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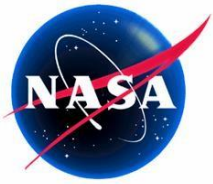
Use of Vacuum Degreasing for Precision Cleaning

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MARSHALL
SPACE FLIGHT CENTER

Who We Are

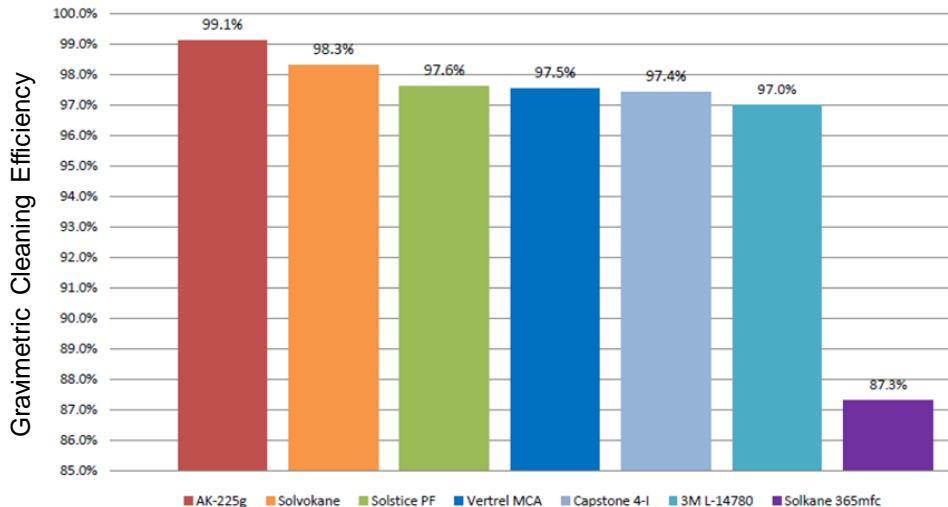


- Contamination Control Team (EM22) at MSFC
- Responsible for FOD and Contamination Control, cleaning process development, and cleanliness verification
- Recent focus on development of cleaning methodology and selection of alternative green solvents
 - **“Laboratory Evaluation of Alternatives to n-Propyl Bromide for Vapor Degreasing”** - U.S. Army Research Laboratory
 - **“Solvent Replacement for HCFC-225 for Cleaning Oxygen System Components”** - DLA- Aviation Hazardous Minimization and Green Products Branch
 - **Solvent Replacement for Cleaning and Verification Sampling of MSFC/SSC Propulsion Oxygen Systems Hardware, Ground Support Equipment, and Associated Test Systems”** - MSFC/SSC/WSTF joint test program

HCFC-225 Replacement Efforts



- Recently qualified trans-1-chloro-3,3,3-trifluoropropene (Solstice) to replace 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225) for use in cleaning and verification of oxygen systems
- Cleaning efficiency is comparable to HCFC-225, but the low boiling point and high heat of vaporization prevent Solstice from being an effective vapor degreasing solvent



Nonvolatile residue removal efficiency test



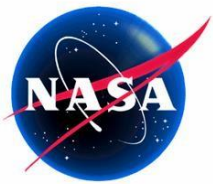
Test plate for evaluation of cleaning performance

