NASA-CR-191949

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ABSTRACT
ASRM PROCESS DEVELOPMENT IN AQUEOUS CLEANING

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IN-20-CR

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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 Taguci 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.

(NASA-CR-191949) ASRM PROCESS DEVELOPMENT IN AQUEOUS CLEANING (Lockheed Missiles and Space Co.) 26 p

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ASRM Process Development In Aqueous Cleaning

Bill Swisher

December 8, 1992

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Aqueous Cleaning Development

Overview

- Purpose And Logic
- Cleaning Agent Selection
- Process Optimization

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Purpose And Logic

ASRM Aqueous Cleaning

- **Case Segments**
  - HP9Ni-4Co-0.3C Steel
- **Nozzle**
  - D6AC Steel
    - Coatings TSA Or Sermetel 64-1
  - 7050/7075 Aluminum
    - Coating Sermetel 1207/1208
- **Igniter Closure**
  - HP9Ni-4Co-0.3C Steel

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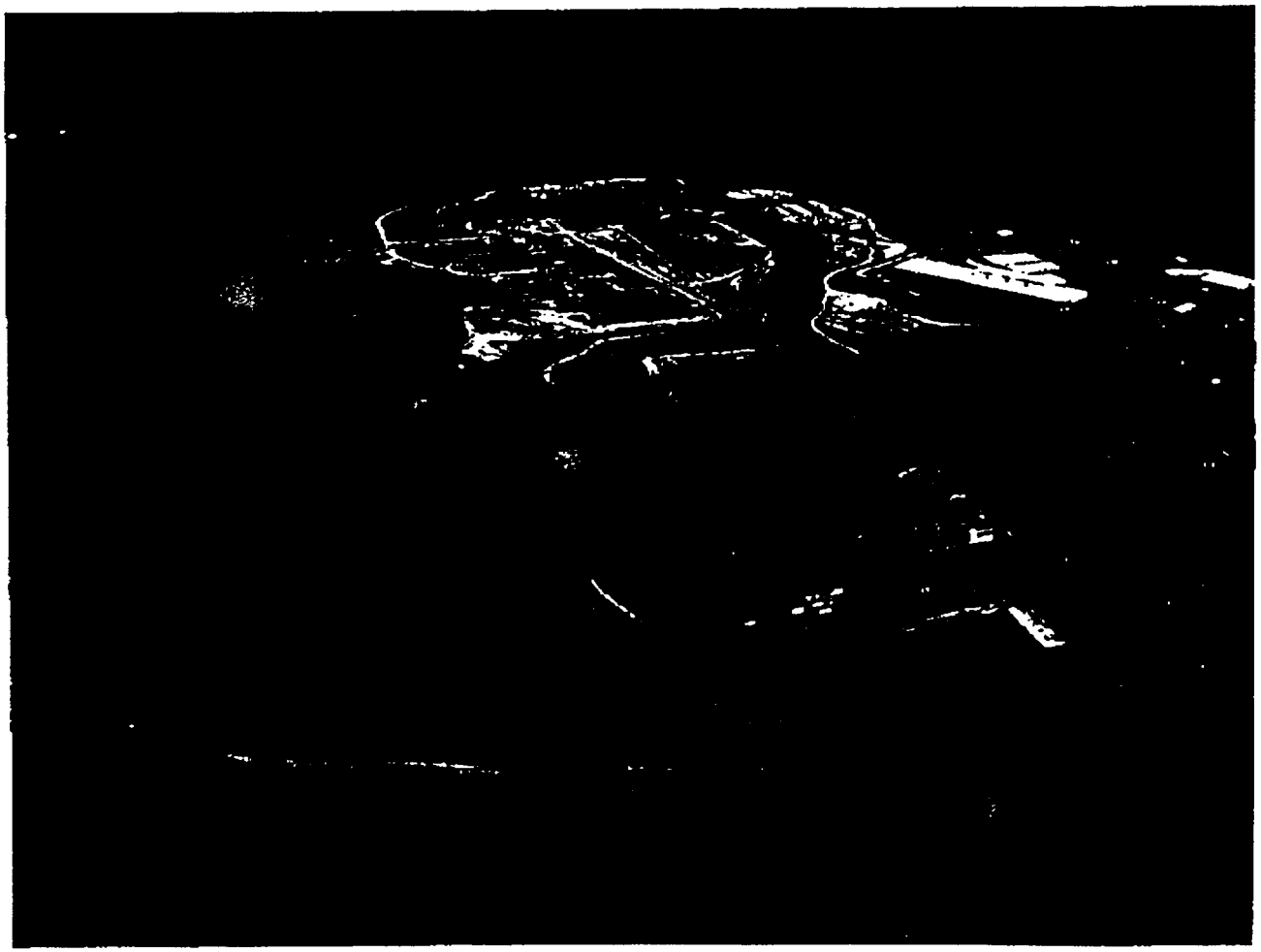
Purpose And Logic

