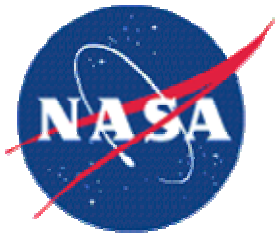

FINAL REPORT ON PART WASHER ALTERNATIVES PROJECT
Including:
A CONSUMER'S GUIDE TO ALTERNATIVE PART WASHER CHEMISTRIES

February 20, 2005

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14. ABSTRACT
Fifty-three "environmentally preferable" part washer cleaning chemistries were tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Four of these chemistries were benchmarks (Acetone, Isopropanol, Methyl Ethyl Ketone and Mineral Spirits) and were tested for comparative purposes. Nine of the non-benchmark chemistries were evaluated at NASA facilities.

The report shows there are alternatives that clean as efficiently and some that clean more efficiently than all of the benchmarks. Shop workers evaluating alternative cleaners were interviewed and asked to score the cleaners they tested and results are discussed.

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part washers, general cleaning, solvent cleaning, environmentally preferable, aqueous, semi-aqueous, bio-based, biodegradable, enzymatic cleaner

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A special thanks to those who participated through teleconferences and meetings during the project. The NASA AP2 Program Office also recognizes the efforts of the process owners, foreman, workers and technicians for answering questions relating to their specific cleaning processes. Their efforts greatly assisted in the completion of this report.

Matthew J Rothgeb
Engineer / Project Manager
NASA AP2 Office

Executive Summary

The National Aeronautics and Space Administration's (NASA) Acquisition Pollution Prevention Program Office was established in 1998 to provide centralized leadership across the Agency for identifying, qualifying and implementing alternatives that reduce or replace hazardous materials used by NASA Programs and Centers.

The NASA AP2 Program began to develop a project in 2004 with the goal of identifying alternatives that were environmentally preferential to currently used solvent based cleaners for general cleaning processes. After identifying stakeholders within NASA Centers that were interested in participating, the project team began by identifying commercially available cleaners that were marketed as "environmentally preferable." The team initially identified several hundred cleaners but this list was narrowed by requiring several material characteristics to be met, namely flash point (≥ 141ºF), Hazardous Air Pollutants (HAP) and volatile organic compound (VOC) content
(≤ 50g/L).

Based on material characteristics of the product, the ability of the vendor to donate a sample for laboratory testing and the project budget, 34 environmentally preferable and 4 benchmark chemistries were selected by the stakeholders for laboratory analysis. The laboratory performing the tests offered to test an additional 15 chemistries as an 'in-kind' contribution to the project. Overall, there were 53 chemistries laboratory tested for cleaning efficiency on two different soils (contaminants). Four of these chemistries were tested at two different dilutions for a grand total of 57 cleaning efficiency tests.

In addition to laboratory testing, 9 chemistries were tested in industrial shops within NASA Centers. Personnel within these shops used the equipment for a minimum of 30 days and were interviewed by shop managers before, during and after the test period. These interviews allowed the stakeholders to see how workers perceived the test cleaners compared to their current ones.

The results from both the laboratory analysis and field trials showed that there are numerous options for shops to procure "environmentally preferable" cleaners that perform as well or better than traditional solvent cleaners. Two of the chemistries tested in the laboratory, "Heavy Duty Cleaner" and "SoySolv II Plus", ranked higher in cleaning efficiency than the most commonly used benchmark (mineral spirits). Additionally, 10 chemistries were within 0.7% of mineral spirit's cleaning efficiency of 99.7%. In fact, a total of 40 chemistries were within just 9.0% of mineral spirit's cleaning efficiency.

The laboratory analysis also showed that some chemistries clean one of the two contaminants better than the other. Most notably, "ArmaKleen M400" cleaned Contaminant #1 with 67.51% efficiency while it cleaned Contaminant #2 with 99.04% efficiency. Conversely, isopropanol cleans Contaminant #1 with 100.18% efficiency and Contaminant #2 with 23.66% efficiency. This shows that if a shop is using isopropanol for their cleaning process there are chemistries to avoid and chemistries that will perform well for their purposes.

The results from the on-site demonstrations showed bias in some cases as personnel were cautious to compliment a new cleaner for fear they would loose their current cleaners. This was most evident in the case of "Heavy Duty Cleaner" and "SS-HD PW Formulation." While "Heavy Duty Cleaner" ranked #1 in cleaning efficiency (and better than mineral spirits), workers who were interviewed still felt it was not as good as mineral spirits and according to three interviews, it scored a 6.87 of 10, coming in 6th for all on-site chemistries. Conversely, "SS-HD PW Formulation" ranked #39 in cleaning efficiency, much lower than Mineral Spirits, but workers who were interviewed gave it a the 2nd highest score when interviewed (9.16 of 10). This exemplifies the importance of involving workers in the decision making process, but also shows

that having the cleaning efficiency data prior to choosing a product can greatly assist the process as well as justifying a replacement for more hazardous cleaners.

Overall the project was a success as 7 of the 9 shops that participated in the on-site demonstrations have either purchased or are planning to purchase one of the chemistries tested during this project. This publication along with the "Consumer's Guide" and "Quick Guide" will give needed assistance and direction to any NASA shop that is planning to procure a new part washer or replace a current one with an environmentally preferable alternative.

1.0 INTRODUCTION

1.1 Background

The National Aeronautics and Space Administration (NASA) is committed to environmental stewardship. This commitment is reinforced through part of NASA's prime mission, "to improve life here."

In 1998, NASA established the Acquisition Pollution Prevention (AP2) Program to provide centralized Agency leadership for identifying, qualifying and implementing alternatives for reduction or replacement of hazardous materials used by NASA Programs and Centers. The mission of the AP2 Program is to reduce and eliminate Agency use of hazardous materials though technology demonstration and migration resulting fro joint projects. The AP2 Program mission directly relates to NASA's prime mission, the One NASA Initiative, and the Environmental Management Strategic Roadmap (EMSR) by focusing on collaboration between Agency centers in identifying and testing environmentally preferable / sustainable technologies.

The mechanism by which NASA's AP2 Program Office identifies manufacturing and maintenance processes with potential pollution prevention (P2) opportunities is through "*Pollution Prevention Opportunity Needs Assessments (PPONAs)"*. These assessments were performed between 1998 and 2002 and reports prepared for each NASA Center. The reports generated from these assessments provided process descriptions of manufacturing, maintenance and institutional procedures, research and development activities and other pertinent facility operations. The NASA AP2 Program Office identified potential P2 opportunities and detailed previously implemented initiatives at each facility. After the identification of common P2 needs, from 2003 to the present, the NASA AP2 Program Office has developed and presented a variety of P2 projects to potential stakeholders within NASA.

1.2 Need for Part Washer Alternatives

Through the course of performing PPONA's, the NASA AP2 Office identified hundreds of opportunities across all the NASA Centers. Many of the needs identified related to common processes such as painting, cleaning, maintenance and machining. Although varying in criticality and volume, all PPONA's identified the need for NASA Centers to *"Input Materials Replacement for General Cleaning, Wipe-Cleaning and Precision Cleaning"*.

Methodology for the Prioritization of Needs:

To assist the NASA AP2 Office in identifying and prioritizing the implementation of potential P2 projects at all NASA Centers, in 1999 the AP2 Office developed a *"Pollution Prevention Opportunity Prioritization Table"* (PPOPT). The PPOPT was applied to resident routine and non-routine operations within NASA Centers.

The PPOPT uses an objective scoring system to assign numerical values to process specific chemical constituents. These values are assigned to the following three categories:

- Perceived health effect(s)
- Potential environmental impact(s)
- Actual disposal impact(s)

Numerical risk/hazard ratings were assigned for each identified process constituent. Assignments reflect the perceived hazard(s) and/or risk(s) associated with the targeted constituent. Scoring values were then used to prioritize the risks of continued use of each chemical. Detailed information pertaining to the health and environmental ranking system used can be found in Appendix A.

Table 1.2.1 is a compilation PPOPT and it covers the environmental and health risk scores for all solvent cleaning related opportunities across NASA. The table shows a variety of solvents and constituents within solvent-blends that were being used by NASA for cleaning. In this part washer project, four benchmarks were used during the cleaning efficiency testing and are highlighted in Table 1.2.1.

The four benchmarks were selected by the AP2 Office because they were the most commonly found 'pure' solvents used for cleaning within NASA shops. Two of these chemistries represent cleaners found in machine, facility and automotive/heavy equipment or similar shops (methyl ethyl ketone, mineral spirits). The two remaining chemistries (isopropanol, acetone) were commonly found in laboratories and other areas where light cleaning was taking place.

It was observed at several shops during the PPONA process that isopropanol and acetone were also commonly used for degreasing in processes where it would be better served to use other cleaners. This is reflected in the cleaning efficiency ranking of isopropanol and acetone. While they both clean one of the two contaminants well, they are very inefficient at cleaning the other, whereas methyl ethyl ketone and mineral spirits are effective cleaning both.

It should be noted that while Table 1.2.1 is a compilation of constituents identified during PPONA's, they do not include all possible constituents nor do they express the current 2006 inventory of constituents found within these processes at NASA Centers. Since the completion of the PPONA's many Centers have proactively implemented recommendations found within the PONA reports for their Facility and therefore, some of these constituents have been replaced with environmentally preferable alternatives. Constituents in Table 1.2.1 are listed in alphabetical order. Note that the higher the score for each constituent, the higher the risk to human health and the environment. Benchmarks identified and tested for this project are highlighted.

Table 1.2.1: Pollution Prevention Opportunity Prioritization Table

(Constituents found within cleaning processes across NASA Centers.)

Recommended Action:
Input Material Substitution, Material and Waste Reduction, Out-Process Recycling/Reuse

Related Processes:
Hazardous Constituents used in Part Cleaning and Wiping Procedures

Related Activities:
General cleaning, surface preparation, machining, metal finishing, coating removal, vehicle/equipment maintenance, precision cleaning, coating application, sealing/adhesive cleaning and other cleaning/degreasing activities.

Hazardous Constituent	Health	Environmental	Total
1,1,1,2-Tetrafluoroethane	2	11	**13**
1,1,1-Trichloroethane	4	19	**23**
1,2,4-Trimethylbenzene	4	10	**14**
1,2-Butylene Oxide	6	10	**16**
1,3-Dioxolane	3	12	**15**
1,4-Dichlorobenzene	5	13	**18**
1,4-Dioxane	6	8	**14**
1-Butanol	3	15.5	**18.5**
1-Methyl-2-Pyrrolidinone	6	11	**17**
2,4-Toluene Diisocyanate	9	1	**10**
Acetic Acid	7	13	**20**
Acetone	2	20	**22**
Benzene	9	14	**23**
Butane	2	7	**9**
CFC-113 (Trichlorotrifluoroethane)	3	12	**15**
Cyclohexanone	4	14	**18**
Dichloromethane	6	14	**20**
Diethylene glycol monobutyl ether	4	14.5	**18.5**
Dipropylene Glycol Methyl Ether	2	7	**9**
Ethanol	2	9	**11**
Ethyl acetate	3	12	**15**
Ethyl Benzene	4	6	**10**
Ethylene Glycol	4	10.5	**14.5**
Ethylene Glycol Monobutyl Ether	5	9	**14**
Ethylene Glycol Monoethyl Ether Acetate	4	18	**22**
Ethylene Glycol Mono-N-Butyl Ether	5	9	**14**
Heptane	3	11	**14**
Hydroquinone	7	8	**15**
Isoamyl Methyl Ketone	4	10	**14**
Isobutane	2	11	**13**
Isobutyl Acetate	4	10	**14**
Isobutyl Alcohol	3	6	**9**
Isopropanol	3	6	**9**
Methanol	4	10.5	**14.5**
Methy Ethyl Ketone	3	13	**16**
Methyl Isobutyl Ketone	4	17	**21**
Mineral Oils	5	10.5	**15.5**
Naphthalene	6	9.5	**15.5**
N-Butanol	3	15	**18**
n-Butyl Acetate	3	10	**13**
n-butyl alcohol	3	15	**18**
N-Propanol	3	8	**11**
Petroleum Ether	3	9	**12**
Phenol	8	7.5	**15.5**
Propane	2	8	**10**
Propylene Glycol	3	11	**14**
Sec-Butyl Alcohol	3	9	**12**
Sodium Hydroxide	7	14	**21**
Stoddard Solvent (Petroleum Ether)	4	8	**12**
Tertiary-Butyl Alcohol	3	10	**13**
Tetrachloroethylene	6	13	**19**
Tetrafluoroethylene	3	17	**20**
Tetrahydrofuran	2	11.5	**13.5**
Toluene	4	16	**20**
Trichloroethylene	6	12	**18**
VM&P Naphtha	4	8	**12**
Xylene	4	10	**14**

1.3 Project Approach

Need Identification

It was noted in several PPONA's that solvent cleaning represented a need based both on the hazardous nature of both chlorinated and non-chlorinated solvents used, the hazardous wastes that are generated from the process as well as the overall volume of waste that can be generated in a busy shop.

While several NASA Centers had begun finding replacements for these cleaning materials, it was often difficult to determine which alternatives would work at an acceptable level for their shops. Additionally, some centers only implemented changes at a few shops while others were kept their traditional solvent-based part washers. Environmental Office representatives at several Centers noted that it was difficult to select an alternative due to the lack of 0budget and time that could be dedicated to research and testing of the available alternatives. Because of this, on some occasions an alternative was procured but later found to be ineffective, causing the shop to move back to a traditional solvent cleaning process.

Part washing within facility auto maintenance, heavy equipment, industrial plant area, machine and other shops offered the opportunity to develop a project that focused on replacing or identifying for future replacement, part washers that are environmentally preferable. Environmental preferability can be defined as any product/service whose environmental impacts have been considered and found to be less damaging to the environment and human health when compared to competing products/services.

Project Initiation and Scope

Next, potential stakeholders who might be interested in demonstrating and validating alternatives to currently used solvent based part washers were contacted and project scoping meetings were begun. Stakeholders were identified from twelve NASA facilities, all of whom have participated in the project from beginning to end. Stakeholders determined that on-site demonstrations of several alternative products should be performed, along with a standardized test to show cleaning capabilities of as many cleaning chemistries as possible.

At the request of the project team the AP2 Office generated a list of over 100 part washing chemistries that were advertised as "environmentally preferable". From this initial list of alternatives the stakeholders narrowed the list based on certain pre-qualifiers such as Volatile Organic Compound (VOC) content (based on vendor recommended dilutions), Hazardous Air Pollutant (HAP) content and Flash Point. While the AP2 Office suggested that the study focus on aqueous chemistries only, stakeholders were also interested in bio-based solvents and semi-aqueous chemistries that were more environmentally preferable than pure solvent cleaners. It was decided that the project scope would cover any chemistries as long as they met the pre-qualifications the group agreed and/or were of significant interest to the group.

VOC Regulations and the South Coast Air Quality Management District:

VOC content of cleaners was of high concern to the stakeholders based on regulations nationwide as well as regional air pollutant regulations. Several NASA facilities fall within the South Coast Air Quality Management District (SCAQMD) in California. Because of the high pollution in this area of California the regulation of solvents is more stringent than the EPA's national regulations. Currently to qualify as a clean-air solvent under EPA regulations there can be no more than 50g/L VOC content in the solvent. In order to qualify as a clean-air solvent under SCAQMD regulations a solvent can contain no more than 25 g/L VOCs. It was the desire of the stakeholders to find as many part washing chemistries that fell within SCAQMD regulations as possible both because several NASA Centers must follow SCAQMD regulations and because the EPA often adopts their regulations.

Project Stakeholders

Tables 1.3.1 and 1.3.2 below identify all primary stakeholders who participated in the project from scoping to closing.

Table 1.3.1: Primary Technical Stakeholders:

Name	Location
Dan Winningham	ARC
Linda Sekura	GRC
Walt Kocher	GRC
Phillina Peete-Tookes	GSFC
Harry Stein	GSFC
Eugene Harm	KSC
Jennifer Hobbs	KSC
Hien Nguyen	KSC
Sue Davis	KSC
Merilyn Hall	KSC
Rebecca Jordan	MAF
Nathan Coffee	MSFC
Matt Rothgeb (Project Manager)	NASA AP2
John Herrington	NASA AP2
Pat Edgens	SSC
Carolyn Kennedy	SSC
Marianne Simko	WFF
Joel Mitchell	WFF
Harold Harrison	WSTF

Down-selection Process and On-Site Product Demonstration

Nine parts washing chemistries were selected for on-site demonstration at multiple NASA Centers. These qualitative demonstrations lasted for 45-60 days and occurred between November 2004 and March 2005. All agreed that shop-owners and shop-personnel should be informally interviewed during on-site demonstrations concerning how the alternative chemistry compared to other cleaners they had encountered in the past.

In addition to the qualitative analysis, the nine chemistries selected for demonstrated as well as the other chemistries that met pre-qualifying material characteristics were selected for quantitative laboratory testing to determine their cleaning efficiency. These chemistries would be compared to each other and to four standard solvent cleaners typically found in industrial shops within federal facilities. The Rochester Institute of Technology (RIT) was tasked to perform the cleaning efficiency test based on a portion of MIL-PRF-29602: "Performance Specification Cleaning Compound, Parts Washer and Spray Cabinet". This specification is approved for use by the U.S. Department of Defense. The portion of the specification used was: *4.5.8 – "Cleaning Efficiency"*. The specification was modified slightly because of obsolescence of specified soil components and the equipment specified to mix them. Replacements of materials were identified by companies that manufactured the specified materials and equipment was used as specified in a 2002 draft update (MIL-PRF-29602A).

It should be noted that of the 49 alternative chemistries tested by RIT, 15 were provided and tested by RIT at no additional cost to the project team. The AP2 Office selected the remaining 34 (including benchmarks) and provided them to RIT for testing. Because of varying vendor recommendations for temperature and dilution, four chemistries were tested at multiple dilutions or temperatures, this brought the total number of cleaning efficiency tests to 53 alternative chemistries and 4 benchmarks.

The experimental design for this project will give measurable results through field demonstrations and laboratory analysis as well as valued shop personnel opinions of identified alternatives for

their cleaning processes. Furthermore, since only nine chemistries could be initially demonstrated on site, the remaining chemistries tested at RIT can be compared to those tested at NASA facilities and further site-demonstrations of lab tested chemistries can be justified.

Table 1.3.2: Interview Participants (Shop Personnel)

Name	Location
Steve Streaker	GSFC – Adv. Manufacturing
Jerry Geraneo	KSC – Central Heat Plant
Steve Johnson	KSC – Central Heat Plant
Ken Hughs	KSC – Industrial Chiller Plant
Joe Maxwell	KSC – Industrial Chiller Plant
Mark Stratton	KSC – Machine Shop
Bobby Cox	KSC – Machine Shop
Robert Pedeaux	MAF – Motor Pool
C.J. Vieira	MSFC – Motor Pool
Tommy Guerin	MSFC – PM Shop
Mark Smith	PAFB – NASA Aircraft Hangar
Glenn Finney	WFF – Machine Shop

1.4 Justification, Goals and Deliverables

The main objective of this project was to prove the viability of alternatives to part washing chemistries in current use at NASA which meet or exceed the regulatory standards of the (SCAQMD) and the EPA and meet the expectations of shop personnel within a spectrum of work environments.

While alternative part washing studies have been performed in the past by individual services within the US Department of Defense, the NASA AP2 Office could not identify any similar NASA-wide efforts in this area. The need for a NASA-wide identification of available alternatives was a primary driving force for this effort.

The ability of the NASA AP2 Office to coordinate the simultaneous demonstration and laboratory analysis of over 50 alternative chemistries has allowed in a short duration, all NASA facilities to see from first hand accounts how well nine alternatives work in real-world environments and how over 40 chemistries compare to the nine site demonstrated and four benchmark standard cleaners tested during this project.

The major deliverable for this project is a NASA focused guide to alternative part washers, which is included as a portion of this final report. It will serve as a quick reference for any NASA facility, contractor or sub-contractor that may be purchasing or replacing a part washer unit in the near future. It will allow those personnel to review the site demonstrated alternatives as well as the laboratory tested chemistries and compare them to each other as well as benchmark solvents so that the best environmentally preferable alternative for their working environment can be selected for procurement.

1.5 Accomplishments and Lessons Learned

Summary of Accomplishments

- Nine part washer chemistries were tested at shops across five NASA Centers (KSC, MSFC, GSFC, MAF and WFF).
- Fifty-three chemistries were tested for cleaning efficiency in an accredited laboratory, of which four were benchmark (solvent) solutions.
- Based on the positive results, NASA Centers plan to purchase four cleaning unit(s).
- Three other NASA shops are in the process of securing funding for the purchase of cleaning units, which would bring the total number of equipment installations to seven.

Lessons Learned

- Should other phases of this project be undertaken, the duration of on-site demonstrations should be extended by a minimum of 30 working days (60 total work days) to ensure that there is enough time for workers to use the equipment and properly judge the effectiveness of the cleaner.
- Agreements should be written and signed, stating that test units and related equipment borrowed or leased for similar projects be returned promptly at the end of the test period. This should be signed prior to shipment of the test units.
- VOC content and other chemistry characteristics should be checked and double-confirmed before site or laboratory testing. Several vendors gave product characteristics for cleaners that were within the bounds of the project, but at a later time the team discovered that the VOC content or other characteristics were not as stated initially by the vendor. Some of these can be contributed to dilution of the chemistry, while others cannot be explained. Several chemistries were tested that would have been eliminated if data had been expressed by vendors properly.

1.6 Primary Deliverables - Document Descriptions

Below is a brief summary of the primary deliverable: *Consumer's Guide to Alternative Part Washers*. It was decided that a separate, simpler document should be designed for wide distribution to cover only the pertinent material that shop owners and others within the procurement areas of NASA Centers would find important and of interest. This guide can be updated as needed to include new or otherwise demonstrated alternatives that may be of interest to facilities across NASA. The document you are now reading is to serve as a report as well as guide that can give greater description of the project and the guide.

Purpose of Document

The overall purpose of the *Consumer's Guide to Alternative Part Washers* is to provide valuable information regarding environmentally preferable part washers from the perspective of shop owners and workers within NASA. Additionally to this, it is to provide quantitative analysis of a variety of part washing chemistries that have been historically used and the alternatives that are available for use that will help decrease risk, environmental footprint, hazardous materials and waste handling costs associated with part washing.

This guide is only a partial analysis of the numerous part washing chemistries that are available on the market today. The chemistries tested were based on several pre-qualifiers and the vendor's ability to supply any NASA facility across the Contiguous U.S. with the materials needed on an ongoing basis to assure there would be less risk of obsolescence concerning a cleaning material or related equipment.

Down-selection Process

The selection of materials for testing began by identifying companies that supplied or manufactured cleaning chemistries for part washers. These companies were identified through the

internet, industrial and trade periodicals as well as industry conferences attended over the past five years by the NASA AP2 Office. From this search, over 100 companies were polled to identify which had cleaning products that were in their perception, "environmentally preferable" as compared to Mineral Spirits, Isopropanol or MEK. The list of vendors was reduced at this point down to 26. Each vendor was contacted individually and Material Safety Data Sheets (MSDS) and product information sheets were requested. This research derived 50+ products that could be perceived as "environmentally preferable". There were more than 50 products that met the qualifications, but some vendors did not respond to requests for information.

From this point, the stakeholders were polled and it was determined that any products reviewed should meet or exceed the following material characteristics: Flash Point greater than or equal to 140°F, less than or equal to 25g/L VOC content preferably but no greater than 50g/L VOC content (non-exempt VOCs), low or no-HAP, and pH (hydrogen ion concentration) between 2-12. It was later decided by the group to drop the pH requirement as nearly all chemistries met this qualification and it was not as critical as Flash Point, VOC and HAP requirements.

Through these two processes, the original list of over 100 products was reduced to 30 and nine candidates were chosen for the site demonstrations, limited by the number of sites within NASA who could offer a location for the testing and the willingness of vendors to donate product and equipment for the project. In total, thirty alternative chemistries were selected based on meeting the above criteria and availability of the product. Four benchmarks (acetone, isopropanol, methyl ethyl ketone and mineral spirits) were also selected for testing. All chemistries on the final list (34) underwent laboratory testing for cleaning efficiency at RIT. Additionally to these selected chemistries, 15 additional chemistries were added to laboratory testing by RIT as an in-kind contribution to the project. In total the project lab-tested 49 “environmentally preferable” chemistries and four benchmarks for cleaning efficiency. A total of 57 tests were performed because four of the selected chemistries were tested at varying temperature or dilution.

Document Layout

This document has five main sections. The first section (Section 2.0) contains the test site and cleaning efficiency matrices, its purpose is to introduce the reader to the materials that were tested by category and location where site demonstrations occurred. This section also compares the material characteristics of each chemistry tested. The second section (Section 3.0) is a very brief overview of all test results and is referred to as the "Quick Guide". The third section (Section 4.0) covers individual chemistries that were demonstrated during this project at NASA facilities. Depending on the chemistry and situation involved with the donation of equipment, the equipment that was used is also highlighted for information purposes, though the primary focus is on the cleaning materials. Two pages of information are dedicated to each cleaning chemistry that was demonstrated on-site and each covers the same categories and comparative charts. The fourth section (Section 5.0) of the document covers the cleaning efficiency tests procedures. The last section (Section 6.0) is a summary of the entire document.

How to Use the Consumer’s Guide

The Consumer's Guide should be used as a reference for selecting a truly environmentally preferable cleaner for your part washing process. Although the nine demonstrated parts washers are highlighted and have more details covering their performance, the other environmentally preferable chemistries tested for cleaning efficiency should also be taken into consideration for your process. Section 4.0 should be reviewed first to categorize your current cleaning chemistry and how well the test chemistries relate to each other. Once you have determined which chemistry may best suit your particular needs, Sections 5.0 should be referenced to see detailed information from NASA demonstrated units. Lastly Section 6.0 should be reviewed to identify any other chemistries that hold similar properties to the ones you are considering, as well as to determine if there are others that may clean better than others and how these compare to the benchmark cleaning chemistries.

It should be noted that one should take into account the decreased health and environmental risks that can be correlated with lower cleaning efficiency. When selecting chemistry, the goal should be a balance of the lowest cleaning efficiency required for the job and the highest level of environmental health and safety.

It should also be noted that four categories of chemistries - aqueous, semi-aqueous, bio-based solvents and non-bio based solvents were studied during this project and the order for selection of an alternative should be in a corresponding order. Table 1.6.1 shows the test data organized by this hierarchy of product selection. All things being equal (e.g. equivalent performance), part washer chemistries should be considered in this same order of preference. Table 3.0.2 shows all chemistries tested during this project according to this hierarchy, and includes the benchmarks with each group for comparative purposes.

Hierarchy for Choosing a Environmentally Preferable Cleaning Chemistry:
Aqueous > Semi-aqueous > Bio-based solvents > Non-bio-based solvents

It should be noted that the Federal Bio-based Products Preferred Procurement Program has recently completed its final rule. This program, authorized by section 9002 of the 2002 Farm Bill, requires all federal agencies to preferentially purchase bio-based products that have been designated by United States Department of Agriculture (USDA) as eligible under this program. Additionally to this new requirement, Federal Facilities are required to follow Executive Orders such as EO 12873 – "Federal Acquisition, Recycling and Waste Prevention," and EO 13101 – "Greening of the Government through Waste Prevention, Recycling and Federal Procurement". The goal of this type of legislation is to move Federal Facilities toward environmentally preferable alternatives to historically used hazardous materials in maintenance and manufacturing operations and to provide aid in making such decisions.

The overall goal of this guide and indeed P2 and sustainability efforts is to reduce the amount of hazardous materials used at the source first, and then to control the emissions to the environment and worker's exposure second.

Description of Attachments:

Though not included in the more-widely distributed Consumer's Guide (Sections 2.0 to 4.0), an appendix including PPONA risk ranking and methodology, Materials Safety Data Sheets / Technical Data Sheets for each site-tested chemistry, interview sheets used during the project, the full lab report from RIT and project schedules are included within this publication.

2.0 Part Washer Test Matrices

Table 2.0.1 below shows physical and chemical properties all chemistries that were tested for cleaning efficiency according to MIL-PRF 29602A at RIT.

Table 2.0.1: Selected Chemistries Test Matrix

ID	Chemistry Name	Supplier Name	Flash Point	VOC Content	pH (Conc.)	Test Temp	Concen-tration	Realized Cost
			ºF	g/L	-	ºF	% by Vol.	($/gal)
X	Acetone *	Fisher Scientific	0	790	N/A	70	20.0%	$12.97
○	Aerowash 4 *	Rochester Midland	none	0	7.8	160	100.0%	$1.84
○	Aerowash 4 *	Rochester Midland	none	0	7.8	160	100.0%	$0.92
●	Agriplast	Cook Composites	300	14.38	N/A	130	10.0%	$12.00
●	Aquaworks MM Dip Concentrate	Church & Dwight	>212	8.3	12.8	160	100.0%	$1.44
●	Armakleen HP-2	Church & Dwight	>212	0	11.8	160	20.0%	$1.20
●	Armakleen M100	Church & Dwight	N/A	0	13.95	160	20.0%	$1.40
●	Armakleen M400	Church & Dwight	none	0	9.4	160	100.0%	$1.51
▼	Armakleen M-Aero	Church & Dwight	>212	13.7	11.6	160	7.5%	$1.47
●	Armakleen MPC Concentrate	Church & Dwight	>212	0	11.5	160	100.0%	$1.44
▼	Axarel 58	Petroferm Inc.	175	< 25	N/A	150	10.0%	$19.63
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	>425	23.9	6.65	130	7.5%	$13.99
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	>425	23.9	6.65	160	100.0%	$7.00
▼	Bioact MSO	Petroferm Inc.	N/A	745	N/A	110	25.0%	$4.72
●	Bio-Circle-L	Walter Surface Technologies	N/A	0	7	100	20.0%	$35.80
▼	Breakthrough	Inland Technology Inc	150	770*	N/A	70	10.0%	$31.24
▼	California Parts Washer Solution	Phase III Inc.	N/A	< 50	9 - 10	105	7.5%	$3.27
●	Citrusoy Super High Flash	Florida Chemical Company	>200	70	N/A	160	100.0%	$20.00
●	Clean Safe 7445-05	Petroferm Inc.	>210	10	12.5	160	3.0%	$1.33
●	Clean Safe 7448-05	Petroferm Inc.	>210	25	13.4	160	100.0%	$1.22
○	Cleanaire 1200 *	Rochester Midland	none	0	12.2	160	100.0%	$0.16
○	Daraclean *	Magnaflux	none	0	12.5	131	7.5%	$4.80
●	EnviroClear	Soy Technologies	>237	5	7	100	100.0%	$31.91
●	EnviroLogic - Partwasher Solution	EnviroLogic	none	0	7.2	100	11.1%	$3.18
○	EXP 1300 *	Brulin	>200	0	11.9	145	50.0%	N/A
○	Flightline 2 *	Rochester Midland	none	0	7.8	160	10.0%	$2.10
○	Flightline 2 *	Rochester Midland	none	0	7.8	160	5.0%	$1.05
●	Gold Matrix	Walter Surface Technologies	N/A	0	11.5	160	7.5%	$20.60
●	Green 4 Kleen	IPAX Cleanogel Inc	none	0	9.5-9.8	70	16.7%	$0.71
▼	Heavy Duty Cleaner	Phase III Inc.	N/A	< 25	9 - 10	105	100.0%	$4.99
X	Isopropanol	Fisher Scientific	53	790	N/A	70	25.0%	$19.60
●	KT600C	Kleen Tec	>212	80	8.7 - 9.5	112	100.0%	$4.32
○	Low pH Concentrated Cleaner *	Spray-Nine	166	N/A	9.8	130	100.0%	$0.82
X	Methyl Ethyl Ketone	Fisher Scientific	22	810	N/A	70	10.0%	$17.37
●	Millennium	Inland Technology Inc	>200	0	N/A	105	100.0%	$6.99
X	Mineral Spirits (Stoddard Solvent)	Fisher Scientific	102	790	N/A	70	100.0%	$6.37
○	Natural Orange *	Giant Cleaning Systems	N/A	N/A	N/A	160	2.2%	$0.18
○	Neugenic 4177 *	Rochester Midland	none	317	12.2	70	100.0%	$14.90
○	NZD Ultra Degreaser *	Global Specialty Products	147.5	766.13	8.5 - 8.8	70	20.0%	$26.00
▼	Oleocal ME-130	SoySolv	>300	< 50	N/A	160	25.0%	$16.66
○	Optima 100 GP *	Global Specialty Products	>200	0	11	148	3.6%	$1.60
○	Optima 2001 CR *	Global Specialty Products	>200	0	11.7	148	0.5%	$15.50
○	Powerkleen III *	Mart Corporation	N/A	0	12.5	160	10.0%	$0.40
●	Sea Wash 8	Warren	none	15	7	130	100.0%	$3.40
●	Silicon Wash Concentrate	Silicon Chemistries Solutions	N/A	0	10 - 11.1	140	100.0%	Service
○	Simple Green *	Sunshine Makers	none	7.96	9.5	70	7.5%	$10.99
●	Soy Green Solvent (SG5000)	Soy Technologies	>200	5	7	100	16.7%	$23.29
●	SoySolv II	SoySolv	>300	< 50	5 - 7	160	100.0%	$16.58
●	SoySolv II Plus	SoySolv	>150	0.55	6.9	100	100.0%	$16.58
●	SoySolv II Plus	SoySolv	>150	0.55	6.9	70	10.0%	$16.58
○	Spray-Nine AV-8 *	Spray-Nine	none	26.2	9.7	70	100.0%	$1.30
▼	SS-HD Parts Washer Formulation	Solvent Systems International	N/A	25	11.5	110	100.0%	Service
●	SW-3 OzzyJuice	ChemFree Corp	>200	< 5	7.3	105	100.0%	$16.80
▼	SW-8 Aircraft OzzyJuice	ChemFree Corp	none	10	9	105	100.0%	$17.50
●	SW-LF OzzyJuice	ChemFree Corp	none	5	7.3	105	10.0%	$11.60
●	US-2003	Anchor Atlantic	N/A	9	11	160	12.0%	$1.29
○	Vertrel CMS *	Dupont	none	536	7	70	11.1%	$312.00

▼- On-Site and Lab Tested ● - NASA Identified Chemistries ○ - RIT Identified Chemistries X, X, X, X – Benchmarks
* Breakthrough's VOC content is exempt from air monitoring regulations and meets SCAQMD standards.

Of the over 200 chemistries researched at the onset of this project, several were selected to be tested on-site in a variety of shops and cleaning environments. The chemistries were selected based on meeting several qualifiers (Flash Point, VOC Content, pH, HAP Content, etc.) and availability for project testing (vendors could supply the chemistry at no-cost to our project and could arrange for equipment to be delivered).

Table 2.0.2 alphabetically lists the nine chemistries that were field tested, the test location and the key pre-qualifying physical characteristics of the material. Table 2.0.3 lists the currently used chemistries for each of the shops listed in table 2.0.2.

Table 2.0.2: Site Evaluated Environmentally Preferable Chemistries

Chemistry Name	Supplier Name	Test Site	Shop Name	Flash Point	VOC Content	pH
				ºF	-	-
Armakleen M-Aero	Church & Dwight	KSC	Machine Shop	>212	13.7 g/L	11.6
Axarel 58	Petroferm Inc.	MSFC	Motor Pool	175	<25 g/L	N/A
Bioact MSO	Petroferm Inc.	KSC	Industrial Chiller Plant	N/A	745 g/L	N/A
Breakthrough	Inland Technology Inc	WFF	Machine Shop	150	770 g/L	N/A
California Parts Washer Solution	Phase III Inc.	KSC	Central Heat Plant	N/A	<50 g/L	9 - 10
Heavy Duty Cleaner	Phase III Inc.	GSFC	Advanced Manufacturing	N/A	<25 g/L	9 - 10
Oleocal ME-130	SoySolv	MAF	Vehicle Maintenance Shop	>300	< 50 g/L	N/A
SS-HD (Grease Gator)	Solvent Systems Intnl.	MSFC	PM Shop	N/A	25 g/L	11.5
SW-8 Aircraft OzzyJuice	ChemFree Corp.	KSC (PAFB)	Aircraft Hangar	none	10 g/L	9

Table 2.0.3: Currently Used Chemistries:

Test Site	Shop Name	Currently Used Chemistry	Current Chemistry Supplier
KSC	LETF Machine Shop	DM32 w/ Electron Solvent	Ecolink
MSFC	Motor Pool	Mineral Spirits	Various
KSC	Industrial Chiller Plant	ChemFree SmartWasher	ChemFree Corp.
WFF	Machine Shop	Safety Kleen Premium Gold 150	Safety Kleen
KSC	Central Heat Plant	ChemFree SmartWasher	ChemFree Corp.
GSFC	Advanced Manufacturing	Hot Water + Detergent	Unknown
MAF	Vehicle Maintenance Shop	ZEP Dyna 143	ZEP
MSFC	PM Shop	Degreasol Solvent	Kleer-Flo Co.
KSC (PAFB)	Aircraft Hangar	Mineral Spirits	Various

Notes:
After testing began, it was determined by discussions with the vendor that Bioact MSO (semi-aqueous cleaning agent suitable for removing a wide variety of soils) had a higher VOC content than originally advertised. The vendor stated that if diluted as suggested, it would fall below the VOC limits and flashpoint set for this project. Documentation was requested to substantiate this claim, but has not yet been provided to the NASA AP2 Office at the time this report was written. It is suggested not consider BIOACT MSO for use in part washing until this issue can be resolved.

After testing began, it was determined that Breakthrough was also higher in VOC content than was suggested for the purposes of this project. Although Breakthrough contains higher VOC content, the VOCs contained within it are exempt from reporting. It was decided to keep this as a suggested cleaner to replace standard Mineral Spirits in critical cleaning applications where other environmentally preferable cleaners such as aqueous based cleaners, do not accomplish the job.

3.0 Laboratory Testing Results

Overview of Section 3.0 Tables

This section summarizes the results of the project testing. Table 3.0.1 in this section serves as a guide for quick product comparison. Table 3.0.2 accompanies the quick guide and is organized by chemistry type and ordered in the preferred hierarchy for selecting a cleaning chemistry from left to right. Table 3.0.3 details the cleaning efficiency of each test performed at RIT. Table 3.1.1 compares the results qualified in the field to the cleaning efficiency of each field tested chemistry. Table 3.1.2 compares the cleaning efficiency to the benchmarks tested during the project. Table 3.2.1 details the costs of all field tested chemistries and Table 3.2.2 details the costs of all tested chemistries.

Hierarchy for Choosing a New Chemistry:

As mentioned above, Table 3.0.2 lists the preferred order for choosing an alternative chemistry and shows the cleaning efficiency ranking for each chemistry and realized costs. Benchmarks that were tested are listed in each column for ease of comparison.

Synthetic Contaminants

Two synthetic soil contaminants were created for laboratory testing according to the specification, with some minor modifications where equipment or materials were not available. Suitable replacements for both were identified by comparison of previous versions of MIL-PRF-29602 and all were approved by the AP2 Office before the testing began.

The first simulated soil contaminant (Contaminant #1) is composed of *Aeroshell 17 molybdenum disulfide grease* mixed with *Raven 1020 carbon black.* It simulates heavier grease contaminants, such as bearing grease, that are encountered in heavy equipment shops. The second simulated soil contaminant (Contaminant #2) is *Alox 2028S* and simulates lighter oils and corrosion inhibitors that coat a surface, causing it to become hydrophobic, and is representative of many machining oils.

Steps to Take in Selecting a New Chemistry:

While every shop will differ from the next, there are some common steps that should be taken when selecting a cleaning chemistry. It should be noted that they may vary for your specific process or operation and factors such as time, priority of process, process specific standards and other factors may affect the steps outlined below.