Sustainable Vapor Degreasing

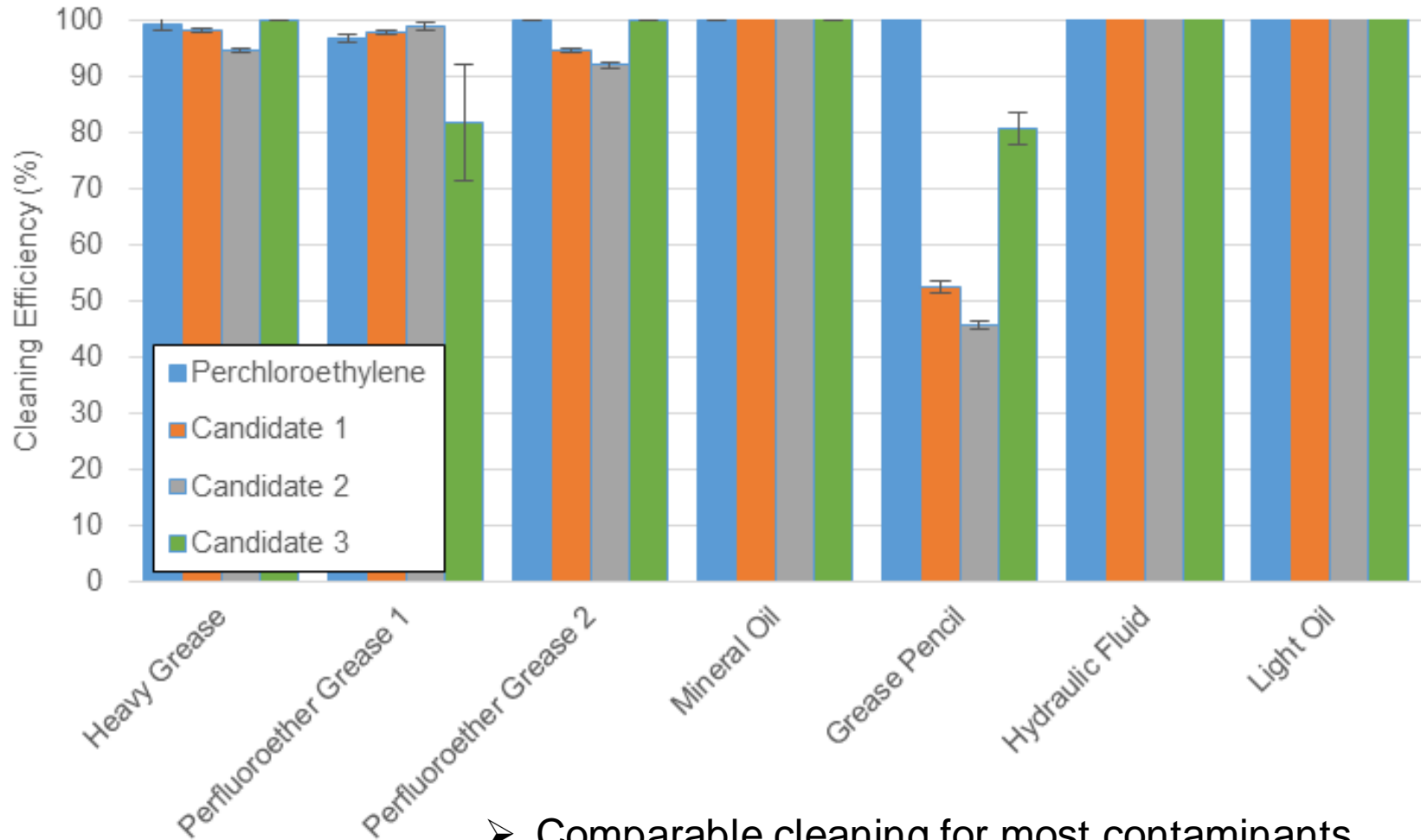


- Most recent work is a joint project with the US Army Tank Automotive Research Development and Engineering Center
- **“Development of Sustainable Vapor Degreasing Solvent(s) (SVDS)”** - DLA- Aviation Hazardous Minimization and Green Products Branch
- Common aerospace contaminants including hydrocarbon oils/greases, perfluoroether greases, corrosion prevention compounds, fluorescent dyes, and carbon black
- Both coupon and small parts tests
- Goal is to identify a solvent that can be used a drop in replacement for the restricted or soon to be restricted solvents currently in use
- Currently testing four solvents

