ABSTRACT
ASRM PROCESS DEVELOPMENT IN AQUEOUS CLEANING

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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
- HP9NI-4CO-0.3C Steel
- Igniter Closure
- Coating Semifin 1207/1208
- 7050/7075 Aluminum
- Coatings TSA or Semifin 64-1
- DAC Steel
- Nozzle
- HP9NI-4CO-0.3C Steel
- Case Segments

ASRM Aqueous Cleaning
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)

Cleanliness and Compatibility Comparison

- Core 419
- Blue Gold
- Humiseal Special
- Humiseal HD
- Duraclean 222
- Duraclean 815ED
- Turoco 6778
- Turoco 3878 LF-NC

Bonding Effects with D6AC 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 Marcella
- Blue Gold (Modern Chemical Co.)
- History Cleaning Small Parts In Industry
- Darclean 283 (W.R. Grace Co.)
- Propulsion Division
- Emulsion Cleaning History By Aeroflot
- Turco 3878 LF-NC (Turco, Inc.)

Three Agents Selected

- Bond Strength Similar
- 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 (HP4-4.30)  
Cleaning Ability Demonstration (AII)  
Compatibility Characterization of Coated Materials  
Residual Species Analysis (HP4-4.30)  

Data Collected:

7075-T73 Aluminum  
HP4-4.30, TSA 4130 Steel, and Serrated 
Several Basis Metals Tested 

Blue Cold  
Darclean 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. Daclean 283 6
2. Turco 3678 LF-NC 3
6. No Agent (Control) 5

Particulate
Agent: NR

Results:

Remain On Cleaned Metal Surface
Purpose: To Demonstrate If Residual Species

Residual Species Analyses

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

Task 2A - Cleaning Ability Test (Contd)

• Purpose: To Demonstrate Effect Of Cleaning Solutions On Nozzle Metals

• Results:

<table>
<thead>
<tr>
<th>Agent</th>
<th>Rust Color Under Surface Coat</th>
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<tbody>
<tr>
<td>Daraclean</td>
<td>Most Rust Color Under Surface Coat</td>
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<tr>
<td>Blue Gold</td>
<td>Moderate Rust Color Under Surface Coat</td>
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<tr>
<td>Turco 3878</td>
<td>No Foaming Applications</td>
</tr>
<tr>
<td>LF-NC</td>
<td>Mild Rust Color Under Surface Coat</td>
</tr>
<tr>
<td>Sermet Aluminum</td>
<td>Lightly Tarnished Aluminum</td>
</tr>
<tr>
<td>TSA Steel</td>
<td>No Reaction</td>
</tr>
<tr>
<td>- No Reaction</td>
<td></td>
</tr>
<tr>
<td>- No Reaction</td>
<td></td>
</tr>
<tr>
<td>- No Reaction</td>
<td></td>
</tr>
<tr>
<td>- Lightly Tarnished Aluminum</td>
<td></td>
</tr>
<tr>
<td>- Moderately Tarnished (Blackened)</td>
<td></td>
</tr>
<tr>
<td>- Heavily Tarnished</td>
<td></td>
</tr>
</tbody>
</table>
Steel to develop corrosion
And rinse water which over time caused underlying
Surface discoloration and apparent coating loss
- TSA coatings were adversely affected

- Light to heavy spraying caused by agents

- Bare Aluminum requires more testing (Turco Best)

- Agents compatible with Semetl coating

Compatibility Characterization

Results Of

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

- Task 2A - Cleaning Ability Test (Cont'd)
Removed by any agents

- Clumps of grease in panel holes were not

Blue Gold Failed

(Except TSA coated steel)

Turco and Daradlean Removed Surface Grease

Blue Gold Less Vigorously

Three agents continued cleaning 30 minutes

Cleaning Ability Demonstration Results

Task 2A - Cleaning Ability Test (cont'd)
Dariclane 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:

- 2364 Adhesive - Keveler Fillled Insulation
- Bond In Tension Testing (Chemlok 205 Primer - Chemlok
- Contaminant Was Conoco HD-2 Grease
- HP-94-30 Test Panels

Purpose: To Demonstrate Bonding Strength

Bonding Demonstration

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

- Thermal Protection Residue
- EPM Rubber Residue
- Shop Dirt
- Road Dirt
- Hydrocarbon Soot
- Teflon®, Teflon
- Bird Droppings
- Camphor Wax (Tool Coating)
- Volatile Corrosion Inhibitor Residue
- Plastic Blast Media Residue
- Nylan Residue
- Zinc Chromate Residue
- Bugs Organic Residue
- Fingerprints
- Trimetal Cutting Fluid
- Shop Marker Grease Pencil
- Tolybendole
- Sodium Borate
- Sodium Nitrite
- Sodium Molybdate
- Corrosion Inhibitors:
  - Hydraulic Fluid
  - Conoco HD-2 Grease

Specification Bond Strength
Levels That Do Not Interfer With
Success Criteria: To Remove Contaminants To

All Expected Potential Contaminants

Purpose: To Verify Turoco 3878 LF-NC Able To Clean

Task 2B - Case Cleaning Ability

Agent Selection

AEROCORP
ATOMIC DIVISION

4018789397-205 544 4810

#20
<table>
<thead>
<tr>
<th>Degraded</th>
<th>HD-2 Grease</th>
<th>Trichloroethylene</th>
<th>Bird Droppings</th>
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<td>0.7</td>
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<tr>
<td>Improved</td>
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</tr>
</tbody>
</table>

**Task 2B Results**

**Task 2B - Case Cleaning Ability (Cont'd)**
Chemlok 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 ASRM Contaminants
Demonstrated Ability To Remove Wide Variety Of
Analyses
Co-Winner With Blue Gold In Residual Species
Cleaning Ability Demonstration
Co-Winner With Daraclean 283 In HD-2 Grease
Bonding Demonstration
Compatibility Characterization Testing
Best Results Over Other Two Agents In
Turco 3878 LF-NC Selected

Agent Selection
Task 3 - Process Optimization

Task 3: Currently in Progress

Process Settings

Bonding To Be Verified In Task 4 Utilizing Optimized

Demonstrating Successful Bonding

Also Be Within Level Previously

NVR Cleanliness Levels Must

Settings And Functional Limits

Success Criteria: Identity Preliminary Target Process

Taguchi Matrix Utilized

Parameters That Control The Process

Aqueous Cleaning Process To Changes In

Purpose: To Evaluate The Sensitivity Of The

Task 3 - Process Optimization
Taguchi Matrix

Task 3 Process Optimization (Cont'd)
General Observations

- Aqueous Cleaning Appears Effective For Steel And SermeTel Coated Metal

- Aqueous Cleaning Appears Unsuitable For Thermal Spray Aluminum Coatings

- Aqueous Cleaning Agents Apparently Stain And/Or Attack Bare Aluminum To Various Extents (Effect Not Characterized)

- Aqueous Cleaning Appears To Remove Wide Variety Of Contaminants From Flat Surfaces, But Supplementary Assistance Needed To Remove Tenacious Contaminants From Holes

- Hot Rinse Water Appears To Be Beneficial To Aid Drying To Prevent Rapid Oxidation Of Bare Steel
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

ASRM Aqueous Cleaning Development