



***Development of NASA Plan for Testing
Alternative Solvents for Precision
Cleaning and Cleanliness Verification***

NASA Johnson Space Center
White Sands Test Facility

Christina Y. Piña Arpin



Outline

- Back ground of PC³ (Precision Cleaning and Contamination Control Group)
- Current Solvents used across the agency
- PC³ Member's recent research of solvents
- PC³ activities
- A plan to find a replacement for AK-225G
- Summary



PC3 Group Members

- NASA Centers/groups
 - Glen Research Center (GRC)
 - Goddard Space Flight Center (GSFC)
 - Johnson Space Center (JSC)
 - Kennedy Space Center (KSC)
 - Marshall Space Flight Center (MSFC)
 - Regulatory Risk Analysis & Communication (RRAC)
 - Stennis Space Center (SSC)
 - Technology Evaluation for Environmental Risk Mitigation (TEERM)
 - White Sands Test Facility (WSTF)
 - Boeing
 - Pratt & Whitney Rocketdyne
 - Navair (US Navy)
 - SpaceX
-



PC³ – Precision Cleaning and Contamination Control Group

- History of group
 - Why the group came together
 - Started meeting in Fall of 2010
 - Group Objective:
 - To maintain a peer-driven network of individuals, engaged in precision cleaning and contamination control issues, who come together to share their collective knowledge and learn from one another. Members will work together to identify common problems and explore solutions, to develop and implement best practices, and seek to advance the technology.
 - Monthly telecoms
-



Range of Topics Discussed by PC³

- Solvent's "Oxygen Compatibility"
 - Cleaning techniques and challenges
 - Hardware size
 - Various medias
 - Various cleanliness requirements
 - Hardware integrity
 - Sample integrity
 - Various cleaning & cleanliness verification methods
 - [Relationship between Solvents and the media in systems](#)
-

Solvent vs Media

Below is a list of solvents and its correlation with media that flows through the systems that the solvents are used for cleaning.

Solvent	Material	Method of use (or other exceptions)	Media
IPA	metallic/elastomers	wiping,	MMH & Hydrazine, ammonia, water
	metallic	flushing	MMH & Hydrazine, ammonia, water, natural gas
	metallic	verification	MMH & Hydrazine
	metallic	only if sniffers are used after to verify all IPA is removed	LOX
Hexane	metallic	verification	LOX & GOX (sniffers)
	various	verification	electronics
	various	verification	optical surfaces
Freon (CFC113)	metallic	verification	various
DI water 18 mega ohms	non metallic/ metallic	verification, cleaning, wiping, flushing,	LOX
	non metallic/ metallic	verification, cleaning, wiping, flushing,	GOX
	non metallic/ metallic	verification, cleaning, wiping, flushing,	nitrogen tetroxide
	non metallic/ metallic	verification, cleaning, wiping, flushing,	MMH & Hydrazine
	non metallic/ metallic	verification, cleaning, wiping, flushing,	nitrogen
	non metallic/ metallic	verification, cleaning, wiping, flushing,	helium
Vertrel MCA	metallic	hand wipe, flushing	nitrogen tetroxide
	metallic	hand wipe	all other

Vertrel XF	metallic	hand wipe	nitrogen tetroxide
	metallic	hand wipe	all other
HFE7100	metallic	hand wipe, flushing, vapor degreaser	LOX
	metallic	hand wipe, flushing, vapor degreaser	GOX
	metallic	flushing, wiping	ammonia, water
	metallic	hand wipe, flushing, vapor degreaser	nitrogen tetroxide
HCFC 225 G	metallic	verification, flushing, cleaning, vapor degreaser	Hydrogen
	metallic	verification, flushing, cleaning, vapor degreaser	LOX
	metallic	verification, flushing, cleaning, vapor degreaser	GOX
	metallic	verification, flushing, cleaning, vapor degreaser	pneumatic
TCE	metallic	-	LOX
EnSolv	-	surface cleaning, vapor degreaser	electronics non media
Acetone	metallic	wipe cleaning, ultrasonic	bonding surfaces
	metallic	gross contamination before actual cleaning process.	general media
TCA	metallic	-	Bonding surfaces (booster)
cyclohexane	-	verification	all media (with a sniffer)



