PRECISION CLEANING AND VERIFICATION PROCESSES USED AT MARSHALL SPACE FLIGHT CENTER FOR CRITICAL HARDWARE APPLICATIONS

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1. INTRODUCTION

BACKGROUND

Marshall Space Flight Center Operations and Responsibilities

- Propulsion
- Microgravity Experiments
- International Space Station
- Space Transportation System
- Advance Vehicle Research

MSFC ORGANIZATION

- Center Organization
- Science & Engineering Directorate
- Materials and Processes Laboratory
  - Fabrication Services Division (Cleaning Services)
- Project and Environmental Engineering Division (Chemistry, Verification Testing)
2. "SPECIFICATION-DRIVEN" CLEANING AT MSFC

- **MSFC-SPEC-164a, Cleanliness of Components for Use in Oxygen, Fuel & Pneumatic Systems**, specifies CFC 113 and Trichloroethylene (TCE) and Trichloroethane (TCA) for precision cleaning, field cleaning and as the cleanliness verification test solvent for Nonvolatile Residue (NVR) and particulate analysis.

- **MSFC-SPEC-164a** is applied to MSFC fabrication and testing activities and is a contract requirement for Space Shuttle propulsion elements:
  - External Tank (ET)
  - Space Shuttle Main Engine (SSME)
  - Alternate Turbopump Development (ATD) and Production
  - Solid Rocket Booster (SRB)

- **MSFC-SPECT-164b** supersedes MSFC-SPEC-164a as of November 1994. This revised specification is "performance based" versus "how to" and provides for alternative cleaning/verification methodologies and media. However, replacements must be base-lined to CFC-113. It does not address the aspect of CFC-113 not being available.

- Trichloroethylene (TCE) is a replacement for CFC-113 in specification (Engineering Requirements) driven cleaning applications at MSFC. Trichloroethylene is not necessarily the alternative for MSFC Shuttle contractors.
3. CLEANING FACILITIES

- "Rough Cleaning", Metal Treating and Electro-Plating (Figures 1, 2, 3, 4)
- Precision Cleaning (Figures 5, 6, 7, 8, 9)
- Verification Testing Laboratory (Figures 10, 11, 12)

4. CLEANING PROCESSES

- Liquid Oxygen, Fuels and Pneumatic Systems (MSFC-SPEC-164b)
  - Manufacturing Procedure for Vapor Degreasing of Metallic Surfaces-
    Tetrachloroethylene (Perchloroethylene) MP206
  - Cleaning Procedure for Low Strength Steel & Steel Alloy, High Strength Steel & Alloy
    & Aluminum Alloy MP200
    - Vapor Degrease - Handwipe - Sand Blast (as necessary)
    - Alkaline bath-Turco 4215***
    - Etch - Caustic Solution
    - Acid Bath
    - Electro-Clean (Turco Surj.)***
    - Deoxidizing Solution - Turco Smut-go 1***
    - DI Water rinse - Hot & Cold
    - Forced High Purity Air Dry

*** TURCO is a registered trademark of Elf Aquitaine, Inc.
• Component Cleaning

• Non-Lox Service
  Optics   Electronics   Computer Electronics
  Film     Load Cells   Photographic Components
  Flow Meters  Ball Bearing Testers

5. VERIFICATION TESTING

• Non-volatile Residue (NVR) determination by gravimetric procedure
• Particulate count by microscopic visual examination
• NVR & Particulate Procedure base-line with CFC-113 solvent

6. CFC-113 REPLACEMENT FOR VERIFICATION TESTING

• ODC Solvent Study at MSFC
  • CFC-113 - Isopropyl Alcohol - Trichloroethylene - AK225* - Vertrel MCA**

• Trichloroethylene (TCE) was selected for use at MSFC. Significant data base exists from Saturn to Shuttle which supports the implementation of TCE as an alternate verifications solvent.

* AK225 is a registered trademark of ASAHI Glass Co., Ltd.
** Vertrel is a registered trademark of DuPont
• Advantages of TCE
  • Short atmospheric lifetime
  • Non-ODC
  • Cost is many times less than other alternate solvents
  • No foreseeable punitive taxation/restrictions
  • Removed from list of potential carcinogens per ACGIH and MSDS
  • Very small volume used (Only for NVR and Particulate)

• Disadvantages of TCE
  • Hazardous Air Pollutant (HAP)
  • Water & Ground Pollutant
  • Associated Toxicity Problems
    • OSHA PEL = 50 ppm
    • MSFC PEL = 25 ppm

• TCE Implementation - Guidelines & Precautions
  • Minimize solvent usage for cleanliness verification
  • Assure material compatibility
  • Special handling procedures to protect personnel & equipment
    • Containment barriers to protect groundwater
    • Personnel protective equipment
    • Personnel Training
7. ALTERNATE CLEANING AND VERIFICATION STUDIES

- Critical Cleaning Evaluation and Implementation for Chlorofluorocarbon Replacement Study by CH2M Hill Southeast, INC. for the Environmental Engineering and Management Office, Marshall Space Flight Center
  - Task 1 Printed Wire Board Acceptance
  - Task 2 CFC Distillation Implementation
  - Task 2A Development of a Pharmacy System Concept
  - Task 2B Alternatives to ODS Cleaning
  - Task 3 Alternative CFC Cleaning for TBE
  - Task 4 Transition from CFC-113 for Engine Test Activities
  - Task 5 Evaluation of an Alternative Cleaner for Ion Pumps
  - Task 6 Implementation Status of Non-ODS Alternative Recommendations
  - Task 7 Development of Air Emissions Data for ADEM Fee Assessment

- CFC-113 Replacement Project By Daniel E. Adams, Mechanical Systems Test Branch, Propulsion Laboratory (Handwipe cleaning replacement study for CFC-113)
8. CONCLUSION

- CFC-113 usage (Cleaning - Verification) at MSFC has reduced from 64,000lbs. (CY93) to 30,000lbs. (CY94) to close to zero in 1998. Remaining stock re-distilled for very special requirements.

- MSFC will utilize TCE as an interim replacement for CFC-113 for Verification testing.

- The MSFC-managed Space Shuttle contractors are providing "lessons learned" for implementation of aqueous and semi-aqueous cleaning.

- MSFC will continue to use the perchlorethylene degreasing solution. The current cleaning processes are essentially water-based. Chromate solutions will be replaced with no-chromate solutions.

- Studies are planned for maximizing use of aqueous cleaning and water verification