1. Evaluate Current or Candidate Cleaning Process Fully
   - Identify types of contaminants encountered and specific parts cleaned
   - Identify currently used cleaners and their pros/cons
   - Identify any alternatives that the shop may have already tried
   - Incorporate worker feedback into decision making process

2. Identify Specific Criteria for Your Cleaning Process
   - Determine level of cleanliness required for parts (i.e. is residue allowable? Some cleaners leave residue and some processes allow for this, others do not.)
   - Identify current costs and available budget
   - Determine importance of factors such as drying time, odor, cost and maintenance
   - Identify specific environmental health and safety goals for the shop and facility (i.e. waste reduction, VOC emissions, worker exposure)
   - Determine flexibility points in criteria (i.e. cleaning time vs. environmental impact, drying time vs. equipment readiness)

3. Review Data Outlined Here and Compare to Cleaners you Have Used Before
   - Most shops are familiar with at least one of the benchmarks, and may have tried one or more of the chemistries tested for this project
   - Determine how far below or above the benchmark is acceptable for cleaning efficiency of any new cleaners
   - Compare procurement cost(s) of material(s) currently used with those of this project

4. If Permitted, Procure Samples of Cleaning Chemistries of the Greatest Interest
   - Select one or more chemistries of interest, contact vendors and acquire samples for in-house testing (most vendors are happy to send samples at no cost if there is a possibility of a new customer)
   - Select chemistries according to the preferable hierarchy on Table 3.0.2 (furthest to the left possible) that you believe will meet your process criteria

5. Perform In-House Review of Sampled Chemistries
   - Test sample chemistries on parts and contaminants that best represent those seen in your cleaning process
   - Be sure to work with the vendors to identify required maintenance, lifecycle of chemistry, ideal working environment (i.e. temperature, dilution) and associated operating costs (i.e. electricity, filters, pumps, oil separators, etc.). Compare these with both current process and other identified alternatives of interest.

6. Select and Procure a Chemistry
   - Select the chemistry that best suits your needs.
   - Things to consider: performance, environmental goals, costs, lifecycle of chemistry, maintenance of equipment, and any other criteria of importance identified during your process-specific review.

Table 3.0.1 Quick Guide

Environmentally Preferrable Part Washers - Ranked by Cleaning Efficiency (CE)

(1 of 2)

ID	Chemistry Name	Supplier Name	Type	Bio-degrade	Flash Point	VOC Content	pH (Conc.)	Test Temp	Concen-tration	Retail Cost	Realized Cost	Average Cleaning Efficiency	CE Rank	Point of Contact	Phone Number
					ºF	g/L	-	ºF	% by Vol.	($/gal)	($/gal)	%			
▼	Heavy Duty Cleaner	Phase III Inc.	aqueous	Yes	N/A	< 25	9 - 10	105	20%	$24.95	$4.99	100.1%	1	Beau Brandt	480-503-2847
●	SoySolv II Plus	SoySolv	bio-based solvent	Yes	>150	0.55	6.9	100	100%	$16.58	$16.58	100.0%	2	Steve Smith	419-992-4570
X	Mineral Spirits (Stoddard Solvent)	Fisher Scientific	solvent	No	102	790	N/A	70	100%	$6.37	$6.37	99.7%	3	Customer Service	201-796-7100
○	Optima 2001 CR *	Global Specialty Products	aqueous	Yes	>200	0	11.7	148	10%	$15.50	$1.55	99.7%	4	Anthony Faghani	609-518-7577
●	SoySolv II	SoySolv	bio-based solvent	Yes	>300	< 50	5 - 7	160	100%	$16.58	$16.58	99.6%	5	Steve Smith	419-992-4570
○	Aerowash 4 *	Rochester Midland	aqueous	Yes	none	0	7.8	160	20%	$9.20	$1.84	99.4%	6	Customer Service	585-336-2200
▼	California Parts Washer Solution	Phase III Inc.	aqueous / microbial	Yes	N/A	< 50	9 - 10	105	20%	$16.36	$3.27	99.4%	7	Beau Brandt	480-503-2847
●	EnviroClear	Soy Technologies	bio-based solvent	Yes	>237	5	7	100	100%	$31.91	$31.91	99.3%	8	Mike Hynes	770-366-8536
●	Armakleen MPC Concentrate	Church & Dwight	aqueous	No	>212	0	11.5	160	7.5%	$19.15	$1.44	99.3%	9	Aladino Ramos	407-321-6080
▼	Breakthrough	Inland Technology Inc	solvent	No	150	770*	N/A	70	100%	$31.24	$31.24	99.2%	10	Eric Lethe	253-383-1177
○	Aerowash 4 *	Rochester Midland	aqueous	Yes	none	0	7.8	160	10%	$9.20	$0.92	99.2%	11	Customer Service	800-762-4448
▼	Armakleen M-Aero	Church & Dwight	aqueous	Yes	>212	13.7	11.6	160	7.5%	$19.55	$1.47	99.1%	12	Aladino Ramos	407-321-6080
●	SW-3 OzzyJuice	ChemFree Corp	aqueous / microbial	Yes	>200	< 5	7.3	105	100%	$16.80	$16.80	99.0%	13	Pat Bodelson	770-564-5591
▼	Bioact MSO	Petroferm Inc.	bio-based solvent	Yes	N/A	745	N/A	110	25%	$18.86	$4.72	98.8%	14	Michelle Mecurio	904-261-8286
○	Flightline 2 *	Rochester Midland	semi-aqueous	No	none	0	7.8	160	20%	$10.50	$2.10	98.7%	15	Customer Service	585-336-2200
○	Flightline 2 *	Rochester Midland	semi-aqueous	No	none	0	7.8	160	10%	$10.50	$1.05	98.7%	16	Customer Service	585-336-2200
●	Armakleen HP-2	Church & Dwight	aqueous	Yes	>212	0	11.8	160	7.5%	$16.06	$1.20	98.6%	17	Aladino Ramos	407-321-6080
●	Soy Green Solvent (SG5000)	Soy Technologies	bio-based solvent	Yes	>200	5	7	100	100%	$23.29	$23.29	98.6%	18	Mike Hynes	770-366-8536
○	Cleanaire 1200 *	Rochester Midland	aqueous	No	none	0	12.2	160	3%	$5.35	$0.16	98.5%	19	Customer Service	585-336-2200
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	bio-based solvent	Yes	>425	23.9	6.65	130	100%	$13.99	$13.99	98.5%	20	Dan Brown	309-452-7526
●	Bio-Circle-L	Walter Surface Technologies	aqueous / microbial	Yes	N/A	0	7	100	100%	$35.80	$35.80	98.4%	21	John Columbo	503-880-3067
●	Aquaworks MM Dip Concentrate	Church & Dwight	aqueous	No	>212	8.3	12.8	160	7.5%	$19.15	$1.44	98.3%	22	Aladino Ramos	407-321-6080
●	Gold Matrix	Walter Surface Technologies	aquous	Yes	N/A	0	11.5	160	100%	$20.60	$20.60	98.2%	23	John Columbo	503-880-3067
●	Clean Safe 7445-05	Petroferm Inc.	semi-aqueous	Yes	>210	10	12.5	160	11.1%	$12.00	$1.33	98.0%	24	Michelle Mecurio	904-261-8286
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	bio-based solvent	Yes	>425	23.9	6.65	160	50%	$13.99	$7.00	98.0%	25	Dan Brown	309-452-7526
○	Optima 100 GP *	Global Specialty Products	aqueous	Yes	>200	0	11	148	10%	$16.00	$1.60	97.6%	26	Anthony Faghani	609-518-7577
●	Sea Wash 8	Warren	aqueous	Yes	none	15	7	130	5%	$68.00	$3.40	97.1%	27	Roger Handy	508-375-9940
●	Armakleen M100	Church & Dwight	aqueous	Yes	N/A	0	13.95	160	7.5%	$18.70	$1.40	96.8%	28	Aladino Ramos	407-321-6080

▼- On-Site and Lab Tested ● - NASA Identified Chemistries ○ - RIT Identified Chemistries X, X, X, X – Benchmarks

Environmentally Preferrable Part Washers - Ranked by Cleaning Efficiency (CE)

(2 of 2)

ID	Chemistry Name	Supplier Name	Type	Bio-degrade	Flash Point	VOC Content	pH (Conc.)	Test Temp	Concen-tration	Retail Cost	Realized Cost	Average Cleaning Efficiency	CE Rank	Point of Contact	Phone Number
					ºF	g/L	-	ºF	% by Vol.	($/gal)	($/gal)	%			
●	KT600C	Kleen Tec	aqueous	Yes	>212	80	8.7 - 9.5	112	16.7%	$25.89	$4.32	96.5%	29	Aarron Rocklin	507-373-5152
X	Methyl Ethyl Ketone	Fisher Scientific	solvent	No	22	810	N/A	70	100%	$17.37	$17.37	96.5%	30	Customer Service	201-796-7100
○	Daraclean *	Magnaflux	aqueous	Yes	none	0	12.5	131	25%	$19.20	$4.80	96.5%	31	David Geis	847-657-5328
●	SW-LF OzzyJuice	ChemFree Corp	aqueous / microbial	Yes	none	5	7.3	105	100%	$11.60	$11.60	96.3%	32	Pat Bodelson	770-564-5591
○	NZD Ultra Degreaser *	Global Specialty Products	solvent	No	147.5	766.13	8.5 - 8.8	70	100%	$26.00	$26.00	96.1%	33	Anthony Faghani	609-518-7577
●	US-2003	Anchor Atlantic	semi-aqueous	Yes	N/A	9	11	160	10%	$12.90	$1.29	96.1%	34	Dave Weaver	800-458-0355
▼	Axarel 58	Petroferm Inc.	bio-based solvent	Yes	175	< 25	N/A	150	100%	$19.63	$19.63	95.7%	35	Michelle Mecurio	904-261-8286
▼	SW-8 Aircraft OzzyJuice	ChemFree Corp	aqueous / microbial	Yes	none	10	9	105	100%	$17.50	$17.50	95.4%	36	Pat Bodelson	770-564-5591
○	Powerkleen III *	Mart Corporation	bio-based solvent	No	N/A	0	12.5	160	2.2%	$18.30	$0.40	94.9%	37	Jesse Adams	800-543-6278
○	Vertrel CMS *	Dupont	solvent	No	none	536	7	70	100%	$312.00	$312.00	94.8%	38	Customer Service	800-969-4758
▼	SS-HD Parts Washer Formulation	Solvent Systems International	semi-aqueous	No	N/A	25	11.5	110	20%	Service	Service	94.7%	39	Steve Rundell	847-437-1100
●	Millennium	Inland Technology Inc	aqueous	No	>200	0	N/A	105	25%	$27.95	$6.99	94.1%	40	Eric Lethe	253-383-1177
○	EXP 1300 *	Brulin	aqueous	Yes	>200	0	11.9	145	3.6%	N/A	N/A	92.8%	41	Customer Service	317-923-3211
○	Natural Orange *	Giant Cleaning Systems	bio-based solvent	Yes	N/A	N/A	N/A	160	0.5%	$36.00	$0.18	91.1%	42	Customer Service	800-344-4268
○	Low pH Concentrated Cleaner *	Spray-Nine	semi-aqueous	Yes	166	N/A	9.8	130	10%	$8.16	$0.82	91.1%	43	Michael Pozefsky	518-762-4591
▼	Oleocal ME-130	SoySolv	bio-based solvent	Yes	>300	< 50	N/A	160	100%	$16.66	$16.66	89.4%	44	Steve Smith	419-992-4570
●	Citrusoy Super High Flash	Florida Chemical Company	bio-based solvent	Yes	>200	70	N/A	160	100%	$20.00	$20.00	84.7%	45	Mark Henneberry	863-294-8483
●	Armakleen M400	Church & Dwight	aqueous	No	none	0	9.4	160	7.5%	$20.15	$1.51	83.3%	46	Aladino Ramos	407-321-6080
●	Silicon Wash Concentrate	Silicon Chemistries Solutions	aqueous	No	N/A	0	10 - 11.1	140	16.7%	Service	Service	82.8%	47	Mike Davis	636-734-8547
●	Agriplast	Cook Composites	bio-based solvent	Yes	300	14.38	N/A	130	100%	$12.00	$12.00	79.1%	48	James Tyrakoski	816-391-6000
●	SoySolv II Plus	SoySolv	bio-based solvent	Yes	>150	0.55	6.9	70	100%	$16.58	$16.58	78.5%	49	Steve Smith	419-992-4570
●	EnviroLogic - Partwasher Solution	EnviroLogic	aqueous / microbial	Yes	none	0	7.2	100	10%	$31.76	$3.18	78.4%	50	Mark Weinberg	215-887-4400
X	Acetone *	Fisher Scientific	solvent	No	0	790	N/A	70	100%	$12.97	$12.97	65.8%	51	Customer Service	201-796-7100
X	Isopropanol	Fisher Scientific	solvent	No	53	790	N/A	70	100%	$19.60	$19.60	61.9%	52	Customer Service	201-796-7100
○	Simple Green *	Sunshine Makers	bio-based solvent	Yes	none	7.96	9.5	70	100%	$10.99	$10.99	46.5%	53	Tim Fisher	800-228-0709
○	Neugenic 4177 *	Rochester Midland	semi-aqueous	No	none	317	12.2	70	100%	$14.90	$14.90	36.0%	54	Customer Service	585-336-2200
○	Spray-Nine AV-8 *	Spray-Nine	semi-aqueous	Yes	none	26.2	9.7	70	10%	$12.95	$1.30	34.9%	55	Michael Pozefsky	518-762-4591
●	Green 4 Kleen	IPAX Cleanogel Inc	aqueous	Yes	none	0	9.5-9.8	70	12%	$5.90	$0.71	26.8%	56	Paul Katz	800-930-4729
●	Clean Safe 7448-05	Petroferm Inc.	semi-aqueous	Yes	>210	25	13.4	160	11.1%	$11.00	$1.22	Disregard	N/A	Michelle Mecurio	904-261-8286

▼- On-Site and Lab Tested ● - NASA Identified Chemistries ○ - RIT Identified Chemistries X, X, X, X – Benchmarks

Table 3.0.2 Environmental Preferable Hierarchy & Choosing the Right Chemistry for You

Note: Highlighted cells under each category are the BENCHMARKS tested for the project and are placed in EVERY column so that cleaning efficiency and cost can be easily compared.

Aqueous Cleaners w/ Microbial >

Good Choice if:
- ► Want to reduce or eliminate VOC emissions
- ► Want to reduce or eliminate worker exposure
- ► Drying time is not an issue
- ► Want to reduce or eliminate hazardous waste
- ► Shop performs non-critical cleaning

Price Range:
- ► $3.27 - $35.80

Points to Consider:
- ► Increased maintenance to keep microbes alive
- ► Potential to eliminate hazardous waste stream

Chemistry Name	Cleaning Efficiency Rank	Realized Cost ($/gal)
Mineral Spirits (Stoddard Solvent)	3	$6.37
California Parts Washer Solution	7	$3.27
SW-3 OzzyJuice	13	$16.80
Bio-Circle-L	21	$35.80
Methyl Ethyl Ketone	30	$17.37
SW-LF OzzyJuice	32	$11.60
SW-8 Aircraft OzzyJuice	36	$17.50
EnviroLogic - Partwasher Solution	50	$3.18
Acetone *	51	$12.97
Isopropanol	52	$19.60

Aqueous Cleaners >

Good Choice if:
- ► Want to reduce or eliminate VOC emissions
- ► Want to reduce or eliminate worker exposure
- ► Drying time is not an issue
- ► Want to reduce hazardous waste
- ► Shop performs non-critical cleaning

Price Range:
- ► $0.16 - $20.60

Points to Consider:
- ► Oil separator is suggested to increase cleaner life
- ► Hazardous waste stream is reduced

Chemistry Name	Cleaning Efficiency Rank	Realized Cost ($/gal)
Heavy Duty Cleaner	1	$4.99
Mineral Spirits (Stoddard Solvent)	3	$6.37
Optima 2001 CR *	4	$1.55
Aerowash 4 * (20% Concentration)	6	$1.84
Armakleen MPC Concentrate	9	$1.44
Aerowash 4 * (10% Concentration)	11	$0.92
Armakleen M-Aero	12	$1.47
Armakleen HP-2	17	$1.20
Cleanaire 1200 *	19	$0.16
Aquaworks MM Dip Concentrate	22	$1.44
Gold Matrix	23	$20.60
Optima 100 GP *	26	$1.60
Sea Wash 8	27	$3.40
Armakleen M100	28	$1.40
KT600C	29	$4.32
Methyl Ethyl Ketone	30	$17.37
Daraclean *	31	$4.80
Millennium	40	$6.99
EXP 1300 *	41	N/A
Armakleen M400	46	$1.51
Silicon Wash Concentrate	47	Service
Acetone *	51	$12.97
Isopropanol	52	$19.60
Green 4 Kleen	56	$0.71

Semi-Aqueous Cleaners >

Good Choice if:
- ► Want to reduce VOC emissions
- ► Want to reduce worker exposure
- ► Require shorter drying times
- ► Want to reduce hazardous waste
- ► Require higher than general cleaning standards

Price Range:
- ► $0.82 - $14.90

Points to Consider:
- ► Oil separator is suggested to increase cleaner life
- ► De-water solutions to reduce hazardous waste
- ► Potential more waste/gal. compared to aqueous

Chemistry Name	Cleaning Efficiency Rank	Realized Cost ($/gal)
Mineral Spirits (Stoddard Solvent)	3	$6.37
Flightline 2 * (20% Concentration)	15	$2.10
Flightline 2 * (10% Concentration)	16	$1.05
Clean Safe 7445-05	24	$1.33
Methyl Ethyl Ketone	30	$17.37
US-2003	34	$1.29
SS-HD Parts Washer Formulation	39	Service
Low pH Concentrated Cleaner *	43	$0.82
Acetone *	51	$12.97
Isopropanol	52	$19.60
Neugenic 4177 *	54	$14.90
Spray-Nine AV-8 *	55	$1.30
Clean Safe 7448-05	N/A	$1.22

Bio-Based Solvents >

Good Choice if:
- ► Want to reduce VOC emissions
- ► Want to reduce worker exposure
- ► Require short drying times
- ► Require high cleaning standards
- ► Want to use bio-based materials

Price Range:
- ► $0.40 -$31.91

Points to Consider:
- ► Bio-solvents derived from renewable resources
- ► Reduced but not eliminated hazardous materials
- ► Exposure risks are present (Still a solvent)

Chemistry Name	Cleaning Efficiency Rank	Realized Cost ($/gal)
SoySolv II Plus (100º F Test Temp.)	2	$16.58
Mineral Spirits (Stoddard Solvent)	3	$6.37
SoySolv II	5	$16.58
EnviroClear	8	$31.91
Bioact MSO	14	$4.72
Soy Green Solvent (SG5000)	18	$23.29
Bean-e-doo PW Solvent (130º F TT- 100% Conc.)	20	$13.99
Bean-e-doo PW Solvent (160º F TT- 50% Conc.)	25	$7.00
Methyl Ethyl Ketone	30	$17.37
Axarel 58	35	$19.63
Powerkleen III *	37	$0.40
Natural Orange *	42	$0.18
Oleocal ME-130	44	$16.66
Citrusoy Super High Flash	45	$20.00
Agriplast	48	$12.00
SoySolv II Plus (70º F Test Temp.)	49	$16.58
Acetone *	51	$12.97
Isopropanol	52	$19.60
Simple Green *	53	$10.99

Solvents

Good Choice if:
- ► VOC emission reduction is not as critical
- ► Worker exposure not as critical as cleaning
- ► Require very short drying times
- ► Have high / critical cleaning standards
- ► Cost is not an issue

Price Range:
- ► $6.37 - 312.00

Points to Consider:
- ► Exposure and emissions reduced, not eliminated
- ► Only a possible reduction of haz. Materials
- ► Some Recyclable but at a high cost

Chemistry Name	Cleaning Efficiency Rank	Realized Cost ($/gal)
Mineral Spirits (Stoddard Solvent)	3	$6.37
Breakthrough	10	$31.24
Methyl Ethyl Ketone	30	$17.37
NZD Ultra Degreaser *	33	$26.00
Vertrel CMS *	38	$312.00
Acetone *	51	$12.97
Isopropanol	52	$19.60

Table 3.0.3: Cleaning Efficiency Laboratory Results

ID	Chemistry Name	Supplier Name	Type	Test Temp	Concen-tration	Cleaning Efficiency Contam. 1	Cleaning Efficiency Contam. 2	Average Cleaning Efficiency	CE Rank
				ºF	% by Vol.	%	%	%	
▼	Heavy Duty Cleaner	Phase III Inc.	aqueous	105	20%	99.99%	100.18%	**100.1%**	1
●	SoySolv II Plus	SoySolv	bio-based solvent	100	100%	99.92%	100.02%	**100.0%**	2
X	Mineral Spirits (Stoddard Solvent)	Fisher Scientific	solvent	70	100%	99.59%	99.77%	**99.7%**	3
○	Optima 2001 CR *	Global Specialty Products	aqueous	148	10%	99.06%	100.29%	**99.7%**	4
●	SoySolv II	SoySolv	bio-based solvent	160	100%	99.87%	99.29%	**99.6%**	5
○	Aerowash 4 *	Rochester Midland	aqueous	160	20%	99.14%	99.73%	**99.4%**	6
▼	California Parts Washer Solution	Phase III Inc.	aqueous / microbial	105	20%	99.12%	99.59%	**99.4%**	7
●	EnviroClear	Soy Technologies	bio-based solvent	100	100%	99.53%	99.13%	**99.3%**	8
●	Armakleen MPC Concentrate	Church & Dwight	aqueous	160	7.5%	98.80%	99.79%	**99.3%**	9
▼	Breakthrough	Inland Technology Inc	solvent	70	100%	98.97%	99.46%	**99.2%**	10
○	Aerowash 4 *	Rochester Midland	aqueous	160	10%	98.82%	99.58%	**99.2%**	11
▼	Armakleen M-Aero	Church & Dwight	aqueous	160	7.5%	99.10%	99.17%	**99.1%**	12
●	SW-3 OzzyJuice	ChemFree Corp	aqueous / microbial	105	100%	98.40%	99.57%	**99.0%**	13
▼	Bioact MSO	Petroferm Inc.	bio-based solvent	110	25%	98.82%	98.75%	**98.8%**	14
○	Flightline 2 *	Rochester Midland	semi-aqueous	160	20%	97.88%	99.51%	**98.7%**	15
○	Flightline 2 *	Rochester Midland	semi-aqueous	160	10%	97.69%	99.62%	**98.7%**	16
●	Armakleen HP-2	Church & Dwight	aqueous	160	7.5%	97.88%	99.42%	**98.6%**	17
●	Soy Green Solvent (SG5000)	Soy Technologies	bio-based solvent	100	100%	98.92%	98.24%	**98.6%**	18
○	Cleanaire 1200 *	Rochester Midland	aqueous	160	3%	97.30%	99.79%	**98.5%**	19
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	bio-based solvent	130	100%	99.40%	97.61%	**98.5%**	20
●	Bio-Circle-L	Walter Surface Technologies	aqueous / microbial	100	100%	96.69%	100.04%	**98.4%**	21
●	Aquaworks MM Dip Concentrate	Church & Dwight	aqueous	160	7.5%	98.52%	98.16%	**98.3%**	22
●	Gold Matrix	Walter Surface Technologies	aquous	160	100%	96.96%	99.44%	**98.2%**	23
●	Clean Safe 7445-05	Petroferm Inc.	semi-aqueous	160	11.1%	96.56%	99.51%	**98.0%**	24
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	bio-based solvent	160	50%	97.73%	98.31%	**98.0%**	25
○	Optima 100 GP *	Global Specialty Products	aqueous	148	10%	96.91%	98.39%	**97.6%**	26
●	Sea Wash 8	Warren	aqueous	130	5%	94.13%	100.06%	**97.1%**	27
●	Armakleen M100	Church & Dwight	aqueous	160	7.5%	94.83%	98.79%	**96.8%**	28
●	KT600C	Kleen Tec	aqueous	112	16.7%	93.36%	99.73%	**96.5%**	29
X	Methyl Ethyl Ketone	Fisher Scientific	solvent	70	100%	99.57%	93.40%	**96.5%**	30
○	Daraclean *	Magnaflux	aqueous	131	25%	92.75%	100.18%	**96.5%**	31
●	SW-LF OzzyJuice	ChemFree Corp	aqueous / microbial	105	100%	94.14%	98.36%	**96.3%**	32
○	NZD Ultra Degreaser *	Global Specialty Products	solvent	70	100%	99.73%	92.41%	**96.1%**	33
●	US-2003	Anchor Atlantic	semi-aqueous	160	10%	92.69%	99.43%	**96.1%**	34
▼	Axarel 58	Petroferm Inc.	bio-based solvent	150	100%	95.90%	95.49%	**95.7%**	35
▼	SW-8 Aircraft OzzyJuice	ChemFree Corp	aqueous / microbial	105	100%	93.06%	97.74%	**95.4%**	36
○	Powerkleen III *	Mart Corporation	bio-based solvent	160	2.2%	90.40%	99.50%	**94.9%**	37
○	Vertrel CMS *	Dupont	solvent	70	100%	91.38%	98.32%	**94.8%**	38
▼	SS-HD Parts Washer Formulation	Solvent Systems International	semi-aqueous	110	20%	89.43%	100.00%	**94.7%**	39
●	Millennium	Inland Technology Inc	aqueous	105	25%	89.12%	99.02%	**94.1%**	40
○	EXP 1300 *	Brulin	aqueous	145	3.6%	85.86%	99.66%	**92.8%**	41
○	Natural Orange *	Giant Cleaning Systems	bio-based solvent	160	0.5%	97.12%	85.06%	**91.1%**	42
○	Low pH Concentrated Cleaner *	Spray-Nine	semi-aqueous	130	10%	94.18%	87.98%	**91.1%**	43
▼	Oleocal ME-130	SoySolv	bio-based solvent	160	100%	97.57%	81.29%	**89.4%**	44
●	Citrusoy Super High Flash	Florida Chemical Company	bio-based solvent	160	100%	97.46%	71.93%	**84.7%**	45
●	Armakleen M400	Church & Dwight	aqueous	160	7.5%	67.51%	99.04%	**83.3%**	46
●	Silicon Wash Concentrate	Silicon Chemistries Solutions	aqueous	140	16.7%	67.30%	98.30%	**82.8%**	47
●	Agriplast	Cook Composites	bio-based solvent	130	100%	63.84%	94.43%	**79.1%**	48
●	SoySolv II Plus	SoySolv	bio-based solvent	70	100%	99.58%	57.39%	**78.5%**	49
●	EnviroLogic - Partwasher Solution	EnviroLogic	aqueous / microbial	100	10%	80.79%	76.11%	**78.4%**	50
X	Acetone *	Fisher Scientific	solvent	70	100%	99.39%	32.18%	**65.8%**	51
X	Isopropanol	Fisher Scientific	solvent	70	100%	100.18%	23.66%	**61.9%**	52
○	Simple Green *	Sunshine Makers	bio-based solvent	70	100%	81.11%	11.93%	**46.5%**	53
○	Neugenic 4177 *	Rochester Midland	semi-aqueous	70	100%	83.50%	-11.60%	**36.0%**	54
○	Spray-Nine AV-8 *	Spray-Nine	semi-aqueous	70	10%	67.97%	1.79%	**34.9%**	55
●	Green 4 Kleen	IPAX Cleanogel Inc	aqueous	70	12%	53.34%	0.20%	**26.8%**	56
●	Clean Safe 7448-05	Petroferm Inc.	semi-aqueous	160	11.1%	268.76%	175.51%	**Disregard**	N/A

▼- On-Site and Lab Tested ● - NASA Identified Chemistries ○ - RIT Identified Chemistries X, X, X, X – Benchmarks

3.1 Site Demonstrated Chemistries - Results

Table 3.3.1 outlines how the nine site-demonstrated part washers performed according to laboratory analysis and according to personnel who worked with each cleaning chemistry. They are ordered according to cleaning efficiency as determined in laboratory testing. It should be noted that there is a difference between *Overall Score* and *AVG*. This can be explained by the nature of the questions asked during the interview. Some questions cross-over categories and therefore included multiple times when computing the *Overall Score*. The average of all ranking questions asked (without duplicates) is represented in *AVG*.

Table 3.1.1: Field & Laboratory Results

Laboratory - Cleaning Efficiency Results				Site Demonstration Scorecard					
				Workers Scored on These Topics from 1 (worst) to 10 (best)					
Chemistry Name	Supplier Name	Average Cleaning Efficiency	Rank	Cleaning Effectivness	Ease of Use	Negative Smell	Would Replace Current Chemistry	Overall Score	AVG
		%	-						
Heavy Duty Cleaner	Phase III Inc.	100.09%	1	5.86	6.76	9.00	6.33	*6.38*	***6.87***
California PW Solution	Phase III Inc.	99.36%	7	7.86	8.29	9.00	9.39	*8.64*	***8.63***
Breakthrough	Inland Technology Inc	99.22%	10	7.71	6.87	10.00	7.82	*7.36*	***7.95***
Armakleen M-Aero	Church & Dwight	99.13%	12	6.57	6.76	5.50	6.85	*6.91*	***6.52***
Bioact MSO	Petroferm Inc.	98.78%	14	8.57	9.07	10.00	9.46	*9.20*	***9.26***
Axarel 58	Petroferm Inc.	95.70%	35	2.00	2.83	8.00	2.64	*2.75*	***3.64***
SW-8 Aircraft OzzyJuice	ChemFree Corp	95.40%	36	6.43	6.34	10.00	5.97	*5.91*	***6.93***
SS-HD PW Formulation	Solvent Systems Intnl	94.72%	39	8.43	8.74	10.00	9.52	*9.09*	***9.16***
Oleocal ME-130	SoySolv	89.43%	44	5.14	6.51	9.00	6.21	*6.18*	***6.61***

Table 3.1.2 shows the cleaning efficiency for both contaminants, the average cleaning efficiency and rank of all site-tested chemistries in comparison to the four benchmarks tested in the laboratory.

Table 3.1.2: Site Demonstration Cleaning Efficiency / Benchmarks

Chemistry Name	Supplier Name	Cleaning Efficiency Contam. 1	Cleaning Efficiency Contam. 2	Average Cleaning Efficiency	Rank
		%	%	%	-
Heavy Duty Cleaner	Phase III Inc.	99.99%	100.18%	100.09%	1
Mineral Spirits	**Fisher Scientific**	**99.59%**	**99.77%**	**99.68%**	**3**
California Parts Washer Solution	Phase III Inc.	99.12%	99.59%	99.36%	7
Breakthrough	Inland Technology Inc	98.97%	99.46%	99.22%	10
Armakleen M-Aero	Church & Dwight	99.10%	99.17%	99.13%	12
Bioact MSO	Petroferm Inc.	98.82%	98.75%	98.78%	14
Methyl Ethyl Ketone	**Fisher Scientific**	**99.57%**	**93.40%**	**96.48%**	**30**
Axarel 58	Petroferm Inc.	95.90%	95.49%	95.70%	35
SW-8 Aircraft OzzyJuice	ChemFree Corp	93.06%	97.74%	95.40%	36
SS-HD Parts Washer Formulation	Solvent Systems Intnl	89.43%	100.00%	94.72%	39
Oleocal ME-130	SoySolv	97.57%	81.29%	89.43%	44
Acetone *	**Fisher Scientific**	**99.39%**	**32.18%**	**65.79%**	**51**
Isopropanol	**Fisher Scientific**	**100.18%**	**23.66%**	**61.92%**	**52**

X, X, X, X – Benchmarks

3.2 Cost Matrix

The cost of chemistries that were reviewed as a part of this project is listed in the tables below. Each vendor was asked to provide the cost of their product per gallon. The price of individual gallons is typically higher than if buying in bulk so if an intermediate sized container was available (5 or 10 gallon) its price per gallon was calculated based on that intermediate size. From these prices per gallon, if a vendor suggested dilution rates, the cost per gallon was adjusted to compensate. The end calculation shows an estimated cost per gallon after dilution. To assist in selecting an alternative, the tables also show the cleaning efficiency rank of the chemistry.

In Table 3.2.1, chemistries that were tested on-site, the score-card average score is listed (10 being best) along with the cost and cleaning efficiency rank are listed.

Table 3.2.1: Site Demonstration / Benchmark Cost Matrix

ID	Chemistry	Supplier	Realized Cost ($/gal)	Cost ($/gal)	Concen-tration	CE Rank	Score Card (AVG)
▼	Heavy Duty Cleaner	Phase III Inc.	$4.99	$24.95	20.0%	1	6.87
X	Mineral Spirits (Stoddard Solvent)	Fisher Scientific	$6.37	$6.37	100.0%	3	N/A
▼	California Parts Washer Solution	Phase III Inc.	$3.27	$16.36	20.0%	7	8.63
▼	Breakthrough	Inland Technology Inc.	$31.24	$31.24	100.0%	10	7.95
▼	Armakleen M-Aero	Church & Dwight	$1.47	$19.55	7.5%	12	6.52
▼	Bioact MSO	Petroferm Inc.	$4.72	$18.86	25.0%	14	9.26
X	Methyl Ethyl Ketone	Fisher Scientific	$17.37	$17.37	100.0%	30	N/A
▼	Axarel 58	Petroferm Inc.	$19.63	$19.63	100.0%	35	3.64
▼	SW-8 Aircraft OzzyJuice	ChemFree Corp	$17.50	$17.50	100.0%	36	6.93
▼	SS-HD PW Formulation	Solvent Systems Intnl.	Service	$ 75/yr	20.0%	39	9.16
▼	Oleocal ME-130	SoySolv	$16.66	$16.66	100.0%	44	6.61
X	Acetone	Fisher Scientific	$12.97	$12.97	100.0%	51	N/A
X	Isopropanol	Fisher Scientific	$19.60	$19.60	100.0%	52	N/A

Table 3.2.2: Cost Matrix for All Chemistries

ID	Chemistry	Supplier	Realized Cost ($/gal)	Cost ($/gal)	Concen-tration	CE Rank
▼	Heavy Duty Cleaner	Phase III Inc.	$4.99	$24.95	20.00%	1
●	SoySolv II Plus	SoySolv	$16.58	$16.58	100.00%	2
X	Mineral Spirits (Stoddard Solvent)	Fisher Scientific	$6.37	$6.37	100.00%	3
○	Optima 2001 CR	Global Specialty Products	$15.50	$15.50	10.00%	4
●	SoySolv II	SoySolv	$16.58	$16.58	100.00%	5
○	Aerowash 4	Rochester Midland	$1.84	$9.20	20.00%	6
▼	California Parts Washer Solution	Phase III Inc.	$3.27	$16.36	20.00%	7
●	EnviroClear	Soy Technologies	$31.91	$31.91	100.00%	8
●	Armakleen MPC Concentrate	Church & Dwight	$1.44	$19.15	7.50%	9
▼	Breakthrough	Inland Technology Inc	$31.24	$31.24	100.00%	10
○	Aerowash 4	Rochester Midland	$0.92	$9.20	10.00%	11
▼	Armakleen M-Aero	Church & Dwight	$1.47	$19.55	7.50%	12
●	SW-3 OzzyJuice	ChemFree Corp	$16.80	$16.80	100.00%	13
▼	Bioact MSO	Petroferm Inc.	$4.72	$18.86	25.00%	14
○	Flightline 2	Rochester Midland	$2.10	$10.50	20.00%	15
○	Flightline 2	Rochester Midland	$1.05	$10.50	10.00%	16
●	Armakleen HP-2	Church & Dwight	$1.20	$16.06	7.50%	17
●	Soy Green Solvent (SG5000)	Soy Technologies	$23.29	$23.29	100.00%	18
○	Cleanaire 1200	Rochester Midland	$0.16	$5.35	3.00%	19
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	$13.99	$13.99	100.00%	20
●	Bio-Circle-L	Walter Surface Technologies	$35.80	$35.80	100.00%	21
●	Aquaworks MM Dip Concentrate	Church & Dwight	$1.44	$19.15	7.50%	22
●	Gold Matrix	Walter Surface Technologies	$20.60	$20.60	100.00%	23
●	Clean Safe 7445-05	Petroferm Inc.	$1.33	$12.00	11.11%	24
●	Bean-e-doo Parts Washer Solvent	Franmar Chemical	$7.00	$13.99	50.00%	25
○	Optima 100 GP	Global Specialty Products	$1.60	$16.00	10.00%	26
●	Sea Wash 8	Warren	$3.40	$68.00	5.00%	27
●	Armakleen M100	Church & Dwight	$1.40	$18.70	7.50%	28
●	KT600C	Kleen Tec	$4.32	$25.89	16.67%	29
X	Methyl Ethyl Ketone	Fisher Scientific	$17.37	$17.37	100.00%	30
○	Daraclean	Magnaflux	$4.80	$19.20	25.00%	31
●	SW-LF OzzyJuice	ChemFree Corp	$11.60	$11.60	100.00%	32
○	NZD Ultra Degreaser	Global Specialty Products	$26.00	$26.00	100.00%	33
●	US-2003	Anchor Atlantic	$1.29	$12.90	10.00%	34
▼	Axarel 58	Petroferm Inc.	$19.63	$19.63	100.00%	35
▼	SW-8 Aircraft OzzyJuice	ChemFree Corp	$17.50	$17.50	100.00%	36
○	Powerkleen III	Mart Corporation	$0.40	$18.30	2.20%	37
○	Vertrel CMS	Dupont	$312.00	$312.00	100.00%	38
▼	SS-HD Parts Washer Formulation	Solvent Systems International	Service	$ 75/yr	20.00%	39
●	Millennium	Inland Technology Inc	$6.99	$27.95	25.00%	40
○	EXP 1300	Brulin	N/A	N/A	3.60%	41
○	Natural Orange	Giant Cleaning Systems	$0.18	$36.00	0.50%	42
○	Low pH Concentrated Cleaner	Spray-Nine	$0.82	$8.16	10.00%	43
▼	Oleocal ME-130	SoySolv	$16.66	$16.66	100.00%	44
●	Citrusoy Super High Flash	Florida Chemical Company	$20.00	$20.00	100.00%	45
●	Armakleen M400	Church & Dwight	$1.51	$20.15	7.50%	46
●	Silicon Wash Concentrate	Silicon Chemistries Solutions	Service	Service	16.67%	47
●	Agriplast	Cook Composites	$12.00	$12.00	100.00%	48
●	SoySolv II Plus	SoySolv	$16.58	$16.58	100.00%	49
●	EnviroLogic - Partwasher Solution	EnviroLogic	$3.18	$31.76	10.00%	50
X	Acetone	Fisher Scientific	$12.97	$12.97	100.00%	51
X	Isopropanol	Fisher Scientific	$19.60	$19.60	100.00%	52
○	Simple Green	Sunshine Makers	$10.99	$10.99	100.00%	53
○	Neugenic 4177	Rochester Midland	$14.90	$14.90	100.00%	54
○	Spray-Nine AV-8	Spray-Nine	$1.30	$12.95	10.00%	55
●	Green 4 Kleen	IPAX Cleanogel Inc	$0.71	$5.90	12.00%	56
●	Clean Safe 7448-05	Petroferm Inc.	$1.22	$11.00	11.11%	N/A

▼- On-Site and Lab Tested ● - NASA Selected Chemistries ○ - RIT Selected Chemistries X, X, X, X – Benchmarks

4.0 ANALYSIS OF ON-SITE PART WASHER DEMONSTRATIONS

(Part Washers are ordered alphabetically)

Table of Contents

4.1 LEGEND FOR PRODUCT SHEETS

Introduction:

In an effort to make this guideline as simple as possible to quickly reference, several symbols, charts and graphs are included for each chemistry that was evaluated during site assessments. Some of these also appear with chemistries that were only tested in the laboratory as well. This should allow the shop or procurement the ability to easily identify what type of material they are selecting and how well it performed without having to read a lengthy technical document.

Chemical Characteristic Symbols:

One or more symbols appear next to the description of the alternative chemistry tested during this project. The symbol shows what category the material belongs to. In some cases, chemistries will have multiple categories (i.e. Bio-Based Solvent or Solvent with Microbial Cleaners).