Sustainable Vapor Degreasing

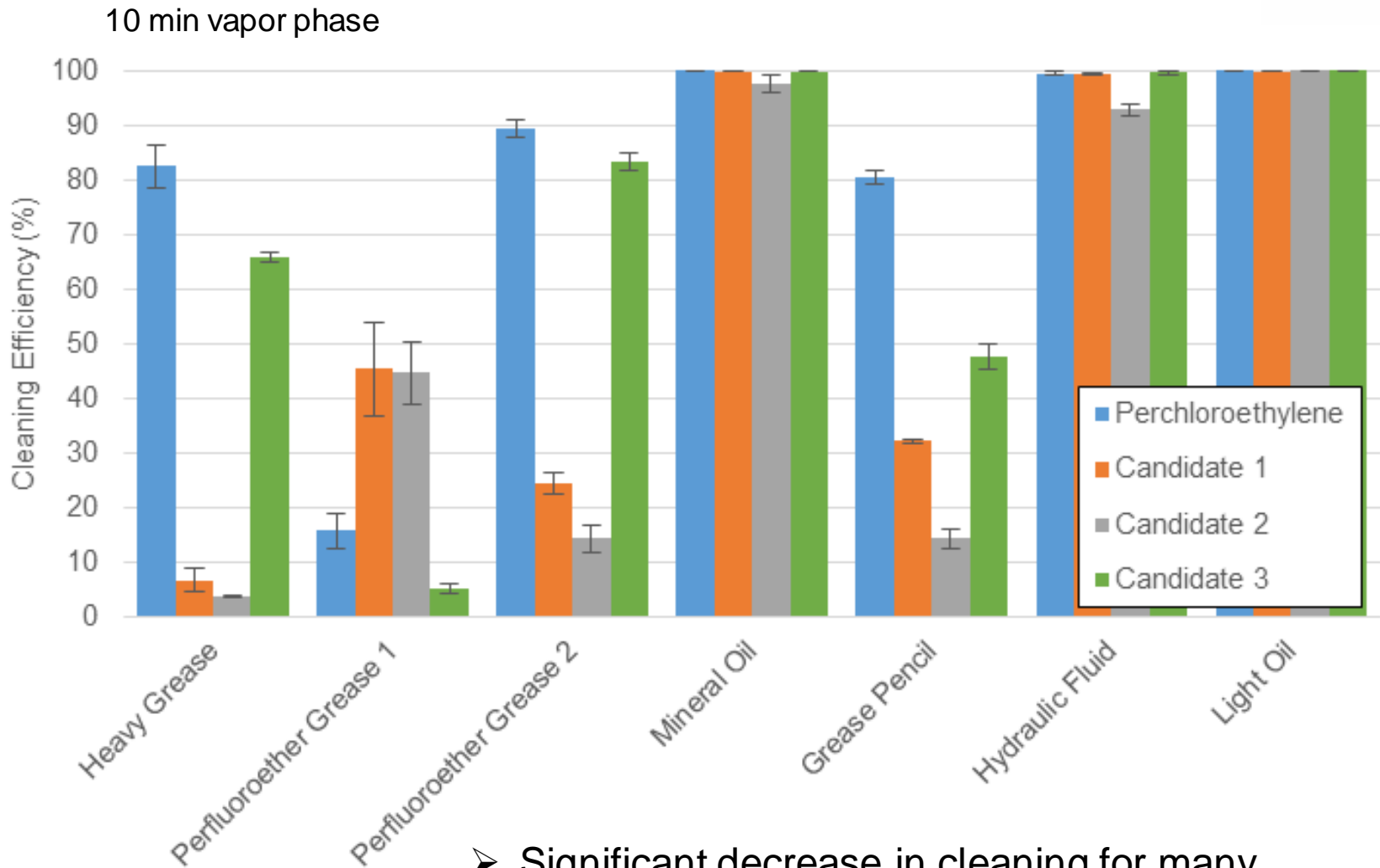


10 min boil sump, 10 min rinse sump w/ ultrasonics, 10 min vapor phase



- Comparable cleaning for most contaminants compared to perchloroethylene

Sustainable Vapor Degreasing

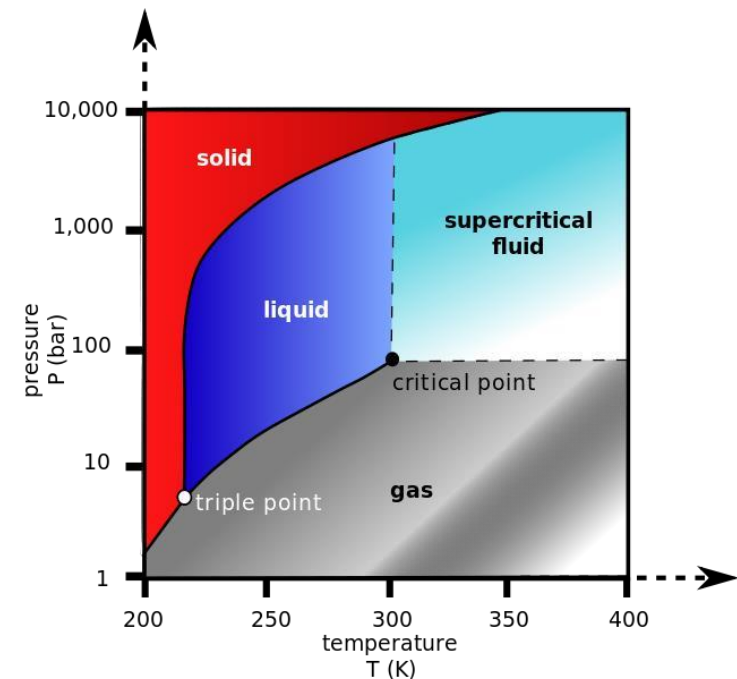


- Significant decrease in cleaning for many contaminants relative to perchloroethylene

Alternative Cleaning Processes



- Preliminary results indicate that candidate solvents do not offer the same level of cleaning performance as current solvents
