqueous cleaning agents, three agents (Turco 3878 LF-NC, Daraclean 283, and Blue Gold) were chosen for cleaning ability demonstrations. As a result, Turco 3878 LF-NC has been selected for further process testing. Process parameters are currently being tested for optimization utilizing a Taguchi Matrix, including agent concentration, cleaning solution temperature, agitation and immersion time, rinse water amount and temperature, and use/non-use of drying air.

Based on results of process development testing to date, several observations are offered:

- Aqueous cleaning appears effective for steels and SermeTel-coated metals in ASRM processing.
- Aqueous cleaning agents may stain and/or attack bare aluminum metals to various extents. Effects have not been characterized.
- Aqueous cleaning appears unsuitable for thermal sprayed aluminum-coated steel.
- Aqueous cleaning appears to adequately remove a wide range of contaminants from flat metal surfaces, but supplementary assistance may be needed to remove clumps of tenacious contaminants embedded in holes, etc.
- Hot rinse water appears to be beneficial to aid in drying of bare steel and retarding oxidation rate.

In summary, process development in aqueous cleaning for the ASRM Project is progressing satisfactorily. An agent has been selected and subscale process optimization is in progress. Aqueous cleaning has been demonstrated at the lab scale to be an effective alternative to vapor degreasing. The Aerojet ASRM Division and the entire ASRM Team are committed to successful activation of full-scale aqueous cleaning processes.
ASRM Process Development
In Aqueous Cleaning

December 8, 1992

Bill Swisher
ASRM Augerous Cleaning

- HP9N1-4Co-0.3C Steel
- Igniter Closure
- Coating Semmerl 1207/1208
- 7050/7075 Aluminum
- Coating TSA OR Semmerl 64-1
- DAC Steel
- Nozzle
- HP9N1-4Co-0.3C Steel
- Case Segments

Purpose And Logic
ASRM Manufacturing Process Development Specification TM0528

Development Testing Logic

Purpose and Logic
Goal To Select Three Agents For Further Testing

- Steel - Chemlok - EPDM Insulation
- Bond In Tension Comparison
  (Storage in Nitrogen)
- CONSCAN Readings at 2 Hours and 24 Hours
- Cleanliness and Compatibility Comparison

- Corec 419
- Cuntin 8156D
- Duraclean 822
- Duraclean 283
- Turoco 6778 - Turoco 3878 LF-NC

Bonding Effects with DAC G and HPG-4-30 Steel
Eleven Candidates Tested for Corrosion And

Literature Search Inconclusive

Task 1 - Screening Demonstration Test

Agent Selection
Space Vehicle Division

- Emulsion Cleaning History By Martin Marreta
  - Blue Gold (Modern Chemical Co.)
  - History Cleaning Small Parts In Industry
  - Dacelean 283 (W.R. Grace Co.)
  - Propulsion Division
  - Emulsion Cleaning History By Aerogel
  - Turco 3878 LF-NC (Turco, Inc.)

Three Agents Selected

- Bond Strength Similiar
- None Caused Lowered CONSCAN Readings
- No Adverse Corrosion Or Compatibility Reactions
- Above Others

No Candidate Agent Performed Definitively

Results

Task 1 - Screening Demonstration Test (Cont'd)
Bonding Demonstration (HP9-4-30)
Cleaning Ability Demonstration (AIL)
Compatibility Characterization of Coated Materials
Residual Species Analysis (HP9-4-30)

Data Collected:

7075-T73 Aluminium
HP9-4-30, TSA 4130 Steel, and Sermetel
Several Basis Metals Tested

- Blue Cold
- Daraclean 283
- Turco 3878 LF-NC

Three Agents Tested for Down Selection

Task 2A - Cleaning Ability Test

Agent Selection
Media Blast
Provided Cleaner Base Metal Surface Than
All Three Removed Particulate And

1. Blue Cold
0.0

2. Daraclean 228
6.0

3. Tuxco 3878 LF-NC
3.0

5. No Agent (Control)
5.0

Results:
Remain On Cleaned Metal Surface
Purpose: To Demonstrate if Residual Species

Residual Species Analyses

Task 2A - Cleaning Ability Test (Contd)
Results:

Solutions On Nozzle Metals

Purpose: To Demonstrate Effect of Cleaning Compatibility Characterization

Task 2A - Cleaning Ability Test (Cont'd)
Steel to develop corrosion and blister water which over time caused underlying surface discoloration and apparent coating loss.