 **- Bio Based Cleaner (Soy, Citrus, etc.)**

 **- Biodegradable**

 **- Aqueous Based**

 **- Solvent Based**

 **- Microbial Cleaner / Recycling Unit Available for Washer**

Chart and Graph Symbols:

Four benchmark chemistries were tested during the laboratory phase of this project for comparative purposes. Each benchmark will be listed by the following symbols and colors throughout all graphs and charts in this guide. Lastly, a single symbol (▼) will be used to identify the alternative that the particular section of this guide is discussing. This way, it can be quickly determined how well any particular alternative performed in comparison to each of the benchmarks.

X – Acetone
X – Isopropanol
X - Methyl Ethyl Ketone
X - Mineral Spirits
▼- Alternative Test Chemistries

Ranking Charts:

For each alternative chemistry tested, five charts will show the cleaning efficiency, VOC Content and realized cost ($/gal based on dilutions). Although these charts appear to be similar, they should be interpreted differently. The examples on the following page describe how each should be interpreted. All charts are ordered left-to-right from best to worst.

Chart 1: Test Chemistry Characteristics

This chart simply shows the tested chemistry's characteristics, Flash Point, VOC Content and pH, when applicable. Some chemistries did not have a flash point and/or pH was not available. In these cases, "N/A" is listed.

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
>212 ºF	13.7 g/L	11.6

Chart 2: Chemistry Characteristics Compared to Benchmarks

This chart shows the test chemistry in comparison to the tested benchmarks. Here, test chemistries' physical characteristics are compared directly to Acetone, Isopropanol, Methyl Ethyl Ketone and Mineral Spirits.

Chemistry	Tested Chemistry	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	>212 ºF	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	13.7 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	160 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	7.50%	100%	100%	100%	100%

Chart 3: Realized Cost

This chart shows the realized cost per gallon of the chemistries. Cost was determined by taking the price per gallon and multiplying it by the concentration percentage (i.e. $5.35/gal * .03 = $0.16/gal). The cheapest chemistry per gallon ($0.16/gal) is on the far left, while the most expensive ($312.00/gal) is on the far right. This chart is also not represented in a true linear format. For this reason, the realized costs of importance for each chart will be printed below the chart. It should be noted that one of the chemistries is no longer available on the market and two are only available through a service plan or contract so the cost per gallon could not be accurately determined. These three chemistries will not be represented in these charts unless noted.

Chart 4: Site Evaluation Scorecard

Nine of the cleaning chemistries reviewed during this project were also demonstrated at separate sites across five NASA Centers. During that time, a series of three interviews were given to shop workers that used the alternative chemistries. Workers were asked to rank different aspects of the alternative, sometimes against their currently or historically used cleaners, on a scale of 1 to 10 with 10 being the best. These questions were categorized and averaged to give a scorecard that covers each category. Some questions were asked several times over the 45 day testing period while others only applied to setup/teardown and overall use/opinion. The chart shows numerically and graphically how well chemistries were perceived to have performed by shop workers. In these charts, green represents positive perception, red represents poor perception.

Effectivness	5.14	
Ease of Use	6.51	
Smell	9.00	
Replace?	6.21	
Overall	6.18	
AVERAGE	6.61	

Charts 5-7: Cleaning Efficiency

This chart shows how well the chemistry cleaned, far left point is the highest cleaning efficiency and far right is the lowest cleaning efficiency. For each chemistry, three of these charts will be listed, efficiency of cleaning Contaminant #1, efficiency of cleaning Contaminant #2 and the Average Cleaning Efficiency. It should be noted that one of the chemistries caused damage to the test coupon and will not be represented in these charts.

4.2 - AXAREL 58

Company: Petroferm
Washer Unit: Omega Systems Inc.
NASA-Site Testing: MSFC
Type of Shop: EG&G Logistics (Motor Pool)

Description:

Axarel 58 is a blend of esters, citrus terpenes and surfactants formulated to offer a balance of selective solvency, low toxicity and no environmental impact. It is biodegradable and does not contribute to ozone depletion. It has a low VOC content and is a concentrate, but is most powerful when used at full strength. Axarel 58 effectively removes light oils, greases, lubricants and other metal-working soils. It provides some corrosion protection when left on the surface of a metal part, but may be also blended with other corrosion inhibitors.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
175 ºF	< 25 g/L	N/A

Note: APPENDIX B includes MSDS for Axarel 58. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

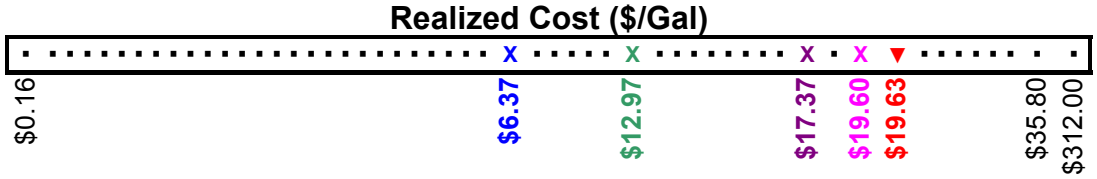
Chemistry	Axarel 58	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	175 ºF	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	< 25 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	150 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	100%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
20 gal	$19.63	$392.60

Note: Axarel 58 can be purchased in can be purchased in 1 gallon and greater quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.2 - AXAREL 58

Site Demonstration Analysis:

Personnel on-site at MSFC used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

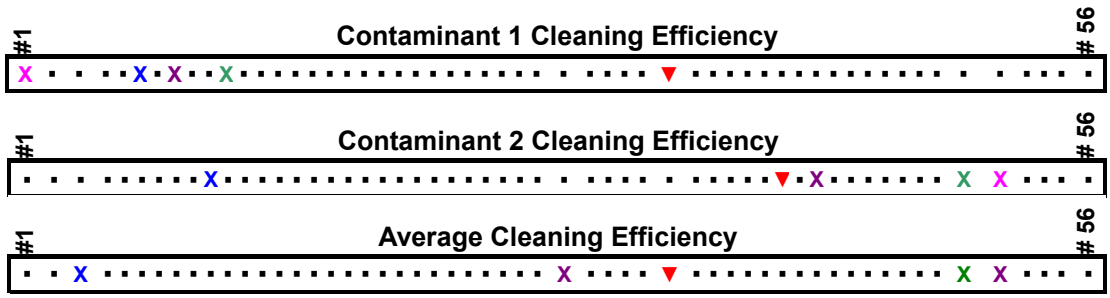
Axarel 58 - Site Demonstration Scorecard	
Effectivness	2.00
Ease of Use	2.83
Smell	8.00
Replace?	2.64
Overall	2.75
AVERAGE	***3.64***

Interview Comments:

Workers interviewed at MSFC's Motor Pool noted that their current cleaner (recycling unit with Mineral Spirits) cleaned very well for their needs and was easy to use. They noted that they are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. Only parts that have "caked on" grease are difficult to clean with their current washer. Soon after testing the alterative chemistry in their operations (5 parts cleaned), workers noted that Axarel 58 did clean some parts but overall worked poorly for their needs. It left an undesirable oily residue and workers requested discontinuation of its use. This factor, along with poor cleaning characteristics, were reason enough for workers to not desire or suggest the use of Axarel 58 in Motor Pools or Heavy Equipment Shops. This chemistry scored the lowest of all based on the quantitative questions asked during interviews.

Laboratory Analysis:

Axarel 58 was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the Axarel 58 solution are show below:



Contact Information:

Petroferm Inc.,
2416 Lynndale Road,
Fernandina Beach, FL 32034
Phone: 904-261-8286 or Fax: 904-261-6994
http://www.petroferm.com

Omega Recycling Technologies
5742 Ferrier Montreal, Qc
H4P 1M7 - Canada
Phone: 1-800-361-1194
http://www.omega-systems.ca

4.3 - BIOACT MSO

Company: Petroferm
Washer Unit: Omega Systems Inc.
NASA-Site Testing: KSC
Type of Shop: Industrial Chiller Plant

Description:

BIOACT MSO Precision Cleaner is a blend of citrus terpenes and surfactant agents formulated for high soil-loading capacity and free-rinsing characteristics. It is readily biodegradable, essentially non-toxic, and does not contribute to ozone depletion. BIOACT MSO is a semi-aqueous cleaning agent suitable for removing a wide variety of soils. It was specially developed to rinse completely from surfaces, leaving no residue to interfere with subsequent processing of the parts.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
N/A	745 g/L	N/A

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for BIOACT MSO. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

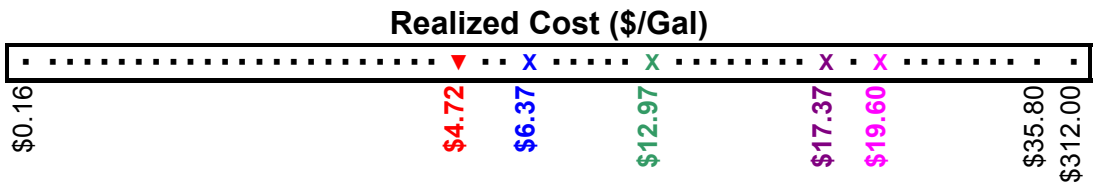
Chemistry	Bioact MSO	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	N/A	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	745 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	110 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	25%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
5 gal	$18.86	$94.30

Note: BIOACT MSO can be purchased in can be purchased in 5 gallon and greater quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.3 - BIOACT MCO

Site Demonstration Analysis:

Personnel on-site at KSC used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

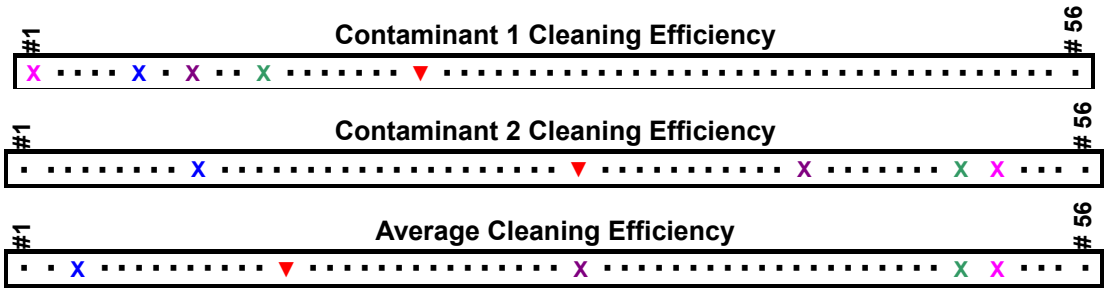
Bioact MCO - Site Demonstration Scorecard	
Effectivness	8.57
Ease of Use	9.07
Smell	10.00
Replace?	9.46
Overall	9.20
AVERAGE	***9.26***

Interview Comments:

Workers interviewed at KSC's Industrial Chiller Plant (ICP) noted that their current cleaner (OzzyJuice SW-3) cleaned very well for their needs and was easy to use. They noted that they are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. This shop cleans bearings, housings, couplings, springs, bolts and other miscellaneous metal parts. Only parts contaminated with heavy grease are more difficult to clean with their current washer. Soon after testing the alterative chemistry in their operations (5-8 parts), workers noted that BIOACT MSO cleaned better than their current washer, but not as well as Mineral Spirits. They noted that it did not have an undesirable odor and did not leave residue on parts. Workers noted that it had a significantly better smell and did not dry or irritate the skin. After completion of the testing (20-25 parts), workers were very pleased with BIOACT MSO. Workers felt it was better than other alternatives they have tried and would recommend its use in similar environments. KSC is hoping to fund the permanent use of BIOACT MSO in the ICP.

Laboratory Analysis:

BIOACT MSO was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for BIOACT MSO are show below:



Contact Information:

Petroferm Inc.,
2416 Lynndale Road,
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http://www.petroferm.com

Omega Recycling Technologies
5742 Ferrier Montreal, Qc
H4P 1M7 - Canada
Phone: 1-800-361-1194
http://www.omega-systems.ca

4.4 BREAKTHROUGH

Company: Inland Technologies
Washer Unit: EDGE TEK, (Inland Technologies)
NASA-Site Testing: WFF
Type of Shop: Machine Shop

Description:

Breakthrough is an environmentally friendly blend cleaner that meets the specifications of PD-680 Type II. It is a virtually odorless, low toxicity, high-purity hydrocarbon that exhibits a very low degree of irritancy to the eyes and is non-irritating to the skin. It has low vapor pressure to control volatile organic compound (VOC) emissions, is non-photochemically reactive, non-carcinogenic and is exempt from SARA, Title III, Sections 302 or 313, CERCLA, and RCRA requirements. Inland Technologies parts washers utilize the Edge Tek filtration system which filters to .1 micron nominal and removes tramp oil and grease from the solvent.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
150 ºF	770 g/L	N/A

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for Breakthrough. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

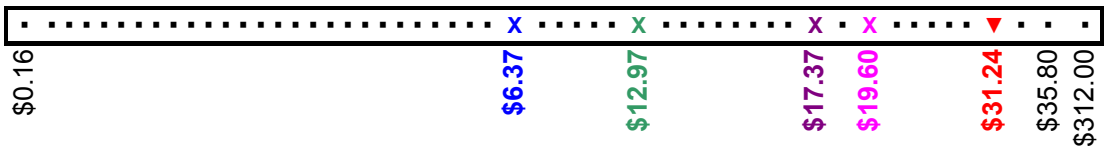
Chemistry	Breakthrough	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	150 ºF	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	770 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	70 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	100%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
20 gal	$31.24	$624.80

Note: Breakthrough can be purchased in can be purchased in 1 gallon and greater quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.4 BREAKTHROUGH

Site Demonstration Analysis:

Personnel on-site at WFF used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

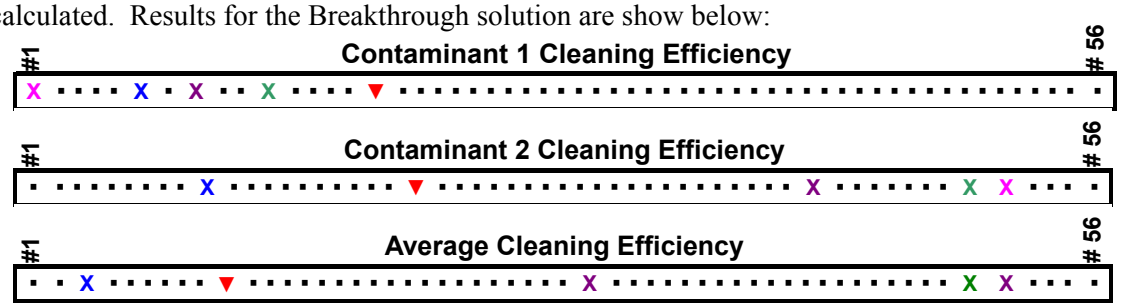
Breakthrough - Site Demonstration Scorecard	
Effectivness	7.71
Ease of Use	6.87
Smell	10.00
Replace?	7.82
Overall	7.36
AVERAGE	***7.95***

Interview Comments:

Workers interviewed at WFF's Machine Shop noted that their current cleaner (SafetyKleen Premium Gold 150) cleaned some parts well, but left residue on parts and could not be used on aluminum. They noted that they are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. This shop cleans machined rocket motor parts, deck plates, machining tools and other miscellaneous metal parts. Workers noted that their current cleaner cleaned grease better, but rocket parts cannot be cleaned because of the residue left behind. Soon after testing the alterative chemistry in their operations (20-30 parts), workers noted that though requiring a bit more work, Breakthrough cleaned very well for their needs, had no undesirable odor, and felt it was a better cleaner for their needs. Workers noted at this time that the chemistry did not dry as well but it was able to clean aluminum parts and did not remove paint, which is a redeeming value for their operations. After completion of the testing (>100 parts), workers were very pleased with Breakthrough. Workers felt it was better than other alternatives they have tried and would recommend its use in similar environments. WFF has begun using Breakthrough as its primary cleaner for this shop.

Laboratory Analysis:

Breakthrough was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the Breakthrough solution are show below:



Contact Information:

Inland Technology Incorporated
401 East 27th Street
Tacoma, WA 98421
Phone: 206-383-1177 or Fax: 206-593-8749

e-mail:
elethe@inlandtech.com

4.5 CALIFORNIA PART WASHER SOLUTION

Company: Phase III
Washer Unit: Kleentec.
NASA-Site Testing: KSC
Type of Shop: Central Heating Plant

Description:

California Parts Washer Solution is a Bio-based Microbial Parts Washer Solution. It is readily biodegradable and does not contribute to ozone depletion.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
N/A	<50 g/L	10

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for California Parts Washer Solution. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

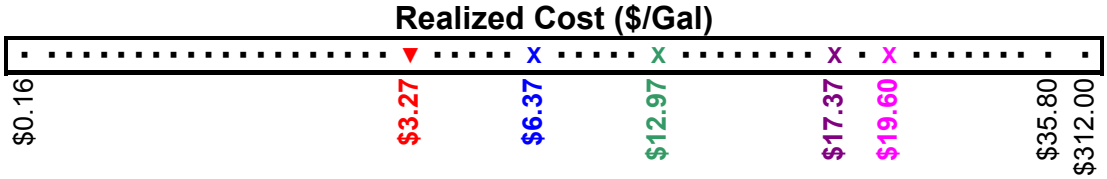
Chemistry	CA Part Washer Solution	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	N/A	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	< 50g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	105 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	20%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
4 gal	$16.36	$65.44

Note: California Parts Washer Solution can be purchased in 1 gallon and greater quantities.



***Note:** Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.5 CALIFORNIA PART WASHER SOLUTION

Site Demonstration Analysis:

Personnel on-site at KSC used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

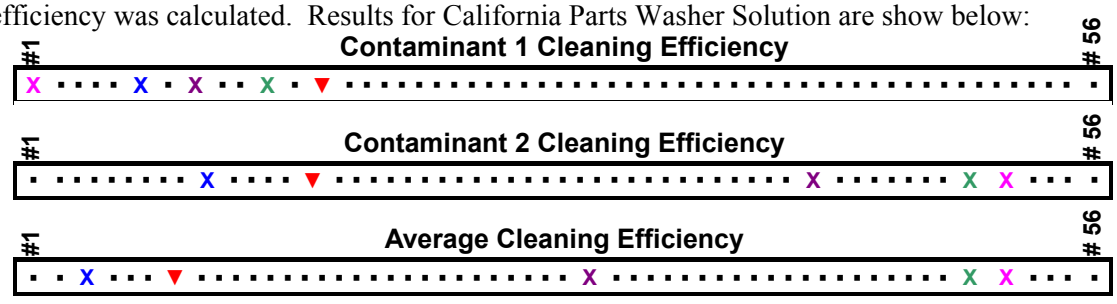
CA Part Washer Solution - Site Demonstration Scorecard	
Effectivness	7.86
Ease of Use	8.29
Smell	9.00
Replace?	9.39
Overall	8.64
AVERAGE	***8.63***

Interview Comments:

Workers interviewed at KSC's Central Heat Plant noted that their current cleaner (OzzyJuice SW-3) worked well for most applications in their shop but was unable to clean certain contaminants. Workers noted that they are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. The Central Heat Plant cleans valves, pumps, bearings and tools and miscellaneous metal parts. Contaminants include grease, gear oil, rust, carbon coking and burnt oil. After completion of the testing (≈ 100 parts), workers were very pleased with California Part Washer Solution. They noted that it worked better than their current cleaner, but still did not perform as well as Mineral Spirits. They noted that the solution did have an odor, but it was not at all undesirable and that the cleaner was able to clean all contaminants except carbon coking and burnt oil. Workers liked that the part washer equipment allowed them to soak parts in an agitator, so they could leave them in there and come back later to detail clean parts. Workers overall felt it was better than other alternatives they have tried and would recommend its use in similar environments. KSC's Central Heat Plant has decided to begin procuring California Part Washer Solution for this shop, but will also be keeping their other part washing unit.

Laboratory Analysis:

California Parts Washer Solution was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for California Parts Washer Solution are show below:



Contact Information:

Phase III Inc.
916 E. Baseline Rd. Suite 101
Mesa, Arizona 85204-6603
Phone: 480-503-2847 or Fax: 904-261-6994
http://www.petroferm.com

Kleentec
1212 Sykes Street
Albert Lea, MN 56007
Phone: 1-800-435-5336
http://www.kleentec.com

4.6 GREASE GATOR

Company: Solvent Systems International
Washer Unit: Grease Gator
NASA-Site Testing: MSFC
Type of Shop: CG&G Building (Machine Shop)

Description:

Grease Gator is a self cleaning aqueous solution with a patented mechanical oil separation process. Separated oil is ready for recycling.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
N/A	25 g/L	11.5

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for Grease Gator. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

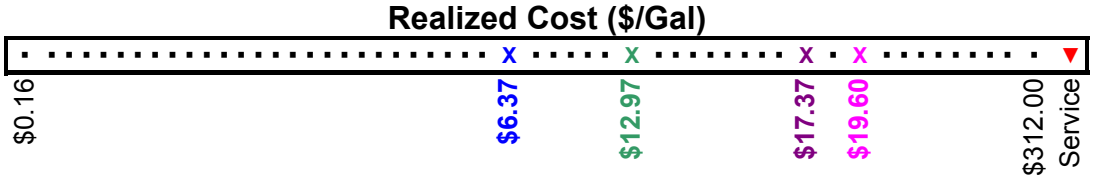
Chemistry	Grease Gator (SS-HD)	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	N/A	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	25 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	110 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	20%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
5 gal	$75/year	$75/year

Note: Grease Gator can be purchased as a service, where cleaning fluids are replaced and the equipment is maintained by Solvent-Systems International.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.6 GREASE GATOR

Site Demonstration Analysis:

Personnel on-site at MSFC used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

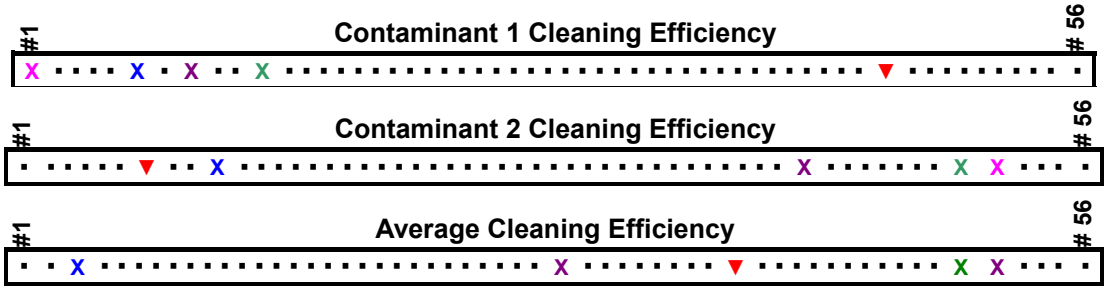
Solvent Systems - Grease Gator - Site Demonstration Scorecard	
Effectivness	8.43
Ease of Use	8.74
Smell	10.00
Replace?	9.52
Overall	9.09
AVERAGE	***9.16***

Interview Comments:

Workers interviewed at MSFC's PM Shop noted that their current cleaner (Degreasol Solvent) worked very well for all applications in their shop. They noted that their current cleaner has a very harsh odor, and for this reason, it is kept outside the building. Workers are open to using an alternative, but only if it works as well or better than their current cleaner. The PM Shop cleans mechanical parts from general vehicle, crane, emergency generators and other miscellaneous metal parts. Contaminants include oil and grease. Soon after testing began (25-30 parts) workers noted that Solvent Systems Grease Gator worked very well for all applications in their shop, had no undesirable odor and it took less time to clean parts than with their current cleaner. They also noted that the unit requires slightly more maintenance than their other unit, but this was acceptable. After completion of testing (>45 parts) workers were very pleased with the Grease Gator. Workers noted that baked on oils and grease were harder to clean than expected, but that the chemistry performed better than their current cleaner and the odor was far superior. Workers would recommend its use in similar environments. MSFC's PM Shop has decided to procure the Grease Gator for their use.

Laboratory Analysis:

Grease Gator was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the Grease Gator Solution are show below:



Contact Information:

Solvent Systems International
70 King St.
Elk Grove Village, IL 60007
Phone: 847-437-1100 ext 18 or Fax: 904-261-6994

Steve Rundell: srundell@solvent-systems.com

4.7 HEAVY DUTY

Company: Phase III Inc.
Washer Unit: KleenTec
NASA-Site Testing: GSFC
Type of Shop: Machine Shop, Bldg. N050B

Description:

Phase III Heavy Duty is a microbial parts washer solution. It is a readily biodegradable surfactant system that delivers low Dynamic Surface Tension (DST), critical to optimum cleaning.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
N/A	<25 g/L	10

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for Phase III Heavy Duty. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

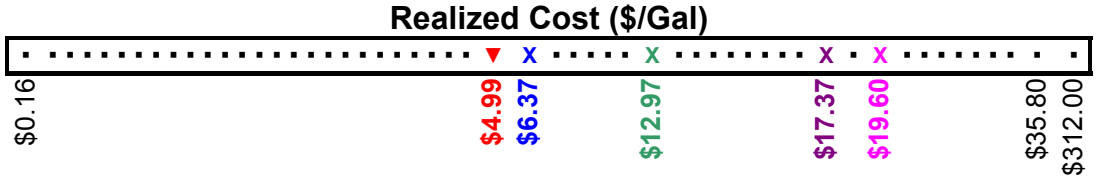
Chemistry	Heavy Duty Cleaner	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	N/A	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	<25 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	105 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	20%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
4 gal	$24.95	$99.80

Note: Phase III Heavy Duty can be purchased in 1 gallon and greater quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.7 HEAVY DUTY

Site Demonstration Analysis:

Personnel on-site at GSFC used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

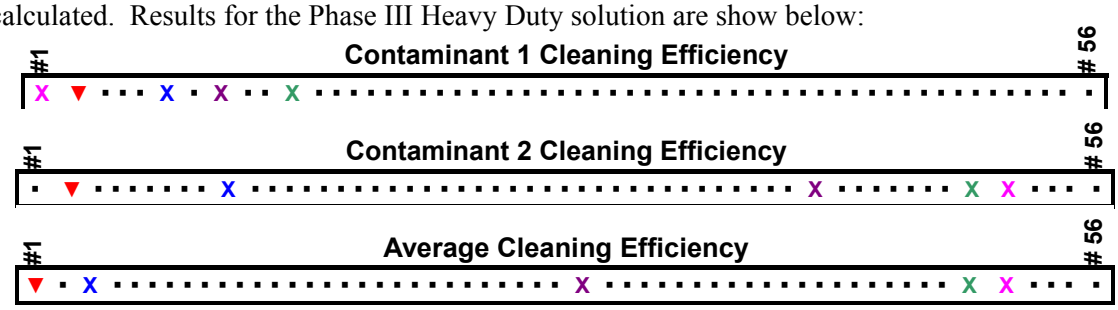
Heavy Duty - Site Demonstration Scorecard		
Effectivness	5.86	
Ease of Use	6.76	
Smell	9.00	
Replace?	6.33	
Overall	6.38	
AVERAGE	***6.87***	

Interview Comments:

Workers interviewed at GSFC's Advanced Manufacturing Shop noted that their current cleaner (High pressure hot water spray cabinet with detergent) works well for most applications in their shop, but takes a significant amount of time (20-25 min/part), is bulky and generates a lot of waste. Additionally, their current cleaning system cannot clean heat-sensitive parts, electric parts, removes paint and leaves a film on parts. Workers noted they are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. The Advanced Manufacturing Shop cleans bearings, machined parts and housings, miscellaneous metal parts and other substrates. Contaminants include machine coolant, grease and oils. Initially, workers were hesitant about the test chemistry and uncertain if it cleaned well for their needs, but by completion of testing, workers were very pleased with the Phase III Heavy Duty Cleaner. Workers noted that in some cases it worked better than their current cleaner, but felt that Mineral Spirits cleaned better. Workers also noted that while it took more effort to clean parts with the manual unit, it was easier to maintain and generated less waste than current equipment. Workers would recommend the use of this chemistry in similar environments. GSFC's Advanced Manufacturing Shop is in the process of procuring Phase III Heavy Duty Cleaner for their use.

Laboratory Analysis:

Phase III Heavy Duty was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the Phase III Heavy Duty solution are show below:



Contact Information:

Phase III Inc.
916 E. Baseline Rd. Suite 101
Mesa, AZ 85204-6603
Phone: 480-503-2847 or Fax: 480-503-1077
richard@phaseiii.com

Kleentec
1212 Sykes Street
Albert Lea, MN 56007
Phone: 1-800-435-5336
http://www.kleentec.com

4.8 M-AERO

Company: ArmaKleen Company
Washer Unit: Safety-Kleen Systems Inc.
NASA-Site Testing: KSC
Type of Shop: Machine Shop

Description:

M-Aero is an aqueous, silicated, non-corrosive alkaline concentrated cleaner that is to be diluted with water. It is safe on all metals and most plastics.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
>212 ºF	13.7 g/L	11.6

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for M-Aero. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

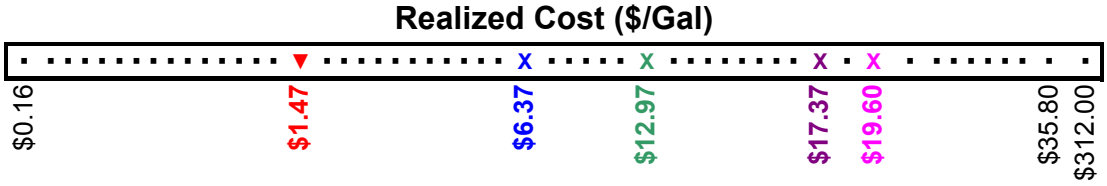
Chemistry	Armakleen M-Aero	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	>212 ºF	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	13.7 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	160 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	7.50%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
1.5 gal	$19.55	$29.33

Note: M-Aero can be purchased in 1 gallon and greater quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.8 M-AERO

Site Demonstration Analysis:

Personnel on-site at KSC used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

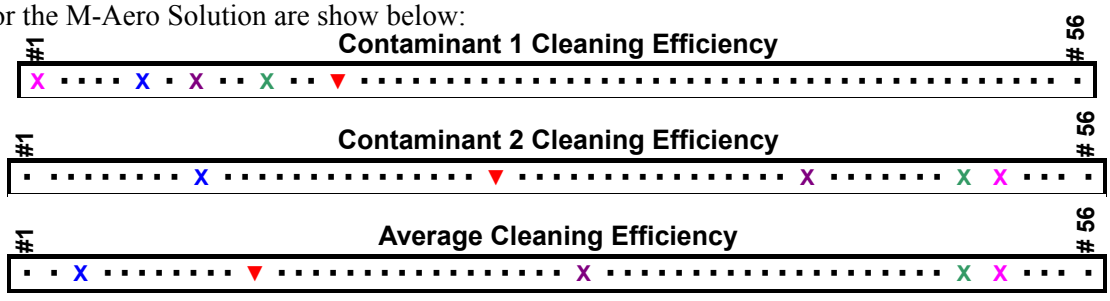
M-Aero - Site Demonstration Scorecard	
Effectivness	6.57
Ease of Use	6.76
Smell	5.50
Replace?	6.85
Overall	6.91
AVERAGE	***6.52***

Interview Comments:

Workers interviewed at KSC's LETF Machine Shop noted that their current cleaner (Electron Solvent) works well for their needs, but that it had an odor and dried out worker's hands. They noted that their current solvent cleaned old oils particularly well and that they were open to using an alternative as long as it performed as well as their current cleaner. Workers are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. The LETF Shop cleans machined parts, mechanical parts and other miscellaneous metal and plastic parts. Contaminants include cutting fluids, oils and grease. Soon after testing began (15-20 parts) workers noted that ArmaKleen M-Aero cleaned well for their applications, smelled better and did not dry out their hands as much as their current cleaner. Workers noted that it works as well as their current cleaner in all applications, but did not work for some applications as well as another alternative they have tested (Sea Wash). After completion of testing (>20 parts) workers were very pleased with M-Aero and some noted that they found it to work better than their current cleaner. Workers overall felt it was better than some of alternatives they have tried and would recommend its use in similar environments. KSC's LETF Machine Shop has decided to procure ArmaKleen M-Aero for use in their shop.

Laboratory Analysis:

M-Aero was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the M-Aero Solution are show below:



Contact Information:

The ArmaKleen Company.
469 North Harrison Street
Princeton, NJ 08543
Phone: 609-683-5900 or Fax: 904-261-6994
Aladino.Ramos@Safety-Kleen.com

Safety-Kleen Systems, Inc.
5400 Legacy Drive, Cluster II, Bldg 3
Plano, TX 75024
Phone: 1-800-669-5740
http://www.safety-kleen.com

4.9 ME-130

Company: SoySolv
Washer Unit: SoySolv
NASA-Site Testing: MAF
Type of Shop: Garage

Description:

SoySolve ME-130 is a methyl-ester produced from soy-bean oil. It is based on natural raw materials and is practically non-toxic and is biodegradable. ME-130 may be used as a wetting agent in agricultural adjuvant formulations and as the base fluid in environmentally friendly solvents and cleaning products, as was the case for this trial.

Chemical Characteristics:

Flash Point (°F)	VOC Content (diluted)	pH (Concentrate)
>300 °F	< 50 g/L	N/A

Note: APPENDIX B includes MSDS and/or Technical Data Sheets SoySolve ME-130. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

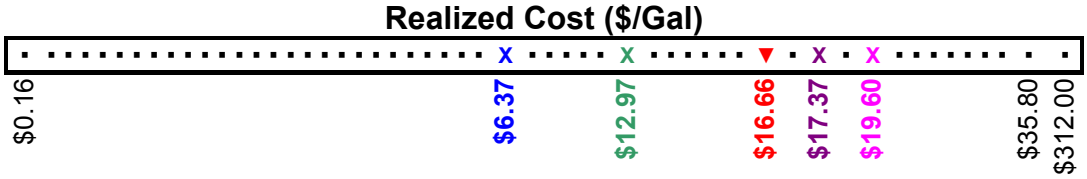
Chemistry	Oleocal ME-130	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	>300 °F	0 °F	53 °F	22 °F	102 °F
VOC Content	<50 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	160 °F	70 °F	70 °F	70 °F	70 °F
Concentration	100%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
20 gal	$16.66	$333.20

Note: SoySolve ME-130 can be purchased in 1 gallon and greater quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.9 ME-130

Site Demonstration Analysis:

Personnel on-site at MAF used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

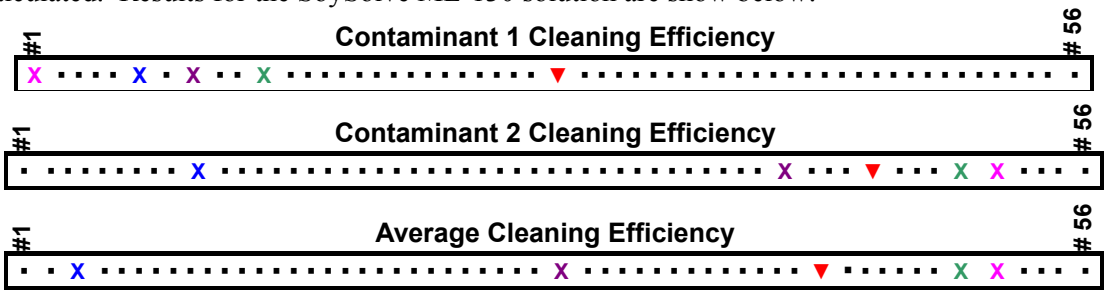
ME-130 - Site Demonstration Scorecard		
Effectivness	5.14	
Ease of Use	6.51	
Smell	9.00	
Replace?	6.21	
Overall	6.18	
AVERAGE	***6.61***	

Interview Comments:

Workers interviewed at MAF's Vehicle Maintenance Garage noted that their current cleaner (Zep Dyna 143) works well for their needs. They noted that their current solvent cleans light oils better than greases. Workers are open to using an alternative that is better for the environment even if it takes slightly longer to clean parts. The Vehicle Maintenance Garage cleans bearings, carburetors and other small engine parts. Contaminants include oils and greases. Soon after testing began (10-15 parts) workers noted that SoySolve ME-130 cleaned as well as their current cleaner for nearly all applications, but that the part washer equipment that was sent for testing was small and they would require a larger one if they wanted to use it for all parts in their shop. After completion of testing (≈50 parts) workers noted that the cleaner worked well, but required a lot more scrubbing than their current cleaner and did not dissolve grease. Workers felt that the test chemistry had a lower cleaning efficiency than their current cleaner, required more soaking and scrubbing and in some cases left residue on parts. They ranked the cleaner much lower during the initial interviews and overall felt that this chemistry was not as good as their current cleaner and would not select it for use in their shop, however, they are interested in trying other alternatives.

Laboratory Analysis:

SoySolve ME-130 was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the SoySolve ME-130 solution are show below:



Contact Information:

SoySolv
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Tiffin, OH. 44883
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sales@soysolv.com, www.soysolv.com

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4.10 OZZYJUICE SW-8

Company: ChemFree Corporation
Washer Unit: Smart Washer Bioremediating parts Washing System (ChemFree)
NASA-Site Testing: KSC
Type of Shop: NASA Hangar at Patrick AFB.

Description:

Ozzy Juice SW-8 is a Non Hazardous proprietary water based degreaser. Identified as SW-8 Aircraft and Weapons, it is environmentally safe and biodegradable. It is not corrosive to aircraft or weapons metals and is suitable for all painted and unpainted aircraft surfaces. The unique blend of surfactants effectively allows dirty deposits to be easily rinsed.

Chemical Characteristics:

Flash Point (ºF)	VOC Content (diluted)	pH (Concentrate)
N/A	10 g/L	9

Note: APPENDIX B includes MSDS and/or Technical Data Sheets for Ozzy Juice SW-8. Some substrates or materials may not be compatible with this cleaning chemistry, please see these additional documents and/or contact the manufacturer to determine if a compatibility issue exists prior to purchasing any new materials.

Characteristics Compared to Benchmarks:

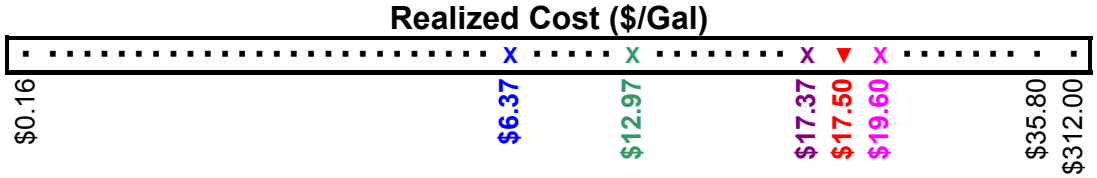
Chemistry	SW-8 Ozzy Juice	Acetone	Isopropanol	MEK	Mineral Spirits
Symbol	▼	X	X	X	X
Flash Point	N/A	0 ºF	53 ºF	22 ºF	102 ºF
VOC Content	10 g/L	790 g/L	790 g/L	810 g/L	790 g/L
Test Temp	105 ºF	70 ºF	70 ºF	70 ºF	70 ºF
Concentration	100.00%	100%	100%	100%	100%

Cost of Materials:

These are the estimated cost for procurement of enough materials to fill an average size part washer unit (20-30 gallon). These costs were estimated in June of 2005 and may fluctuate by region and over time.

Quantity	Unit Price	Total Price
20 gal	$17.50	$350.00

Note: Ozzy Juice SW-8 can be purchased in 5 gallon boxes and 55 gallon drum quantities.



Note: Three Chemistries were eliminated from this chart because they are only purchased as a service and therefore a cost per gallon cannot be calculated.

4.10 OZZYJUICE SW-8

Site Demonstration Analysis:

Personnel on-site at KSC (PAFB) used the equipment for at least a month and later answered a series of questions about the cleaning chemistry and how well it accomplished the day-to-day cleaning ongoing in their shop. Users were asked to compare the alternative unit with other units they have used or currently use for the same jobs.