Yellow Creek



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Facility

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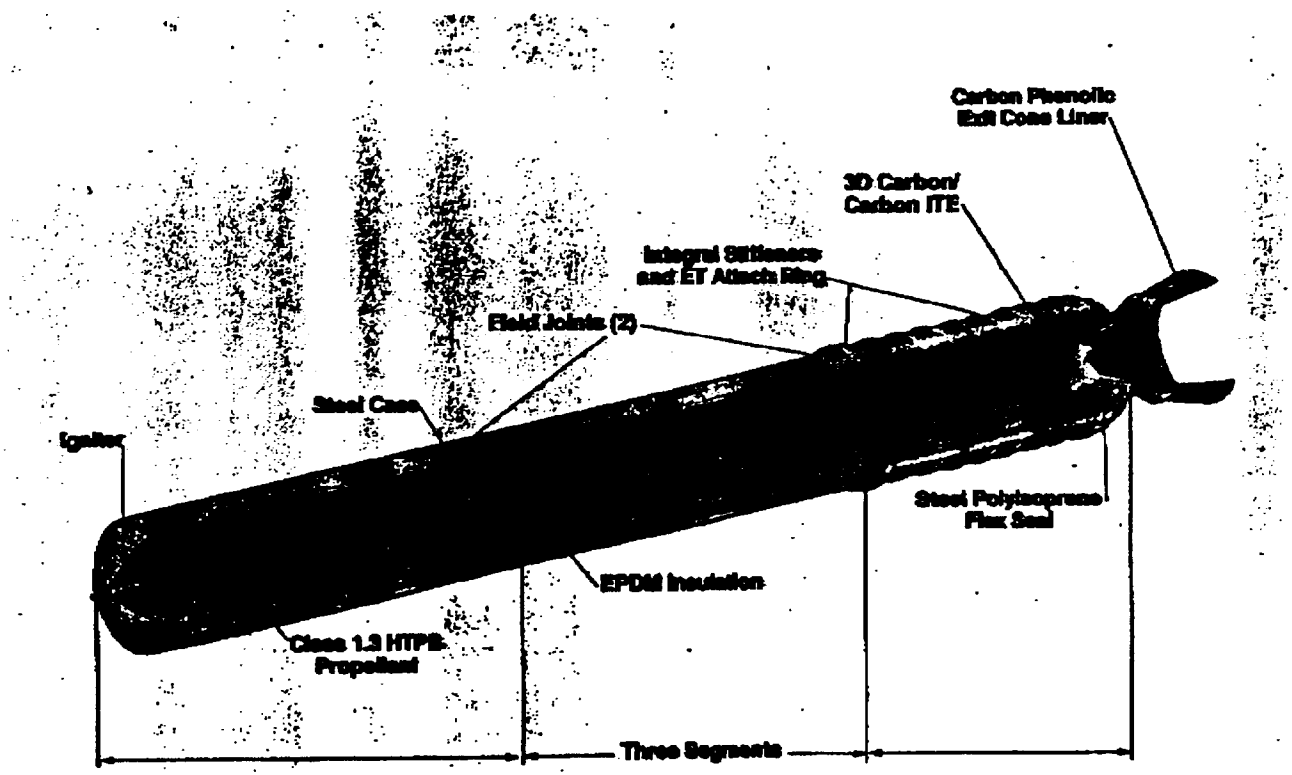
Purpose And Logic