- TSA coatings were adversely affected
- Light to heavy blistering caused by agents
- Bare aluminum requires more testing (Turco Best)
- Agents compatible with semetel coating

Compatibility Characterization Results Of

Task 2A - Cleaning Ability Test (Cont'd)
Cleaning Ability Demonstration

Purpose: To demonstrate ability to clean HD-2 grease

Results:

Agent: Turco 3878 LF-NC

Observations:

TSA Panels Retained Grease in Pores And Surface
Holes in Panels Retained Grease
Grease Over Surface And In Holes
H-P9-4-30 And Serrmetl Panels Cleaned Except
H-P9-4-30 And Serrmetl Panels Retained Visible
Cleaning Progressed Significantly Entire 30 Minutes

Daraclean 283

Blue Gold
Results

Cleaning Ability Demonstration

- Clumps Of Grease In Panel Holes Were Not Removed By Any Agents
- Blue Gold Failed

• Turco And Daraclean Removed Surface Grease (Except TSA Coated Steel)
  - Blue Gold Less Vigorously

• Three Agents Continued Cleaning 30 Minutes
Dariclan 283
Blue Gold
Turco 3878 LF-NC

Mean Stress At Peak (PSI)

Agent

Test Data Summary:

- Turco 3878 LF-NC Slightly Higher Strength Than Others
- All Samples Failed Cohesively In Insulation

Results:

Purpose: To Demonstrate Bonding Strength

Bonding Demonstration

Task 2A - Cleaning Ability Test (Cont'd)
List of Contaminants:

- Specified Bond Strength
- Levels that do not interfere with
- Success Criteria: To remove contaminants to

All expected potential contaminants
Purpose: To verify Turoco 3879 LF-NC Able to clean

Task 2B - Case Cleaning Ability

Agent Selection
<table>
<thead>
<tr>
<th>Task 2B Results</th>
<th>Task 2B - Case Cleaning Ability (cont'd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleanliness Measurements</td>
<td>Particulate (mg), Mean OSEE, Mean QSEF Button Pull, Mean Stress Bond Strength</td>
</tr>
<tr>
<td>HD-2 Grease</td>
<td>0.3</td>
</tr>
<tr>
<td>Thicker Slurry</td>
<td>0.5</td>
</tr>
<tr>
<td>Bird Droppings</td>
<td>0.3</td>
</tr>
<tr>
<td>Camlub Wax</td>
<td>0.1</td>
</tr>
<tr>
<td>VCI Film</td>
<td>0.5</td>
</tr>
<tr>
<td>Plastic Blast</td>
<td>0.1</td>
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<tr>
<td>Nylor Residue</td>
<td>0.6</td>
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<tr>
<td>Na Moly</td>
<td>0.3</td>
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<tr>
<td>Cor Inhibitors</td>
<td>0.2</td>
</tr>
<tr>
<td>Zn Chromate</td>
<td>0.5</td>
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<tr>
<td>Curing Fluid</td>
<td>0.6</td>
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<tr>
<td>Grease Pencil</td>
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<tr>
<td>Cutting Fluid</td>
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<tr>
<td>Hydraulic Fluid</td>
<td>0.1</td>
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<tr>
<td>Fingerprints</td>
<td>0.1</td>
</tr>
<tr>
<td>Control</td>
<td>1.0</td>
</tr>
</tbody>
</table>

And After Corrosion Cleanup (CCL)

Before Corrosion Cleanup (CCL)
Chemical Bonding Ability Must Be Factor

Considering Diversity Of Contaminants - Small Bond Strength Variation

All Samples Failed Cohesively In Rubber

All Contaminants Removed Sufficiently

Turco 3878 LF-NC

Adequate Bond Strength Demonstrated For

Task 2B Results (Cont'd)
Potential ARM Contaminants
Demonstrated Ability To Remove Wide Variety Of

Analyses
Co-Winner With Blue Gold In Residual Species

Cleaning Ability Demonstration
Co-Winner With Darclean 283 In HD-2 Grease

Bonding Demonstration
Compatibilty Characterization Testing

Best Results Over Other Two Agents In

Turco 3878 LF-NC Selected
Task 3 - Process Optimization

- Purpose: To Evaluate The Sensitivity Of The Aqueous Cleaning Process To Changes In Parameters That Control The Process
- Bonding To Be Verified In Task 4 Utilizing Optimized Process Settings
- Success Criteria: Identify Preliminary Target Process Settings And Functional Limits (NVR Cleanliness Levels Must Also Be Within Level Previously Demonstrating Successful Bonding)
- Taguchi Matrix Utilized

Task 3 Currently In Progress
Drilling To Prevent Rapid Oxidation Of Bare Steel

- Hot Rinse Water Appears To Be Beneficial To Aid
  Tenacious Contaminants From Holes
  Supplementary Assistance Needed To Remove
  Variety Of Contaminants From Flat Surfaces, But
  Aqueous Cleaning Appears To Remove Wide
  (Effect Not Characterized)
  And/Or Attack Bare Aluminum To Various Extents
  Aqueous Cleaning Agents Apparent Stain
  Spray Aluminum Coatings
  Aqueous Cleaning Appears Unsuitable For Thermal
  Searched Coated Metal
  Aqueous Cleaning Appears Effective For Steel And

General Observations
Full-Scale Factory Activation

We're Committed To Successful

is Effective Alternative To Vapor Degreasing

Demonstrated At Lab Scale That Aqueous Cleaning

Optimization in Progress

Agent Selected

is Progressing Satisfactorily

ASRM Process Development in Aqueous Cleaning

Summary