Below is a scorecard that summarizes the quantitative questions asked during the on-site demonstration interviews. Full interview sheets are located in APPENDIX C.

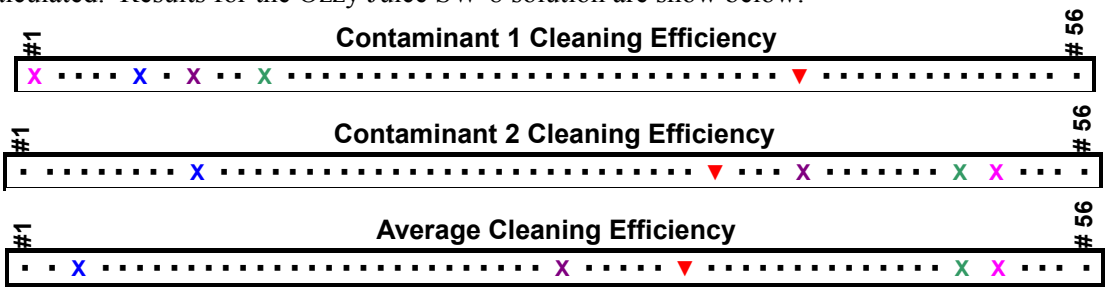
OzzyJuice SW-8 - Site Demonstration Scorecard	
Effectivness	6.43
Ease of Use	6.34
Smell	10.00
Replace?	5.97
Overall	5.91
AVERAGE	***6.93***

Interview Comments:

Workers interviewed at PAFB's NASA Aircraft Maintenance Hangar noted that their current cleaner (Mineral Spirits) works very well for their needs. They noted that their current equipment allows them to soak parts in the solvent prior to scrubbing. Workers are open to using an alternative as long as it performs as good as their current cleaner. The Aircraft Hangar cleans bearings, generator shrouds, oil filters and other miscellaneous parts. Contaminants include oils, grease and dirt. Soon after testing began (5 parts) workers noted that OzzyJuice SW-8 worked well on the parts they cleaned. They felt that it took almost the same amount of time to clean the parts, but with more scrubbing. After completion of the testing (>12 parts) workers felt the chemistry cleaned well for their applications, but were not entirely pleased with the setup of the equipment as they could not soak parts. They felt it took just as long to clean parts as with their current cleaner. While they noticed no odors during use, workers did mention that the chemistry is known to smell after some time of use, however. Workers overall felt that this cleaner is a good environmentally preferable cleaner for use in their hangar and would recommend it for use for some applications in similar environments, however, if implemented, they would still require a Mineral Spirits washer or other cleaner for more aggressive cleaning.

Laboratory Analysis:

OzzyJuice SW-8 was tested according to Section 4.5.8 of MIL-PRF-29602A for cleaning efficiency. Two synthetic contaminants were created for the test, according to specifications. Cleaning efficiency was calculated for each contaminant and an average cleaning efficiency was calculated. Results for the Ozzy Juice SW-8 solution are show below:



Contact Information:

ChemFree Corporation
8 Meca Way
Norcross, GA 30093
Phone: 770-564-5580, 800-521-7182

Smart Washer Bioremediating Parts Washing System
provided by ChemFree Corporation

www.chemfree.com

5.0 CLEANING EFFICIENCY TESTING METHOD

5.1 Test Procedures

Tests were performed according to Section 4.5.8 of MIL-PRF-29602 by Rochester Institute of Technology's (RIT) National Center for Remanufacturing and Resource Recovery (NC3R). This section of the report summarizes the operating procedures followed by RIT/NC3R for preparation, testing, and determination of cleaning efficiency for the selected cleaning chemistries tested for this project.

Prepare Test Coupons, Synthetic Hard Water, and Synthetic Contaminants
48 test coupons with dimensions 1" wide x 4" long x ¼" thick were manufactured from 6061 aluminum alloy in Rochester Institute of Technology's (RIT's) Brinkman CNC laboratory of the Rochester Institute of Technology, Rochester, New York.. Each coupon had a 1/16" depression in the center with dimensions as specified in MIL-PRF-29602A, part 4.5.8.3. Each test coupon was engraved with an ID number to facilitate quick identification, as shown below. Each test coupon weighed approximately 40 grams.

Test Coupons

NC3R prepared a quantity of synthetic hard water stock solution sufficient to support analysis of all cleaning chemistries evaluated in this project. The synthetic hard water was created from distilled water, reagent grade calcium acetate monohydrate, and reagent grade magnesium sulfate heptahydrate in accordance with MIL-PRF-29602A, part 4.5.5.1.

Two synthetic soil contaminants were created. The first soil contaminant (Contaminant #1) was composed of 10 parts MIL-G-21664 Aeroshell 17 molybdenum disulfide grease mixed with 1 part Raven 1040 carbon black in a high speed disperser. As mentioned previously, a high speed disperser was used to mix these components instead of the mechanical grease worker specified in MIL-PRF-29602A, part 4.5.8.1. Note also that MIL-C-29602 (the predecessor to MIL-PRF-29602A) called for the use of a high speed disperser to mix similar components (see Part 4.6.6.1.1). The resulting mixture was a jet black, viscous mixture.

The second soil contaminant (Contaminant #2) consisted of Alox 2028S, manufactured by Lubrizol Corporation, which acquired Alox Corporation. It should be noted that MIL-PRF-29602A calls for the use of Alox 2028, which is no longer manufactured, having

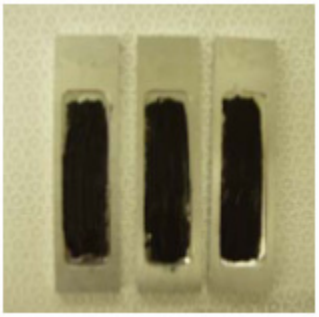
been replaced with Alox 2028S. Alox 2028S was used instead of Alox 2028 with prior approval from the NASA technical representatives on the project.

Selection of Cleaning Chemistries

After reviewing the list of cleaning chemistries provided by NASA AP2 Office, NC3R noted that certain mil spec-approved cleaning chemistries – as well as other cleaning chemistries of interest - were not on this list. These were not initially included for testing due to funding constraints. After discussing this with NASA AP2, NC3R agreed to evaluate these additional chemistries at no additional charge to NASA. In addition, some chemistries were tested under more than one operating condition, e.g. at a different temperature and concentration, as requested by the vendor. In some cases, this resulted in a significant change in cleaning efficiency. As a result, a total of 57 cleaning trials (not 36) were conducted for this project.

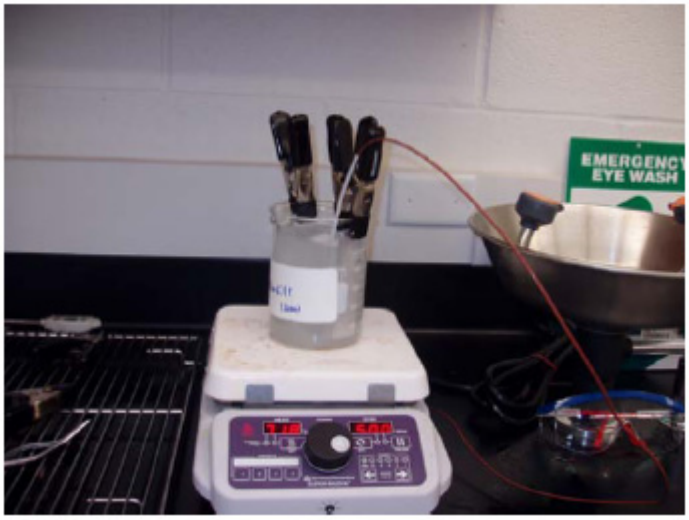
Conduct Cleaning Efficiency Testing per MIL-PRF-29602A, part 4.5.8

NC3R determined the cleaning efficiency of all cleaning chemistries evaluated in this project using the procedure described in MIL-PRF-29602A, part 4.5.8. Test coupons were precleaned with acetone using wipers in accordance with CCC-C-46, class 7, until the wipe was free of visual residue. Precleaned test coupons were dried in a mechanical convection oven at 105 ± 2ºC for 30 minutes, air cooled to room temperature, and weighed to the nearest 0.1 mg (W_1). Three precleaned test coupons were then loaded with 100-150 mg of Contaminant #1 using a clean acid brush as shown below. The coupons were reweighed to the nearest 0.1 mg (W_2) and the new weight recorded.



Coupons Loaded with Contaminant #1

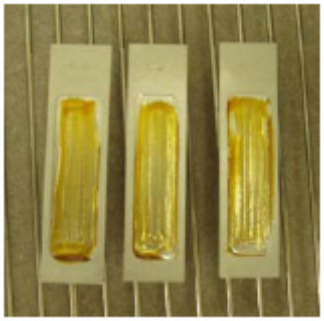
500 mls of the cleaning solution in the proper concentration to be evaluated were added to a heavy duty glass beaker. It should be noted that cleaning chemistries are diluted to a wide variety of concentrations – some cleaning chemistries are run full strength, while others are diluted to 3% or less by volume. In all cases, the concentration that was established was that recommended by the vendor. After the solution was created, it was stabilized at the manufacturer's recommended operating temperature using a digital stirrer/hot plate. Unless otherwise noted, the chemistry was heated to 71 ± 1ºC. Some cleaning chemistries will degrade if heated to this temperature, so the lesser of 71ºC and the maximum recommended temperature for each chemistry was used. The three test coupons loaded with Contaminant #1 were then clamped to the inside of the beaker and the solution stirred with a 2" x 3/8" magnetic stirring bar at 500 RPM for 10 minutes as shown on the next page.



Cleaning of Test Coupons with Digital Stirrer/Hot Plate

The cleaned test coupons were then rinsed under a 4 liter/minute water stream from a laboratory faucet with serrated tip and dried in a mechanical convection oven at 105 ± 2ºC for 5 minutes. The cleaned and dried test coupons were allowed to cool to room temperature and reweighed to the nearest 0.1 mg (W_3) so that the extent of contaminant removal could be determined.

Following this test, three additional precleaned test coupons (which had been precleaned using the same procedure as those for Contaminant #1) were loaded with 100-150 mg of Contaminant #2 using a clean acid brush, dried for one hour in a mechanical convection oven at 105ºC, air cooled, and weighed to the nearest 0.1 mg (W_2). A photograph of test coupons loaded with Contaminant #2 is shown below.



Coupons Loaded with Contaminant #2

These loaded test coupons were cleaned in the same manner as Contaminant #1, using the same (dirty) solution that was used to clean the test coupons containing Contaminant #1. Cleaned test coupons were then rinsed under flowing cold tap water for 1 minute without impinging on the soiled area. Test coupons were then dried for 5 minutes in a mechanical convection oven at 105 ± 2ºC for 5 minutes, air cooled, and weighed to the nearest 0.1 mg (W_3). The above process was repeated for all cleaning chemistries evaluated in this project over a period of 3 weeks.

Determination of Cleaning Efficiency

The cleaning efficiency was calculated for each test coupon evaluated in the procedure described above using the equation provided in MIL-PRF-29602A, part 4.5.8.6. The overall cleaning efficiency for each of the 57 specific cleaning trials for each of the two contaminants was calculated as the arithmetic mean of the three cleaning efficiencies calculated for those respective test coupons (refer to equation below).

$$Cleaning\ Efficiency = \frac{(W_2 - W_3)}{(W_2 - W_1)}\ x\ 100$$

5.2 Specification Description

The specification chosen for the purposes of this project was MIL-PRF-29602A: "Performance Specification for Part Washers and Spray Cabinets." Portions of this specification were selected by the stakeholders to evaluate the cleaning efficiency of alternative cleaning chemistries. Some modifications to the specification were necessary due to availability of materials or equipment. Wherever possible, previous versions of MIL-PRF-29602A, namely MIL-C-29602 were used for substitutions of materials and equipment. Additionally, during testing, some changes were made to allow for greater accuracy of results. These changes are outlined below.

5.3 Specification and Test Modification

It should be noted that significant variation was noted in W_1 (the weight of the precleaned test coupon) throughout cleaning efficiency testing. This is explained in detail below.

Mil spec MIL-PRF-29602A stipulates that prior to testing, the test coupon is to be precleaned with acetone and clean room wipes until no further contamination is visible on the wipes. This precleaning process is inadequate to remove residual contamination from test coupons, in particular Contaminant #2, which is transparent. In addition, many of the cleaning chemistries evaluated in this project are superior to acetone. For example, the 12 best cleaning trials resulted in cleaning efficiencies in excess of 99%, whereas the average cleaning efficiency of acetone itself is less than 66%.

It should be noted that NC3R used a more aggressive test coupon precleaning procedure than that delineated in the mil spec, as NC3R noted early on that it was difficult to preclean test coupons adequately with acetone. In fact, an ultrasonic tank was used to preclean test coupons in addition to the mandated acetone/wiper procedure. However, in some cases, test coupons were still not precleaned completely. As a result, the precleaned test coupon weight still included transparent contamination in some cases.

This irregularity produced some unusual test results. If a test coupon had residual transparent contamination following the precleaning procedure, its measured clean bare mass (W_1) was heavier than its actual clean bare mass. If this same test coupon was loaded with a contaminant and cleaned in a superior cleaning chemistry, this chemistry

not only removed all of the loaded contaminant, but the residual contamination on the precleaned test coupon prior to the start of the test as well. As a result, some cleaning efficiencies were greater than 100%, above and beyond what could be explained by inaccuracies of linearity in the analytical balance.

Fortunately, this problem was easily remedied. Following completion of all cleaning efficiency testing, all test coupons were thoroughly cleaned for one last time in a multistep cleaning process that involved multiple cleaning steps in an ultrasonic tank, as well as manual wiping with solvents and clean room wipers. These test coupons were then dried in a mechanical convection oven, allowed to cool, and weighed. For all 48 test coupons, the final mass was within 0.1 mg of the smallest precleaned mass ever recorded for that respective test coupon during any cleaning trial (it should be noted that inaccuracies of linearity in the analytical balance are twice this amount). This showed that the cleaning chemistries evaluated in this project (except for Test #8, explained below) did not attack the aluminum substrate of the test coupons, so the clean bare test coupon mass was constant throughout testing. Cleaning efficiencies were then recalculated using this mass as the precleaned test coupon weight W_1. After this correction was made, all cleaning efficiencies (except for Test #8) were less than 100%, taking into account inaccuracies in linearity of the analytical balance.

The original test data is presented in Appendix D as a part of RIT's report. The data shows average cleaning efficiencies for each contaminant calculated for each trial. This data utilizes the actual precleaned test coupon weight at the start of each trial for W_1, which may have included residual contamination from previous cleaning trials. As a result, several calculated cleaning efficiencies exceed 100%, as explained previously.

The revised test data is discussed in this report and in Appendix D as well. In the revised test data, the weight of the test coupon after a thorough final cleaning is used for W_1 for all cleaning trials. As a result, all cleaning efficiencies (except Test #8) are less than 100%, taking into account inaccuracies in linearity of the analytical balance.

A detailed case study of this phenomenon is presented in the RIT Report found in Appendix D, and highlights the differences in the measured precleaned mass of a specific test coupon throughout its use in this project. The average cleaning efficiency of the tests using this particular test coupon are calculated using both methods described above and compared.

Other Irregularities

Cleansafe 7448-05 is the cleaning chemistry that was used for Test #8. Initially, this cleaning chemistry generated cleaning efficiencies of 269% and 176% for Contaminants #1 and #2, respectively. However, significant discoloration was immediately noted on the test coupons. After additional analysis, it was determined that this cleaning chemistry attacked the aluminum substrate of the test coupon. Additional review of the MSDS revealed that this compound is not aluminum safe. As a result, the excess cleaning efficiencies can be wholly attributed to aluminum degradation of the test coupon itself, and therefore must be discarded.

It should be noted that the six test coupons used for Test #8 (test coupons #22 - #27) underwent a change in clean bare mass as a result of aluminum degradation. Therefore, for the revised test data, these test coupons have two different precleaned weights – one

used for Tests #1 - #8, and another used for Tests #9 - #57. The precleaned weight used for Tests #1 - #8 is the weight of the test coupon before the very first cleaning test. The precleaned weight used for Tests #9 - #57 is the final weight of the respective test coupon after the very thorough final cleaning procedure conducted after all cleaning efficiency testing had been completed.

Neugenic 4177 is the cleaning chemistry that was used for Test #45, and was used full strength. The test results for this cleaning chemistry showed a negative cleaning efficiency for Contaminant #2, implying that the test coupons had gained contaminant mass during the cleaning process. In actuality, Neugenic 4177 is very thick and is composed of 20% surfactants. These surfactants were not completely rinsed away by the less aggressive rinsing procedure mandated for Contaminant #2. As a result, the test coupons contained both residual contamination and cleaning chemistry, and therefore had more mass at the end of the cleaning test for Contaminant #2. This resulted in a negative cleaning efficiency.

6.0 SUMMARY

This guidance document is intended to be used by NASA Centers in guiding decisions on replacing current part cleaning equipment and chemistries.

Of the 53 alternative chemistries tested for this project, the performance of several surpassed the benchmarks in overall cleaning efficiency. Some chemistries were better at cleaning Contaminant 1 and others Contaminant 2. It should be noted that this was also seen among the benchmarks, giving reason for two different types of contaminants for the standardized efficiency test. An example of this can be seen with Isopropanol. While Isopropanol removed 100% of Contaminant 1, it cleaned only 24% of Contaminant 2. This shows that users should be aware of what benchmarks work best for their cleaning operations even before picking an alternative. If acetone or Isopropanol currently do the job well, then there are more choices for the user to select from.

The benchmark with the greatest cleaning efficiency, as expected, was mineral spirits. Mineral Spirits cleaned both contaminants equally well with over 99% efficiency. There were however two alternatives that faired better than even Mineral Spirits. These were Heavy Duty Cleaner by Phase III Inc. and SoySolve II Plus by SoySolv. These two cleaners would be the best choice for a job that requires Mineral Spirits currently as long as compatibility is not an issue.

When comparing the associated costs of each cleaner, there is also a wide variety of choices. Some of the less-effective cleaners were more expensive than more-efficient ones. The cost comparison chart shows that Heavy Duty Cleaner and SoySolve II Plus would be comparable to other cleaners used for industrial cleaning applications. SoySolv II Plus is comparable to MEK at $16.58 per gallon and Heavy Duty Cleaner is comparable to Mineral Spirits at $4.99 per gallon.

Nine of the 53 alternative chemistries were tested at NASA Centers. Of these nine, one had the highest cleaning efficiency of all chemistries tested including benchmarks. Four of the alternatives tested on-site scored higher in cleaning efficiency than three of the four benchmarks and four scored higher in cleaning efficiency than two of the benchmarks tested.

Shop workers that tested cleaners were asked a series of questions concerning the performance an physical characteristics of the alternative cleaners. These questions were asked several times to gain a more balanced opinion, before using it, after using it for several weeks and at the end of the test period. The results were not as positive as expected, most probably because the workers that tested the alternatives were still permitted to use solvent-based cleaners and were reluctant to compliment cleaners, as they did not want to loose their current ones. Overall, however, those that tested alternatives were happy with their results, except for with one cleaner, Axarel 58. Personnel within the shop that tested Axarel 58 complained that it was too oily and left a residue on parts they cleaned. This was the only test unit that did not complete its test period.

Overall, the NASA AP2 Office would suggest that persons interested in purchasing a new part washer or those looking to move to environmentally preferable ones should refer to

the data gathered during this project for both the on-site and laboratory testing. While some cleaners would clearly not be selected for use, due to cleaning efficiency, cost or compatibility, the data shows there are alternatives for nearly any situation and any shop. The NASA AP2 Office encourages those who are interested in selecting a new cleaning chemistry to find which benchmark works the best for their application and then use that as a reference to identify an alternative on the "Quick Guide" found in Section 3.0 of this report. While some shops currently use Mineral Spirits, other cleaners may work better for their applications.

6.1 Successes

Nine alternative chemistries were tested within six NASA Centers in real-world environments. Of these nine chemistries, two should not be considered for use within other NASA shops. BIOACT MSO and Axarel 58 should not be considered successes within the boundaries of this project.

Although Petrofirm has stated that if BIOACT MSO is properly diluted, it has low VOC and low flash point characteristics, this has yet to be proven and as such it does not qualify as an "environmentally preferable" cleaner. The shop that tested BIOACT MSO is not permitted to use it after the test due to the high flash point in its un-diluted form. Instead, they will be procuring one of the other alternatives tested during this project.

Axarel 58 performed moderately well in laboratory testing, ranking 35th out of the 57 chemistries tested. But it did not perform well for the shop that tested it. Shop personnel complained that it left residue on parts and was too oily for use in their general cleaning applications. While it cleans well for most purposes, unless oily film is acceptable for your cleaning applications, it should be avoided.

6.2 Recommendations / Implementation

Overall, those interested in procuring a new part washer or chemistry should take the data into consideration and select one or more chemistries that fit within an acceptable price range and cleaning efficiency for their needs. The data shows that there are environmentally preferable options for a spectrum of cleaning efficiency needs as well as price.

The least expensive cleaner is Natural Orange by the Giant Cleaning Systems at $0.18 per gallon once it is diluted, however, it ranked 42nd of 57 chemistries in cleaning efficiency. There are some very inexpensive chemistries, however that do rank high in cleaning efficiency. One example is Aerowash 4 by Rochester Midland. This chemistry was tested at 20% dilution and 10% dilution. At the 20% dilution, it costs only $1.84 per gallon after dilution, but ranks 6th in cleaning efficiency. At 10% is costs only $0.92 per gallon and ranks 11th in cleaning efficiency. The chart in Section 3.3 shows cost and cleaning efficiency rank for every chemistry tested.

Persons interested in implementing one of these cleaners should review the charts included in this document and contact the vendors for more information regarding the availability and costs as both change over time.

It is recommended that Sections 1.0-4.0 of this document be printed as the "Consumer's Guide to Alternative Part Washers" and distributed as widely throughout NASA as possible, targeting shops and procurement offices in order to attain the highest level of implementation of environmentally preferable part washers across NASA Centers. Additionally, the complete report including Sections 5.0-6.0 and the Appendices should be distributed to the Environmental Offices within each Center to allow for easy reference to all data pertaining to this project and the alternatives that were tested for it.

6.3 Closing Comments

Through the efforts of numerous people at all the NASA Centers, the AP2 Office was able to field test nine part washers and lab test over fifty. The data that was gathered will allow NASA Centers to easily access information regarding environmentally preferable chemistries for their general cleaning processes. The guidance found within this document will speed the process and save time and money when shops are ready to purchase or upgrade their part washers. Although solvent based cleaning is still available to some shops, it is being more stringently regulated across the U.S. and it may soon be cost prohibitive to use such cleaners. By acting now and finding alternatives, NASA will save funding, time and efforts as well as reducing worker and regulatory risk to their facilities.

Sources:

1. International Agency for Research on Cancer: Monographs on the Evaluation of the Carcinogen Risk of Chemicals to Man.
2. US Environmental Protection Agency: Integrated Risk Information System.
3. The National Fire Protection Association Chemical Hazard Labels.
4. Genium Publishing Corporation: Chemical Container Label Database.
5. US Department of Labor: Occupational Safety and Health Administration.
6. Source: National Library of Medicine. Toxicology Data Network: Hazardous Substance Data Bank

APPENDICES

APPENDIX A - PPONA Risk Ranking and Methodology

APPENDIX B - MSDS / Technical Data Sheets

APPENDIX C - Interview Questionnaires

APPENDIX D - Rochester Institute of Technology Report

APPENDIX E - Project Schedule

APPENDIX A
PPONA RISK RANKING AND METHODOLOGY

PPONA Risk Ranking and Methodology

PPONA Findings:

Through the course of performing PPONA's, the NASA AP2 Office identified hundreds of opportunities across all the NASA Centers. Many of the needs identified related to common processes such as painting, cleaning, maintenance and machining. Although varying in criticality and volume, all PPONA's identified the need for NASA Centers to *"Input Materials Replacement for General Cleaning, Wipe-Cleaning and Precision Cleaning"*.

Methodology for the Prioritization of Needs:

To assist NASA AP2 Office personnel in identifying and prioritizing the implementation of potential P2 projects at all NASA Centers, a "Pollution Prevention Opportunity Prioritization Table" (PPOPT) was developed. To better understand and identify potential P2 opportunities, the PPOPT was applied to resident routine and non-routine operations within NASA Centers.

The PPOPT uses an objective scoring system to assign numerical values to process specific chemical constituents. These values are assigned to the following three categories:

- Perceived health effect(s)
- Potential environmental impact(s)
- Actual disposal impact(s)

Numerical risk/hazard ratings were assigned for each identified process constituent. Assignments reflect the perceived hazard(s) and/or risk(s) associated with the targeted constituent. Scoring values used for prioritization are provided in Table A.1 and Table A.2.

A compilation PPOPT of all solvent cleaning related opportunities across NASA is captured within Table 1.2.1 in Section 1.2 of this report. For ease of reading, Table A.5 is identical to Table 1.2.1, and included at the end of Appendix A.

i. Health Effects

Health effects were determined for each constituent according to their associated risk for cancer and associated health risks. The "Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man" and the "Integrated Risk Information System" (IRIS) were both utilized during numerical risk/hazard assignment for cancer. Potential health effects were numerically ranked using the "National Fire Protection Association" (NFPA) Health Ranking System and OSHA Permissible Exposure Limit. Definitions relating to health effects are listed in Table A.1.

Cancer Risk

To quantify human health risks, chemicals are characterized as carcinogens (i.e. chemicals with demonstrated propensity for cancer induction) and non-carcinogens. Since carcinogens tend to dominate public concerns about health risk, they will receive the highest score. Due to a lack of experimental data, several hazardous constituents appearing within the PPOPT were determined to have unclassifiable carcinogen rankings.

The experimental research effort involved in developing a new dose-response relationship for a toxic substance takes considerable time. To determine cancer risk, information from International Agency for Research on Cancer (IARC): "Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man" and United States Environmental Protection Agency: "Integrated Risk Information System" was used. These rankings ranged from zero to four. The following values were assigned: "0" = non-carcinogenic; "1" = unclassifiable as to carcinogenity; "2" = possible carcinogen; "3" = probable carcinogen; and "4" = human carcinogen. Scores for cancer risk are provided in Table A.3.

National Fire Protection Association Health Rating

The hazard posed by a chemical or waste is a function of its toxicity, mobility and persistence. To understand potential health effects of a chemical, the hazard rating (the intrinsic capability of a hazardous chemical to cause harm) should be determined. Sources used to determine health risk include NFPA Chemical Hazard Labels and a Chemical Container Label Database maintained by Genium Publishing Corporation. The NFPA Chemical Hazard Label provides the health, flammability and reactivity hazards of chemicals. As with the IARC and IRIS systems, the NFPA numeric values ranged from zero to four. An assigned value of "0" indicates the lowest hazard potential contrasted by an assigned value of "4". A value of "4" represents the most significant health hazard. Scores based on the NFPA Chemical Hazard Label are provided in Table A.3.

OSHA Permissible Exposure Limit

The Occupational Safety and Health Administration (OSHA) have established "Permissible Exposure Limits" (PELs). Permissible Exposure Limits have been calculated from data sets for exposure to a chemical hazard. An exposure limit may be a time-weighted average (TWA) or a maximum concentration exposure limit. OSHA PEL values are enforceable under federal law and should not be exceeded during an eight-hour workday. In addition, OSHA PEL values are intended to express the harmful effects of chemical exposure. Chemicals with low PELs have a greater risk of causing negative health effects. OSHA PEL numeric values were assigned scores ranging from zero to four. An assigned value of "0" indicates a chemical with a high OSHA PEL. An assigned value of "4" represents a chemical with a low OSHA PEL. Scores relating to OHSA Permissible Exposure Limits are provided in Table A.3.

Table A.1: Health Effects

Cancer Risk	Health	OSHA PEL
4= Human carcinogen	4= May be fatal on short exposure	4= 0 to 1ppm
3= Probable carcinogen	3= Corrosive or toxic	3= 2ppm to 10ppm
2= Possible carcinogen	2= May be harmful if inhaled or absorbed	2= 11ppm to 50ppm
1= Unclassifiable as to carcinogenity	1= May be irritating	1= 51ppm to 500ppm
0= Non-carcinogen	0= Non-unusual hazard	0= > 500ppm

ii. Environmental Impact

Each hazardous constituent was evaluated for its potential to impact the environment through accidental release and/or fugitive emissions. Five methods of environmental fate and transport were evaluated during environmental impact analysis. They include Atmospheric Fate, Terrestrial Fate, Soil Mobility, Atmospheric Fate and Bio-concentration Factor

Numerical values used for environmental impact assignment were obtained from the "Hazardous Substance Data Bank" (HSDB), a data file within the "Toxicology Data Network" (TOXNET®). The National Library of Medicine (NLM) maintains TOXNET®. Definitions relating to environmental impact are provided in Table A.2.

Atmospheric Fate

Hazardous constituents are discharged to the atmosphere as gases or particulate matter. Once introduced, they undergo chemical transformations that deleteriously affect the atmosphere. Since transformations vary between chemicals, the extent of impact occurring in the atmosphere relates to chemical persistence.

Atmospheric fate scores range from zero to seven. Hazardous constituents with a longer half-life receive a higher score. Since the atmospheric half-life of an ODS exceeds three years, a score of seven was assigned. In addition, it was determined that chemical degradation by reaction with hydroxyl radicals or gravitational settling is responsible for reducing or eliminating hazardous constituents from the atmosphere. Scores relating to atmospheric persistence are provided in Table A.4.

Terrestrial Fate

Another mechanism by which hazardous constituents can be transported is volatilization. Volatilization is the transfer of a chemical substance from a liquid phase to a gaseous phase. Vapor pressure provides an indication on the extent that hazardous constituent will volatilize. Soil and environmental conditions influence the vapor pressure of a contaminant. Hazardous constituents with higher vapor pressures are easily transported through soil to groundwater.

Scores assigned for terrestrial fate range from zero to one. The following values were assigned: "0" = stable in soil; "0.5" = biodegradation and leaching; and "1" = volatilization and leaching. Stable in soil refers to hazardous constituents that remain in the upper layer (two to five cm) of soil. Biodegradation and leaching refers to hazardous constituents that undergo biodegradation. Due to biodegradation, it is likely that hazardous constituents will not reach groundwater. Volatilization and leaching represents hazardous constituents that are transported to groundwater. Scores relating to terrestrial fate are provided in Table A.4.

Soil Mobility

One of the most important processes determining how hazardous constituents are transported in the subsurface is adsorption. Adsorption is the adherence of atoms, ions or molecules of a gas or liquid to the surface of another substance. If a hazardous constituent is strongly adsorbed to soil, the contaminant is relatively immobile and will not migrate within the soil. If the contaminant is weakly adsorbed, it is relatively mobile and may contaminate groundwater. Soil adsorption rates are based on scientifically determined Koc values. The scores assigned for soil mobility range from zero (very high adsorption) to seven (very low or no adsorption). Hazardous constituents scored between one through six were determined to have soil adsorption values between the two extremes. Scores relating to soil mobility are provided in Table A.4.

Aquatic Fate

Once a hazardous constituent is introduced to an aquatic system, it may undergo volatilization. Volatilization half-life refers to the time required for half of a hazardous constituent to undergo volatilization. Scores for aquatic fate range from zero (half-life of less than one day) to seven (deposited in sediment). A score of zero through six represents hazardous constituents that have a volatilization half-life. A score of seven represents hazardous constituents that undergo sediment deposition. Sediment deposition was assigned the highest score due to probable bioaccumulation within an aquatic system. Scores relating to aquatic fate are provided in Table A.4.

Bio-concentration Factor

The bio-concentration factor indicates the amount of a chemical that is likely to accumulate in aquatic organisms. It varies from species to species and is affected by the organism's metabolism. Scores assigned for the bio-concentration factor range from zero (no bio-concentration) to seven (very high bio-concentration). The bio-concentration factor is an essential component in determining risk. Scores relating to bio-concentration factor are provided in Table A.4.

Table A.2: Environmental Impact

Terrestrial Fate	Aquatic Fate	Atmospheric Fate	Soil Mobility	Bio-concentration
1= Volatilization and Leaching	7= Deposited in sediment	7= 3 years and up	7= Very high	7= Very high
0.5= Biodegradation and Leaching and/or Volatilization	6= 36 days and up	6= 1 to 3 years	6= High	6= High
	5= 29 to 35 days	5= 181 to 365 days	5= Moderate to High	5= Moderate to High
	4= 22 to 28 days	4= 61 to 180 days	4= Moderate	4= Moderate
0= Stable in soil	3= 15 to 21 days	3= 15 to 60 days	3= Low to Moderate	3= Low to Moderate
	2= 8 to 14 days	2= 1 to 14 days	2= Low	2= Low
	1= 1 to 7 days	1= < 1 day	1= None to Low	1= None to Low
	0= < 1 day	0= Gravitational settling	0= None	0= None

iii. Disposal Impact

NASA has emphasized the importance of implementing cost-effective waste reduction strategies. In order to accomplish these goals, hazardous waste generation and subsequent disposal impacts must be examined.

Hazardous Waste

To determine disposal impacts, the NASA AP2 Office obtained the hazardous waste generation reports for all NASA Centers. After reviewing these reports, it was determined that in many cases identified resident waste streams can not be confidently linked to specific processes within facilities due to the fact that waste streams are often mixed prior to ultimate disposal. As a result, it is difficult to assign numerical rankings for waste disposal. Since numerical assignment is not practical, Pollution Prevention Opportunity Prioritization did not include disposal impacts for the majority of the NASA Centers.

The following tables represent a compilation of the data collected while performing PPONA's at all NASA Facilities. Final PPONA reports included all opportunities identified within the Center, for the purposes of this document only solvent cleaning related opportunities were complied below. These tables show a variety of solvents and constituents within solvent-blends that are used for cleaning. The four benchmarks used for cleaning efficiency testing are highlighted within each table. It should be noted that while these tables are a compilation of constituents identified during PPONA's they do not include all possible constituents nor do they express the current inventory of constituents found within these processes at NASA Centers. Since the completion of the PPONA's many Centers have proactively implemented recommendations found within the PPONA reports for their Facility and therefore, some of these constituents have been replaced with environmentally preferable alternatives.

Table A.3: PPONA Health Effects Worksheet with Scores

(Constituents found within cleaning processes across NASA Centers.)

Hazardous Constituent	Carcinogen Ranking[1, 2]	Health[3, 4]	OSHA PEL[5]	Score
1,1,1,2-Tetrafluoroethane	1	1	0	**2**
1,1,1-Trichloroethane	1	2	1	**4**
1,2,4-Trimethylbenzene	1	1	2	**4**
1,2-Butylene Oxide	1	2	3	**6**
1,3-Dioxolane	1	2	0	**3**
1,4-Dichlorobenzene	2	2	1	**5**
1,4-Dioxane	3	2	1	**6**
1-Butanol	1	1	1	**3**
1-Methyl-2-Pyrrolidinone	1	2	3	**6**
2,4-Toluene Diisocyanate	2	3	4	**9**
Acetic Acid	1	3	3	**7**
Acetone	1	1	0	**2**
Benzene	4	2	3	**9**
Butane	1	1	0	**2**
CFC-113 (Trichlorotrifluoroethane)	1	2	0	**3**
Cyclohexanone	1	2	1	**4**
Dichloromethane	2	2	2	**6**
Diethylene Glycol Mononbutyl Ether	1	2	1	**4**
Dipropylene Glycol Methyl Ether	1	0	1	**2**
Ethanol	1	1	0	**2**
Ethyl acetate	1	1	1	**3**
Ethyl Benzene	1	2	1	**4**
Ethylene Glycol	1	1	2	**4**
Ethylene Glycol Monobutyl Ether	1	2	2	**5**
Ethylene Glycol Monoethyl Ether Acetate	1	2	1	**4**
Ethylene Glycol Mono-N-Butyl Ether	1	2	2	**5**
Heptane	1	1	1	**3**
Hydroquinone	1	2	4	**7**
Isoamyl Methyl Ketone	1	1	2	**4**
Isobutane	1	1	0	**2**
Isobutyl Acetate	1	1	2	**4**
Isobutyl Alcohol	1	1	1	**3**
Isopropanol	1	1	1	**3**
Methanol	1	2	1	**4**
Methyl Ethyl Ketone	1	1	1	**3**
Methyl Isobutyl Ketone	1	2	1	**4**
Mineral Oils	1	1	3	**5**
Naphthalene	1	2	3	**6**
n-Butanol	1	1	1	**3**
n-Butyl Acetate	0	1	1	**2**
n-Butyl Alcohol	1	1	1	**3**
n-Propanol	1	1	1	**3**
Petroleum Ether	1	1	1	**3**
Phenol	1	4	3	**8**
Propane	1	1	0	**2**
Propylene Glycol	1	0	2	**3**
Sec-Butyl Alcohol	1	1	1	**3**
Sodium Hydroxide	1	3	3	**7**
Stoddard Solvent (Petroleum Ether)	1	2	1	**4**
Tertiary-Butyl Alcohol	1	1	1	**3**
Tetrachloroethylene	3	2	1	**6**
Tetrafluoroethylene	1	2	0	**3**
Tetrahydrofuran	1	0	1	**2**
Toluene	1	2	1	**4**
Trichloroethylene	3	2	1	**6**
VM&P Naphtha	1	1	1	**3**
Xylene	1	2	1	**4**

Table A.4: PPONA Environmental Impact Worksheet with Scores [6]

(Constituents found within cleaning processes across NASA Centers.)

Hazardous Constituent	Terrestrial Fate	Aquatic Fate	Atmospheric Fate	Soil Mobility	Bio-concentration	Score
1,1,1,2-Tetrafluoroethane	1	0	5	5	0	**11**
1,1,1-Trichloroethane	1	4	7	6	1	**19**
1,2,4-Trimethylbenzene	1	1	1	2	5	**10**
1,2-Butylene Oxide	1	1	2	6	0	**10**
1,3-Dioxolane	1	3	1	7	0	**12**
1,4-Dichlorobenzene	1	1	3	3	5	**13**
1,4-Dioxane	1	1	1	0	5	**8**
1-Butanol	0.5	6	2	5	2	**15.5**
1-Methyl-2-Pyrrolidinone	1	0	1	7	2	**11**
2,4-Toluene Diisocyanate	0	0	1	0	0	**1**
Acetic Acid	1	1	3	6	2	**13**
Acetone	1	2	4	7	2	**16**
Benzene	1	4	2	7	0	**14**
Butane	1	1	2	3	0	**7**
CFC-113 (Trichlorotrifluoroethane)	1	0	7	4	0	**12**
Cyclohexanone	1	5	2	6	0	**14**
Dichloromethane	1	0	4	7	2	**14**
Diethylene Glycol Mononbutyl Ether	0.5	4	1	7	2	**14.5**
Dipropylene Glycol Methyl Ether	0	0	1	6	0	**7**
Ethanol	1	1	2	5	0	**9**
Ethyl acetate	1	1	2	6	2	**12**
Ethyl Benzene	1	1	2	2	0	**6**
Ethylene Glycol	0.5	0	3	7	0	**10.5**
Ethylene Glycol Monobutyl Ether	1	0	1	6	1	**9**
Ethylene Glycol Monoethyl Ether Acetate	1	6	2	7	2	**18**
Ethylene Glycol Mono-N-Butyl Ether	1	0	1	6	1	**9**
Heptane	1	2	2	2	4	**11**
Hydroquinone	0	0	1	7	0	**8**
Isoamyl Methyl Ketone	1	1	2	4	2	**10**
Isobutane	1	1	2	7	0	**11**
Isobutyl Acetate	1	1	2	4	2	**10**
Isobutyl Alcohol	1	1	2	2	0	**6**
Isopropanol	1	1	2	2	0	**6**
Methanol	0.5	0	3	7	0	**10.5**
Methyl Ethyl Ketone	1	2	2	6	2	**13**
Methyl Isobutyl Ketone	1	6	2	6	2	**17**
Mineral Oils	0.5	4	2	2	2	**10.5**
N-Amyl Acetate	1	1	2	4	4	**12**
n-Butanol	0.5	6	2	5	2	**15.5**
n-Butyl Acetate	1	1	2	4	2	**10**
n-Butyl Alcohol	0.5	6	2	5	2	**15.5**
n-Propanol	1	1	2	4	0	**8**
Petroleum Ether	1	1	2	5	0	**9**
Phenol	0.5	0	1	6	0	**7.5**
Propane	1	1	2	4	0	**8**
Propylene Glycol	1	1	2	7	0	**11**
Sec-Butyl Alcohol	1	1	2	5	0	**9**
Sodium Hydroxide	1	5	2	2	4	**14**
Stoddard Solvent (Petroleum Ether)	1	1	2	4	0	**8**
Tertiary-Butyl Alcohol	1	2	3	4	0	**10**
Tetrachloroethylene	1	5	4	3	0	**13**
Tetrafluoroethylene	1	1	6	7	2	**17**
Tetrahydrofuran	0.5	2	2	7	0	**11.5**
Toluene	1	6	1	6	2	**16**
Trichloroethylene	1	0	2	5	4	**12**
VM&P Naphtha	1	1	2	5	0	**9**
Xylene	1	1	1	5	2	**10**

Table A.5: Pollution Prevention Opportunity Prioritization Table

(Constituents found within cleaning processes across NASA Centers.)

