ABSTRACT
ASRM PROCESS DEVELOPMENT IN AQUEOUS CLEANING

BILL SWISHER - AEROJET ASRM DIVISION
1 NASA DRIVE, IUKA, MS 38852
PHONE: (601) 423-0855
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
- Igniter Closure
- 7050/7075 Aluminum
- Coating Sermetel 1207/1208
- D6AC Steel
- Coatings TSA Or Sermetel 64-1
- HP9Ni-4Co-0.3C Steel
- Case Segments

ASRM Aqueous Cleaning

Purpose And Logic
ASRM Cleaning Process Flow

Purpose and Logic
ASRM Manufacturing Process Development Specification TM0528

Development Testing Logic

Purpose And Logic
Goal To Select Three Agents For Further Testing
- Steel - Chernox - EPM Insulation
Bond In Tension Compatibility

Cleanliness And Compatibility Comparison

- Storage In Nitrogen
- CONSACAN Readings At 2 Hours And 24 Hours

Bonding Effects With DEAC and HP4-4.30 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
  - Darclean 283 (W.R. Grace Co.)
  - Propulsion Division
  - Emulsion Cleaning History By Aerocel
  - 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 (Con’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 Stainless
Several Basis Metals Tested

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

Three Agents Tested For Down Selection

Task 2A - Cleaning Ability Test

Agent Selection
Residual Species Analysis

Purpose: To demonstrate if residual species remain on cleaned metal surface

Results:

<table>
<thead>
<tr>
<th>Agent</th>
<th>Particulate</th>
<th>NVR</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Agent (Control)</td>
<td>.5</td>
<td>.6</td>
</tr>
<tr>
<td>Blue Gold</td>
<td>.6</td>
<td>.2</td>
</tr>
<tr>
<td>Daraclean 283</td>
<td>.3</td>
<td>.1</td>
</tr>
<tr>
<td>Turco 3878 LF-NC</td>
<td>.0</td>
<td>.2</td>
</tr>
</tbody>
</table>

All Three Removed Particulate And Provided Cleaner Base Metal Surface Than Media Blast
**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 release water which over time caused underlying
Surface discoloration and apparent coating loss
TSA coatings were adversely affected
- Light to heavy crumbling caused by agents
Bare aluminum requires more testing (Turco Best)
- Agents compatible with ceramic 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:

Observations

Agents

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 Daclean Removed Surface Grease

Blue Gold Less Vigorously

Three Agents Continued Cleaning 30 Minutes

Cleaning Ability Demonstration

Results

Task 2A - Cleaning Ability Test (cont'd)
Purpose: To Demonstrate Bonding Strength

Results:

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

Agent: Turco 3878 LF-NC

Mean Stress At Peak (PSI):

- 423
- 412
- 406

Bond in Tension Testing (Chemlok 205 Primer - Chemlok 236A Adhesive - Kevlar Filled Insulation)

HP-4-30 Test Panels
**Task 2B - Case Cleaning Ability**

**Agent Selection**

**ASRM Division**

**Concorp**

**List of Contaminants:**
- Conoco HD-2 Grease
- Hydraulic Fluid
- Corrosion Inhibitors:
  - Sodium Molybdate
  - Sodium Borate
- Shop Marker Grease Pencil
- Trimsol Cutting Fluid
- Fingerprints
- Bugs Organic Residue
- Shop Dirt
- Road Dirt
- EPOM Rubber Residue
- Thermal Protection Residue
- Bird Droppings
- Hydrocarbon Soot
- Zinc Chromate Residue
- Nylon Residue
- Plastic Blast Media Residue
- Volatile Corrosion Inhibitor Residue
- Camuba Wax (Tool Coating)

**Success Criteria:**
- To remove contaminants to levels that do not interfere with specification bond strength.

**Purpose:**
- To verify Turco 3878 LF-NC able to clean all expected potential contaminants.

**All Expected Potential Contaminants**


_NOV 20 '92 9:12  4078673737 PAGE 020_
### Table: Before and After Combination cleaned off

<table>
<thead>
<tr>
<th>Task 2B Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 2B - Case Cleaning Ability (Cont'd)</td>
</tr>
</tbody>
</table>

#### Comparison of OSEE Readings

| HD-2 Grease | 0.3 |
| Thin film | 0.5 |
| Bird Droppings | 0.3 |
| Camel wax | 0.3 |
| PVC Film | 0.5 |
| Plastic Blast | 0.5 |
| Nylon Residue | 0.5 |
| Na Moly | 0.5 |
| Cor inhibitors | 0.2 |
| Zn Chromate | 0.3 |
| Buns | 0.5 |
| Grease Pencil | 0.6 |
| Cutting Fluid | 0.5 |
| Hydraulic Fluid | 0.2 |
| Fingerprints | 0.1 |

#### Cleanliness Measurements

- Particulate (mg) mean @ OSEE
- Button Pull Mean Stress
- Bond Strength

#### Cleanability

- Control
- AT peak (PSI)

---

**Sent by:** TM-PCO-3/SMAC/x4825
**Date:** 11-20-92
**Time:** 9:15AM
**Number:** 4078573737_205514
Chemlink 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 AFRM 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

- 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
- Purpose: To Evaluate The Sensitivity Of The Aqueous Cleaning Process To Changes In Parameters That Control The Process
Taguchi Matrix

Task 3 Process Optimization (Cont'd)
Drying 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

(Effective, Not Characterized)

And/or Attack Bare Aluminum To Various Extents
Aqueous Cleaning Agents Apparent
Spray Aluminum Coatings
Aqueous Cleaning Appears Unsuitable For Thermal

Ceramic 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