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

Bill Swisher
December 8, 1992
Overview

- Process Optimization
- Cleaning Agent Selection
- Purpose and Logic

Aqueous Cleaning Development
ASRM Alloys Cleaning

Purpose And Logic

1. HP9N1-4Co-0.3C Steel
2. Igniter Closure
3. Coating: Semitool 1207/1208
4. 7050/7075 Aluminum
5. Coatings: TSA or Semitool 641
6. DAG Steel
7. Nozzle
8. HP9N1-4Co-0.3C Steel
9. Case Segments
ASRM Cleaning Process Flow

Purpose and Logic
Development Testing Logic

Purpose and Logic
Goal: To Select Three Agents For Further Testing

- Steel - Chernox - EPDM Insulation
- Bond In Tension Comparison
- Storage In Nitrogen
- CONSCAN Readings At 2 Hours And 24 Hours
- Cleanliness And Compatability Comparison

Bonding Effects With DAC and HP-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 Maretta
- Blue Gold (Modern Chemical Co.)
- History Cleaning Small Parts In Industry
  - Darcelan 283 (W.R. Grace Co.)
- Propulsion Division
  - Emulsion Cleaning History By Aerogel
    - 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 (HP9-4.30)
Cleaning Ability Demonstration (All)
Compatibility Characterization of Coated Materials
Residual Species Analysis (HP9-4.30)

Data Collected:

7075-T73 Aluminum
- HP9-4.30, TSA 4130 Steel, and Sermetel
- Several Alloys Tested

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. Dacleen 2B 3 6
3. Turo 3878 LF-NC 3
4. No Agent (Control) 5
5. Agent Particulate
6. NVR

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

Residual Species Analyses

Task 2A - Cleaning Ability Test (Cont'd)
Results: Solutions On Nozzle Metals

Purpose: To Demonstrate Effect Of Cleaning

Compatibility Characterization

Task 2A - Cleaning Ability Test (Contd.)
Steel To Develop Corrosion
And Then Water Which Over Time Caused Underlying
Surface Discoloration And Apparent Coating Loss
- TSA Coatings Were Adversely Affected

Light To Heavy Swirling Caused By Agents
- Bare Aluminum Requires More Testing (Turco Best)

Agents Compatible With Semtech Coating

Compatibility Characterization

Results Of

Task 2A - Cleaning Ability Test (Contd)
Cleaning Ability Demonstration

Purpose: To demonstrate ability to clean HD-2 Grease

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 Daraclean Removed Surface Grease

Blue Gold Less Vigorously

Three Agents Contained Cleaning 30 Minutes

Cleaning Ability Demonstration

Results

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

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

- Test Data Summary:
  - Turoco 3878 LF-NC Slightly Higher Strength than Others
  - All Samples Failed Cohesively in Insulation

Results:

- 236A Adhesive - Kevelar Filled Insulation (Chemlink 205 Primer - Chemlink
  - Contaminant Was Conoco HD-2 Grease
- HP-4-30 Test Panels

Purpose: To Demonstrate Bonding Strength
List of Contaminants:

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

All Expected Potential Contaminants
Purpose: To Verify Turco 3878 LF-NC Able To Clean

Task 2B - Case Cleaning Ability

Agent Selection
<table>
<thead>
<tr>
<th>Product</th>
<th>Degraded</th>
<th>Improved</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD-2 Grease</td>
<td>0.0</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Thicker Slurry</td>
<td>0.5</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Bird Droppings</td>
<td>0.6</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Camlin Wax</td>
<td>0.9</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>VCI Film</td>
<td>0.7</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Plastic Blast</td>
<td>1.0</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Nylon Residue</td>
<td>2.5</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Na Moly</td>
<td>1.1</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Cor Inhibitors</td>
<td>0.6</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Zn Chromate</td>
<td>0.6</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Bugs</td>
<td>0.6</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Grease Pencil</td>
<td>0.7</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Cutting Fluid</td>
<td>1.0</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Hydraulic Fluid</td>
<td>1.3</td>
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<td>0.1</td>
</tr>
</tbody>
</table>

**Task 2B Results**

**Task 2B - Case Cleaning Ability (Cont'd)**
Chemist 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
Analysis
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

Process Optimization

Task 3 Currenty 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

Tauguchi Matrix Utilized

Parameters That Control The Process

Aqueous Cleaning Process To Changes In

Purpose: To Evaluate The Sensitivity Of The

Task 3 - Process Optimization

ASMA Division

AEROSOL

DENCORP

#24
Taguchi Matrix

Task 3 Process Optimization (Cont'd)
General Observations

- Hot Rinse Water Appears To Be Beneficial To Aid Drying To Prevent Oxidation Of Bare Steel
- Aqueous Cleaning Appears To Remove Wide Variety Of Contaminants From Flat Surfaces, But Supplementary Assistance Needed To Remove Tenacious Contaminants From Holes
- Aqueous Cleaning Appears Unsuitable For Thermal Spray Aluminum Coatings
- Aqueous Cleaning Appears Effective For Steel And Sermetel Coated Metal
Full-Scale Factory Activation
Successful

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