Recommended Action:
Input Material Substitution, Material and Waste Reduction, Out-Process Recycling/Reuse

Related Processes:
Hazardous Constituents used in Part Cleaning and Wiping Procedures

Related Activities:
General cleaning, surface preparation, machining, metal finishing, coating removal, vehicle/equipment maintenance, precision cleaning, coating application, sealing/adhesive cleaning and other cleaning/degreasing activities.

Hazardous Constituent	Health	Environmental	Total
1,1,1,2-Tetrafluoroethane	2	11	**13**
1,1,1-Trichloroethane	4	19	**23**
1,2,4-Trimethylbenzene	4	10	**14**
1,2-Butylene Oxide	6	10	**16**
1,3-Dioxolane	3	12	**15**
1,4-Dichlorobenzene	5	13	**18**
1,4-Dioxane	6	8	**14**
1-Butanol	3	15.5	**18.5**
1-Methyl-2-Pyrrolidinone	6	11	**17**
2,4-Toluene Diisocyanate	9	1	**10**
Acetic Acid	7	13	**20**
Acetone	2	20	**22**
Benzene	9	14	**23**
Butane	2	7	**9**
CFC-113 (Trichlorotrifluoroethane)	3	12	**15**
Cyclohexanone	4	14	**18**
Dichloromethane	6	14	**20**
Diethylene glycol monobutyl ether	4	14.5	**18.5**
Dipropylene Glycol Methyl Ether	2	7	**9**
Ethanol	2	9	**11**
Ethyl acetate	3	12	**15**
Ethyl Benzene	4	6	**10**
Ethylene Glycol	4	10.5	**14.5**
Ethylene Glycol Monobutyl Ether	5	9	**14**
Ethylene Glycol Monoethyl Ether Acetate	4	18	**22**
Ethylene Glycol Mono-N-Butyl Ether	5	9	**14**
Heptane	3	11	**14**
Hydroquinone	7	8	**15**
Isoamyl Methyl Ketone	4	10	**14**
Isobutane	2	11	**13**
Isobutyl Acetate	4	10	**14**
Isobutyl Alcohol	3	6	**9**
Isopropanol	3	6	**9**
Methanol	4	10.5	**14.5**
Methy Ethyl Ketone	3	13	**16**
Methyl Isobutyl Ketone	4	17	**21**
Mineral Oils	5	10.5	**15.5**
Naphthalene	6	9.5	**15.5**
N-Butanol	3	15	**18**
n-Butyl Acetate	3	10	**13**
n-butyl alcohol	3	15	**18**
N-Propanol	3	8	**11**
Petroleum Ether	3	9	**12**
Phenol	8	7.5	**15.5**
Propane	2	8	**10**
Propylene Glycol	3	11	**14**
Sec-Butyl Alcohol	3	9	**12**
Sodium Hydroxide	7	14	**21**
Stoddard Solvent (Petroleum Ether)	4	8	**12**
Tertiary-Butyl Alcohol	3	10	**13**
Tetrachloroethylene	6	13	**19**
Tetrafluoroethylene	3	17	**20**
Tetrahydrofuran	2	11.5	**13.5**
Toluene	4	16	**20**
Trichloroethylene	6	12	**18**
VM&P Naphtha	4	8	**12**
Xylene	4	10	**14**

APPENDIX B

SITE-TESTED CHEMISTRIES

MATERIAL SAFETY DATA SHEETS / TECHNICAL DATA SHEETS

Armakleen M-Aero

Church & Dwight

Armakleen® M-Aero

MATERIAL SAFETY DATA SHEET FOR USA AND CANADA

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **Armakleen® M-Aero**

SYNONYM(S): Not available.

PRODUCT PART NUMBERS: **6330, 6430**

PRODUCT USE: Aqueous, alkaline, concentrated cleaner that is to be diluted with water. If this product is used in combination with other products, refer to the Material Safety Data Sheets for those products.

	24-HOUR EMERGENCY PHONE NUMBERS	
These numbers are for emergency use only. If you desire non-emergency product information, please call a phone number listed below.	**MEDICAL:**	**TRANSPORTATION (SPILL):**
	1-800-752-7869	**1-800-468-1760**

MANUFACTURER:
The ArmaKleen Company
469 North Harrison Street
Princeton, NJ 08543
USA
(609) 683-5900

SUPPLIER:
Safety-Kleen Systems, Inc.
5400 Legacy Drive, Cluster II, Building 3
Plano, TX 75024
USA
(800) 669-5740

TECHNICAL INFORMATION: 1-800-332-5424

SAFETY-KLEEN MSDS FORM NUMBER: 82796
THE ARMAKLEEN COMPANY MSDS NUMBER: 955F

ISSUE: November 20, 2003

ORIGINAL ISSUE: July 16, 1996

SUPERSEDES: November 20, 2002

PREPARED BY: ArmaKleen MSDS Coordinator

APPROVED BY: The ArmaKleen Company

SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS

				OSHA PEL		ACGIH TLV®			
WT%	NAME	SYNONYM	CAS NO.	TWA	STEL	TWA	STEL	LD[a]	LC[b]
3 to 7	Alcohols, C6 – C10, ethoxylated	Linear alcohol alkoxylate	68987-81-5	N. Av.	N. Av.	N. Av.	N. Av.	N. Av.	N. Av.
3 to 7	Polyoxyethylene-polyoxypropylene glycol	Alcohol alkoxylate	9003-11-6	N. Av.	N. Av.	N. Av.	N. Av.	>5000	N. Av.
3 to 7	3,5,5-trimethylhexanoic acid	Isononanoic acid	3302-10-1	N. Av.	N. Av.	N. Av.	N. Av.	N. Av.	N. Av.
1 to 5	Sodium Carbonate	Soda Ash	497-19-8	N. Av.	N. Av.	10 mg/m^3[c]	N. Av.	>3000	2300 mg/m^3 /2 hours
1 to 5	Sodium hydroxide	Caustic soda	1310-73-2	2 mg/m^3	N. Av.	2mg/m^3 (ceiling)	N. Av.	>104[d]	N. Av.
1 to 5	2-pyrrolidinone, 1-octyl	N-(n-octyl)-2-pyrrolidone	2687-94-7	N. Av.	N. Av.	N. Av.	N. Av.	2050[e]	N. Av.
1 to 5	Alcohols, C11, ethoxylated	Linear, primary alcohol ethoxylate	34398-01-1	N. Av.	N. Av.	N. Av.	N. Av.	>700	N. Av.
1 to 5	Alcohol alkoxylate	N. Av.*	N. Av.*	N. Av.	N. Av.	N. Av.	N. Av.	>2000	N. Av.

N.Av. = Not Available

*Supplier advises that this is a trade secret.
New Jersey TSRN-489909-5125-PL

[a] Oral-Rat LD_{50} (mg/kg)

[b] Inhalation LC_{50}

[c] Particulates not otherwise classified

[d] Skin-Rabbit LD_{50} 1350 mg/kg

[e] Skin-Rabbit LD_{50} 5000mg/kg

SECTION 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

APPEARANCE
Liquid, clear, tan color, and mild detergent odor.

CAUTION!

HEALTH HAZARDS
May irritate the respiratory tract (nose, throat, and lungs), eyes, and skin.

POTENTIAL HEALTH EFFECTS

INHALATION (BREATHING): High concentrations of vapor or mist may irritate the respiratory tract (nose, throat, and lungs).

EYES: May cause irritation

SKIN: May cause irritation. Not likely to be absorbed through the skin in harmful amounts

INGESTION (SWALLOWING): May be harmful if swallowed. May cause vomiting and/or diarrhea.

MEDICAL CONDITIONS Individuals with pre-existing respiratory tract (nose, throat, and

AGGRAVATED BY EXPOSURE: lungs), eye, and/or skin disorders may have increased susceptibility to the effects of exposure.

CHRONIC: Prolonged or repeated skin contact may cause drying, cracking, redness, itching, and/or swelling (dermatitis).

CANCER INFORMATION: No known carcinogenicity. For more information, see **SECTION 11: CARCINOGENICITY**.

POTENTIAL ENVIRONMENTAL EFFECTS
Not available. Also see **SECTION 12: ECOLOGICAL INFORMATION**.

SECTION 4: FIRST AID MEASURES

INHALATION: (BREATHING) Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Oxygen should only be administered by qualified personnel. Someone should stay with victim. Get medical attention if breathing difficulty persists.

EYES: If irritation or redness from exposure to vapor develops, move away from exposure into fresh air and flush with water for 5 minutes. Upon direct contact with liquid, immediately flush eyes with plenty of lukewarm water, holding eyelids apart, for 15 minutes. Get medical attention.

SKIN: Remove affected clothing and shoes. Wash skin thoroughly with soap and water. Get medical attention if irritation or pain develops or persists.

INGESTION: (SWALLOWING) Do NOT induce vomiting. Immediately get medical attention. Call medical emergency telephone number (1-800-752-7869) for additional information. If conscious, give water to drink. If spontaneous vomiting occurs, keep head below hips to avoid breathing the product into the lungs. Never give anything to an unconscious person by mouth.

NOTE TO PHYSICIANS: Treat symptomatically and supportively. Ingesting large amounts may cause systemic alkalosis. Treatment may vary with condition of victim and specifics of incident. Call 1-800-752-7869.

SECTION 5: FIRE FIGHTING MEASURES

FLASH POINT: greater than 212ºF (100ºC)

FLAMMABLE LIMITS IN AIR: Not applicable.

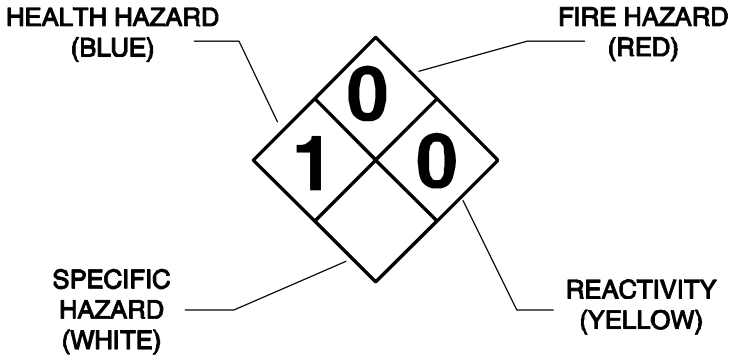
AUTOIGNITION TEMPERATURE: Not applicable.

HAZARDOUS COMBUSTION PRODUCTS: Product itself does not burn, but may decompose upon heating to produce carbon monoxide, carbon dioxide, sulfur oxides, and nitrogen oxides.

CONDITIONS OF FLAMMABILITY: Product will not burn.

EXTINGUISHING MEDIA: Not applicable.

NFPA 704 HAZARD IDENTIFICATION: This information is intended solely for the use by individuals trained in this system.



FIRE FIGHTING INSTRUCTIONS: Keep storage containers cool with water spray. A positive-pressure, self-contained breathing apparatus (SCBA) and full-body protective equipment are required for fire emergencies.

FIRE AND EXPLOSION HAZARDS: Heated containers may rupture. “Empty” containers may retain residue and can be dangerous. Not sensitive to mechanical impact or static discharge.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Spilled product is slippery. Do not touch or walk through spilled product. Stop leak if you can do it without risk. Wear protective equipment and provide engineering controls as specified in **SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION**. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Ventilate area and avoid breathing vapor or mist. Contain away from surface waters and sewers. Contain spill as a liquid for possible recovery or sorb with compatible sorbent material and shovel with a clean tool into a sealable container for disposal.

Additionally, for large spills: Dike far ahead of liquid spill for collection and later disposal.

There may be additional regulatory reporting requirements associated with spills, leaks, or releases of this product. Also see **SECTION 15: REGULATORY INFORMATION**.

SECTION 7: HANDLING AND STORAGE

HANDLING: Use clean tools. Do not breathe vapor or mist. Use in a well ventilated area. Avoid contact with eyes, skin, clothing, and shoes.

SHIPPING AND STORING: Keep container tightly closed when not in use and during transport. Store containers in a cool, dry place. Empty product containers may retain product residue and can be dangerous.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Provide general ventilation needed to maintain concentration of vapor or mist below applicable exposure limits. Where adequate general ventilation is unavailable, use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits.

PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY PROTECTION: Use NIOSH-certified, combination N-, P-, or R- series particulate filter respiratory protective equipment when concentration of vapor or mist exceeds applicable exposure limits. Selection and use of respiratory protective equipment should be in accordance in the USA with OSHA General Industry Standard 29 CFR 1910.134; or in Canada with CSA Standard Z94.4.

EYE PROTECTION: Where eye contact is likely, wear chemical goggles; contact lens use is not recommended.

SKIN PROTECTION: Where skin contact is likely, wear nitrile, neoprene, or equivalent protective gloves; use of polyvinyl alcohol (PVA), natural rubber, or equivalent gloves is not recommended.

To avoid skin contact where spills and splashes are likely, wear appropriate chemical-resistant faceshield, boots, apron, whole body suits, or other protective clothing.

PERSONAL HYGIENE: Use good personal hygiene. Wash thoroughly with soap and water after handling and before eating, drinking, or using tobacco products. Clean affected clothing, shoes, and protective equipment before reuse. Discard affected clothing, shoes, or protective equipment if they cannot be thoroughly cleaned. Discard leather articles, such as shoes, saturated with the product.

OTHER Where spills and splashes are likely, facilities storing or using this product

PROTECTIVE EQUIPMENT: should be equipped with an emergency eyewash and shower, both equipped with clean water, in the immediate work area.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE, APPEARANCE, AND ODOR: Liquid, clear, tan color, and mild detergent odor.

ODOR THRESHOLD: Not available.

MOLECULAR WEIGHT: Not applicable.

SPECIFIC GRAVITY: 1.05 (water = 1)

DENSITY: 8.8 LB/US gal (1050 g/L)

VAPOR DENSITY: less than 1 (air = 1)

VAPOR PRESSURE: 17.5 mm Hg at 68°F (20°C) (approximately)

BOILING POINT: 212°F (100°C)

FREEZING/MELTING POINT: 32°F (0°C)

pH: 11.6

EVAPORATION RATE: Less than 1 (butyl acetate = 1)

SOLUBILITY IN WATER: Complete.

FLASH POINT: greater than 212ºF (100ºC)

FLAMMABLE LIMITS IN AIR: Not applicable.

AUTOIGNITION TEMPERATURE: Not applicable.

SECTION 10: STABILITY AND REACTIVITY

STABILITY: Stable under normal temperatures and pressures.

INCOMPATIBILITY: Avoid acids, oxidizing agents, or reducing agents.

REACTIVITY: Polymerization is not known to occur under normal temperatures and pressures. Not reactive with water.

HAZARDOUS

DECOMPOSITION PRODUCTS:	None under normal temperatures and pressures. See also **SECTION 5: HAZARDOUS COMBUSTION PRODUCTS**.

SECTION 11: TOXICOLOGICAL INFORMATION

SENSITIZATION:	Based on best current information, there is no known human sensitization associated with this product.
MUTAGENICITY:	Based on best current information, there is no known mutagenicity associated with this product.
CARCINOGENICITY:	Based on best current information, there is no known carcinogenicity as regulated by OSHA; as categorized by ACGIH A1 or A2 substances; as categorized by IARC Group 1, Group 2A, or Group 2B agents; or as listed by NTP as either known carcinogens or substances for which there is limited evidence of carcinogenicity in humans or sufficient evidence of carcinogenicity in experimental animals.
REPRODUCTIVE TOXICITY:	Based on best current information, there is no known reproductive toxicity associated with this product.
TERATOGENICITY:	Based on best current information, there is no known teratogenicity associated with this product.
TOXICOLOGICALLY SYNERGISTIC PRODUCT(S):	Based on best current information, there are no known toxicologically synergistic products associated with this product.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICITY:	No data available.
OCTANOL/WATER PARTITION COEFFICIENT:	Not available.
VOLATILE ORGANIC COMPOUNDS:	Contains 13.7 g/L VOC (as soaps and detergents) as per EPA Method 24

SECTION 13: DISPOSAL CONSIDERATIONS

DISPOSAL: Dispose in accordance with federal, state, provincial, and local regulations. Regulations may also apply to empty containers. The responsibility for proper waste disposal lies with the owner of the waste. Contact Safety-Kleen regarding recycling or proper disposal.

USEPA WASTE CODE(S): This product, if discarded, is not expected to be a characteristic or listed hazardous waste. Processing, use, or contamination by the user may change the waste code(s) applicable to the disposal of this product.

SECTION 14: TRANSPORT INFORMATION

DOT: Not regulated.

TDG: Not regulated.

EMERGENCY RESPONSE GUIDE NUMBER: Not applicable.
Reference *North American Emergency Response Guidebook*

SECTION 15: REGULATORY INFORMATION

USA REGULATIONS

SARA SECTIONS 302 AND 304: This product does not contain any “extremely hazardous substances” listed pursuant to Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) Section 302 or Section 304 as identified in 40 CFR Part 355, Appendix A and B.

SARA SECTIONS 311 AND 312: This product poses the following health hazards as defined in 40 CFR Part 370 and is subject to the requirements of sections 311 and 312 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA):

Immediate (Acute) Health Hazard

SARA SECTION 313: This product does not contain toxic chemicals subject to the requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

CERCLA: This product contains the following "hazardous substance" listed under the Comprehensive Environmental Response, compensation and Liability Act of 1980 (CERCLA) in 40 CFR Part 302, Table 302.4 with the following reportable quantity (RQ):

Material	CAS	RQ
Sodium hydroxide	1310-73-2	1000 LB (454 kg)

TSCA: All the components of this product are listed on, or are automatically included as "naturally occurring chemical substances" on, or exempted from the requirement to be listed on, the TSCA Inventory.

CALIFORNIA: This product does not contain detectable amounts of any chemical known to the State of California to cause cancer.

This product does not contain detectable amounts of any chemical known to the State of California to cause birth defects or other reproductive harm.

CANADIAN REGULATIONS
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS: D2B

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA): All the components of this product are listed on, or are automatically included as "substances occurring in nature" on, or are exempted from the requirement to be listed on, the Canadian Domestic Substances List (DSL).

SECTION 16: OTHER INFORMATION

REVISION INFORMATION: Regulatory review of content.

LABEL/OTHER INFORMATION: Not available.

Axarel 58
Petroferm Inc.

MATERIAL SAFETY DATA SHEET

PETROFERM INC.
2416 Lynndale Road
Fernandina Beach, Florida 32034
(904) 261-8286
www.petroferm.com

CHEMTREC 24-HOUR EMERGENCY RESPONSE
TOLL FREE NUMBER: (800) 424-9300
INTERNATIONAL CALLS: COLLECT (703) 527-3887
CHEMTREC should only be contacted in the event of chemical emergencies involving a spill, leak, fire, exposure, or accident involving chemicals.

1. PRODUCT NAME

AXAREL®* 58 Precision Cleaner

2. COMPOSITION AND INFORMATION ON INGREDIENTS

	CAS Number	Weight %	OSHA PEL	ACGIH TLV
Methyl ester of soybean oil	67784-80-9	> 90	Not est.	Not est.
1-Methyl-4-(1-methylethenyl)-cyclohexene	5989-27-5	1-3	Not est.	Not est.
Alkyloxy polyethylene oxyethanol	84133-50-6	1-3	Not est.	Not est.

3. HAZARDS IDENTIFICATION

SYMPTOMS/EFFECTS OF OVEREXPOSURE

Inhalation: Low volatility makes vapor inhalation unlikely unless the product is heated. Vapors or finely misted materials may irritate the mucous membranes and cause irritation, dizziness, and nausea.

Ingestion: Low order of toxicity. May cause mild nausea.

Skin: Repeated or prolonged contact with skin may cause very mild irritation.

Eyes: Contact with eyes may cause mild irritation.

Listed Carcinogens: None

4. FIRST AID MEASURES

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Consult a physician.

Ingestion: Do not induce vomiting. Give one or two glasses of water to drink. If gastro-intestinal symptoms develop, seek medical attention. Never give anything by mouth to an unconscious person.

Skin: Remove contaminated clothing. Thoroughly wash affected area with soap and water.

Eyes: Immediately flush eyes with water for 15 minutes. Call a physician if signs of irritation appear.

5. FIRE FIGHTING MEASURES

Extinguishing Media: Dry chemical, chemical foam, carbon dioxide. Class BC, ABC fire extinguisher.

Special Fire Fighting Procedures: Self-contained positive pressure breathing apparatus and protective clothing should be worn in fighting fires involving chemicals.

Unusual Fire and Explosions Hazard: Exercise care when disposing of rags contaminated with this product. Use normal precautions appropriate for oily rags.

6. ACCIDENTAL RELEASE MEASURES

Absorb spill with inert material, then place in chemical waste container. For large spills, dike for later disposal. Observe government regulations.

* Registered trademark of Petroferm Inc.

7. HANDLING AND STORAGE

Store in original container, preferably in a cool, ventilated, fire-resistant building. Avoid overheating or freezing. Since empty containers may retain product residues (vapor, liquid, or solid) all label precautions must be observed.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION

Respiratory: Use NIOSH/MSHA approved respirator if ventilation is not sufficient and if mists are generated.

Ventilation: Local exhaust can be effective in minimizing odor. Mechanical (general) ventilation should have an airflow of 55 CFM.

Clothing/Glove: Chemically resistant gloves should be used with all industrial chemicals.

Eye Protection: Safety glasses/goggles are recommended. Provide eye bath near work site.

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point(760 mm Hg):	> 392 °F (200°C)	**Vapor Density (Air = 1):**	> 1
% Volatile (By Weight):	None	**Evaporation Rate (BUAC = 1):**	< 1
Specific Gravity (H_2O =1):	0.88 @ 77 °F (25°C)	**Solubility in Water:**	Emulsifiable
Vapor Pressure(20°C):	< 2 mm Hg	**Appearance and Odor:**	Yellow liquid with a citrus odor.
Flash Point:	185°F (ASTM D93-85, Pensky-Martens Closed Cup)	**Flammable Limits (% By Volume in Air):**	Not determined.

10. STABILITY AND REACTIVITY

Stability: AXAREL 58 is stable.

Conditions to Avoid: Temperatures above 400 °F (205°C).

Incompatibility: Strong oxidizing agents.

Hazardous Decomposition Products: None, other than normal products of combustion.

Hazardous Polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

No information available.

12. ECOLOGICAL INFORMATION

No information available.

13. DISPOSAL CONSIDERATIONS

Waste treat or incinerate used material in compliance with all applicable government regulations.

14. TRANSPORT INFORMATION

Non-regulated.

15. REGULATORY INFORMATION

The component of AXAREL 58 does not appears on any of the EPA's lists of toxic or hazardous substances, or on the SARA 313 toxic chemicals list (40 CFR 372.65).

This product contains a secondary alcohol ethoxylate which contains traces of dioxane, ethylene oxide, formaldehyde, and acetaldehyde which are listed in California's Safe Drinking Water and Toxic Enforcement Act of 1986 - Proposition as chemicals known to cause cancer, birth defects, or other reproductive harm.

15. REGULATORY INFORMATION (Continued)

The component of this product is listed on the TSCA inventory.

16. OTHER INFORMATION

NFPA Codes: Health: 1 Fire: 1 Reactivity: 0

Bioact MSO

Petrofirm Inc.

MATERIAL SAFETY DATA SHEET

PETROFERM INC.
2416 Lynndale Road
Fernandina Beach, Florida 32034
(904) 261-8286
www.petroferm.com

CHEMTREC 24-HOUR EMERGENCY RESPONSE
TOLL FREE NUMBER: (800) 424-9300
INTERNATIONAL CALLS: COLLECT (703) 527-3887
CHEMTREC should only be contacted in the event of chemical emergencies involving a spill, leak, fire, exposure, or accident involving chemicals.

1. PRODUCT NAME

BIOACT®* MSO

2. COMPOSITION AND INFORMATION ON INGREDIENTS

	CAS Number	Weight %	OSHA PEL	ACGIH TLV
1-Methyl-4-(1-methylethenyl)-cyclohexene	5989-27-5	80 - 90	Not est.	Not est.
Proprietary Surfactant Blend	Not Applicable	10 - 20	Not est.	Not est.

3. HAZARDS IDENTIFICATION

SYMPTOMS/EFFECTS OF OVEREXPOSURE

Inhalation: Acute or chronic inhalation in unventilated areas may cause irritation of the respiratory tract.

Ingestion: Low order of toxicity. May cause mild nausea and abdominal discomfort.

Skin: Excessive skin contact will remove natural skin oils which could lead to reversible dermatitis.

Eyes: Contact with eyes will cause irritation.

Listed Carcinogens: None

4. FIRST AID MEASURES

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Consult a physician.

Ingestion: Do not induce vomiting. Seek medical attention.

Skin: Remove contaminated clothing. Thoroughly wash affected area with soap and water; use skin cream if irritation is severe.

Eyes: Immediately flush eyes with water for 15 minutes. Call a physician if irritation persists.

5. FIRE FIGHTING MEASURES

Extinguishing Media: Dry chemical, chemical foam, carbon dioxide. Class BC, ABC fire extinguisher.

Special Fire Fighting Procedures: Self-contained positive pressure breathing apparatus and protective clothing should be worn in fighting fires involving chemicals..

Unusual Fire and Explosions Hazard: Exercise care when disposing of rags contaminated with this product. Use normal precautions appropriate for oily rags.

6. ACCIDENTAL RELEASE MEASURES

Absorb spill with inert material, then place in chemical waste container. For large spills, dike for later disposal. Observe government regulations.

* Registered trademark of Petroferm Inc.

7. HANDLING AND STORAGE

Store in original container, preferably in a cool, ventilated, fire-resistant building. Avoid overheating or freezing. Avoid open flames and sparks. Since empty containers may retain product residues (vapor, liquid, or solid) all label precautions must be observed.

8. EXPOSURE CONTROLS – PERSONAL PROTECTION

Respiratory: Use NIOSH/MSHA approved respirator if ventilation is not sufficient and if mists are generated.

Ventilation: If desirable to reduce odor, mechanical (general) ventilation should have an airflow of 55 CFM. Local exhaust can also be effective in minimizing odor.

Clothing/Glove: Chemically resistant gloves should be used with all industrial chemicals.

Eye Protection: Safety glasses/goggles are recommended. Provide eye bath near work site.

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point(760 mm Hg):	340°-372°F (171°-189°C)	**Vapor Density (Air = 1):**	> 1
% Volatile (By Weight):	Not determined.	**Evaporation Rate (BUAC = 1):**	< 1
Specific Gravity (H_2O =1):	0.86 @ 77°F (25°C)	**Solubility in Water:**	Emulsifiable
Vapor Pressure(20°C):	< 2 mm Hg	**Appearance and Odor:**	Colorless to light yellow liquid with a citrus odor.
Flash Point:	117°F (47°C) (ASTM D93-85, Pensky-Martens Closed Cup)	**Flammable Limits (% By Volume in Air):**	Not determined.

10. STABILITY AND REACTIVITY

Stability: BIOACT MSO is stable.

Conditions to Avoid: Temperatures above 340°F (171°C), sparks, and open flames.

Incompatibility: Strong mineral acids and strong oxidizing agents.

Hazardous Decomposition Products: None, other than normal products of combustion.

Hazardous Polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

1-Methyl-4-(1-methylethenyl)-cyclohexene

LD50/oral/rat = > 5,000 mg/kg

LD50/dermal/rabbit = > 5,000 mg/kg

12. ECOLOGICAL INFORMATION

No information available.

13. DISPOSAL CONSIDERATIONS

Waste treat or incinerate used material in compliance with all applicable government regulations.

14. TRANSPORT INFORMATION **UN-No.: 2319**

IATA

UN/ID No.: 2319	Class: 3
Packaging group: III	ICAO-Label: Flammable liquid
Proper shipping name:	Terpene hydrocarbons, N.O.S.

IMO

Class: 3	IMDG page: 108
Packaging group: III	IMO-Label: Flammable liquid
Proper shipping name:	Terpene hydrocarbons, N.O.S.

15. REGULATORY INFORMATION

None of the components of BIOACT MSO appears on any of the EPA's lists of toxic or hazardous substances, or on the SARA 313 toxic chemicals list (40 CFR 372.65).

None of the components of this product is listed in California's Safe Drinking Water and Toxic Enforcement Act of 1986 – Proposition 65 as a chemical known to cause cancer, birth defects, or other reproductive harm.

All the components of this product are listed on the TSCA inventory.

16. OTHER INFORMATION

NFPA Codes: Health: 1 Fire: 2 Reactivity: 0

Breakthrough

Inland Technology Inc.

Material Safety Data Sheet

SECTION I - Material Identity

Item	
Name	
Part Number/Trade Name	BREAKTHROUGH CLEANING COMPOUND
National Stock Number	6850013780666
CAGE Code	0K209
Part Number Indicator	A
MSDS Number	190201
HAZ Code	B

SECTION II - Manufacturer's Information

Manufacturer Name	INLAND TECHNOLOGY INC
Street	401 EAST 27TH ST
City	TACOMA
State	WA
Country	US
Zip Code	98421
Emergency Phone	800-424-9300 CHEMTREC
Information Phone	800-255-3100

MSDS Preparer's Information

Street	401 E 27TH STREET
City	TACOMA

State	WA
Zip Code	98421
Date MSDS Prepared/Revised	03AUG98
Date of Technical Review	28JUN96
Active Indicator	N

Alternate Vendors

SECTION III - Physical/Chemical Characteristics

Specification Number	N/R
Specification Type/Grade/Class	N/R
Appearance/Odor	CLEAR WITH MILD PETROLEUM ODOR
Boiling Point	370 F
Melting Point	N/K
Vapor Pressure	<2
Vapor Density	>5
Specific Gravity	0.77
Evaporation Rate	<1 (N-BUTYL ACETATE=1)
Solubility in Water	NOT WATER SOLUBLE
Percent Volatiles by Volume	100
Container Pressure Code	1
Temperature Code	4
Product State Code	L

SECTION IV - Fire and Explosion Hazard Data

Flash Point	150
Flash Point Method	PMCC
Lower Explosion Limit	0.8
Upper Explosion Limit	7
Extinguishing Media	FOAM, WATER SPRAY, DRY CHEMICAL, CARBON DIOXIDE
Special Fire Fighting Procedures	USE AIR SUPPLIED BREATHING EQUIPMENT FOR ENCLOSED AND CONFINED SPACES OR AS OTHERWISE NEEDED
Unusual Fire/Explosion Hazards	NONE KNOWN

SECTION V - Reactivity Data

Stability	YES
Stability Conditions to Avoid	NONE SPECIFIED BY MANUFACTURER
Materials to Avoid	AVOID CONTACT WITH STRONG ACIDS AND STRONG OXIDIZING AGENTS
Hazardous Decomposition Products	CARBON DIOXIDE, CARBON MONOXIDE, AND HYDROCARBONS
Hazardous Polymerization	NO
Polymerization Conditions to Avoid	NONE

SECTION VI - Health Hazard Data

Route of Entry: Skin	YES
Route of Entry: Ingestion	NO
Route of Entry: Inhalation	YES
Health Hazards - Acute and Chronic	[EYE] LIQUID CONTACTING THE EYES MAY CAUSE EYE IRRITATION. [INGEST] LOW ORDER OF TOXICITY. [SKIN] LOW ORDER OF TOXICITY. PROLONGED OR REPEATED SKIN EXPOSURE CAN LEAD TO MILD IRRITATION DEFATTING AND DERMATITIS. [INHAL] INHALATION OF VAPORS CAN CAUSE IRRITATION TO NOSE, THROAT AND UPPER RESPIRATORY TRACT
Carcinogenity: NTP	NO
Carcinogenity: IARC	NO
Carcinogenity: OSHA	NO
Explanation of Carcinogenity	NONE KNOWN
Symptoms of Overexposure	NONE SPECIFIED BY MANUFACTURER
Medical Cond. Aggrevated by Exposure	SKIN CONTACT MAY AGGRAVATE EXISTING DERMATITIS
Emergency/First Aid Procedures	[EYES] IF CONTACT OCCURS FLUSH WITH WATER FOR AT LEAST 15 MIN OR UNTIL IRRITATION DUBSIDES. IF IRRITATION PERSISTS CONTACT PHYSICIAN. [SKIN] IN CASE OF SKIN CONTACT, REMOVE ANY CONTAMINATED CLOTHING AND WASH SKIN THOROUGHLY WITH SOAP AND WATER. [INHAL] IF OVERCOME BY VAPOR, REMOVE FROM EXPOSED AREA AND CALL PHYSICIAN IMMEDIATELY. [INGEST] DO NOT INDUCE VOMITING. CALL PHYSICIAN IMMEDIATELY

SECTION VII - Precautions for Safe Handling and Use

Steps if Material Released/Spilled	SHUT OFF AND ELIMIATE ALL IGNITABLE SOURCES. CONTAIN AND COLLECT MATERIAL. ABSORB RESIDUE
Neutralizing Agent	NONE SPECIFIED BY MANUFACTURER
Waste Disposal Method	CONTACT FEDERAL, STATE, COUNTRY OR LOCAL ENVIRONMENTAL REGULATORY AGENCIES FOR GUIDANCE
Handling and Storage Precautions	USE AND STORE AWAY FROM HEAT, SPARKS AND OPEN FLAMES. KEEP CONTAINER SEALED WHEN NOT IN USE
Other Precautions	READ AND UNDERSTAND ALL CAUTIONS, LABELS AND MSDS BEFORE USING ANY CHEMICAL PRODUCT

SECTION VIII - Control Measures

Respiratory Protection	NONE NORMALLY REQUIRED
Ventilation	USE MECHANICAL VENTILATION WHENEVER PRODUCT IS USED IN CONFINED SPACE, IS HEATED ABOVE AMBIENT TEMPERATURE OR IS AGITATE
Protective Gloves	USE CHEMICAL RESISTANT GLOVES, IF NEEDED
Eye Protection	SPLASH GOGGLES/FACE SHIELD
Other Protective Equipment	NONE NORMALLY REQUIRED
Work Hygenic Practices	MINIMIZE BREATHING OF VAPOR OR MIST. AVOID PROLONGED OR REPEATED CONTACT SKIN
Supplemental Health/Safety Data	WASH CONTAMINATED CLOTHING BEFORE REUSE. KEEP ALL CHEMICALS OUT OF THE REACH OF CHILDREN

SECTION IX - Label Data

Protect Eye	YES
Protect Skin	YES
Protect Respiratory	YES
Chronic Indicator	YES
Contact Code	SLIGHT
Fire Code	UNKNOWN

Health Code	UNKNOWN
React Code	UNKNOWN
Specific Hazard and Precaution	TARGET ORGANS: SKIN

SECTION X - Transportation Data

Container Quantity	55
Unit of Measure	GL

SECTION XI - Site Specific/Reporting Information

Volatile Organic Compounds (P/G)	6.42
Volatile Organic Compounds (G/L)	769.3653

SECTION XII - Ingredients/Identity Information

Ingredient #	1
Ingredient Name	C12-C13 PARAFFINIC HYDROCARBONS
CAS Number	64742489
Proprietary	NO
Percent	0
OSHA PEL	NOT LISTED
ACGIH TLV	NOT LISTED

California Parts Washer Solution

Phase III Inc.

Ross Environmental
Material Safety Data Sheet

MSDS 14-JUNE-2002

"CALIFORNIA" PARTS WASHER SOLUTION

Parts Cleaners

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1. CHEMICAL PRODUCT/COMPANY IDENTIFICATION

"CALIFORNIA PARTS WASHER SOLUTION" is a trademark of Phase III, Inc.

Material Identification

Product Use: MICROBIAL PARTS WASHER SOLUTION

Company Identification

DISTRIBUTOR

Ross Environmental Products Ltd,
Unit 207a Foley Industrial Estate,
Lisle Avenue, Kidderminster.
Dy11 7dh

PHONE NUMBERS

01562 752400 Tel/Fax
01562 752299 Sales
Web Site.www.rossenvironmental.co.uk

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2. COMPOSITION/INFORMATION ON INGREDIENTS

Components CAS# EINECS# PERCENTAGE

Water 7732-18-5 231-791-2 >82
Chelating Agent 64-02-8 200-573-9 <5
Alcohol Ethoxylate 68991-48-0 <10
Alcohol Ethoxylate 68439-46-3 <3
Fragrance, Coloring N/A N/A <0.5

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3. HAZARDS IDENTIFICATION

**********EMERGENCY OVERVIEW**********
* May irritate eyes and skin. Blue liquid. *
****

Potential Health Effects:

EYE: May cause irritation.

SKIN: May cause irritation.

INGESTION: May cause nausea or diarrhea.

INHALATION: May cause nose and throat irritation.

CHRONIC (CANCER) INFORMATION: Unlikely to present a cancer hazard to man.

4. FIRST AID MEASURES

First Aid:

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a Physician.

SKIN OR EYE CONTACT: In case of eye contact, immediately wash eye with plenty of water for at least 15 minutes. Call a physician if irritation develops.

INGESTION: Drink plenty of water. Do not induce vomiting. Call a physician. Never give anything by mouth to an unconscious person.

5. FIRE FIGHTING MEASURES

Non-flammable.

Extinguishing Media: As required for surrounding fire.

6. ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel): NOTE: Review FIRE FIGHTING MEASURES and HANDLING

PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up.

Flush area with water into sewer system. Caution - may be slippery.

7. HANDLING AND STORAGE

Handling (Personnel): Do not get in eyes, on skin, or on clothing.

Storage: Store away from heat. Keep container closed.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls: Use ventilation that is adequate to keep employee exposure to airborne concentrations below exposure limits.

Personal Protective Equipment: Have available and wear as appropriate: gloves, safety glasses and apron.

Exposure Guidelines
Exposure Limits

None.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Data
Solubility in water: 100%
Specific Gravity : .996
Percent volatile : <50 g/L (diluted)
Color : Blue
Form : Slightly viscous liquid
Odor : Pleasant.
PH : 8.0 - 9.0

10. STABILITY AND REACTIVITY

Chemical Stability: Stable.

Incompatibility with Other Materials: Incompatible with strong oxidizers.

Decomposition: Occurs with strong heat.

Polymerization: Polymerization will not occur.

11. TOXICOLOGICAL INFORMATION

Mixture not tested but based on components, may cause irritation to skin and eyes. Ingestion may cause nausea or diarrhea.

Inhalation may cause nose and throat irritation.

None of the components of this material are listed by IARC, NTP, OSHA, or ACGIH as carcinogens.

12. ECOLOGICAL INFORMATION

Biodegradable.

13. DISPOSAL CONSIDERATIONS

Waste Disposal:
Treatment, storage, transportation, and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations.