- This necessitates identifying other cleaning solvents and/or processes
- MSFC is currently evaluating numerous alternative cleaning procedures
- Two of which are-
 - Vacuum degreasing
 - Liquid CO₂ cleaning



What is Vacuum Degreasing?

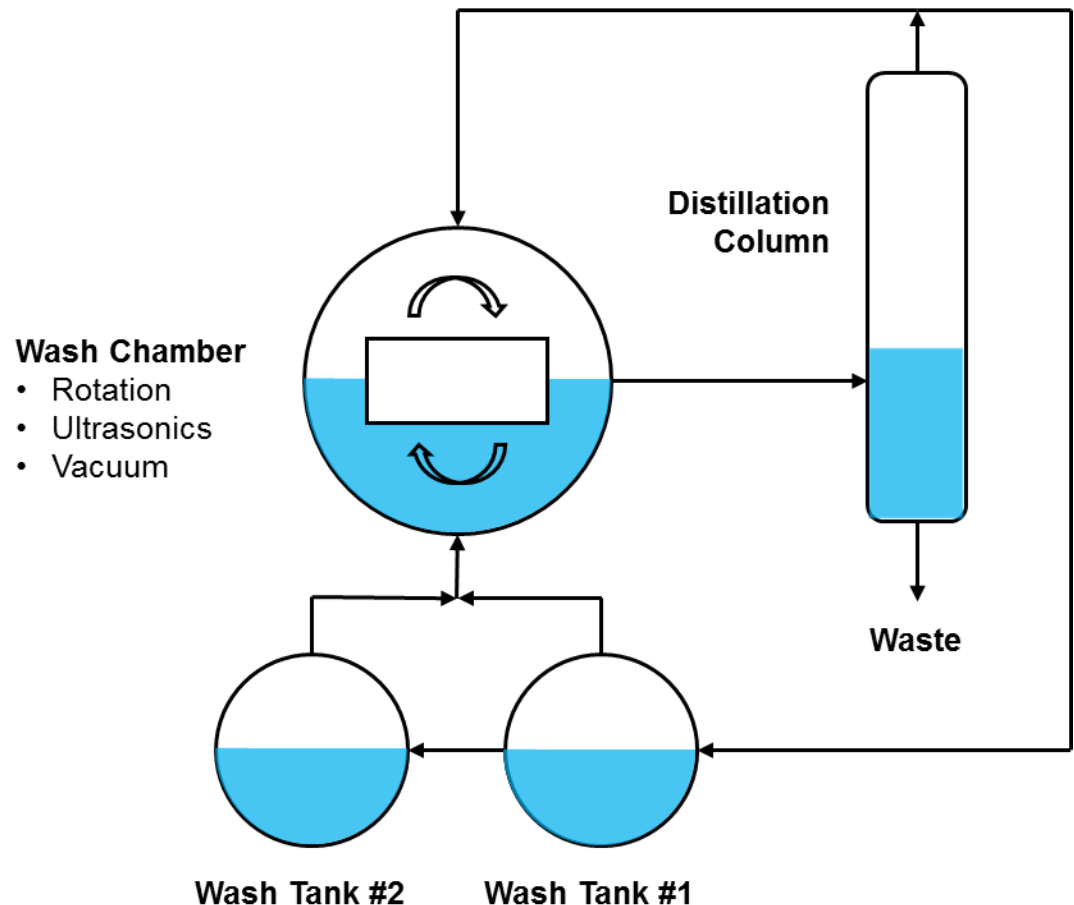


Advantages

- Fully contained
- A wide range of solvent types can be used
 - Hydrocarbons
 - Chlorinated solvents
 - Modified alcohols
- No fugitive emissions or entrained solvent on parts