ASRM



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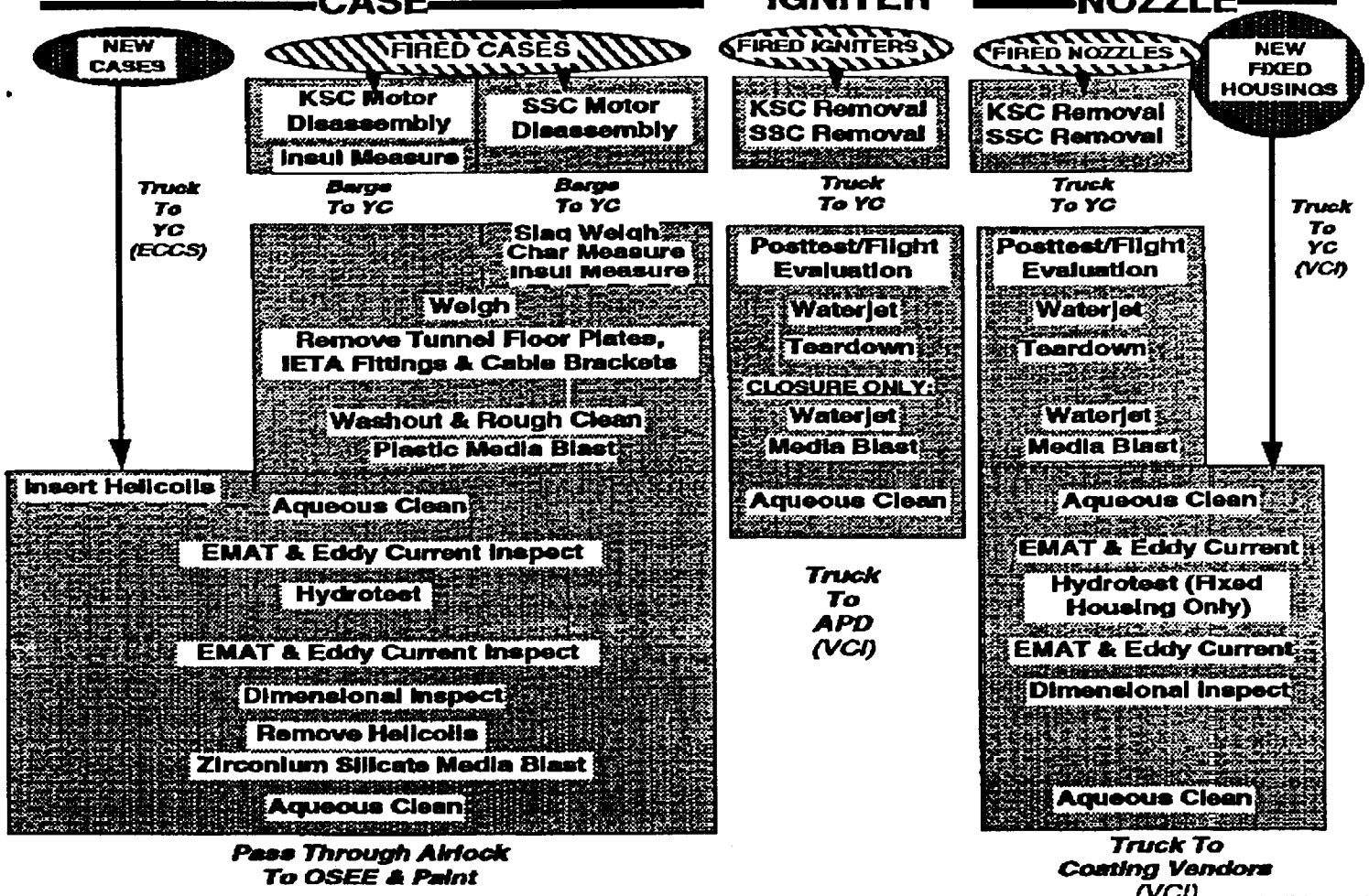
Purpose And Logic

ASRM Cleaning Processes Flow



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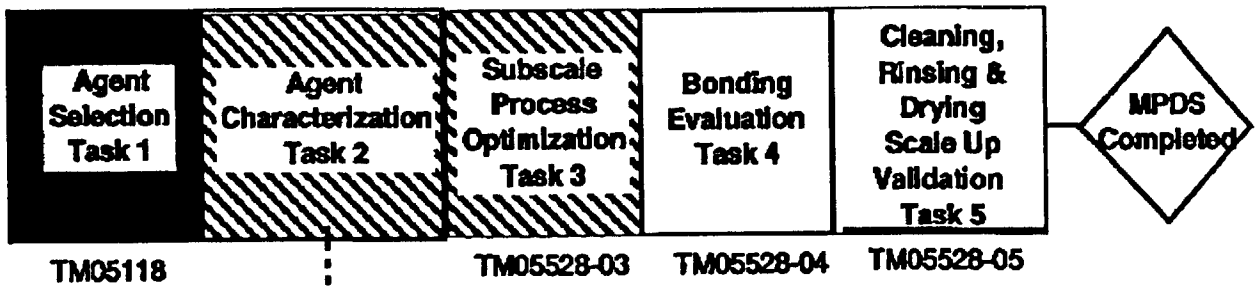
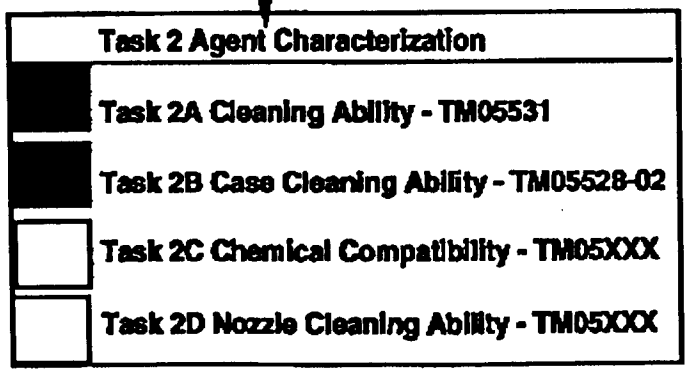
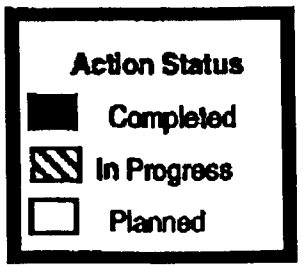
Purpose And Logic