14. TRANSPORTATION INFORMATION

Shipping Information

DOT: Not regulated.

15. REGULATORY INFORMATION

Not classified as hazardous to users or for transport.

U.S. Federal Regulations
CERCLA and SARA regulations (40 CFR 355, 370 and 372): Does not contain any chemicals subject to the reporting requirements of SARA 313.

TSCA Inventory Status : Reported/Included.

16. OTHER INFORMATION

NPCA-HMIS Rating
Health : 1
Flammability : 0
Reactivity : 0
Personal Protection rating to be supplied by user depending on use conditions.

STATE RIGHT-TO-KNOW LAWS

No substances on the state hazardous substances list, for the states indicated below, are used in the manufacture of products on this Material Safety Data Sheet, with the exceptions indicated. While we do not specifically analyze these products, or the raw materials used in their manufacture, for substances on various state hazardous substances lists, to the best of our knowledge the products on this Material Safety Data Sheet contain no such substances except for those specifically listed below:

WARNING: SUBSTANCES KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER:
None known.

WARNING: SUBSTANCES KNOWN TO THE STATE OF CALIFORNIA TO CAUSE BIRTH DEFECTS
OR OTHER REPRODUCTIVE HARM: None known.

This information is furnished gratuitously, independent of any sale, and for your independent verification. Although we believe the data to be correct as of this date as the date indicated, we make no representation as to its accuracy and such information may not be valid when product is used in any process or combined with other materials. No REPRESENTATION(S), GAURANTEE(S), OR WARRANTY, either EXPRESSED, IMPLIED, or of any NATURE, is made with respect to the product or data provided.

Responsibility for MSDS :

Phase III,
Arizona

Heavy Duty Cleaner

Phase III Inc.

PHase III, Inc.

Material Safety Data Sheet

MSDS 01-January-05

PHase III, Inc. Heavy Duty Cleaner

1. CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification

Product Use: Heavy Duty Cleaner / Degreaser

Company Identification

MANUFACTURER/DISTRIBUTOR

Phase III, Inc.
916 E. Baseline Rd. Suite 101
Mesa, Arizona 85204-6603

PHONE NUMBERS

480-503-2847
480-503-1077 fax

2. COMPOSITION/INFORMATION ON INGREDIENTS

Components

Water, surfactants.

3. HAZARDS IDENTIFICATION

**********EMERGENCY OVERVIEW**********
* May irritate eyes and skin. Blue liquid. *
****

Potential Health Effects:

EYE: May cause irritation.

SKIN: May cause irritation.

INGESTION: May cause nausea or diarrhea.

INHALATION: May cause nose and throat irritation.

CHRONIC (CANCER) INFORMATION: Unlikely to present a cancer hazard to man.

4. FIRST AID MEASURES

First Aid:

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN OR EYE CONTACT: In case of eye contact, immediately wash eye with plenty of water for at least 15 minutes. Call a physician if irritation develops.

INGESTION: Drink plenty of water. Do not induce vomiting. Call a physician. Never give anything by mouth to an unconscious person.

5. FIRE FIGHTING MEASURES

Non-flammable.

Extinguishing Media: As required for surrounding fire.

6. ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel): NOTE: Review FIRE FIGHTING MEASURES and HANDLING PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up.

Flush area with water into sewer system. Caution - may be slippery.

7. HANDLING AND STORAGE

Handling (Personnel): Do not get in eyes, on skin, or on clothing.

Storage: Store away from heat. Keep container closed.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls: Use ventilation that is adequate to keep employee exposure to airborne concentrations below exposure limits.

Personal Protective Equipment: Have available and wear as appropriate: gloves, safety glasses and apron.

Exposure Guidelines
Exposure Limits

None.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Data
Solubility in water: 100%

Specific Gravity : 1.030
Percent volatile : <25 g/L (diluted)
Viscosity : 1.9 cSt @ 40° C
Color : Blue
Form : Slightly viscous liquid
Odor : Pleasant.
pH : 9.0 – 10.0

10. STABILITY AND REACTIVITY

Chemical Stability: Stable.

Incompatibility with Other Materials: Incompatible with strong oxidizers.

Decomposition: Occurs with strong heat.

Polymerization: Polymerization will not occur.

11. TOXICOLOGICAL INFORMATION

Mixture not tested but based on components, may cause irritation to skin and eyes. Ingestion may cause nausea or diarrhea.

Inhalation may cause nose and throat irritation.

None of the components of this material are listed by IARC, NTP, OSHA, or ACGIH as carcinogens.

12. ECOLOGICAL INFORMATION

Biodegradable.

13. DISPOSAL CONSIDERATIONS

Waste Disposal:
Treatment, storage, transportation, and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations.

14. TRANSPORTATION INFORMATION

Shipping Information

DOT: Not regulated.

15. REGULATORY INFORMATION

Not classified as hazardous to users or for transport.

U.S. Federal Regulations

CERCLA and SARA regulations (40 CFR 355, 370 and 372): Does not contain any chemicals subject to the reporting requirements of SARA 313.

TSCA Inventory Status : Reported/Included.

16. OTHER INFORMATION

NPCA-HMIS Rating
Health : 1
Flammability : 0
Reactivity : 0
Personal Protection rating to be supplied by user depending on use conditions.

STATE RIGHT-TO-KNOW LAWS

No substances on the state hazardous substances list, for the states indicated below, are used in the manufacture of products on this Material Safety Data Sheet, with the exceptions indicated. While we do not specifically analyze these products, or the raw materials used in their manufacture, for substances on various state hazardous substances lists, to the best of our knowledge the products on this Material Safety Data Sheet contain no such substances except for those specifically listed below:

WARNING: SUBSTANCES KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER: None known.

WARNING: SUBSTANCES KNOWN TO THE STATE OF CALIFORNIA TO CAUSE BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM: None known.

This information is furnished gratuitously, independent of any sale, and for your independent verification. Although we believe the data to be correct as of this date as the date indicated, we make no representation as to its accuracy and such information may not be valid when product is used in any process or combined with other materials. **No REPRESENTATION(S), GAURANTEE(S), OR WARRANTY**, either **EXPRESSED, IMPLIED**, or of any **NATURE,** is made with respect to the product or data provided.

Responsibility for MSDS :

Phase III, Inc.
916 E. Baseline Rd. Suite 101
Mesa, Arizona 85204-6603

Oleocal ME-130

SoySolv

MATERIAL SAFETY DATA SHEET

LAMBENT TECHNOLOGIES CORP.
7247 North Central Park Avenue
Skokie, IL 60076
(847) 675-3950

CHEM-TEL EMERGENCY RESPONSE
TOLL FREE NUMBER: (800) 255-3924
INTERNATIONAL CALLS: COLLECT (813) 248-0585

1. PRODUCT IDENTIFICATION

Product Name: **OLEOCAL®* ME - 130**
Synonym: Methyl soyate

2. COMPOSITION / INFORMATION ON INGREDIENTS

	CAS Number	Weight %	ACGIH TLV	OSHA PEL
Methyl ester of soybean oil	67784-80-9		Not est.	Not est.

3. HAZARDS IDENTIFICATION

Potential Health Effects

INHALATION: Negligible unless heated to produce vapors. Vapors or finely misted materials may irritate the mucous membranes and cause irritation, dizziness, and nausea. Remove to fresh air.

EYE CONTACT: May cause irritation. Irrigate eye with water for at least 15 to 20 minutes. Seek medical attention if symptoms persist.

SKIN CONTACT: Prolonged or repeated contact is not likely to cause significant skin irritation. Material is sometimes encountered at elevated temperatures. Thermal burns are possible.

INGESTION: No hazards anticipated from ingestion incidental to industrial exposure.

4. FIRST AID MEASURES

EYES: Irrigate eyes with a heavy stream of water for at least 15 to 20 minutes.

SKIN: Wash exposed areas of the body with soap and water.

INHALATION: Remove from area of exposure, seek medical attention if symptoms persist.

INGESTION: Give one or two glasses of water to drink. If gastro-intestinal symptoms develop, consult medical personnel. (Never give anything by mouth to an unconscious person.)

5. FIRE FIGHTING MEASURES

FLASH POINT (Method Used): > 175°C (COC)
FLAMMABILITY LIMITS: None known

EXTINGUISHING MEDIA: Dry chemical, foam, halon, CO_2, water spray (fog). Water stream may splash burning liquid and spread fire.

SPECIAL FIRE FIGHTING PROCEDURES: Use water spray to cool drums exposed to fire.

* Registered trademark of Lambent Technologies Corp.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Firefighters should use self-contained breathing apparatus to avoid exposure to smoke and vapor.

Exercise care when disposing of rags contaminated with the product.

6. ACCIDENTAL RELEASE MEASURES

SPILL CLEAN-UP PROCEDURES: Remove sources of ignition, contain spill to smallest area possible. Stop leak if possible. Pick up small spills with absorbent materials such as paper towels, "Oil Dry", sand or dirt. Recover large spills for salvage or disposal. Wash hard surfaces with safety solvent or detergent to remove remaining oil film. Greasy nature will result in a slippery surface.

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7. HANDLING AND STORAGE

Store in closed containers between 50°F and 120°F. Keep away from oxidizing agents, excessive heat, and ignition sources. Store and use in well ventilated areas. Do not store or use near heat, spark, or flame; store out of sun. Do not puncture, drag, or slide this container. Drum is not a pressure vessel; never use pressure to empty.

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8. EXPOSURE CONTROLS / PERSONAL PROTECTION

RESPIRATORY PROTECTION: If vapors or mists are generated, wear a NIOSH approved organic vapor/mist respirator.

PROTECTIVE CLOTHING: Safety glasses, goggles, or face shield recommended to protect eyes from mists or splashing. PVC coated gloves recommended to prevent skin contact.

OTHER PROTECTIVE MEASURES: Employees must practice good personal hygiene, washing exposed areas of skin several times daily and laundering contaminated clothing before re-use.

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9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point, 760mm Hg:	> 200°C
Specific Gravity, (H_20=1):	0.88
Vapor Pressure, mm Hg:	< 2
Vapor Density, (Air=1):	> 1
Volatiles, % by Volume:	< 2%
Evaporation Rate, (Butyl Acetate=1):	< 1
Solubility in Water, % by Volume:	Insoluble
Appearance and Odor:	Yellow liquid with a mild fatty odor

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10. STABILITY AND REACTIVITY

GENERAL: This product is stable and hazardous polymerization will not occur.

INCOMPATIBLE MATERIALS AND CONDITIONS TO AVOID: Strong oxidizing agents

HAZARDOUS DECOMPOSITION PRODUCTS: Combustion produces carbon monoxide, carbon dioxide along with thick smoke.

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11. DISPOSAL CONSIDERATIONS

Waste may be disposed of by a licensed waste disposal company. Contaminated absorbent material may be disposed of in an approved land fill. Follow local, state and federal disposal regulations.

12. TRANSPORT INFORMATION

UN HAZARD CLASS: N/A

13. REGULATORY INFORMATION

OSHA STATUS: This product is not hazardous under the criteria of the Federal OSHA hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in Section 3.
TSCA STATUS: The components of this product are listed on TSCA.

CERCLA (Comprehensive Response Compensation, and Liability Act): Not reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act)
Section 312 Extremely Hazardous Substances: None
Section 311/312 Hazard Categories: Non-hazardous Under Section 311/312
Section 313 Toxic Chemicals: None

RCRA STATUS: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste. (40 CFR 261.20-24)

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California safe Drinking Water and Toxic Enforcement Act of 1986. The product contains no chemicals known to the State of California to cause cancer.

14. OTHER INFORMATION:

NFPA Codes: Health: 1 Fire: 1 Reactivity: 0

Revision Notes: New 2/1/99
Revision Notes: 4/22/02 Change International emergency number

This information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any other process. Such information is to the best of the company's knowledge and believed accurate and reliable as of the date indicated. However, no representation, warranty or guarantee of any kind, express or implied, is made as to its accuracy, reliability or completeness and we assume

no responsibility for any loss, damage or expense, direct or consequential, arising out of use. It is the user's responsibility to satisfy himself as to the suitableness and completeness of such information for his own particular use.

SS-HD Parts Washer Formulation

Solvent Systems Intnl.

24 Hour Emergency:
INFOTRAC: 1-800-535-5053

SOLVENT SYSTEMS International, Inc.
Environmental Services

NOTE: INFOTRAC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

Material Safety Data Sheet

Section 1 - Chemical Product / Company Information

Product Name: SS-HD PARTS WASHER FORMULATION Revision Date: 03/10/2004
Identification Number: 44991 Supercedes : 03/10/2004
Supplier: Solvent Systems International
70 King Street
Elk Grove Village, IL 60007
(847) 437-1100

Section 2 - Composition / Information On Ingredients

Chemical Name	CAS Number	Weight % Less Than	ACGIH TLV-TWA	ACGIH TLV-STEL	OSHA PEL-TWA	OSHA PEL-CEILING
TETRAPOTASSIUM PYROPHOSPHATE	7320-34-5	10.0			10 mg/m3	
HYDROTROPE	1300-72-7	5.0				
ALKANOLAMIDE	68603-42-9	5.0				
SODIUM CARBONATE	497-19-8	5.0			5 mg/m3	
ALCOHOLS, C10-C12, ETHOXYLATED, PROPOXYLATED	68154-97-2	5.0				
ALKANOLAMIDE		5.0				
2-BUTOXYETHANOL, GLYCOL ETHERS; 2-BUTOXYETHANOL, 1,2-ETHANEDIOL, 1-BUTANOL	111-76-2	5.0	20 ppm		50 ppm	
SODIUM METASILICATE PENTAHYDRATE	6834-92-0	5.0				2 mg/m3
SODIUM SULFATE	7757-82-6	0.1				

Exposure Notes

Section 3 - Hazards Identification

*** Emergency Overview ***: No Information.

Effects Of Overexposure - Eye Contact: Can cause permanent injury to the eyes.

Effects Of Overexposure - Skin Contact: Prolonged or repeated contact can result in defatting and drying of the skin

which may result in skin irritation and dermatitis (rash). May be absorbed in toxic amounts through the skin.

Effects Of Overexposure - Inhalation: May be irritating to the respiratory system. Dust/Mist irritates nose and throat. Vapors can cause irritation of the respiratory tract. High concentrations can cause headache, nausea, weakness, lightheadedness, and stupor (CNS depression). High vapor concentrations may cause drowsiness and irritation.

Effects Of Overexposure - Ingestion: May cause dizziness and drowsiness and/or stupor. Ingestion may result in nausea, vomitting, diarrhea and restlesness. Corrosive and may cause severe and permanent damage to mouth, throat, and stomach. Irritating to mouth, throat, and stomach. Overexposure may cause nausea, diarrhea, and/or vomiting.

Effects Of Overexposure - Chronic Hazards: May cause delayed lung damage. Significant exposure to this chemical may adversely affect people with chronic disease of the respiratory system, central nervous system, kidney, liver, skin, and/or eyes. Overexposure may cause kidney damage.

Primary Route(s) Of Entry: N/A

Section 4 - First Aid Measures

First Aid - Eye Contact: Flush eyes with water a minimum of 15 minutes occasionally lifting lower and upper lids. Get medical attention promptly.

First Aid - Skin Contact: Remove contaminated shoes and clothes and clean before reuse. Immediately flush skin with plenty of water. Remove clothing. Get medical attention immediately. Wash clothing separately before reuse.

First Aid - Inhalation: To prevent aspiration, keep head below knees. Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get immediate medical attention.

First Aid - Ingestion: DO NOT induce vomiting. Get medical attention immediately. Do not induce vomiting. Do not give liquids. Obtain emergency medical attention.

Section 5 - Fire Fighting Measures

Flash Point, F: N/A (TCC)

Lower Explosive Limit, %: N.D.

Upper Explosive Limit, %: N.D.

Extinguishing Media: N/A

Unusual Fire And Explosion Hazards: May form expolsive peroxides.

Special Firefighting Procedures: Small fires: Dry chemical, carbon dioxide, water spray or alcohol-resistant foam. Large fires: Water spray, water fog, and alcohol-resistant foam. Water spray and foam must be applied carefully to avoid frothing As in any fire, wear self-contained breathing apparatus pressure-demand (MSHA/NIOSH approved or equivalent) and full protective gear. Water runoff can cause environmental damage. Dike and collect water used to fight fire. Water spray to cool containers or protect personnel. Use with caution.

Section 6 – Accidental Release Measures

Steps To Be Taken If Material Is Released Or Spilled: Recover by pumping (use an explosion proof or hand pump). Eliminate all ignition sources. Flush spill area with water after clean up. Ventilate spill area. Take up spill with clean, dry shovel and place in chemical waste container. Do not touch or walk through spilled material. Flush spill area with water. Absorb spill with inert material (e.g. dry sand or earth), then place in a chemical waste container. Avoid runoff into storm sewers and ditches which lead to waterways.

Section 7 - Handling And Storage

Handling: Potential peroxide former. After opening, purge container with nitrogen before reclosing. Ground and bond containers when transferring material. Follow all MSDS/label precautions even after containers are emptied because they may retain product residues. Use only in a well ventilated area.

Storage: Do not allow to evaporate to near dryness. Keep from freezing. Keep away from heat, sparks, and flame. Keep container closed when not in use. Store containers in a cool, well ventilated place.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Local exhaust ventilation may be necessary to control any air contaminants to within their TLVs during the use of this product.

Respiratory Protection: NIOSH/MSHA approved respirators may be necessary if airborne concentrations are expected to exceed exposure limits. A NIOSH/MSHA approved air purifying respirator with an organic vapor cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits.

Skin Protection: Wear long sleeves when contact is likely to occur. Wear impervious gloves to prevent contact with the skin. Wear protective gear as needed - apron, suit, boots.

Eye Protection: Do not wear contact lenses. Wear safety glasses with side shields (or goggles) and a face shield. Use chemical splash goggles and face shield (ANSI Z87.1 or approved equivalent).

Other protective equipment: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower.

Hygienic Practices: Wash thoroughly after handling. Do not eat, drink, or smoke in areas where this material is used.

Section 9 - Physical And Chemical Properties

Boiling Range:	N.D. - N.D.	Vapor Density:	N.D.
Odor:	MILD	Odor Threshold:	N.D.
Appearance:	clear liquid	Evaporation Rate:	N.D.
Solubility in H2O:	100%		
Freeze Point:	32 degrees F	Specific Gravity:	
Vapor Pressure:	N.D.	PH:	11.5
Physical State:	liquid	Viscosity:	N.D.
RVOC:	25 g/L		

(See section 16 for abbreviation legend)

Section 10 - Stability And Reactivity

Conditions To Avoid: Avoid impact, friction, heat, sparks or flame.

Incompatibility: Prevent contact with strong oxidizing agents. Do not use sodium nitrite or other nitrosating agents in formulations containing thos product. Suspected cancer-causing nitrosamines could be formed. Avoid contact with metals. Do not store in aluminum or aluminum alloy containers. Avoid contact with moisture and/or water. Keep away from acids.

Hazardous Decomposition: Decomposition under fire conditions can lead to the formation of oxides of phosphorus. Combustion can lead to the formation of ammonia. Decomposition causes sulfur oxides to be released. Decomposition

releases nitrogen oxides. During combustion carbon dioxide may be formed. During combustion carbon monoxide may be formed. Toxic gases/fumes are given off during burning or thermal decomposition.

Hazardous Polymerization: No Information.

Stability: No Information.

Section 11 - Toxicological Information

Product LD50: N.D. Product LC50: N.D.

Chemical Name	LD50	LC50
TETRAPOTASSIUM PYROPHOSPHATE	1000.0	
HYDROTROPE		
ALKANOLAMIDE	620.0	
SODIUM CARBONATE	4090.0	2300.0
ALCOHOLS, C10-C12, ETHOXYLATED, PROPOXYLATED	2.06	
ALKANOLAMIDE	620.0	
2-BUTOXYETHANOL, GLYCOL ETHERS; 2-BUTOXYETHANOL, 1,2-ETHANEDIOL, 1-BUTANOL	320.0	500.0
SODIUM METASILICATE PENTAHYDRATE	800.0	
SODIUM SULFATE	5989.0	.

Section 12 - Ecological Information

Ecological Information: No Information.

Section 13 - Disposal Information

Disposal Information: Dispose of waste in accordance with all local, state and federal regulations.

For assistance with your waste management needs, contact Solvent Systems International at (847) 437-1100

Section 14 - Transportation Information

Non-regulated cleaning material.

Section 15 - Regulatory Information

CERCLA – SARA Hazard Category

This product has been reviewed according to the EPA 'Hazard Categories' promulgated under Sections 311and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

IMMEDIATE HEALTH HAZARD, CHRONIC HEALTH HAZARD, FIRE HAZARD

SARA Section 313:

This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendment and Reauthorization Act of 1986 and 40 CFR part 372:

Chemical Name	CAS Number
2-BUTOXYETHANOL, GLYCOL ETHERS; 2-BUTOXYETHANOL, 1,2-ETHANEDIOL, 1-BUTANOL	111-76-2

Toxic Substances Control Act:

All components of this product are listed or are exempt from listing on the TSCA 8(b) inventory. If identified components o this product are listed under the TSCA 12(b) export notification rule, they will be listed below:

Chemical Name	CAS Number
SODIUM CARBONATE	497-19-8
SODIUM SULFATE	7757-82-6

U.S. State Regulations: As follows –

New Jersey Right-to-Know:

The following materials are non-hazardous, but are among the top five components in this product.

Chemical Name	CAS Number
DEIONIZED WATER, BULK	7732-18-5

Pennsylvania Right-to-Know:

The following non-hazardous ingredients are present in the product at greater than 3%.

Chemical Name	CAS Number
DEIONIZED WATER, BULK	7732-18-5

California Proposition 65:

Warning: The following ingredients present in the product are known to the state of California to cause Cancer:

Chemical Name	CAS Number
ALCOHOLS, C10-C12, ETHOXYLATED, PROPOXYLATED	68154-97-2

Warning: The following ingredients present in the product are known to the state of California to cause birth defects, or other reproductive hazards.

Chemical Name	CAS Number
ALCOHOLS, C10-C12, ETHOXYLATED, PROPOXYLATED	68154-97-2

International Regulations: As follows –

CANADIAN WHMIS:

This MSDS has been prepared in compliance with Controlled Product Regulations except for the use of the 16 headings.

CANADIAN WHMIS CLASS:

Section 16 - Other Information

HMIS Ratings:

Health: 1	Flammability: 0	Reactivity: 0	Personal Protection:

RVOC: 25 g/L

REASON FOR REVISION:

Legend: N.A. - Not Applicable, N.E. - Not Established, N.D. - Not Determined

OzzyJuice SW-8

ChemFree Corp.

MATERIAL SAFETY DATA SHEET

ChemFree Corporation
8 Meca Way, Norcross, GA 30093
Tel: (770) 564-5580 Fax: (770) 564-5533 website: www.chemfree.com

SECTION I

Product Name: OzzyJuice® SW-8 Aircraft & Weapon Degreasing Solution
Product Use: Degreasing Fluid for the SmartWasher system

24 H Emergency Response: HEPACO (800) 888-7869

Manufactured by: ChemFree Corporation
8 Meca Way
Norcross, GA 30093
U.S.A

SECTION II
HAZARDOUS INGREDIENTS / INFORMATION

HAZARDOUS INGREDIENTS	%	CAS # NUMBER	LD50 OF INGREDIENTS (SPECIES & ROUTE)	LC50 OF INGREDIENT (SPECIES & ROUTE)
Non Hazardous proprietary water based degreaser All ingredients are listed on the TSCA Chemical Substance Inventory and on the Domestic Substance List	100	N/A	N/A	N/A

SECTION III
HAZARDS IDENTIFICATION

UN Number: Not Required
Dangerous Goods Classification: Non Hazardous

HAZARD RATINGS (NFPA/HMIS)

HEALTH	1	0 = least
		1 = slight
FLAMMABILITY	0	2 = moderate
		3 = high
REACTIVITY	0	4 = extreme.

SECTION IV
PHYSICAL / CHEMICAL CHARACTERISTICS

PHYSICAL STATE: Liquid
BOILING POINT: 210° F/99° C
APPEARANCE AND ODOR : Clear, low odor fluid
SPECIFIC GRAVITY: 1.0036
VOC Content: 10 g/L
VOC composite partial pressure: < 1 mm Hg

SOLUBILITY IN WATER: Infinite
PH: 9.0

SECTION V
FIRST AID MEASURES

EMERGENCY & FIRST AID PROCEDURES:

EYES: It is unlikely that emergency treatment will be required; if adverse effects occur, rinse eyes with large amounts of water until no evidence of chemical remains. Seek medical attention if necessary.

SKIN: It is unlikely that emergency treatment will be required; if adverse effects occur, rinse affected area with large amounts of water until no evidence of chemical remains. Seek medical attention if necessary.

INGESTION: It is unlikely that emergency treatment will be required; if adverse effects occur, treat symptomatically and seek medical attention if necessary.

INHALATION: It is unlikely that emergency treatment will be required; if adverse effects occur, remove to fresh air and observe. Seek medical attention if necessary.

SECTION VI
FIRE & EXPLOSION HAZARD DATA

FLAMMABILITY: None
MEANS OF EXTINCTION: N/A
FLASH POINT : None > 200 F **METHOD USED : Open cup**
FLAMMABLE LIMITS :
UPPER : None
LOWER : None
SPECIAL FIRE FIGHTING PROCEDURES : None
USUAL FIRE & EXPLOSION HAZARDS : None

SECTION VII
ACCIDENTAL RELEASE MEASURES

In the event that this material is released or spilled, it can be washed into storm sewer with large quantities of water.

SECTION VIII
HANDLING, STORAGE & TRANSPORT INFORMATION

No special precautions are required. This product is not hazardous for storage and transport according to the U.S. Department of Transportation Regulations.

SECTION IX
EXPOSURE CONTROLS

Exposure Limits: This product presents no health hazards to the user when used according to label directions for its intended purposes.

VENTILATION (Local exhaust) : Not required.

SECTION X
PERSONAL PROTECTION

RESPIRATORY PROTECTION (Specify Type) : Not required.
PROTECTIVE GLOVES : It is recommended that rubber gloves be worn when handling any industrial-use products.
EYE PROTECTION : It is recommended that safety glasses be worn when handling any industrial-use products.
OTHER / HYGIENIC PRACTICES : Always use good housekeeping procedures when using any chemical product.

SECTION XI
STABILITY AND REACTIVITY DATA

REACTIVITY: Non reactive
STABILITY : Stable
HAZARDOUS POLYMERIZATION : Will not occur

SECTION XII
TOXICOLOGICAL PROPERTIES

ROUTES OF ENTRY: Skin, Eyes
EFFECTS OF ACUTE EXPOSURE: It is unlikely that exposure will require treatment because product is considered a dermal non-irritant and a mild ocular irritant.
HEALTH HAZARDS (Acute & Chronic) : None
CARCINOGENICITY : None Known
TETRATOGENICITY: None known

SECTION XIII
BIODEGRADABILITY AND ENVIRONMENTAL TOXICITY INFORMATION

BIODEGRADABILITY : **Biodegradable**

TOXICITY INFORMATION:

	48 hours LC50 value in mg/L
Ceriodaphnia dubia	**141.0 mg/L**
Fathead Minnows	**171.36 mg/L**

SECTION XIV
DISPOSAL CONSIDERATIONS

WASTE DISPOSAL: This product is a water soluble and biodegradable fluid that will not harm sewage-treatment organisms if disposal by sewer or drain is necessary. Dispose of in accordance with Local, State andFfederal regulations.

SECTION XV
ADDITIONAL INFORMATION

Prepared by: Onofre Ortiz **Date: February 6, 2003**

APPENDIX C
INTERVIEW QUESTIONNAIRES

MR - 11/10/04

Interview Outline for Alternative Parts Washer Guide (In-Brief)

General Information:

(Attain from personnel being interviewed)

1. Name and contact information (Phone or E-Mail).

2. Job title.

3. Shop name.

(Attain from shop owner only)

4. Number of personnel working in the shop.

5. Number of personnel that have be using the demonstrated cleaner / parts washer.

6. Type (product detail) of parts washers used currently.

(Center POC to fill this in)

7. Type (product detail) parts washer (or cleaner) being reviewed.

In Depth Questions

Use:

What are the primary uses for parts washers in this shop?

What parts are typically cleaned?

What is the material being cleaned (metal, plastic, combination)?

What contaminants are being removed?

Process:

Is your current Parts Washer a part/portion of a larger cleaning process?

If so, where do parts come from to be cleaned? (Previous steps)

Where do parts go from here? (Future steps)

Describe in detail the cleaning process used with this parts washer / cleaner.

Describe how this trial parts washer process differs from the process used with your current parts washer / cleaner. Describe the currently used process if necessary.

Overall Performance:

How well, in your opinion does ***[insert currently used product name]*** parts washer (or cleaner) work?

In comparison to other parts washers you have used, how well does this parts washer (or cleaner) perform?

How long does it take to clean parts using ***[insert currently used product name]*** parts washer (or cleaner)?

Physical Characteristics:

Are there any noticeable odors from your current cleaner?

Are there any physical qualities (color, texture, etc.) of your current cleaner that discourage some in the shop from using it?

Are there any other physical qualities (color, texture, etc.) of your current cleaner that would encourage use?

Is there any noticeable loss of cleaning fluid due to evaporation when using parts washers currently in use?

Maintenance:

How is maintenance performed for the parts washing unit / cleaner currently in use, and with what frequency? Please describe the general maintenance process.

Specific Performance:

How many parts do you clean with your current Part Washer?

Are there any compatibility issues with your current Part Washer?

Does your current Part Washer clean some contaminants better than others do? If so, which?

Are there any contaminants that your current Part Washer is unable to clean?

Does the currently used Part Washer discolor any parts being cleaned?

Does the currently used cleaner leave an undesirable residue on the cleaned parts?

Are there any corrosion issues with your current cleaner (adequate/inadequate protection if desired)?

Are there any compatibility issues with your cleaner (i.e. Seals, plastics or other non metallic parts)?

User Opinion:

Would you suggest an alternative cleaner to replace the currently used cleaner if it is significantly better for the environment and safer for workers to use but does not clean any better than your current one?

Would you suggest an alternative cleaner to replace the currently used cleaner if it is significantly better for the environment and safer for workers to use but it takes slightly longer to clean with than your current one?

Closure:

Do you have suggestions concerning this project / effort that would help or improve the process when reviewing new / alternative parts washers?

Are there any other comments or questions that you may have for us?

MR 11/17/04

Mid-Point Interview Outline for Alternative Parts Washer Guide

General Information:

(Confirm from Previous In-Brief Interview)

1. Name and contact information (Phone or E-Mail).

2. Shop name.

3. Number of personnel working in the shop.

4. Number of personnel that have used the demonstrated cleaner / parts washer.

5. Type (product detail) of parts washers used currently.

6. Type (product detail) parts washer (or cleaner) being reviewed.

Numeric (Quantitative Observation) or on a scale of 1-10:

1. How well does this parts washer / cleaner clean parts? (Level of cleanliness)
(1 = it does not clean parts well, 5=it cleans at an acceptable level, 10=it cleans parts completely)

1 2 3 4 5 6 7 8 9 10

Comments:

2. How easy/difficult is it to clean parts with this parts washer / cleaner? (Time)
(1= it takes far more time to clean, 5=it takes the same amount of time as current cleaner, 10= it takes a far shorter time than my current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

3. How easy/difficult is it to maintain the equipment?
(1=it is very difficult to maintain equipment, 5=it is equal to my current system when it comes to maintenance, 10=it is far easier to maintain that my current equipment)

1 2 3 4 5 6 7 8 9 10

Comments:

4. How strong is the smell of this cleaner (offensive odors)? describe smell.
(1=the smell of the cleaner is very strong and offensive, 5=the cleaner is as aromatic as the current cleaner, 10=there is no smell associated with this cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

5. How quickly does this part washer / cleaner clean parts? (Function of time)
(1= far longer time than current cleaner, 5= equally as long as current cleaner, 10= far shorter time than current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

6. Can you use this parts washer / cleaner for all parts cleaned in this shop?
(1=cannot use on more than 10% of parts because of compatibility, level of cleanliness or time it takes to clean, 5= can use on 50% of parts, 10= can use on nearly all parts 100%)

1 2 3 4 5 6 7 8 9 10

Comments:

7. Would you replace your currently used cleaner, based on performance, for this alternative if cost is not an obstacle?
(1= I would not replace currently used cleaner, 5=I would more than likely replace current cleaner, 10=I would defiantly replace current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

8. Would you replace your currently used cleaner, based on health and safety, for this alternative? (Considering how much safer it is to human life and health)
(1= I would not replace currently used cleaner, 5=I would more than likely replace current cleaner, 10=I would defiantly replace current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

9. How does this cleaner compare to other "Environmentally Preferable" cleaners you have observed or experienced?
(1= it is far worse than other "Environmentally Preferable" cleaners used, 5=it is equally as good as other "Environmentally Preferable" cleaners used, 10=it is far better than other "Environmentally Preferable" cleaners used.)

1 2 3 4 5 6 7 8 9 10

Comments:

10. Would you consider using this parts washer / cleaner if it were in your shop? (Assuming you did not eliminate the currently used cleaner)
(1=I would not use it, 5=I would use it equally as much as the other cleaner, 10=I would use it far more than the other cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

MR 11/17/04

In Depth Questions

(Determine if there have been any changes in the following information since the In-Brief)

Use:

What are the primary uses for parts washers in this shop?

What parts are typically cleaned?

What is the material being cleaned (metal, plastic, combination)?

What contaminants are being removed?

Process:

Is your current Parts Washer a part/portion of a larger cleaning process?

If so, where do parts come from to be cleaned? (Previous steps)

Where do parts go from here? (Future steps)

Describe in detail the cleaning process used with this parts washer / cleaner.

Describe how this trial parts washer process differs from the process used with your current parts washer / cleaner. Describe the currently used process if necessary.

(New Questions on Test Part Washer)
Overall Performance:

How well, in your opinion does ***[insert test product name]*** parts washer (or cleaner) work?

In comparison to other parts washers you have used, how well does ***[insert test product name]*** parts washer (or cleaner) perform?

How long does it take to clean parts using ***[insert test product name]*** parts washer (or cleaner)?

Physical Characteristics:
Are there any noticeable odors from the ***[insert test product name]*** cleaner? If so, is it an acceptable odor?

Are there any other physical qualities (color, texture, etc.) of the ***[insert test product name]*** cleaner that would discourage use?

Are there any other physical qualities (color, texture, etc.) of the ***[insert test product name]*** cleaner that would encourage use?

Is there any noticeable loss of ***[insert test product name]*** cleaning fluid due to evaporation when compared to parts washers currently in use?

(New Questions Covering Test Part Washer)
Maintenance:

How is maintenance performed for the ***[insert test product name]*** parts washing unit / cleaner, and with what frequency?

How does this maintenance compare to that of other parts washers you have used?

How does this maintenance schedule compare to that of the parts washers currently in use?

Specific Performance:

How many parts did you clean in the test unit / with this test cleaner?

Were there any compatibility issues with this test cleaner?

Does this test cleaner clean some contaminants better than others do? If so, which?

Are there any contaminants that this test cleaner was unable to clean?

(New Questions Covering Test Part Washer)

User Opinion:

Would you suggest this cleaner as an alternative to the cleaner currently used based on its performance?

Would you suggest this cleaner as an alternative to the currently used cleaner if it is significantly better for the environment and/or safer for workers to use?

Pros and Cons:

List some benefits of using this parts washer (or cleaner) compared to the one currently in use.

List some drawbacks of using this parts washer (or cleaner) compared to the one currently in use.

Closure:

Do you have suggestions concerning this project / effort that would help or improve the process when reviewing new / alternative parts washers?

Are there any other comments or questions that you may have for us?

MR 12/07/04

Out-Brief Interview Outline for Alternative Parts Washer Guide

Note: The focus of the interview and questions is on the cleaners. If shop owners or workers are not happy with the equipment on loan to them, please note it but do not factor that into a decision of the quality of the cleaning fluids.

General Information:

(Confirm from Previous In-Brief Interview)

1. Name and contact information (Phone or E-Mail).

2. Shop name.

3. Number of personnel working in the shop.

4. Number of personnel that have used the demonstrated cleaner / parts washer.

5. Type (product detail) of parts washers used currently.

6. Type (product detail) parts washer (or cleaner) being reviewed.

NEW-

7. Number of parts cleaned during 30-day test cycle. (Estimate if necessary)

Numeric (Quantitative Observation) or on a scale of 1-10:

1. Overall, how well did this parts washer / cleaner clean parts? (Level of cleanliness)
(1 = it does not clean parts well, 5=it cleans at an acceptable level, 10=it cleans parts completely)

1 2 3 4 5 6 7 8 9 10

Comments:

2. Overall, how easy/difficult was it to clean parts with this parts washer / cleaner? (Function of Time)
(1= it takes far more time to clean, 5=it takes the same amount of time as current cleaner, 10= it takes a far shorter time than my current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

3. Overall, how easy/difficult was it to maintain the equipment?
(1=it is very difficult to maintain equipment, 5=it is equal to my current system when it comes to maintenance, 10=it is far easier to maintain that my current equipment)

1 2 3 4 5 6 7 8 9 10

Comments:

4. Overall, how strong was the smell of this cleaner (offensive odors)? describe smell.
(1=the smell of the cleaner is very strong and offensive, 5=the cleaner is as aromatic as the current cleaner, 10=there is no smell associated with this cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

5. Overall, how quickly did this part washer / cleaner clean parts? (Function of time)
(1= far longer time than current cleaner, 5= equally as long as current cleaner, 10= far shorter time than current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

6. Can you use this parts washer / cleaner for all parts cleaned in this shop?
(1=cannot use on more than 10% of parts because of compatibility, level of cleanliness or time it takes to clean, 5= can use on 50% of parts, 10= can use on nearly all parts 100%)

1 2 3 4 5 6 7 8 9 10

Comments:

7. Would you replace your currently used cleaner, based on performance, for this alternative if cost is not an obstacle?
(1= I would not replace currently used cleaner, 5=I would more than likely replace current cleaner, 10=I would defiantly replace current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

8. Would you replace your currently used cleaner, based on health and safety, for this alternative? (Considering how much safer it is to human life and health)
(1= I would not replace currently used cleaner, 5=I would more than likely replace current cleaner, 10=I would defiantly replace current cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

9. How does this cleaner compare to other "Environmentally Preferable" cleaners you have observed or experienced?
(1= it is far worse than other "Environmentally Preferable" cleaners used, 5=it is equally as good as other "Environmentally Preferable" cleaners used, 10=it is far better than other "Environmentally Preferable" cleaners used.)

1 2 3 4 5 6 7 8 9 10

Comments:

10. Would you consider using this parts washer / cleaner if it were permanently in your shop? (Assuming you did not eliminate the currently used cleaner)
(1=I would not use it, 5=I would use it equally as much as the other cleaner, 10=I would use it far more than the other cleaner)

1 2 3 4 5 6 7 8 9 10

Comments:

NEW

11. How would you rank this parts washer compared to all others you have used in your experience in Cleaning Efficiency?
(1=Worst Cleaning Efficiency, 5=Not as good as others, but not below expectations, 10=Better than all others used.)

1 2 3 4 5 6 7 8 9 10

Comments:

12. How would you rank this parts washer when compared to the one you are currently using in Cleaning Efficiency?
(1=Worst Cleaning Efficiency, 5=Not as good as others, but not below expectations, 10=Better than all others used.)

1 2 3 4 5 6 7 8 9 10

Comments:

In Depth Questions

(Determine if there have been any changes in the following information since the In-Brief)

Use:

What are the primary uses for parts washers in this shop?

What parts are typically cleaned?

What is the material being cleaned (metal, plastic, combination)?

What contaminants are being removed?

Process:

Is your current Parts Washer a part/portion of a larger cleaning process?