Research Performed by PC³ Members

- KSC
 - Identify and test suitable replacement solvents and alternative technologies for Vertrel MCA.
 - MSFC
 - Tested replacement candidates for n-propyl bromide for vapor degreasing.
 - Investigation of alternative non-solvent methods for cleaning and cleanliness verification for launch vehicle manufacturing.
 - WSTF
 - Used Hansen Solubility Parameters to identify and test replacement solvents for AK225G.
-



PC³ Activities

- Active in the revision of ASTM G-93 “Standard Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments”
 - Active in the revision of IEST-STD-CC-1246 “Product Cleanliness Levels - Applications, Requirements, and Determination”
 - Splinter Group: LCA- Life Cycle Assessment of precision cleaning & cleanliness Verification Methods
 - Splinter Group: Test plan of solvents to replace AK225G
-



Replacement of Cleaning Solvents

- History about the use of AK225G
- Who's using what solvents?

Solvent	Users
AK 225G	SpaceX MSFC SSC WSTF
CFC 113	Navair
Vertrel MCA	UTC Aerospace, KSC



Previous Research on Solvents

- SMC-TR-95-28 *Nonvolatile Residue Solvent Replacement*, Arnold, G. S. and Uht, J. C., The Aerospace Corporation, El Segundo, CA, March 1, 1995.
 - WSTF-IR-95-0048 *Evaluation of Solvent Alternatives to Trichlorotrifluoroethane (CFC-113) for Cleaning of Gauges and Precision Instruments*, Biesinger, P. and H. D. Beeson... NASA JSC WSTF, Las Cruces, New Mexico, January 30, 1995.
-



Standards/Practices for Testing Solvents

- *ASTM G121. Standard Practice for Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents. ASTM International, West Conshohocken, Pennsylvania, 1998.*
 - *ASTM G122. Standard Test Method for Evaluating the Effectiveness for Cleaning Agents. ASTM International, West Conshohocken, Pennsylvania, 1996 Revised 2008.*
 - *ASTM G127. Standard Guide for the Selection of Cleaning Agents for Oxygen Systems. ASTM International, West Conshohocken, Pennsylvania, 1995 revised 2008.*
-



Challenges

- Defining Requirements
 - Real
 - Inherited
 - Funding
 - Not a formally chartered group: some recognition
 - Human Exploration Operation Mission Directorate (HEOMD)
 - Environmental Management Division (EMD)
 - Chemistry limitations
-



General Layout of the Test Plan

- Cleaning Effectiveness
- Material Compatibility
- Media Compatibility
- Additional requirements



Solvents Cleaning Effectiveness

- Identification of contaminants
- Contamination of test samples
- Coupon testing
- Component testing
 - Large items
 - Small items



Solvent's Compatibility with Materials

- Hardware
 - Metals
 - Non-metals/ elastomers
- Cleaning equipment



Solvent's Compatibility with Various Medias

- Oxygen compatibility
 - Mechanical impact test
 - Auto Ignition Test
 - Propellant compatibility
-



Additional Requirements Set on Solvents

- Toxicity
 - Carcinogenicity
 - Recyclability
 - Waste Disposal
 - Ozone Depletion
 - HAP (Hazardous Air Pollutants)
 - VOC (Volatile Organic Compounds)
 - ACS reagent grade chemicals or higher
 - Inertness (Flammability and combustibility)
 - Availability and technical support from supplier
 - Cost effectiveness
 - Compliance with local, state, and federal regulations
 - Application and use of Solvent
-



Summary

- Across the industry there is a desire to go “Green”
 - AK-225G limitations will effect various groups
 - Push to replace other solvents as well.
 - Testing of solvents needs to be performed to replace any solvent.
 - Regardless of the solvent being replaced, the testing needing to be performed is very similar.
-



Questions

- Thank you to all the PC³ members for all the help, information, and time.

Contact information:

Christina Y. Piña Arpin

(575) 524-5195

Christina.y.pina.arpin@nasa.gov

Link to the group's NASA Safety Center Knowledge Now website:

<https://nsckn.nasa.gov/community/Views/Home.aspx?Filter=243>