Development Testing Logic

ASRM Manufacturing Process Development Specification TM05528







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Agent Selection

Task 1 - Screening Demonstration Test

- **Literature Search Inconclusive**
- **Eleven Candidates Tested For Corrosion And Bonding Effects With D6AC ånd HP9-4-.30 Steel**
  - Turco 3878 LF-NC
  - Turco 6778
  - Turco 4215
  - Daraclean 282
  - Duraclean 283
  - Gillite 0650
  - Brulin 815GD
  - HurriSafe Special
  - HurriSafe Heavy Duty
  - Cortec 419
  - Blue Gold
- **Cleanliness And Compatibility Comparison**
  - CONSCAN Readings At 2 Hours And 24 Hours (Storage In Nitrogen)
- **Bond In Tension Comparison**
  - Steel - Chenlok - EPDM Insulation
- **Goal To Select Three Agents For Further Testing**

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Task 1 - Screening Demonstration Test (Cont'd)

Results

- **No Candidate Agent Performed Definitively Above Others**
  - No Adverse Corrosion Or Compatibility Reactions
  - None Caused Lowered CONSCAN Readings
  - Bond Strengths Similar

- **Three Agents Selected**
  - **Turco 3878 LF-NC (Turco, Inc.)**
    - Emulsion Cleaning History By Aerojet Propulsion Division
  - **Daraclean 283 (W.R. Grace Co.)**
    - History Cleaning Small Parts In Industry
  - **Blue Gold (Modern Chemical Co.)**
    - Emulsion Cleaning History By Martin Marietta Space Vehicle Division

Task 2A - Cleaning Ability Test

- Three Agents Tested For Down Selection
  - Turco 3878 LF-NC
  - Daraclean 283
  - Blue Gold
- Several Basis Metals Tested
  - HP9-4-.30, TSA 4130 Steel, And SermeTel 7075-T73 Aluminum
- Data Collected:
  - Residual Species Analysis (HP9-4-.30)
  - Compatibility Characterization Of Coated Materials
  - Cleaning Ability Demonstration (All)
  - Bonding Demonstration (HP9-4-.30)

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

Residual Species Analysis

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

- **Results:**

Agent	Particulate	NVR
No Agent (Control)	.5	.6
Turco 3878 LF-NC	.3	.2
Daraclean 283	.6	.2
Blue Gold	0.0	.1

- **All Three Removed Particulate And Provided Cleaner Base Metal Surface Than Media Blast**

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

Compatibility Characterization

- **Purpose: To Demonstrate Effect Of Cleaning Solutions On Nozzle Metals**

- **Results:**

* Data From Control Panel In Cleaning Ability Demonstration Test

Agent	TSA Steel	SermeTel Aluminum	*Aluminum
Turco 3878 LF-NC	-No Foaming - Mild Staining Of Surface - Least Rust Color Under Surface Coat	-No Reaction	-Lightly Tarnished
Blue Gold	- Moderate Foaming -Moderate Staining Of Surface - Rust Color Under Surface Coat	-No Reaction	-Moderately Tarnished
Daraclean 283	- Heavy Foaming -Heavy Staining Of Surface -Most Rust Color Under Surface Coat	-No Reaction	-Heavily Tarnished (Blackened)