If so, where do parts come from to be cleaned? (Previous steps)

Where do parts go from here? (Future steps)

Describe in detail the cleaning process used with this parts washer / cleaner.

Describe how this trial parts washer process differs from the process used with your current parts washer / cleaner. Describe the currently used process if necessary.

(New Questions on Test Part Washer)
Overall Performance:

How well, in your opinion did ***[insert test product name]*** parts washer (or cleaner) work?

In comparison to other parts washers you have used, how well did ***[insert test product name]*** parts washer (or cleaner) perform?

How long does it take to clean parts using ***[insert test product name]*** parts washer (or cleaner)?

Physical Characteristics:
Are there any noticeable odors from the ***[insert test product name]*** cleaner? If so, is it an acceptable odor?

Are there any other physical qualities (color, texture, etc.) of the ***[insert test product name]*** cleaner that would discourage use?

Are there any other physical qualities (color, texture, etc.) of the ***[insert test product name]*** cleaner that would encourage use?

Was there any noticeable loss of ***[insert test product name]*** cleaning fluid due to evaporation when compared to parts washers currently in use?

(New Questions Covering Test Part Washer)
Maintenance:

What type of maintenance was performed for the ***[insert test product name]*** parts washing unit / cleaner, and with what frequency?

How did this maintenance compare to that of other parts washers you have used?

How does the maintenance schedule of the test washer compare to that of the parts washers currently in use?

Specific Performance:

How many parts did you clean in the test unit / with this test cleaner?

NEW - Name Specific Parts Cleaned and Correlate with Photographs if possible:

Were there any compatibility issues with this test cleaner?

Did this test cleaner clean some contaminants better than others do? If so, which?

Are there any contaminants that this test cleaner was unable to clean?

(New Questions Covering Test Part Washer)
User Opinion:

Would you suggest this cleaner as an alternative to the cleaner currently used based on its performance?

Would you suggest this cleaner as an alternative to the currently used cleaner if it is significantly better for the environment and/or safer for workers to use?

Pros and Cons:

UPDATED - Having completed one month of use, list some benefits of using this parts washer (or cleaner) compared to the one currently in use.

UPDATED - Having completed one month of use, list some drawbacks of using this parts washer (or cleaner) compared to the one currently in use.

Closure:

Would you like to keep the test parts washer on-site permanently if possible considering cost?

NEW - If the test equipment is not satisfactory, but the cleaning materials were, please note this here and describe how in what ways it was not satisfactory:

Do you have suggestions concerning this project / effort that would help or improve the process when reviewing new / alternative parts washers?

Are there any other comments or questions that you may have for us?

APPENDIX D
ROCHESTER INSTITUTE OF TECHNOLOGY REPORT

National Center for Remanufacturing
and Resource Recovery (NC3R)
ROCHESTER INSTITUTE OF TECHNOLOGY

Performance of Cleaning Efficiency Tests

Prepared for:

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Executive Summary

In 1998, National Aeronautics and Space Administration (NASA) Headquarters (HQ) and Kennedy Space Center (KSC) established the NASA Acquisition Pollution Prevention (AP2) Program Office. This office is responsible for identifying pollution prevention (P2) needs and validating environmental technology solutions across enterprises and centers for application to affected systems. The NASA AP2 Program is responsible for intra-agency environmental technology migration among NASA centers and enterprises. It is also responsible for identifying, qualifying, and implementing common alternatives for reduction or replacement of HAZMATs used by NASA Enterprise Programs and Center Process Owners.

The NASA AP2 Office (NASA) requested the National Center for Remanufacturing and Resource Recovery (NC3R) to assist them in conducting cleaning efficiency tests as described in Section 4.5.8 of military specification MIL-PRF-29602A for a parts washer evaluation project. NASA wishes to evaluate the efficacy of several cleaning chemistries being considered for use by this agency. The efficiencies of these cleaning chemistries were evaluated on standard test coupons that were contaminated with two standardized materials. The cleaning efficiency of each cleaning chemistry was determined for each contaminant.

The average cleaning efficiency of a cleaning chemistry is determined by adding the average cleaning efficiencies for Contaminants #1 and #2 and dividing by two. Cleaning chemistries are then ranked from best to worst based on average cleaning efficiency.

Due to inaccuracies in linearity of the analytical balance, reported cleaning efficiencies are accurate to +/- 0.32%. Based on this tolerance level, three cleaning chemistries have potential average cleaning efficiencies of 100% - Heavy Duty Cleaner, SoySolv II Plus, and Mineral Spirits. Eight more cleaning chemistries reported average cleaning efficiencies in excess of 99% - they are Optima 2001 CR, SoySolv II, Aerowash 4, California Parts Washer Solution, Enviroclear, Aquaworks MPC Concentrate, Breakthrough, and Armakleen M-Aero.

A ranked list of all cleaning chemistries evaluated in this project appears on the next page. Cleaning chemistries highlighted in yellow are those that do not appear in NASA's original test matrix provided to NC3R, but were suggested by NC3R for consideration by NASA.

Test Results

(accurate to +/- 0.32%)

Test #	Chemistry name	Temper-ature deg F	Concen-tration % by volume	Cleaning Efficiency Contam. 1 %	Cleaning Efficiency Contam. 2 %	Average Cleaning Efficiency %	Rank -
31	Heavy Duty Cleaner	105	20.00%	99.99%	100.18%	100.09%	1
26	SoySolv II Plus	100	100.00%	99.92%	100.02%	99.97%	2
29	Mineral Spirits (Stoddard Solvent)	70	100.00%	99.59%	99.77%	99.68%	3
43	Optima 2001 CR	148	10.00%	99.06%	100.29%	99.67%	4
11	SoySolv II	160	100.00%	99.87%	99.29%	99.58%	5
54	Aerowash 4	160	20.00%	99.14%	99.73%	99.43%	6
16	California Parts Washer Solution	105	20.00%	99.12%	99.59%	99.36%	7
22	EnviroClear	100	100.00%	99.53%	99.13%	99.33%	8
14	Armakleen MPC Concentrate	160	7.50%	98.80%	99.79%	99.30%	9
15	Breakthrough	70	100.00%	98.97%	99.46%	99.22%	10
53	Aerowash 4	160	10.00%	98.82%	99.58%	99.20%	11
1	Armakleen M-Aero	160	7.50%	99.10%	99.17%	99.13%	12
19	SW-3 OzzyJuice	105	100.00%	98.40%	99.57%	98.98%	13
38	Bioact MSO	110	25.00%	98.82%	98.75%	98.78%	14
56	Flightline 2	160	20.00%	97.88%	99.51%	98.69%	15
55	Flightline 2	160	10.00%	97.69%	99.62%	98.65%	16
12	Armakleen HP-2	160	7.50%	97.88%	99.42%	98.65%	17
21	Soy Green Solvent (SG5000)	100	100.00%	98.92%	98.24%	98.58%	18
50	Cleanaire 1200	160	3.00%	97.30%	99.79%	98.55%	19
36	Bean-e-doo Parts Washer Solvent	130	100.00%	99.40%	97.61%	98.50%	20
24	Bio-Circle-L	100	100.00%	96.69%	100.04%	98.37%	21
2	Aquaworks MM Dip Concentrate	160	7.50%	98.52%	98.16%	98.34%	22
6	Gold Matrix	160	100.00%	96.96%	99.44%	98.20%	23
9	Clean Safe 7445-05	160	11.11%	96.56%	99.51%	98.04%	24
5	Bean-e-doo Parts Washer Solvent	160	50.00%	97.73%	98.31%	98.02%	25
42	Optima 100 GP	148	10.00%	96.91%	98.39%	97.65%	26
35	Sea Wash 8	130	5.00%	94.13%	100.06%	97.09%	27
3	Armakleen M100	160	7.50%	94.83%	98.79%	96.81%	28
23	KT600C	112	16.67%	93.36%	99.73%	96.55%	29
28	Methyl Ethyl Ketone	70	100.00%	99.57%	93.40%	96.48%	30
48	Daraclean	131	25.00%	92.75%	100.18%	96.46%	31
18	SW-LF OzzyJuice	105	100.00%	94.14%	98.36%	96.25%	32
32	NZD Ultra Degreaser	70	100.00%	99.73%	92.41%	96.07%	33
4	US-2003	160	10.00%	92.69%	99.43%	96.06%	34
41	Axarel 58	150	100.00%	95.90%	95.49%	95.70%	35
17	SW-8 Aircraft OzzyJuice	105	100.00%	93.06%	97.74%	95.40%	36
52	Powerkleen III	160	2.20%	90.40%	99.50%	94.95%	37
44	Vertrel CMS	70	100.00%	91.38%	98.32%	94.85%	38
39	SS-HD Parts Washer Formulation	110	20.00%	89.43%	100.00%	94.72%	39
20	Millennium	105	25.00%	89.12%	99.02%	94.07%	40
49	EXP 1300	145	3.60%	85.86%	99.66%	92.76%	41
51	Natural Orange	160	0.50%	97.12%	85.06%	91.09%	42
34	Low pH Concentrated Cleaner	130	10.00%	94.18%	87.98%	91.08%	43
10	Oleocal ME-130	160	100.00%	97.57%	81.29%	89.43%	44
7	Citrusoy Super High Flash	160	100.00%	97.46%	71.93%	84.70%	45
13	Armakleen M400	160	7.50%	67.51%	99.04%	83.27%	46
40	Silicon Wash Concentrate	140	16.67%	67.30%	98.30%	82.80%	47
37	Agriplast	130	100.00%	63.84%	94.43%	79.14%	48
27	SoySolv II Plus	70	100.00%	99.58%	57.39%	78.48%	49
25	EnviroLogic - Partwasher Solution	100	10.00%	80.79%	76.11%	78.45%	50
57	Acetone	70	100.00%	99.39%	32.18%	65.79%	51
30	Isopropanol	70	100.00%	100.18%	23.66%	61.92%	52
46	Simple Green	70	100.00%	81.11%	11.93%	46.52%	53
45	Neugenic 4177	70	100.00%	83.50%	-11.60%	35.95%	54
33	Spray-Nine AV-8	70	10.00%	67.97%	1.79%	34.88%	55
47	Green 4 Kleen	70	12.00%	53.34%	0.20%	26.77%	56
8	Clean Safe 7448-05	160	11.11%	268.76%	175.51%	disregard	N/A

Equipment Used

The equipment to be used for this project was clearly specified in Section 4.5.8 of military specification MIL-PRF-29602A, which is attached as Appendix A. All equipment purchased or leased for this project complied with MIL-PRF-29602A with the single exception of the mechanical grease worker, which was needed to create a synthetic contaminant composed of molybdenum disulfide grease and carbon black. Due to the high cost of this equipment, NASA AP2 agreed to substitute a high shear mixer for the mechanical grease worker, as indicated in the proposal accepted by NASA AP2. Because the high shear mixture could be leased, this substantially reduced the cost of the project with no apparent loss of accuracy.

Details, images, and specifications of equipment used in this project are presented below.

Charles Ross & Son Company
HSM- 100 LSK High Shear Mixer

- Motor Power 1 HP
- Speed Range 0 – 10,000 RPM

Denver Instruments
APX – 100 Chamber

- Weight Range 100g
- Readability 0.1mg
- Linearity ±0.2mg

Barnstead International
Super-Nuova Stirring Hot Plate
Series 1318

- Temperature Range 1 – 370ºC
- Temperature Stability ± 0.5ºC
- Speed Range 50 – 1,200 RPM
- Speed Stability ± 1.5%

Fisher Scientific
Isotemp Programmable Oven 800 Series

- Temperature Range 50 – 325ºC
- Average Uniformity ± 2ºC
- Resolution 1 ºC

NC3R Operating Procedure

In this section of the report, the operating procedures used for preparation, testing, and determination of cleaning efficiency are reviewed.

Prepare Test Coupons, Synthetic Hard Water, and Synthetic Contaminants

48 test coupons with dimensions 1" wide x 4" long x ¼" thick were manufactured from 6061 aluminum alloy in Rochester Institute of Technology's (RIT's) Brinkman CNC laboratory. Each coupon had a 1/16" depression in the center with dimensions as specified in MIL-PRF-29602A, part 4.5.8.3. Each test coupon was engraved with an ID number to facilitate quick identification, as shown below. Each test coupon weighed approximately 40 grams.

Test Coupons

NC3R prepared a quantity of synthetic hard water stock solution sufficient to support analysis of all cleaning chemistries evaluated in this project. The synthetic hard water was created from distilled water, reagent grade calcium acetate monohydrate, and reagent grade magnesium sulfate heptahydrate in accordance with MIL-PRF-29602A, part 4.5.5.1.

Two synthetic soil contaminants were created. The first soil contaminant (Contaminant #1) was composed of 10 parts MIL-G-21664 Aeroshell 17 molybdenum disulfide grease mixed with 1 part Raven 1040 carbon black in a high speed disperser. As mentioned previously, a high speed disperser was used to mix these components instead of the mechanical grease worker specified in MIL-PRF-29602A, part 4.5.8.1. Note also that MIL-C-29602 (the predecessor to MIL-PRF-29602A) called for the use of a high speed disperser to mix similar components (see Part 4.6.6.1.1). The resulting mixture was a jet black, viscous mixture.

The second soil contaminant (Contaminant #2) consisted of Alox 2028S, manufactured by Lubrizol Corporation, which acquired Alox Corporation. It should be noted that MIL-PRF-29602A calls for the use of Alox 2028, which is no longer manufactured, having

been replaced with Alox 2028S. Alox 2028S was used instead of Alox 2028 with prior approval from NASA.

Selection of Cleaning Chemistries

After reviewing the list of cleaning chemistries provided by NASA, NC3R noted that certain mil spec-approved cleaning chemistries – as well as other cleaning chemistries of interest - were not on this list. After discussing this with NASA, NC3R agreed to evaluate these additional chemistries at no additional charge to NASA. In addition, some chemistries were tested under more than one operating condition, e.g. at a different temperature and concentration, as requested by the vendor. In some cases, this resulted in a significant change in cleaning efficiency. As a result, a total of 57 cleaning trials (not 36) were conducted for this project.

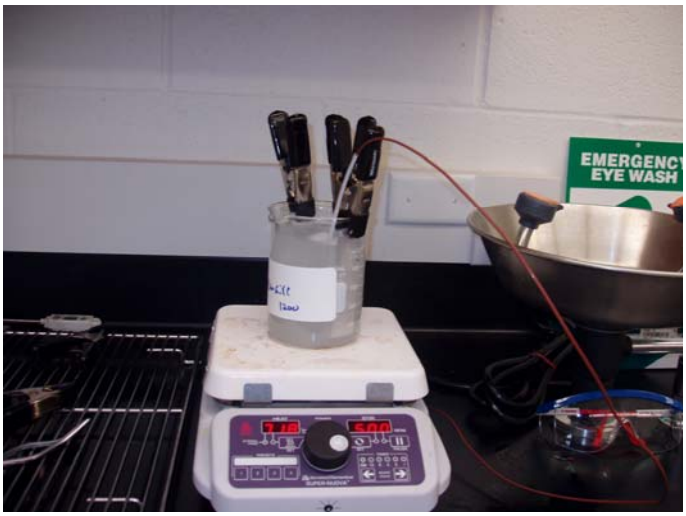
Conduct Cleaning Efficiency Testing per MIL-PRF-29602A, part 4.5.8

NC3R determined the cleaning efficiency of all cleaning chemistries evaluated in this project using the procedure described in MIL-PRF-29602A, part 4.5.8. Test coupons were precleaned with acetone using wipers in accordance with CCC-C-46, class 7, until the wipe was free of visual residue. Precleaned test coupons were dried in a mechanical convection oven at 105 ± 2°C for 30 minutes, air cooled to room temperature, and weighed to the nearest 0.1 mg (W_1). Three precleaned test coupons were then loaded with 100-150 mg of Contaminant #1 using a clean acid brush as shown below. The coupons were reweighed to the nearest 0.1 mg (W_2) and the new weight recorded.

Coupons Loaded with Contaminant #1

500 mls of the cleaning solution in the proper concentration to be evaluated were added to a heavy duty glass beaker. It should be noted that cleaning chemistries are diluted to a wide variety of concentrations – some cleaning chemistries are run full strength, while others are diluted to 3% or less by volume. In all cases, the concentration that was established was that recommended by the vendor. After the solution was created, it was stabilized at the manufacturer's recommended operating temperature using a digital stirrer/hot plate. Unless otherwise noted, the chemistry was heated to 71 ± 1°C. Some

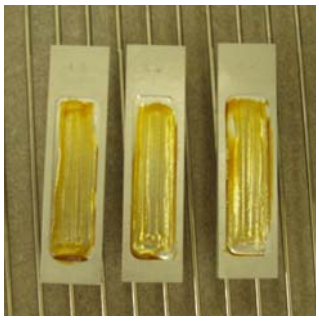
cleaning chemistries will degrade if heated to this temperature, so the lesser of 71 ^{o}C and the maximum recommended temperature for each chemistry was used. The three test coupons loaded with Contaminant #1 were then clamped to the inside of the beaker and the solution stirred with a 2" x 3/8" magnetic stirring bar at 500 RPM for 10 minutes as shown below.



Cleaning of Test Coupons with Digital Stirrer/Hot Plate

The cleaned test coupons were then rinsed under a 4 liter/minute water stream from a laboratory faucet with serrated tip and dried in a mechanical convection oven at 105 ± 2^{o}C for 5 minutes. The cleaned and dried test coupons were allowed to cool to room temperature and reweighed to the nearest 0.1 mg (W_3) so that the extent of contaminant removal could be determined.

Following this test, three additional precleaned test coupons (which had been precleaned using the same procedure as those for Contaminant #1) were loaded with 100-150 mg of Contaminant #2 using a clean acid brush, dried for one hour in a mechanical convection oven at 105^{o}C, air cooled, and weighed to the nearest 0.1 mg (W_2). A photograph of test coupons loaded with Contaminant #2 is shown below.



Coupons Loaded with Contaminant #2

These loaded test coupons were cleaned in the same manner as Contaminant #1, using the same (dirty) solution that was used to clean the test coupons containing Contaminant #1. Cleaned test coupons were then rinsed under flowing cold tap water for 1 minute without impinging on the soiled area. Test coupons were then dried for 5 minutes in a mechanical convection oven at 105 ± 2°C for 5 minutes, air cooled, and weighed to the nearest 0.1 mg (W_3). The above process was repeated for all cleaning chemistries evaluated in this project over a period of 3 weeks.

Determination of Cleaning Efficiency

The cleaning efficiency was calculated for each test coupon evaluated in the procedure described above using the equation provided in MIL-PRF-29602A, part 4.5.8.6. The overall cleaning efficiency for each of the 57 specific cleaning trials for each of the two contaminants was calculated as the arithmetic mean of the three cleaning efficiencies calculated for those respective test coupons (refer to equation below).

$$Cleaning\ Efficiency = \frac{(W_2 - W_3)}{(W_2 - W_1)}\ x\ 100$$

Results of Cleaning Efficiency Testing

In this section of the report, the results of cleaning efficiency testing are reviewed.

Revision of Test Results

It should be noted that significant variation was noted in W_1 (the weight of the precleaned test coupon) throughout cleaning efficiency testing. This is explained in detail below.

Mil spec MIL-PRF-29602A stipulates that prior to testing, the test coupon is to be precleaned with acetone and clean room wipes until no further contamination is visible on the wipes. This precleaning process is inadequate to remove residual contamination from test coupons, in particular Contaminant #2, which is transparent. In addition, many of the cleaning chemistries evaluated in this project are superior to acetone. For example, the 12 best cleaning trials resulted in cleaning efficiencies in excess of 99%, whereas the average cleaning efficiency of acetone itself is less than 66%.

It should be noted that NC3R used a more aggressive test coupon precleaning procedure than that delineated in the mil spec, as NC3R noted early on that it was difficult to preclean test coupons adequately with acetone. In fact, an ultrasonic tank was used to preclean test coupons in addition to the mandated acetone/wiper procedure. However, in some cases, test coupons were still not precleaned completely. As a result, the precleaned test coupon weight still included transparent contamination in some cases.

This irregularity produced some unusual test results. If a test coupon had residual transparent contamination following the precleaning procedure, its measured clean bare mass (W_1) was heavier than its actual clean bare mass. If this same test coupon was loaded with a contaminant and cleaned in a superior cleaning chemistry, this chemistry not only removed all of the loaded contaminant, but the residual contamination on the precleaned test coupon prior to the start of the test as well. As a result, some cleaning efficiencies were greater than 100%, above and beyond what could be explained by inaccuracies of linearity in the analytical balance.

Fortunately, this problem was easily remedied. Following completion of all cleaning efficiency testing, all test coupons were thoroughly cleaned for one last time in a multi-step cleaning process that involved multiple cleaning steps in an ultrasonic tank, as well as manual wiping with solvents and clean room wipers. These test coupons were then dried in a mechanical convection oven, allowed to cool, and weighed. For all 48 test coupons, the final mass was within 0.1 mg of the smallest precleaned mass ever recorded for that respective test coupon during any cleaning trial (it should be noted that inaccuracies of linearity in the analytical balance are twice this amount). This showed that the cleaning chemistries evaluated in this project (except for Test #8, explained below) did not attack the aluminum substrate of the test coupons, so the clean bare test coupon mass was constant throughout testing. Cleaning efficiencies were then recalculated using this mass as the precleaned test coupon weight W_1. After this

correction was made, all cleaning efficiencies (except for Test #8) were less than 100%, taking into account inaccuracies in linearity of the analytical balance.

The original test data is presented in Appendix B, with average cleaning efficiencies for each contaminant calculated for each trial. This data utilizes the actual precleaned test coupon weight at the start of each trial for W_1, which may have included residual contamination from previous cleaning trials. As a result, several calculated cleaning efficiencies exceed 100%, as explained previously.

The revised test data is presented in Appendix C. In the revised test data, the weight of the test coupon after a thorough final cleaning is used for W_1 for all cleaning trials. As a result, all cleaning efficiencies (except Test #8) are less than 100%, taking into account inaccuracies in linearity of the analytical balance.

A detailed case study of this phenomenon is presented in Appendix D, and highlights the differences in the measured precleaned mass of a specific test coupon throughout its use in this project. The average cleaning efficiency of the tests using this particular test coupon are calculated using both methods described above and compared.

Other Irregularities

Cleansafe 7448-05 is the cleaning chemistry that was used for Test #8. Initially, this cleaning chemistry generated cleaning efficiencies of 269% and 176% for Contaminants #1 and #2, respectively. However, significant discoloration was immediately noted on the test coupons. After additional analysis, it was determined that this cleaning chemistry attacked the aluminum substrate of the test coupon. Additional review of the MSDS revealed that this compound is not aluminum safe. As a result, the excess cleaning efficiencies can be wholly attributed to aluminum degradation of the test coupon itself, and therefore must be discarded.

It should be noted that the six test coupons used for Test #8 (test coupons #22 - #27) underwent a change in clean bare mass as a result of aluminum degradation. Therefore, for the revised test data appearing in Appendix C, these test coupons have two different precleaned weights – one used for Tests #1 - #8, and another used for Tests #9 - #57. The precleaned weight used for Tests #1 - #8 is the weight of the test coupon before the very first cleaning test. The precleaned weight used for Tests #9 - #57 is the final weight of the respective test coupon after the very thorough final cleaning procedure conducted after all cleaning efficiency testing had been completed.

Neugenic 4177 is the cleaning chemistry that was used for Test #45, and was used full strength. The test results for this cleaning chemistry showed a negative cleaning efficiency for Contaminant #2, implying that the test coupons had gained contaminant mass during the cleaning process. In actuality, Neugenic 4177 is very thick and is composed of 20% surfactants. These surfactants were not completely rinsed away by the less aggressive rinsing procedure mandated for Contaminant #2. As a result, the test coupons contained both residual contamination and cleaning chemistry, and therefore had

more mass at the end of the cleaning test for Contaminant #2. This resulted in a negative cleaning efficiency.

Presentation of Cleaning Efficiency Test Results

The results of cleaning efficiency testing for each contaminant, for each of 57 tests, are shown on the next page. The average cleaning efficiency of a cleaning chemistry is determined by adding the average cleaning efficiencies for Contaminants #1 and #2 and dividing by two. Cleaning chemistries are then ranked from best to worst based on average cleaning efficiency.

Due to inaccuracies in linearity of the analytical balance, reported cleaning efficiencies are accurate to +/- 0.32%. Based on this tolerance level, three cleaning chemistries have potential average cleaning efficiencies of 100% - Heavy Duty Cleaner, SoySolv II Plus, and Mineral Spirits. Eight more cleaning chemistries reported average cleaning efficiencies in excess of 99% - they are Optima 2001 CR, SoySolv II, Aerowash 4, California Parts Washer Solution, Enviroclear, Aquaworks MPC Concentrate, Breakthrough, and Armakleen M-Aero.

A ranked list of all cleaning chemistries evaluated in this project appears on the next page. For convenience, the supplier, flash point, pH of concentrate, and VOC content of each cleaning chemistry is also provided. Cleaning chemistries highlighted in yellow are those that do not appear in NASA's original test matrix provided to NC3R, but were suggested by NC3R for consideration by NASA. Contact information for the manufacturers of these chemistries is provided in Appendix E.

Test #	Chemistry name	Supplier name	Flash Point deg F	VOC Content -	pH of Concen-trate -	Temper-ature deg F	Concen-tration % by volume	Cleaning Efficiency Contaminant 1 %	Cleaning Efficiency Contaminant 2 %	Average Cleaning Efficiency %	Rank -
31	Heavy Duty Cleaner	Phase III Inc.	N/A	<25 g/L	9 - 10	105	20.00%	99.99%	100.18%	100.09%	1
26	SoySolv II Plus	SoySolv	>150	0.55	6.9	100	100.00%	99.92%	100.02%	99.97%	2
29	Mineral Spirits (Stoddard Solvent)	Fisher Scientific	102	100%	N/A	70	100.00%	99.59%	99.77%	99.68%	3
43	Optima 2001 CR	Global Specialty Products	>200	0	11.7	148	10.00%	99.06%	100.29%	99.67%	4
11	SoySolv II	SoySolv	>300	< 50 g/L	5 - 7	160	100.00%	99.87%	99.29%	99.58%	5
54	Aerowash 4	Rochester Midland	none	0	7.8	160	20.00%	99.14%	99.73%	99.43%	6
16	California Parts Washer Solution	Phase III Inc.	N/A	<50 g/L	9 - 10	105	20.00%	99.12%	99.59%	99.36%	7
22	EnviroClear	Soy Technologies	>237	<50%	7	100	100.00%	99.53%	99.13%	99.33%	8
14	Armakleen MPC Concentrate	Church & Dwight	>212	0	11.5	160	7.50%	98.80%	99.79%	99.30%	9
15	Breakthrough	Inland Technology Inc	150	100%	N/A	70	100.00%	98.97%	99.46%	99.22%	10
53	Aerowash 4	Rochester Midland	none	0	7.8	160	10.00%	98.82%	99.58%	99.20%	11
1	Armakleen M-Aero	Church & Dwight	>212	13.7 g/L	11.6	160	7.50%	99.10%	99.17%	99.13%	12
19	SW-3 OzzyJuice	ChemFree Corp	>200	<5 g/L	7.3	105	100.00%	98.40%	99.57%	98.98%	13
38	Bioact MSO	Petroferm Inc.	N/A	745 g/L	N/A	110	25.00%	98.82%	98.75%	98.78%	14
56	Flightline 2	Rochester Midland	none	0	7.8	160	20.00%	97.88%	99.51%	98.69%	15
55	Flightline 2	Rochester Midland	none	0	7.8	160	10.00%	97.69%	99.62%	98.65%	16
12	Armakleen HP-2	Church & Dwight	>212	0	11.8	160	7.50%	97.88%	99.42%	98.65%	17
21	Soy Green Solvent (SG5000)	Soy Technologies	>200	4.40%	7	100	100.00%	98.92%	98.24%	98.58%	18
50	Cleanaire 1200	Rochester Midland	none	0%	12.2	160	3.00%	97.30%	99.79%	98.55%	19
36	Bean-e-doo Parts Washer Solvent	Franmar Chemical	>425	N/A	6.65	130	100.00%	99.40%	97.61%	98.50%	20
24	Bio-Circle-L	Walter Surface Technologies	N/A	N/A	7	100	100.00%	96.69%	100.04%	98.37%	21
2	Aquaworks MM Dip Concentrate	Church & Dwight	>212	8.3 g/L	12.8	160	7.50%	98.52%	98.16%	98.34%	22
6	Gold Matrix	Walter Surface Technologies	N/A	N/A	11.5	160	100.00%	96.96%	99.44%	98.20%	23
9	Clean Safe 7445-05	Petroferm Inc.	>210	10 g/L	12.5	160	11.11%	96.56%	99.51%	98.04%	24
5	Bean-e-doo Parts Washer Solvent	Franmar Chemical	>425	N/A	6.65	160	50.00%	97.73%	98.31%	98.02%	25
42	Optima 100 GP	Global Specialty Products	>200	0	11	148	10.00%	96.91%	98.39%	97.65%	26
35	Sea Wash 8	Warren	none	N/A	7	130	5.00%	94.13%	100.06%	97.09%	27
3	Armakleen M100	Church & Dwight	N/A	0	13.95	160	7.50%	94.83%	98.79%	96.81%	28
23	KT600C	Kleen Tec	>212	80 g/L	8.7 - 9.5	112	16.67%	93.36%	99.73%	96.55%	29
28	Methyl Ethyl Ketone	Fisher Scientific	22	100%	N/A	70	100.00%	99.57%	93.40%	96.48%	30
48	Daraclean	Magnaflux	none	0%	12.5	131	25.00%	92.75%	100.18%	96.46%	31
18	SW-LF OzzyJuice	ChemFree Corp	none	N/A	7.3	105	100.00%	94.14%	98.36%	96.25%	32
32	NZD Ultra Degreaser	Global Specialty Products	147.5	6.75 lbs/gal	8.5 - 8.8	70	100.00%	99.73%	92.41%	96.07%	33
4	US-2003	Anchor Atlantic	N/A	80%	11	160	10.00%	92.69%	99.43%	96.06%	34
41	Axarel 58	Petroferm Inc.	175	<25 g/L	N/A	150	100.00%	95.90%	95.49%	95.70%	35
17	SW-8 Aircraft OzzyJuice	ChemFree Corp	none	N/A	9	105	100.00%	93.06%	97.74%	95.40%	36
52	Powerkleen III	Mart Corporation	N/A	0%	12.5	160	2.20%	90.40%	99.50%	94.95%	37
44	Vertrel CMS	Dupont	none	N/A	7	70	100.00%	91.38%	98.32%	94.85%	38
39	SS-HD Parts Washer Formulation	Solvent Systems International	N/A	25 g/L	11.5	110	20.00%	89.43%	100.00%	94.72%	39
20	Millennium	Inland Technology Inc	>200	0	N/A	105	25.00%	89.12%	99.02%	94.07%	40
49	EXP 1300	Brulin	>200	0%	11.9	145	3.60%	85.86%	99.66%	92.76%	41
51	Natural Orange	Giant Cleaning Systems	N/A	N/A	N/A	160	0.50%	97.12%	85.06%	91.09%	42
34	Low pH Concentrated Cleaner	Spray-Nine	166	90%	9.8	130	10.00%	94.18%	87.98%	91.08%	43
10	Oleocal ME-130	SoySolv	>300	< 50 g/L	N/A	160	100.00%	97.57%	81.29%	89.43%	44
7	Citrusoy Super High Flash	Florida Chemical Company	>200	N/A	N/A	160	100.00%	97.46%	71.93%	84.70%	45
13	Armakleen M400	Church & Dwight	none	0	9.4	160	7.50%	67.51%	99.04%	83.27%	46
40	Silicon Wash Concentrate	Silicon Chemistries Solutions	N/A	90% as H2O	10 - 11.1	140	16.67%	67.30%	98.30%	82.80%	47
37	Agriplast	Cook Composites	300	0.12 lb/gal	N/A	130	100.00%	63.84%	94.43%	79.14%	48
27	SoySolv II Plus	SoySolv	>150	0.55	6.9	70	100.00%	99.58%	57.39%	78.48%	49
25	EnviroLogic - Partwasher Solution	EnviroLogic	none	0	7.2	100	10.00%	80.79%	76.11%	78.45%	50
57	Acetone	Fisher Scientific	0	100%	N/A	70	100.00%	99.39%	32.18%	65.79%	51
30	Isopropanol	Fisher Scientific	53	100%	N/A	70	100.00%	100.18%	23.66%	61.92%	52
46	Simple Green	Sunshine Makers	none	7.96 g/L	9.5	70	100.00%	81.11%	11.93%	46.52%	53
45	Neugenic 4177	Rochester Midland	none	33%	12.2	70	100.00%	83.50%	-11.60%	35.95%	54
33	Spray-Nine AV-8	Spray-Nine	none	26.2 g/L	9.7	70	10.00%	67.97%	1.79%	34.88%	55
47	Green 4 Kleen	IPAX Cleanogel Inc	none	0%	9.5-9.8	70	12.00%	53.34%	0.20%	26.77%	56
8	Clean Safe 7448-05	Petroferm Inc.	>210	25 g/L	13.4	160	11.11%	268.76%	175.51%	disregard	N/A

Appendix A

Military Specification MIL-PRF-29602A

.NOTE: This draft, dated 23 August 2004, prepared by the Commander, Naval Air Warfare Center Aircraft Division, Code 414100B120-3, Lakehurst, NJ 08733-5100, has not been approved and is subject to modification. DO NOT USE PRIOR TO APPROVAL. (Project 6850-1493)

NOT MEASUREMENT SENSITIVE

MIL-PRF-29602A
DRAFT
SUPERSEDING
MIL-C-29602
28 February 1995

PERFORMANCE SPECIFICATION

CLEANING COMPOUNDS, PARTS WASHER AND SPRAY CABINET

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers two types of cleaning compounds used in parts washers and spray cabinets for cleaning aircraft components.

1.2 Classification. The cleaning compounds covered by this specification are classified as follows:

Type I - Water-soluble liquid concentrate
Type II - Water-soluble powder

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 414100B120-3, Highway 547, Lakehurst, NJ 08733-5100 or emailed to thomas.omara@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at www.dodssp.daps.mil.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

CCC-C-46	-	Cloth, Cleaning, Nonwoven Fabric. (Inactive for new design)

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-680	-	Degreasing Solvent
MIL-A-8625	-	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-G-21164	-	Grease, Molybdenum Disulfide, for Low and High Temperatures, NATO Code Number G-353
MIL-PRF-83282	-	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537
MIL-DTL-83488	-	Coating, Aluminum, High Purity

(Copies of these documents are available on line at http://assist.daps.dla.mil/quicksearch/ or www.dodssp.daps.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government document forms a part of this document to the extent specified herein. Unless otherwise specified, the issue is that cited in the solicitation or contract.

CODE OF FEDERAL REGULATIONS (CFR)

40 CFR	-	Protection of the Environment

(Copies of this document are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-0001.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) INTERNATIONAL

ASTM-A240	-	Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels, and for General Applications, Standard Specification for. (DoD adopted)
ASTM-B152	-	Copper Sheet, Strip, Plate, and Rolled Bar, Standard Specification for. (DoD adopted)
ASTM-D93	-	Flash-Point by Pensky-Martens Closed Cup Tester, Standard Test Methods for. (DoD adopted)
ASTM-D2834	-	Nonvolatile Matter (Total Solids) in Water-Emulsion Floor Polishes, Solvent-Based Floor Polishes, and Polymer-Emulsion Floor Polishes, Standard Test Method for. (DoD adopted)
ASTM-D3278	-	Flash Point of Liquids by Small Scale Closed-Cup Apparatus, Standard Test Methods for. (DoD adopted)
ASTM-E70	-	pH of Aqueous Solutions with the Glass Electrode, Standard Test Method for. (DoD adopted)
ASTM-F483	-	Total Immersion Corrosion Test for Aircraft Maintenance Chemicals, Standard Test Method for. (DoD adopted)
ASTM-F519	-	Mechanical Hydrogen Embrittlement Evaluation of Plating Processes and Service Environments, Standard Test Method for. (DoD adopted)
ASTM-F945	-	Stress-Corrosion of Titanium Alloys by Aircraft Engine Cleaning Materials, Standard Test Method for. (DoD adopted)
ASTM-F1104	-	Preparing Aircraft Cleaning Compounds, Liquid Type, Water Base, for Storage Stability Testing, Standard Test Method for.

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE-AMS-A-250/4	-	Aluminum Alloy 2024, Plate and Sheet. (DoD adopted)
SAE-AMS4375	-	Sheet and Plate, Magnesium Alloy, 3.0Al - 1.0Zn - 0.20Mn (AZ31B-0), Annealed and Recrystallized. (DoD adopted)
SAE-AMS5046	-	Carbon Steel, Sheet, Strip, and Plate (SAE 1020 and 1025) Annealed. (DoD adopted)
SAE-AMS-QQ-P-416		Plating, Cadmium (Electro Deposited). (DoD adopted)
SAE-AMS-T-9046	-	Titanium and Titanium Alloy, Sheet, Strip, and Plate. (DoD adopted)

SAE-AMS5536 - Nickel Alloy, Corrosion and Heat Resistant, Sheet, Strip, and Plate 47.5Ni - 22Cr - 1.5Co - 9.0Mo - 0.60W -18.5Fe, Solution Heat Treated. (DoD adopted)

(Copies of these documents are available from www.sae.org or SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The cleaning compound furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.3 and 6.3).

3.2 Materials. The cleaning compounds shall not contain known or suspected carcinogens, ozone depleting substances, hazardous air pollutants, volatile organic compounds, or total toxic organic (TTO) compounds as specified in 40 CFR. Surface-active agents used in the cleaning compounds shall be not less than 85 percent biodegradable when determined in accordance with methods appropriate to surface-active agent type.

3.3 Unit of issue. To interface with existing equipment and meet the required storage characteristics, the cleaning compounds shall be furnished in 5-, 15-, or 55-gallon containers. The internal surfaces of all containers shall be protected with a material that shall not adversely affect nor be adversely affected by the cleaning compounds.

3.4 Markings. Markings to identify type I and type II cleaning compounds shall appear on each container to indicate that the product should not be used at full strength.

3.5 Performance requirements.

3.5.1 Biodegradability. The supplier of the cleaning compounds shall ensure that the surfactants used in the cleaning compound are biodegradable in accordance with 40 CFR, Part 796, subpart D. Testing for biodegradability shall be in accordance with 4.5.1. The cleaning compounds shall meet the requirement of not less than 85 percent biodegradable at the end of the 28-day period specified in 4.5.1.

3.5.2 Nonvolatile content. The cleaning compound qualification sample shall be tested for nonvolatile content in accordance with 4.3. Conformance inspection results shall not differ from the qualification values by more than ± 1.0 percentage points.

3.5.3 Flash point

3.5.3.1 Type I. The Pensky-Martens flash point of the concentrated liquid cleaning compound shall be greater than 212 °F (100 °C) when tested in accordance with 4.3.

3.5.3.2 Type II. The Setaflash flash point of the concentrated powdered cleaning compound shall be greater than 212 °F (100 °C) when tested in accordance with 4.3.

3.5.4 pH. The pH of the cleaning compounds shall be tested using the manufacturer's recommended cleaning concentration in accordance with 4.3. Conformance inspection results shall not differ from the qualification values by more than ± 0.5 units.

3.5.5 Foaming characteristics. At the manufacturer's recommended concentration, the cleaning compounds shall produce a foam volume of not more than 100 ml, when tested at 120 °F (49 °C) and 160 °F (71 °C) in accordance with 4.5.2.

3.5.6 Corrosivity.

3.5.6.1 Titanium stress corrosion. The cleaning compounds shall not produce any microscopic cracking when tested at the manufacturer's recommended concentration and examined metallographically at 500X magnification (see 4.3).

3.5.6.2 Total immersion corrosion. The cleaning compounds shall cause neither visual corrosion nor a weight change of any specimen greater than that shown in table I, when tested at the manufacturer's recommended concentration and in accordance with 4.5.3.