Disadvantages

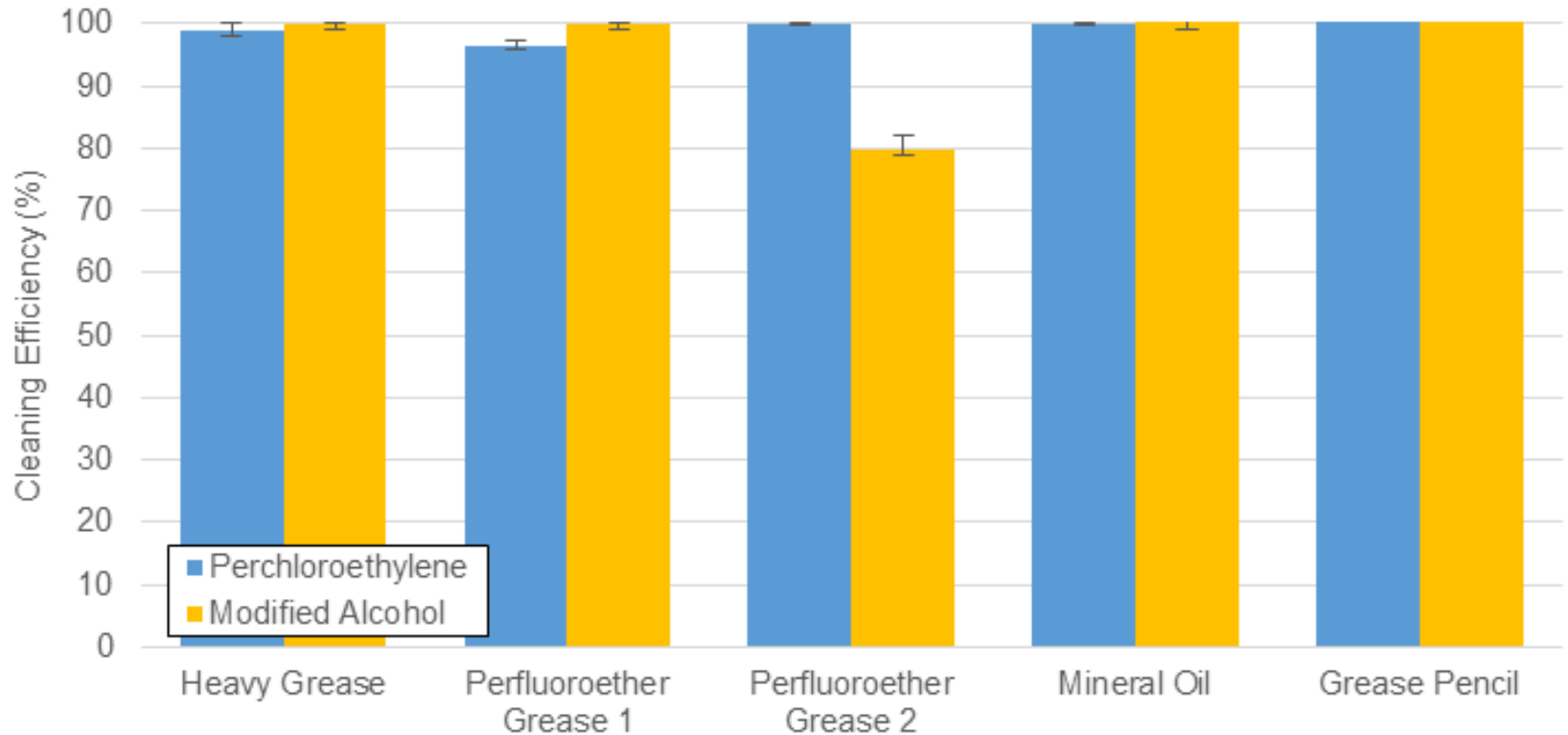
- Larger footprint to cleaning volume ratio
- Capital cost