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

Results Of Compatibility Characterization

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

Cleaning Ability Demonstration

- **Purpose: To Demonstrate Ability To Clean HD-2 Grease**
- **Results:**

Agent	Observtions
Turco 3878 LF-NC	-Cleaning Progressed Significantly Entire 30 Minutes -HP9-4-.30 And SermeTel Panels Cleaned Except Holes In Panels Retained Grease -TSA Panels Retained Grease In Pores And Surface
Blue Gold	-Cleaning Progressed Entire 30 Minutes -HP9-4-.30 And SermeTel Panels Retained Visible Grease Over Surface And In Holes -TSA Panels Retained Grease In Pores And Surface
Daraclean 283	-Cleaning Progressed Significantly Entire 30 Minutes -HP9-4-.30 And SermeTel Panels Cleaned Except Holes In Panels Retained Grease -TSA Panels Retained Grease In Pores And Surface

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

Results
Cleaning Ability Demonstration

- **Three Agents Continued Cleaning 30 Minutes**
  - Blue Gold Less Vigorously
- **Turco And Daraclean Removed Surface Grease (Except TSA Coated Steel)**
  - Blue Gold Failed
- **Clumps Of Grease In Panel Holes Were Not Removed By Any Agents**

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

Bonding Demonstration

- **Purpose: To Demonstrate Bonding Strength**
  - HP9-4-.30 Test Panels
  - Contaminant Was Conoco HD-2 Grease
  - Bond In Tension Testing (Chemlok 205 Primer - Chemlok 236A Adhesive - Kevlar Filled Insulation)

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

Agent	Mean Stress At Peak (PSI)
Turco 3878 LF-NC	423
Blue Gold	412
Daraclean 283	406

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Agent Selection

Task 2B - Case Cleaning Ability

- **Purpose: To Verify Turco 3878 LF-NC Able To Clean <u>All</u> Expected Potential Contaminants**

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

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

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

Task 2B Results

	Cleanliness Measurements			Bond Strength Button Pull Mean Stress
	Particulate (Mg)	NVR (Mg)	*Mean OSEE	At Peak (PSI)
Control	0.1	1.1		427
Fingerprints	0.1	1.3	Degraded	446
Hydraul Fluid	0.2	1.0	*Improved*	438
Cutting Fluid	0.5	0.7	Degraded	447
Grease Pencil	0.6	0.7	Degraded	447
Bugs	0.5	1.0	Degraded	443
Zn Chromate	0.3	0.6	*Improved*	407
Corr Inhibitors	0.2	0.6	Degraded	431
Na Moly	0.5	1.1	Degraded	444
Nylon Residue	0.5	2.5	Degraded	427
Plastic Blast	0.5	1.0	*Improved*	432
VCI Film	0.5	0.7	Degraded	429
Carnuba Wax	0.3	0.9	Degraded	423
Bird Droppings	0.3	0.6	Degraded	426
Trichlor Slurry	0.5	0.5	Degraded	428
HD-2 Grease	0.3	1.0	Degraded	437

*Comparison of OSEE Readings
Before Contamination Applied
And After Contamination Cleaned Off

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

Task 2B Results (Cont'd)

- **Adequate Bond Strength Demonstrated For Turco 3878 LF-NC**
  - **All Contaminants Removed Sufficiently**
  - **All Samples Failed Cohesively In Rubber**
  - **Small Bond Strength Variation Considering Diversity Of Contaminants**
    - Chemlok Bonding Ability Must Be Factor

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Agent Selection

Turco 3878 LF-NC Selected

- Best Results Over Other Two Agents In
  - Compatibility Characterization Testing
  - Bonding Demonstration
- Co-Winner With Daraclean 283 In HD-2 Grease Cleaning Ability Demonstration
- Co-Winner With Blue Gold In Residual Species Analysis
- Demonstrated Ability To Remove Wide Variety Of Potential ASRM Contaminants

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Process Optimiztion

Task 3 - Process Optimization

- **Purpose: To Evaluate The Sensitivity Of The Aqueous Cleaning Process To Changes In Parameters That Control The Process**
- **Taguchi Matrix Utilized**
- **Success Criteria: Identify Preliminary Target Process Settings And Functional Limits**
  (NVR Cleanliness Levels Must Also Be Within Level Previously Demonstrating Successful Bonding)
- **Bonding To Be Verified In Task 4 Utilizing Optimized Process Settings**
- **Task 3 Currently In Progress**

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Task 3 Process Optimiztion (Cont'd)

Taguchi Matrix

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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

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ASRM Aqueous Cleaning Development

Summary

- ASRM Process Development In Aqueous Cleaning Is Progressing Satisfactorily
  - Agent Selected
  - Optimization In Progress
  - Demonstrated At Lab Scale That Aqueous Cleaning Is Effective Alternative To Vapor Degreasing
- ***We're Commited To Successful Full-Scale Factory Activation***