ABSTRACT

ASRM 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

Bill Swisher
December 8, 1992
Overview

Process Optimization

Cleaning Agent Selection

Purpose and Logic
ASRM Aqueous Cleaning

- Nozzle
- Case Segments
- D6AC Steel
- HP9Ni-4Co-0.3C Steel
- 7050/7075 Aluminum
- Coating Sermetel 1207/1208
- Coatings TSA Or Sermetel 64-1
- Igniter Closure
- HP9Ni-4Co-0.3C Steel
ASRM Manufacturing Process Development Specification TMS5828

Development Testing Logic

Purpose and Logic
Task 1 - Screening Demonstration Test

Agent Selection

ASRM DIVISION

ARDORSET

GENCORP
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 Aerolsat
  - Turco 3878 LF-NC (Turco, Inc.)

Three Agents Selected

- Bond Strengths Similar
  - None Caused Lowered CONSCAN Readings
  - No Adverse Corrosion or Compatiblility Reactions
  - Above Others

No Candidate Agent Performed Definitively

Results

Task 1 - Screening Demonstration Test (Cont'd)
Task 2A - Cleaning Ability Test

- Three Agents Tested For Down Selection
  - Turco 3878 LF-NC
  - Daraclean 283
  - Blue Gold

- Several Basis Metals Tested
  - HP-9-30, TSA 4130 Steel, And Sermetel 7075-T73 Aluminum

- Data Collected:
  - Residual Species Analysis (HP-9-30)
  - Compatibility Characterization Of Coated Materials
  - Bonding Demonstration (HP-9-30)

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Media Blast

Provided Cleaner Base Metal Surface Than

All Three Remooved Particulate And

1. Blue Cold 0.0
2. Daraclean 283 6
2. Tuko 3878 LF-NC 3
6. No Agent (Control) 5

Results:

Remain On Cleaned Metal Surface

Purpose: To Demonstrate If Residual Species

Residual Species Analysis

Task 2A - Cleaning Ability Test (Contd)
Results: Solutions On Nozzle Metals
Purpose: To Demonstrate Effect Of Cleaning Compatibility Characterization
Task 2A - Cleaning Ability Test (Contd)
Results Of Compatibility Characterization

- TSA Coatings Were Adversely Affected
- Bare Aluminum Requires More Testing (Turco Best)
- Agents Compatible With SemTel Coating
  - Light To Heavy Smutting Caused By Agents
  - Surface Discoloration And Apparent Coating Loss
  And Rinse Water Which Over Time Caused Underlying
  Steel To Develop Corrosion

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

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

Objectives:
- To Demonstrate Ability To Clean HD-2 Grease

Results:
- Cleaning Progressed Significantly Entire 30 Minutes
- Cleaning Progressed Entire 30 Minutes
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- TSA Panels Retained Grease In Pores And Surface
- TSA Panels Retained Grease In Pores And Surface
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Agent
- Blue Gold
- Turco 3878 LF-NC
- Agent
- Agent

Observations:
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
- Holes In Panels Retained Grease
Removing by Any Agents

- Clumps of Grease in Panel Holes Were Not

- Blue Gold Failed

  (Except TSA Coated Steel)

  Turco And Daclean Removed Surface Grease

  Blue Gold Less Vigorously

- Three Agents Continued Cleaning 30 Minutes

Cleaning Ability Demonstration

Results

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

Purpose: To demonstrate Bonding Strength

Bonding Demonstration

Results:

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

236A Adhesive - Kevlar Filled Insulation
Bond in Tension Testing (Chemolok 205 Primer - Chemolok)
Contaminant was Conoco HD-2 Grease
- HP9-4-30 Test Panels

Mean Stress At Peak (PSI)
406
412
423
Blue Gold
Turco 3878 LF-NC

Agent No. 20
9:15 4078673737 2015 8810 ;#19
### Task 2B - Case Cleaning Ability

<table>
<thead>
<tr>
<th>Agent Selection</th>
<th>ASRM Division</th>
<th>ConcOrp AEROQUET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>Purpose: To Verify Turco 3878 LF-NC Able To Clean</td>
<td>All Expected Potential Contaminants</td>
</tr>
<tr>
<td>2B</td>
<td>Success Criteria: To Remove Contaminants To Levels That Do Not Interfere With Specification Bond Strength</td>
<td></td>
</tr>
</tbody>
</table>