Efficacy of Vacuum Degreasing

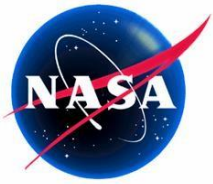


10 min immersion + rotation, 10 min ultrasonics, 6 min vapor phase



- Comparable cleaning except for PFE Grease 2 compared to perchloroethylene

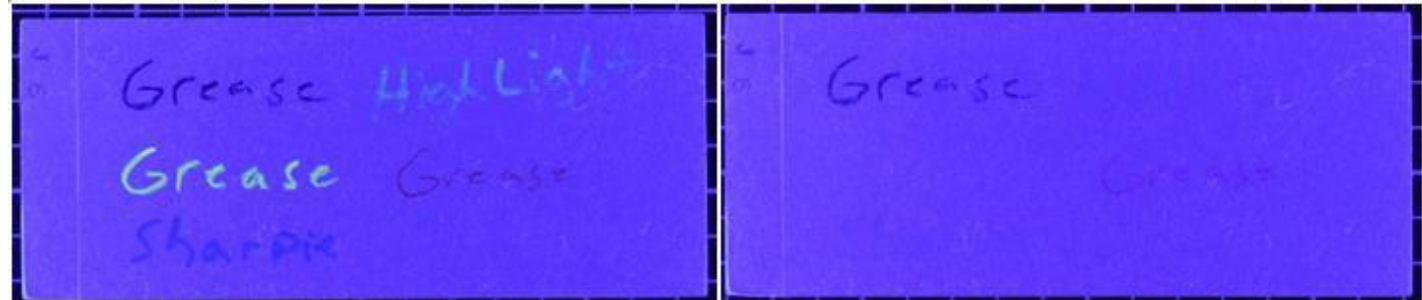
Efficacy of Vacuum Degreasing



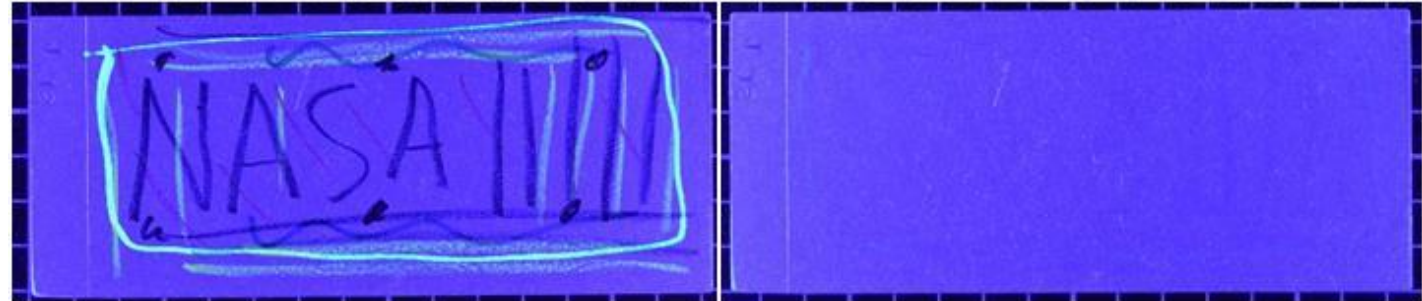
Before Cleaning

After Cleaning

Perchloroethylene

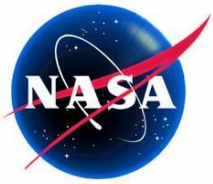


Modified Alcohol



UV light inspection

DPnB/Liquid CO₂ Cleaning



Advantages-

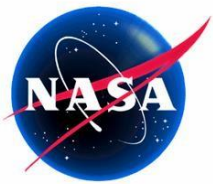
- Low viscosity of liquid CO₂ enhances wetting and cleaning
- Multiple solvent capability allows solvents to be selected for specific contaminants
- Final CO₂ rinse completely recovers other solvents
- 100% capture of CO₂ for reuse

Disadvantages-

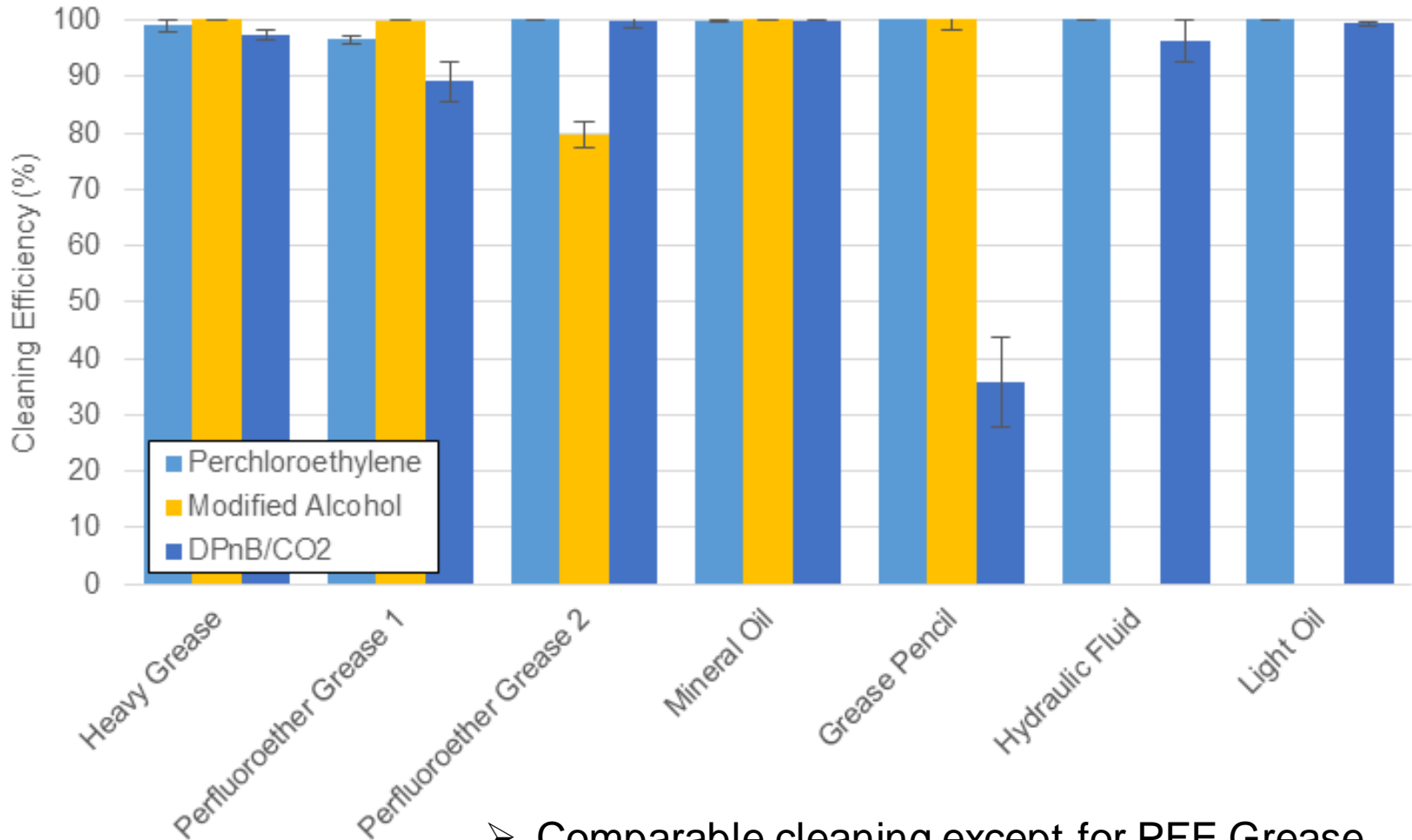
- Lower operating temperature can adversely affect cleaning
- Capital cost