#### List Of Contaminants:
- Conoco HD-2 Grease
- Hydraulic Fluid Corrosion Inhibitors:
  - Sodium Molybdate
  - Sodium Borate
- Shop Marker Grease Pencil
- Fingerprints
- Trimsol Cutting Fluid
- Zinc Chromate Residue
- Nylon Residue
- Plastic Blast Media Residue
- Volatile Corrosion Inhibitor Residue
- Camphu Wax (Tool Coating)
- Bird Droppings
- Trichloroethylene
- Road Dust
- EPDM Rubber Residue
- Thermal Protection Residue
- Hydrocarbon Soot

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### Task 2B Results

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

<table>
<thead>
<tr>
<th>Particulate (mg)</th>
<th>Mean OSEE</th>
<th>Mean OSEE</th>
<th>Bond Strength</th>
<th>Cleanliness Measurements</th>
<th>Button Pull Mean Stress</th>
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</thead>
<tbody>
<tr>
<td>HD-2 Grease</td>
<td>0.3</td>
<td>0.3</td>
<td>1.1</td>
<td>1.1</td>
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<tr>
<td>Tribofilm</td>
<td>0.5</td>
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<tr>
<td>Bird Droppings</td>
<td>0.3</td>
<td>0.3</td>
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<tr>
<td>Camina Wax</td>
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<td>0.3</td>
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<tr>
<td>VCI Film</td>
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<tr>
<td>Plastic Blast</td>
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<tr>
<td>Nylon Residue</td>
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<td>Na Moly</td>
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<tr>
<td>Cor Inhibitors</td>
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<td></td>
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<tr>
<td>Zinc Chromate</td>
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<td>Enz</td>
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<tr>
<td>Grease Penell</td>
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<tr>
<td>Cutting Fluid</td>
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<tr>
<td>Hydraulic Fluid</td>
<td>0.2</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerprints</td>
<td>0.1</td>
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**Before Contamination Applied**

<table>
<thead>
<tr>
<th>Degraded</th>
<th>Improved</th>
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<tr>
<td>437</td>
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<tr>
<td>428</td>
<td>0.5</td>
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<tr>
<td>426</td>
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<td>423</td>
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<td>429</td>
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<td>432</td>
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<td>427</td>
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<tr>
<td>444</td>
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<tr>
<td>441</td>
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<td>407</td>
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<td>447</td>
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<tr>
<td>447</td>
<td>1.0</td>
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<tr>
<td>438</td>
<td>1.3</td>
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</table>

**After Contamination Cleaned Off**

<table>
<thead>
<tr>
<th>Degraded</th>
<th>Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>427</td>
<td>1.1</td>
</tr>
</tbody>
</table>

**At Peak (PSI)**

- Atmospheric Pressure (PSI)
- Mean OSEE

**Measurements**

- Particulate (mg)
- NVR (mg)
- Mean OSEE
- Bond Strength
- Cleanliness
- Button Pull Mean Stress
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)
Task 3 - Process Optimization

**Process Settings**

- Bonding To Be Verified In Task 4 Utilizing Optimized Bonding
- Demonstrating Successful Bonding
- Also Be Within Level Previously
- NVR Clearing Levels Limits Setting And Functional Limits
- Success Criteria: Identity Preliminary Target Process
- Taught Matrix Utilized

**Parameters That Control The Process**

- Aqueous Cleaning Process To Changes In
- Purpose: To Evaluate The Sensitivity Of The

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

Hot Rinse Water Appears To Be Beneficial To Aid

Vigorous 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 Apparently Stain

Spray Aluminum Coatings
Aqueous Cleaning Appears Unsuitable For Thermal

Sputtered Coated Metal
Aqueous Cleaning Appears Effective For Steel And
We're Committed To Successful Full-Scale Facility Activation

is Effective Alternative To Vapor Degreasing

- Optimization In Progress

- Agent Selected

is Progressing Satisfactorily

ASRM Process Development In Aqueous Cleaning

Summary