Efficacy of DPnB/CO₂ Cleaning



Hydrophobic glycol ether (DPnB) wash, 4x liquid CO₂ rinse at 600 psig, 55 °F



➤ Comparable cleaning except for PFE Grease 2 compared to perchloroethylene

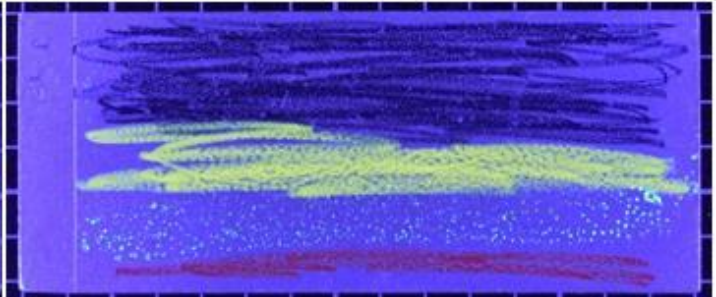
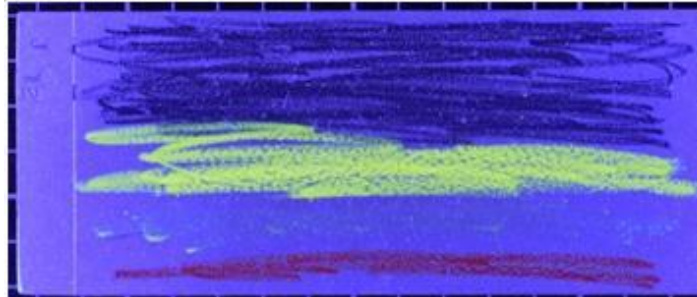
Efficacy of DPnB/CO₂ Cleaning



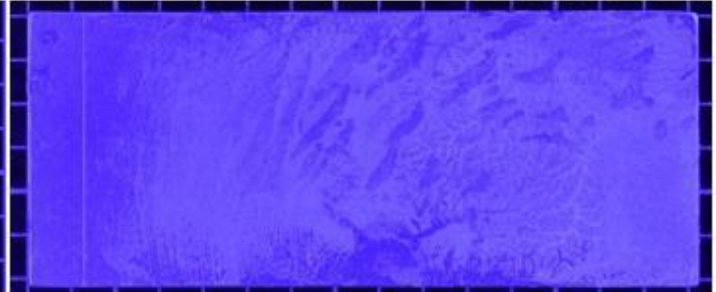
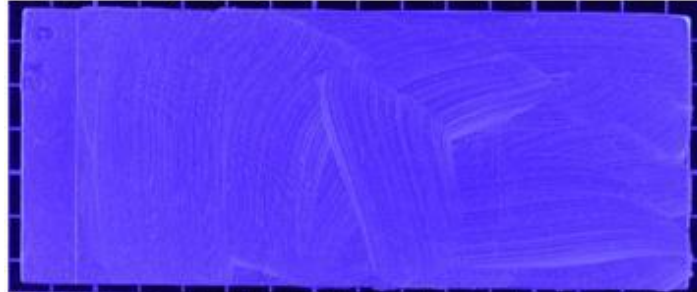
Before Cleaning

After Cleaning

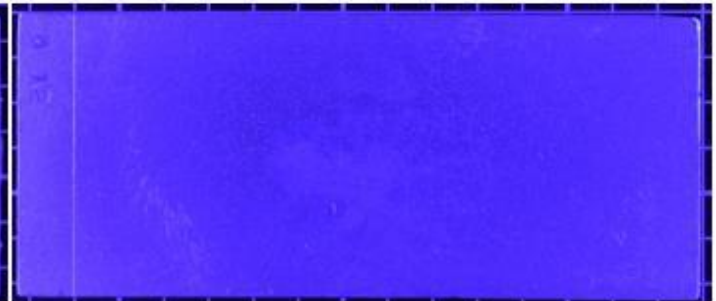
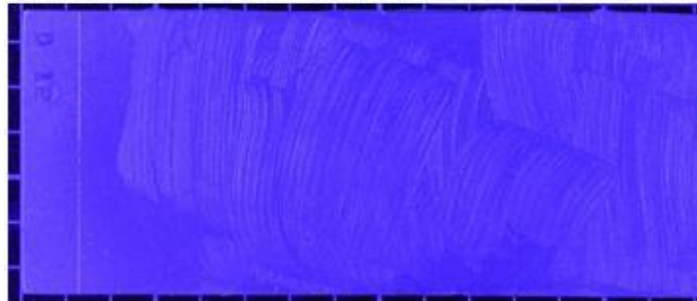
Grease
Pencil



Perfluroether
Grease 1



Perfluroether
Grease 2



UV light inspection

Conclusions



- Vacuum degreasing using a modified alcohol solvent offers comparable cleaning performance as perchloroethylene vapor degreasing for many common classes of contaminants
- DPnB/CO₂ is an effective cleaning solution for many contaminants, but less so for some compared to perchloroethylene
- These results are a rough first pass and more work to fine tune both process conditions and solvent selection is required

Questions?

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