Table I. Total immersion corrosion weight changes.

Test panel material	Former designation	Allowable weight change (mg/cm^2/24 hours)
Aluminum (SAE-AMS-A-250/4)	Alloy 2024; QQ-A-250/4-T3	0.04
Aluminum (SAE-AMS-A-250/4) anodized per MIL-A-8625, type I	Alloy 2024; QQ-A-250/4-T3 anodized per MIL-A-8625, type I	0.04
Carbon steel (SAE-AMS5046)	SAE 1020	0.04
Copper (ASTM-B152)	NA	0.10
Magnesium (SAE-AMS4375), bare	AZ31B-0	0.20
Nickel (SAE-AMS5536)	Hastelloy X	0.04
Stainless steel (ASTM-A240, Class 410)	NA	0.04
Carbon steel (SAE-AMS5046) plated per SAE-AMS-QQ-P-416, Type I	SAE 1020 plated per SAE-AMS-QQ-P-416	0.20
Titanium (SAE-AMS-T-9046, type III,comp C)	Type I, 6Al 4V	0.04

3.5.6.3 Hydrogen embrittlement. When tested at the manufacturer's recommended concentration in accordance with 4.5.4, neither cadmium plated AISI 4340 steel specimens nor IVD aluminum coated AISI 4340 steel specimens shall exhibit embrittlement. Four specimens of each coating shall be tested using either the sustained load procedure or the step load procedure. For the sustained load procedure, embrittlement is indicated if a specimen fractures in less than 200 hours when loaded to 75 percent notched fracture strength. If only one of the four specimens fractures, step load the remaining three specimens at 5 percent of the notched fracture strength per hour to failure. If these three specimens achieve 90 percent for 1 hour, the chemical shall be considered non-embrittling, For the step load procedure, embrittlement is indicated if a specimen fractures at less than 90 percent of notched fracture strength.

3.5.7 Stability.

3.5.7.1 Hard water stability. When tested at the manufacturer's recommended concentration and as specified in 4.5.5, the cleaning compound shall not cause any corrosion of SAE-AMS-A-250/4 aluminum in excess of that allowed in table I.

3.5.7.2 Storage stability. When tested as specified in 4.5.6 and after a 12 month storage period, the type I cleaning compound shall not exhibit any separation, crystallization, or other deterioration of the cleaning compound or container. The type II cleaning compound shall not exhibit any deterioration of the cleaning compound or container. Stored cleaning compounds shall not fail the total immersion corrosion (3.5.6.2) or cleaning efficiency (3.5.8) requirements. For cleaning efficiency, only the MIL-G-21164 soil shall be tested.

3.5.7.3 Accelerated storage stability. After being tested for accelerated storage as specified in 4.5.7, the test sample shall show no marked change in color or uniformity when compared to the control and shall meet the cleaning efficiency requirement for the MIL-G-21164 soil specified in 3.5.8.

3.5.8 Cleaning efficiency. The cleaning compound shall remove not less than 80 percent of unbaked grease in accordance with MIL-G-21164 and not less than 95 percent of baked Alox 2028, when tested at the manufacturer's recommended concentration as specified in 4.5.8.

3.5.9 Oil separation. The oil layer shall be not less than 9 and be not greater than 13 milliliters, when tested as specified in 4.5.9.

3.5.10 Workmanship. When examined visually at room temperature, the type I cleaning compound shall be a homogeneous liquid free of foreign matter. A faint turbidity shall not be cause for rejection. When examined visually at room temperature, the type II cleaning compound should be free-flowing, lump-free, and free from foreign materials. Upon mixing, the cleaner shall form a liquid with no solid sediment.

3.5.11 Service evaluation. Upon completion of all other tests herein, with the exception of storage stability (see 3.5.7.2), the qualifying activity may request a full evaluation of the cleaning compounds by an aircraft depot maintenance facility (Navy, Air Force, Army, or commercial) in accordance with 4.5.10. The cleaning compounds performance shall be equal to or better than an existing qualified product chosen by the maintenance facility.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.3).
b. Conformance inspection (see 4.4).

4.2 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with standard conditions. Standard conditions shall be a temperature of 72 ± 4°F (22 ± 2 °C) and a relative humidity of 50 ±20 percent.

4.3 Qualification inspections. Qualification inspection shall consist of all the tests specified in table II. At the discretion of the qualifying activity, service evaluation of the cleaning compound may be required.

TABLE II. Qualification inspection.

Characteristic	Requirement paragraph	Test method or paragraph
Biodegradability	3.5.1	4.5.1
Nonvolatile content 1/	3.5.2	ASTM-D2834
Flash point (type I)	3.5.3.1	ASTM-D93
Flash point (type II)	3.5. 3.2	ASTM-D3278
PH	3.5.4	ASTM-E70
Foaming	3.5.5	4.5.2
Titanium stress corrosion 2/	3.5.6.1	ASTM-F945
Total immersion corrosion 3/	3.5.6.2	ASTM-F483
Hydrogen embrittlement 4/	3.5.6.3	ASTM-F519
Hard water stability	3.5.7.1	4.5.5
Storage stability	3.5.7.2	ASTM-F1104 and 4.5.6
Accelerated storage stability	3.5.7.3	4.5.7
Cleaning efficiency	3.5.8	4.5.8
Oil separation	3.5.9	4.5.9
Workmanship	3.5.10	Visual examination
Service evaluation	3.5.11	4.5.10

1/ Nonvolatile content shall be determined using 2- to 3-gram sample weights, 100-mm diameter glass Petri dishes, and a forced draft oven at 105 ±2 °C (221 ± 4 °F) for 16 hours.
2/ At 500X magnification
3/ As modified in 4.5.3
4/ As modified in 4.5.4

4.3.1 Samples. Qualification test samples shall consist of two 1-gallon containers of the type in which the manufacturer intends to supply contract quantities of the cleaner(s).

4.4 Conformance inspection. The cleaning compound acquired by the Government under this specification shall be source inspected in accordance with 4.4.2 to ensure the material meets the conformance inspection prior to shipment from the manufacturer's plant.

4.4.1 Sampling. Two containers of cleaning compound shall be randomly selected from each lot and tested as specified in 4.4.2.

4.4.2 Testing. Samples selected in accordance with 4.4.1 shall be tested in accordance with the test methods specified in table III. Each sample selected shall be thoroughly mixed prior to testing. Failure of either sample to conform to any requirement of this specification shall be cause for rejection of the lot represented by these samples.

TABLE III. Conformance inspection.

Inspection	Requirement paragraph	Test method or paragraph
Nonvolatile content 1/	3.5.2	ASTM-D2834
Flash point (Type I)	3.5.3.1	ASTM-D93
Flash point (Type II)	3.5.3.2	ASTM-D3278
pH	3.5.4	ASTM-E70
Foaming	3.5.5.5	4.5.2
Titanium stress corrosion	3.5.6.1	ASTM-F945
Total immersion corrosion 2/	3.5.6.2	ASTM-F483

1/ Nonvolatile content shall be determined using 2- to 3-gram sample weights, 100-mm diameter glass Petri dishes, and a forced draft oven at 221 ± 4 °F (105 ± 2 °C) for 16 hours.
2/ As modified in 4.5.3.

4.5 Methods of inspection.

4.5.1 Biodegradability. Biodegradation of the concentrated cleaning compounds shall be determined over 28 days by the "Shake Flask Biodegradation Tests" for measuring ultimate or ready degradation potential, monitored by analysis of total organic carbon (TOC), as found in

EPA Chemical Fate Test Guidelines 40 CFR, Method 796.3100 (Aerobic Aquatic Biodegradation Test) or 40 CFR, Method 796.3240 (OECD Screening Test for Ready Biodegradability). Biodegradability shall be shown as carbon transformation by both soluble organic carbon reduction and CO_2 evolution.

4.5.2 Foaming. One hundred milliliters (ml) of cleaning solution (prepared in accordance with the manufacturer's instructions) shall be placed in a blender container and conditioned at 160 ± 2 °F (71 ± 1 °C) for 1 hour. The blender shall then be turned on for 2 minutes at 8000 ±1000 rotations per minute. After 2 minutes, the blender shall be turned off and the foam volume shall be determined immediately by reading a graduated scale on the blender container. The test shall be repeated at 120 ± 2 °F (49 ± 1 °C).

4.5.3 Total immersion corrosion. The cleaning compounds shall be diluted to the manufacturer's recommended cleaning concentration. Corrosion specimens that are not plated, anodized, or conversion coated (including magnesium specimens) shall be polished with 240-grit aluminum oxide or silicon carbide paper or cloth. Specimens shall be cleaned with MIL-PRF-680 followed by isopropyl alcohol and exposed as specified in ASTM-F483, except that the cleaning solution shall be heated to 160 ± 2 °F (71 ± 1 °C) prior to and during the test. After 24 hours, the panels shall be removed, cleaned, and weighed in accordance to ASTM-F483.

4.5.4 Hydrogen embrittlement. Hydrogen embrittlement shall be determined in accordance with ASTM-F519, using AISI 4340, type 1a or 1e specimens.

4.5.4.1 Specimen coating. Cadmium-plated specimens shall be prepared as specified using treatment B, without conversion coating. Ion vapor deposited (IVD) aluminum specimens shall be prepared in accordance with MIL-DTL-83488, class 2, type II. The coatings shall cover the notch and surfaces within 0.5 inch of the notch; threaded surfaces shall not be coated. Cadmium-plated specimens shall be baked in accordance with ASTM-F519.

4.5.4.2 Procedure. Four specimens for each coating shall be individually exposed, immediately dried, then immediately tested for embrittlement. Exposure shall consist of immersion in a glass beaker containing fresh cleaning solution per product (at the manufacturer's recommended concentration) at 160 ± 2 °F (71 ± 1 °C) for 30 minutes. Specimens shall be dried without rinsing at ambient conditions for five minutes. Embrittlement testing shall consist of applying a load equivalent to 75 percent of notch fracture strength for 200 hours; or, a load equivalent to 45 percent of notch fracture strength shall be applied for 24 hours, then stepped an additional 5 percent of notch fracture strength each hour until failure. Failure shall be as indicated in 3.5.6.3.

4.5.5 Hard water stability.

4.5.5.1 Preparation of hard water stock solution. A 10-grain hard water stock solution shall be prepared by dissolving 0.20 ± 0.005 gram of analytical reagent grade calcium acetate

($Ca(C_2H_3O_2)_2 \cdot H_2O$) and 0.14 ± 0.005 gram of analytical reagent grade magnesium sulfate ($MgSO_2 \cdot 7H_2O$) in one liter of boiled distilled water.

4.5.5.2 Procedure. In a capped polymethylpentene (PMP) container, prepare 250 ml of total solution by diluting the cleaner concentrate with the prepared hard water stock solution to achieve the manufacturer's recommended concentration. Screw on the cap and shake the container vigorously for 15 seconds, place in a 160 ± 2 °F (71 ± 1 °C) oven for two hours, then allow to stand undisturbed for 16 hours at room temperature. Test the solution for corrosivity on SAE-AMS-A-250/4 aluminum test panels as specified in 4.5.3.

4.5.6 Storage stability. Both types of cleaning compounds shall be stored in their original containers as furnished by the manufacturer. After 12 months of storage in accordance with ASTM-F1104, the cleaning compounds shall be examined for any type of deterioration of the cleaning compounds or of the containers. In addition, a sample of the stored cleaning compounds shall be used to perform the total immersion corrosion test on bare and anodized aluminum alloy (see table II). Finally, the sample shall be tested for cleaning efficiency using only the MIL-G-21164 soil (see 4.5.8) for conformance to the requirements of this specification.

4.5.7 Accelerated storage stability.

4.5.7.1 Preparation of test sample. For type I cleaners, a 150-ml portion of well-shaken concentrated cleaning compound shall be poured into each of two clean 500 ml clear, round, screw cap polymethylpentene (PMP) bottles with an outside diameter of 2.5 inches. One bottle shall be immediately capped and stored in the dark at room temperature for a minimum of 6 days (control sample). The second bottle is the test sample. For type II cleaners, place the powder in a dry capped container and proceed as for type I cleaners.

4.5.7.2 Procedure. The test sample shall be placed in a water bath heated to 140 ± 4 °F (60 ± 2 °C) and held at that temperature for not less than 8 hours. The bath shall then be cooled to room temperature over the next 16 hours. This procedure shall be repeated every day for 5 additional days. After exposure for a total of 6 cycles, the test sample shall be removed from the bath and visually examined for degradation of the cleaning compound. The test sample shall be recapped and, along with the control sample, thoroughly shaken for 1 minute, allowed to stand undisturbed at room temperature for a minimum of 1 hour, then be compared to the control sample. When the test sample is in compliance with the visual requirements of 3.5.7.3, it shall be tested for cleaning efficiency using only the MIL-G-21164 soil (see 4.5.8) for conformance to the requirements of this specification.

4.5.8 Cleaning efficiency. The cleaning compound solution shall be prepared by diluting the concentrated cleaning compound to the manufacturer's recommended cleaning concentration with hard water stock solution (see 4.5.5.1).

4.5.8.1 MIL-G-21164 grease. Molybdenum disulfide grease soil shall be prepared by blending 50 grams of Raven 1040 carbon black (see 6.5) or equal as approved by the qualifing activity and 500 grams of grease in accordance with MIL-G-21164 with a mechanical grease worker for 15 minutes.

4.5.8.2 Alox 2028. Alox 2028 (see 6.5) shall be used as a soil, as received.

4.5.8.3 Test coupons. Test coupons shall be aluminum or stainless steel 0.25 by 1.0 by 4.0 inches with a 0.0625-inch deep rectangular depression 0.75 by 2.75 inches, located 0.375 inches from one end. Prior to soil application, the coupons shall be solvent wiped with acetone (dimethylketone) using wipes in accordance with CCC-C-46, class 7. The pre-cleaning shall continue until the wipe is free of visual residue. The coupons shall be dried in an oven at 221 ± 4 °F (105 ± 2 °C) for 30 minutes. The coupons shall then be removed from the oven, air-cooled to room temperature, and weighed to the nearest 0.1 mg (W_1).

4.5.8.4 Apparatus. The cleaning apparatus shall consist of a 600 ml beaker, heavy-duty glass beaker, a 2-inch long by 0.375-inch diameter cylindrical magnetic stirring bar, a test coupon, and a digital stirrer/hot plate with speed and temperature controls.

4.5.8.5 Soil removal. Test coupons shall be loaded (using a clean acid brush) by brushing the entire bottom of the depression with a test soil to give a uniform film. Avoid contact with the vertical edges. Following the conditioning in table IV, the coupons shall be weighed (W_2). Use only test coupons with soil weights between 100 and 150 mg. Prepare the cleaning solution by diluting the cleaning compounds to the manufacturer's recommended concentration using synthetic hard water as described in 4.5.5.1. Add 500 ml of the cleaning solution and stirring bar to the beaker and stabilize at 160 ± 2 °F (71 ± 1 °C) using the stirrer/hot plate. Clamp the 3 coupons to the side of the beaker so that the soiled depression is fully immersed. Set the stirring speed at 500 rpm and continue stirring for 10 minutes. Rinse the specimen as indicated in table IV.

TABLE IV. Conditioning and rinsing.

SOIL	CONDITIONING	RINSING
MIL-G-21164	None	Remove the test coupon from the beaker and immediately rinse for one minute under a 4-liter/minute water stream from a laboratory faucet with serrated tip. The test coupon shall be 10-12 inches from the tip and held 45° to the water stream.
Alox 2028	1 hour at 221 °F (105 °C); Air-cool to room temperature	Pour the solution from the beaker and immediately place the beaker with coupon under flowing cold tap water for one minute without impinging on the soiled area.

Soils shall be cleaned sequentially in the same prepared solution, with coupons soiled with MIL-G-21164 grease, followed by coupons soiled with Alox 2028.

Dry the coupons for 5 minutes at 105 ± 2 °C (221 ± 5 °F), cool, and then weigh (W_3). The cleaning efficiency result for each of the two soils shall be an average of three test coupons. Calculate coupon cleaning efficiency (CE) as follows:

$$CE\ (\%) = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

4.5.9 Oil separation. Prepare a 100 ml sample of the manufacturer's recommended concentration of the cleaning compound in a stoppered 100 ml graduated cylinder. Discard 10 ml of the solution and replace it with 10 ml of hydraulic fluid in accordance with MIL-PRF-83282. Place the cylinder in a forced convection oven at 160 ± 2 °F (71 ± 1 °C) for one hour. Remove the cylinder from the oven, shake it vigorously for 10 seconds, and allow it to stand at room temperature for one hour. After one hour, observe and record the volume of the top (oil) layer.

4.5.10 Service test. Service testing may be performed at a military aviation depot using an automated parts washer on soiled parts which are typical of those cleaned at the depot. Alternatively, artificially soiled parts may be prepared using fluids normally encountered in service to coat clean parts. In either case, results for the product being tested shall be compared to the results for a product which is already qualified to this specification.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The cleaning compounds covered by this specification are used in the maintenance of military aircraft exposed for prolonged periods to extreme seagoing environments not encountered by civilian aircraft. The cleaning compound is intended for use in parts washers

and spray cabinets for cleaning aviation weapons systems, and engine and support equipment components. The cleaning compound will remove oily contaminants which are present on disassembled components.

6.2 Acquisition requirements. Acquisition documents should specify the following:

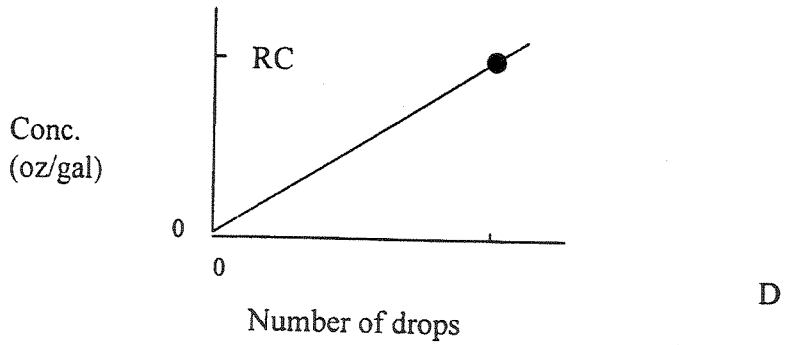
a. Title, number, and date of this specification.
b. Type of cleaning compound required (see 1.2).
c. Unit of issue required (see 3.3).
d. Quantity required.
e. Packaging requirements (see 5.1).

6.3 Solution test kit use. The following test kit components and procedures can be used to maintain the cleaning solution in a tank by replenishment with the concentrated cleaning compound:

25 ml measuring vial
5 ml measuring vial
50 ml chemical resistant plastic flask
25 ml dropper bottle of 0.5 percent phenolphthalein indicator
100 ml dropper bottle of 1.0 N sulfuric acid.

6.3.1 Procedure. This procedure requires the user to make a chart using titration for the product being used, if one has not been made previously. Using this chart and titration results on a questionable tank solution, the amount of cleaner concentrate to be added to the tank can be calculated.

6.3.1.1 Chart. Make up the manufacturer's recommended concentration (RC) and make sure it is well dissolved. Take the appropriate sample size (20 ml for a liquid and 5 ml for a powder), add it to the flask, then add 6 drops of indicator. Add the sulfuric acid solution a drop at a time, swirling the mixture after each drop. Count the number of drops (D) it takes until the pink color is completely gone (use a sheet of white paper under the flask to help see the color). Repeat this procedure to make sure that you have done this correctly. Mark this point on simple graph paper and draw a straight line to the origin (see example below).



6.3.1.2 Determining the concentration of the cleaner solution. Take a sample of the questionable cleaning solution: 20 ml for a type I solution or 5 ml for a type II solution. Pour the sample into a clean 50 ml plastic flask. Add 6 drops of indicator to the flask and swirl to mix. The solution will be a pink or red pink color. Add the sulfuric acid solution a drop at a time, swirling the mixture after each drop. Count the number of drops it takes until the pink color is completely gone. Using the chart above, determine the concentration of the sample by finding the number of drops on the horizontal axis and the corresponding concentration on the vertical axis.

6.3.1.3 Determine the amount of cleaner concentrate to add. Suppose the parts washer has a 150 gallon tank of cleaning solution made up using a type I product designed to be used at 7.5 oz/gal (fluid ounces per gallon). You would use the larger vial to take a 20 ml sample from the tank. After pouring that sample into the flask and adding the correct amount of indicator, you find that it takes a certain number drops of acid to cause the color to change. Suppose your chart indicates the cleaner concentration in the parts washer is 5.0 ounces per gallon (oz/gal). If you want to bring the concentration back up to 7.5 oz/gal, you need to calculate the makeup volume of cleaner to add to the tank. Subtract the indicated concentration from the desired concentration then multiply by the volume of the tank:

Volume = (7.5 - 5.0) oz/gal X 150 gal = 375 oz (or 2.9 gal)

This is the volume of cleaner concentrate that must be added to the tank. If the total of all makeup additions is more than the amount of cleaner initially charged to the tank, the tank should be dumped, cleaned, and recharged with fresh cleaner and water.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL-29602 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for products covered by this specification. Information pertaining to qualification of products may be obtained from the Naval Air Warfare Center Aircraft Division, Building 2188, 48066 Shaw Road, Unit 5, Patuxent River, MD 20670-1908.

6.4.1 Inspection reports and additional information. When authorizing the forwarding of qualification samples, the qualifying activity will require the manufacturer to submit, along with the samples, the following:

a. Two copies of the manufacturer's test report containing complete test data showing that the material submitted for qualification conforms to the requirements of this specification.
b. Certification that the cleaning compound contains no carcinogens, ozone depleting substances, hazardous air pollutants, volatile organic compounds, or total toxic organic and is biodegradable (see 3.2).

c. Material safety data sheets prepared in accordance with FED-STD-313 (see 6.8)
d. Two copies of the manufacturer's instructions for use of the cleaning compound.
e. A proven method for determining and maintaining the proper concentration of cleaning compounds in the parts washer.

The samples must be plainly and durably marked with the following information and forwarded to the test facility identified in the letter of authorization to submit samples:

- Sample for qualification inspection
- CLEANING COMPOUND, PARTS WASHERS AND SPRAY CABINETS
- Specification MIL-PRF-29602A
- Type I or II, as applicable
- Manufacturer's name and address
- Manufacturer's product identification
- Manufacturer's recommended dilution
- Batch number
- Date of manufacture
- Submitted by (name and date) for qualification inspection in accordance with the requirements of MIL-PRF-29602A under authorization of (reference authorization letter).

6.5 Supplier information.

Table V. Item supplier information.

Item	Identification	Supplier	Location
Measuring vial, 25 ml	Cat. No. 2172-40	Hach Company	Loveland, CO
Measuring vial, 5 ml	Cat. No. 2172-38		
Plastic flask, chemical resistant, 50 ml	Cat. No. 20898-71		
Dropper bottle of 0.5% phenolphthalein indicator, 25 ml	Cat. No. 162-36		
Dropper bottle of 1.0 N sulfuric acid, 100 ml	Cat. No. 1270-26		
Carbon black	Raven 1040	Columbia Carbon Company	Atlanta, GA
Soil	Alox 2028	Alox Corporation	Niagara Falls, NY

6.6 Retention of qualification. To retain qualification of the products approved for listing on the QPL, the manufacturer will verify by certification to the qualifying activity that the manufacturer's product complies with the requirements of this specification. The time of periodic verification by certification will be every two years from the date of original

qualification and will be initiated by the Government. The Government reserves the right to re-examine the qualified product whenever deemed necessary to ensure that the product continues to meet any or all of the specification requirements.

6.7 Lot formation. Unless otherwise specified, a lot consists of all the cleaning compound produced by one manufacturer, at one plant, from the same materials and under essentially the same conditions, provided the operation is continuous and does not exceed a 24 hour period. In the event the process is a batch operation, each batch will constitute a lot.

6.8 Toxicity. The cleaning compounds, when used for their intended purpose, must have no adverse effect on the health of personnel. Questions pertaining to this effect will be referred by the acquiring activity to the appropriate medical service who will act as an adviser to the contracting agency.

6.9 Material Safety Data Sheets (MSDSs). MSDSs for items supplied to the Government will conform to FED-STD-313, Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities.

6.10 Subject term (key word) listing.

Aqueous
Biodegradable
Dilutable
Service evaluation

6.11 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

Custodians:
Army - EA
Navy - AS
Air Force - 68

Preparing activity:
Navy - AS

(Project 6850-1493)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at www.dodssp.daps.mil.

Appendix B

Test Data Sheet – Original Results

Description of Tables

While the cleaning efficiency tests were being conducted, all experimental observations were recorded directly on an Excel spreadsheet with a laptop computer in the cleaning laboratory. This section of the appendix contains all of the original data collected during execution of the cleaning efficiency tests. The information contained in these tables is explained below with the use of an actual example, Test #41.

During Test #41, the cleaning compound Axarel 58 was used, as indicated in the top row of the table below. The number appearing to the left of the compound name, 41, is the test number. The numbers to the right of the compound name (150, 100%, and 65.55556) indicate the temperature (degrees F), concentration (% by volume), and temperature (degrees C) of the cleaning solution used in the test, respectively. Directly below these numbers, a comment ("looked and felt completely clean") appears.

Directly below the compound name, two sections are presented, colored pink and yellow. The pink section represents Contaminant # 1; the yellow section represents Contaminant #2. For each contaminant, three test coupons were used. The test coupon number and its precleaned weight for that specific test is recorded in the white section in between the colored rows. Then, directly below these rows, the weight of the test coupon loaded with contaminant before and after cleaning is recorded. For example, for Contaminant #1, the first test coupon used was #15. It had a precleaned weight of 40.7901 grams. After the test coupon was loaded with Contaminant #1, it weighed 40.9219 grams before it was cleaned, and 40.7950 grams after it was cleaned.

Test coupon #15, which was used for Contaminant #1, therefore saw a reduction in mass of 0.1318 grams before and after cleaning in Axarel 58, which corresponds to a cleaning efficiency of 0.96282246, or about 96.28%. These numbers can be found on the right hand side of the table. Test coupon #14 saw a reduction in mass of 0.144 grams; test coupon #13, 0.1405 grams. The average cleaning efficiency for all three coupons for Contaminant #1 is the mean of the cleaning efficiencies for test coupons #15, #14, and #13, and is equal to 0.972145 (or about 97.21%) and is highlighted in pink. The values for Contaminant #2 are located in similar positions on the table.

41	Axarel 58					150	100%	65.55556	
	Contaminant 1								
	Coupon Number	15	14	13		looked and felt completely clean			
	Coupon Weight	40.7901	40.1439	39.7623					
	Coupon Weight with Contaminant 1	40.9219	40.2879	39.9028		0.1318	0.144	0.1405	
	Coupon Weight with Contaminant 1 after cleaning	40.795	40.1473	39.7655		0.96282246	0.976388889	0.977224	0.972145
	Contaminant 2								
	Coupon Number	34	35	36					
	Coupon Weight	39.9969	40.6378	40.9987					
	Coupon Weight with Contaminant 2	40.139	40.7696	41.132		0.1421	0.1318	0.1333	
	Coupon Weight with Contaminant 2 after cleaning	40.0014	40.6434	41.0029		0.96833216	0.957511381	0.968492	0.964779

Test #						Temperature	Concentration		
1	Armakleen M-Aero					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	48	47	46					
	Coupon Weight	40.9474	40.4033	40.9566					
	Coupon Weight with Contaminant 1	41.0701	40.5399	41.0786		0.1227	0.1366	0.122	
	Coupon Weight with Contaminant 1 after cleaning	40.9474	40.4031	40.9578		1	1.001464129	0.990164	0.997209
	Contaminant 2								
	Coupon Number	1	2	3					
	Coupon Weight	40.4016	40.9186	39.4665					
	Coupon Weight with Contaminant 2	40.5318	41.0424	39.5778		0.1302	0.1238	0.1113	
	Coupon Weight with Contaminant 2 after cleaning	40.4019	40.9186	39.4666		0.99769585	1	0.999102	0.998932
2	Aquaworks MM Dip Concentrate					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	45	44	43					
	Coupon Weight	40.9666	40.4899	41.3433					
	Coupon Weight with Contaminant 1	41.0852	40.6275	41.4926		0.1186	0.1376	0.1493	
	Coupon Weight with Contaminant 1 after cleaning	40.9672	40.4919	41.3459		0.99494098	0.985465116	0.982585	0.987664
	Contaminant 2								
	Coupon Number	4	5	6					
	Coupon Weight	39.6591	40.2675	40.3767					
	Coupon Weight with Contaminant 2	39.7826	40.3896	40.4878		0.1235	0.1221	0.1111	
	Coupon Weight with Contaminant 2 after cleaning	39.6606	40.2691	40.3774		0.98785425	0.986895987	0.993699	0.989483
3	Armakleen M100					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	42	41	40					
	Coupon Weight	40.5131	40.6179	40.9447					
	Coupon Weight with Contaminant 1	40.6413	40.7501	41.0689		0.1282	0.1322	0.1242	
	Coupon Weight with Contaminant 1 after cleaning	40.5175	40.6293	40.9476		0.96567863	0.91376702	0.976651	0.952032
	Contaminant 2								
	Coupon Number	7	8	9					
	Coupon Weight	40.0697	39.5566	41.1758					
	Coupon Weight with Contaminant 2	40.2037	39.6711	41.2771		0.134	0.1145	0.1013	
	Coupon Weight with Contaminant 2 after cleaning	40.0697	39.557	41.1765		1	0.99650655	0.99309	0.996532
4	US-2003					160	10.00%	71.11111	
	Contaminant 1								
	Coupon Number	39	38	37					
	Coupon Weight	41.3496	41.4482	41.2762					
	Coupon Weight with Contaminant 1	41.4986	41.5699	41.4144		0.149	0.1217	0.1382	
	Coupon Weight with Contaminant 1 after cleaning	41.3564	41.4593	41.2859		0.95436242	0.908792112	0.929812	0.930989
	Contaminant 2								
	Coupon Number	9	11	12					
	Coupon Weight	41.1752	40.8946	41.1491					
	Coupon Weight with Contaminant 2	41.2961	41.0094	41.2601		0.1209	0.1148	0.111	
	Coupon Weight with Contaminant 2 after cleaning	41.1748	40.8946	41.149		1.00330852	1	1.000901	1.001403
5	Bean-e-doo Parts Washer Solvent					160	50%	71.11111	
	Contaminant 1								
	Coupon Number	27	26	25					
	Coupon Weight	41.3739	41.1622	40.6909					
	Coupon Weight with Contaminant 1	41.4789	41.2728	40.8177		0.105	0.1106	0.1268	
	Coupon Weight with Contaminant 1 after cleaning	41.3747	41.1654	40.6949		0.99238095	0.971066908	0.968454	0.977301
	Contaminant 2								
	Coupon Number	14	15	24					
	Coupon Weight	40.1446	40.7893	40.7896					
	Coupon Weight with Contaminant 2	40.2656	40.8988	40.8953		0.121	0.1095	0.1057	
	Coupon Weight with Contaminant 2 after cleaning	40.1456	40.7905	40.7907		0.99173554	0.989041096	0.989593	0.990123

6	Gold Matrix					160	100%	71.11111		
	Contaminant 1									
	Coupon Number	30	29	28						
	Coupon Weight	39.6222	40.6259	41.2369						
	Coupon Weight with Contaminant 1	39.7589	40.7472	41.3757		0.1367	0.1213	0.1388		
	Coupon Weight with Contaminant 1 after cleaning	39.6223	40.6271	41.2403		0.99926847	0.990107172	0.975504	0.988293	
	Contaminant 2									
	Coupon Number	19	20	21						
	Coupon Weight	39.8028	41.2192	40.5671						
	Coupon Weight with Contaminant 2	39.9232	41.3439	40.6783		0.1204	0.1247	0.1112		
	Coupon Weight with Contaminant 2 after cleaning	39.8031	41.2192	40.5673		0.99750831	1	0.998201	0.99857	
7	Citrusoy Super High Flash					160	100%	71.11111		
	Contaminant 1									
	Coupon Number	33	32	31						
	Coupon Weight	41.2355	41.2721	40.5962						
	Coupon Weight with Contaminant 1	41.3724	41.4039	40.7173		0.1369	0.1318	0.1211		
	Coupon Weight with Contaminant 1 after cleaning	41.2387	41.2749	40.5984		0.97662527	0.97875569	0.981833	0.979071	
	Contaminant 2									
	Coupon Number	16	17	13		Left greasy residue				
	Coupon Weight	41.4625	40.1007	39.7598						
	Coupon Weight with Contaminant 2	41.5915	40.2134	39.8888		0.129	0.1127	0.129		
	Coupon Weight with Contaminant 2 after cleaning	41.4997	40.131	39.7939		0.71162791	0.731144632	0.735659	0.726144	
8	Clean Safe 7448-05					160	11.11%	71.11111		
	Contaminant 1									
	Coupon Number	25	26	27		Foamy and left black residue on entire coupon seem				
	Coupon Weight	40.6919	41.1626	41.3749						
	Coupon Weight with Contaminant 1	40.7971	41.2951	41.5168		0.1052	0.1325	0.1419		
	Coupon Weight with Contaminant 1 after cleaning	40.4999	40.9432	41.1429		2.82509506	2.655849057	2.634954	2.705299	
	Contaminant 2									
	Coupon Number	24	23	22						
	Coupon Weight	40.7903	41.3703	41.7355						
	Coupon Weight with Contaminant 2	40.9293	41.514	41.8623		0.139	0.1437	0.1268		
	Coupon Weight with Contaminant 2 after cleaning	40.6509	41.281	41.6468		2.0028777	1.621433542	1.699527	1.774613	
9	Clean Safe 7445-05					160	11.11%	71.11111		
	Contaminant 1									
	Coupon Number	28	29	30						
	Coupon Weight	41.2377	40.6263	39.6224						
	Coupon Weight with Contaminant 1	41.3871	40.7654	39.7637		0.1494	0.1391	0.1413		
	Coupon Weight with Contaminant 1 after cleaning	41.2377	40.6312	39.6233		1	0.964773544	0.993631	0.986135	
	Contaminant 2									
	Coupon Number	21	20	19						
	Coupon Weight	40.5681	41.2198	39.8033						
	Coupon Weight with Contaminant 2	40.6991	41.354	39.9448		0.131	0.1342	0.1415		
	Coupon Weight with Contaminant 2 after cleaning	40.5674	41.2191	39.8031		1.00534351	1.005216095	1.001413	1.003991	
10	Oleocal ME-130					160	100.00%	71.11111		
	Contaminant 1									
	Coupon Number	31	32	33						
	Coupon Weight	40.5973	41.2728	41.2361						
	Coupon Weight with Contaminant 1	40.7402	41.3921	41.3772		0.1429	0.1193	0.1411		
	Coupon Weight with Contaminant 1 after cleaning	40.5983	41.2742	41.2394		0.9930021	0.988264878	0.976612	0.98596	
	Contaminant 2									
	Coupon Number	18	17	16		Still greasy				
	Coupon Weight	41.3574	40.1023	41.4628						
	Coupon Weight with Contaminant 2	41.4896	40.2307	41.6044		0.1322	0.1284	0.1416		
	Coupon Weight with Contaminant 2 after cleaning	41.3971	40.1123	41.4831		0.69969743	0.92211838	0.856638	0.826151	

11	SoySolv II					160	100.00%	71.11111	
	Contaminant 1								
	Coupon Number	34	35	36					
	Coupon Weight	39.9975	40.6376	40.9986					
	Coupon Weight with Contaminant 1	40.1129	40.7724	41.1482		0.1154	0.1348	0.1496	
	Coupon Weight with Contaminant 1 after cleaning	39.9958	40.6364	40.9975		1.01473137	1.008902077	1.007353	1.010329
	Contaminant 2								
	Coupon Number	15	14	13					
	Coupon Weight	40.7905	40.1452	39.7605					
	Coupon Weight with Contaminant 2	40.9326	40.2808	39.9041		0.1421	0.1356	0.1436	
	Coupon Weight with Contaminant 2 after cleaning	40.7892	40.1443	39.7601		1.00914849	1.006637168	1.002786	1.00619
12	Armakleen HP-2					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	37	38	39					
	Coupon Weight	41.2769	41.4504	41.35					
	Coupon Weight with Contaminant 1	41.4171	41.5546	41.4578		0.1402	0.1042	0.1078	
	Coupon Weight with Contaminant 1 after cleaning	41.2791	41.4501	41.3506		0.98430813	1.002879079	0.994434	0.993874
	Contaminant 2								
	Coupon Number	12	11	10					
	Coupon Weight	41.1491	40.8946	41.8048					
	Coupon Weight with Contaminant 2	41.2916	41.0263	41.9426		0.1425	0.1317	0.1378	
	Coupon Weight with Contaminant 2 after cleaning	41.1492	40.8949	41.803		0.99929825	0.997722096	1.013062	1.003361
13	ArmaKleen M-400					160	7.5	71	
	Contaminant 1								
	Coupon Number	40	41	42					
	Coupon Weight	40.9449	40.6183	40.5138					
	Coupon Weight with Contaminant 1	41.0759	40.7353	40.656		0.131	0.117	0.1422	
	Coupon Weight with Contaminant 1 after cleaning	40.9873	40.6513	40.5642		0.67633588	0.717948718	0.64557	0.679951
	Contaminant 2								
	Coupon Number	9	8	7					
	Coupon Weight	41.1747	39.5576	40.0701					
	Coupon Weight with Contaminant 2	41.3192	39.6836	40.2079		0.1445	0.126	0.1378	
	Coupon Weight with Contaminant 2 after cleaning	41.1755	39.5568	40.0709		0.99446367	1.006349206	0.994194	0.998336
14	Aquaworks MPC concentrate					160	7.5	71	
	Contaminant 1								
	Coupon Number	43	44	45		still contam left but weighed 0			
	Coupon Weight	41.3446	40.4904	40.9677					
	Coupon Weight with Contaminant 1	41.4492	40.6098	41.0901		0.1046	0.1194	0.1224	
	Coupon Weight with Contaminant 1 after cleaning	41.3444	40.4908	40.9678		1.00191205	0.996649916	0.999183	0.999248
	Contaminant 2								
	Coupon Number	6	5	4					
	Coupon Weight	40.3768	40.2678	39.6596					
	Coupon Weight with Contaminant 2	40.5062	40.381	39.8019		0.1294	0.1132	0.1423	
	Coupon Weight with Contaminant 2 after cleaning	40.376	40.2672	39.658		1.00618238	1.005300353	1.011244	1.007576
15	Breakthrough					70	100%	21.11111	
	Contaminant 1								
	Coupon Number	46	47	48					
	Coupon Weight	40.9576	40.403	40.9476					
	Coupon Weight with Contaminant 1	41.0975	40.5118	41.0775		0.1399	0.1088	0.1299	
	Coupon Weight with Contaminant 1 after cleaning	40.9575	40.4031	40.9483		1.0007148	0.999080882	0.994611	0.998136
	Contaminant 2								
	Coupon Number	3	2	1					
	Coupon Weight	39.4676	40.918	40.4022					
	Coupon Weight with Contaminant 2	39.5882	41.0493	40.5332		0.1206	0.1313	0.131	
	Coupon Weight with Contaminant 2 after cleaning	39.4665	40.918	40.4016		1.00912106	1	1.00458	1.004567

16	California Parts Washer Solution					105	20%	40.55556	
	Contaminant 1								
	Coupon Number	25	26	27					
	Coupon Weight	40.4861	40.9338	41.1375					
	Coupon Weight with Contaminant 1	40.6144	41.0784	41.2504		0.1283	0.1446	0.1129	
	Coupon Weight with Contaminant 1 after cleaning	40.4857	40.9331	41.1366		1.00311769	1.004840941	1.007972	1.00531
	Contaminant 2								
	Coupon Number	1	2	3					
	Coupon Weight	40.4025	40.9192	39.4681					
	Coupon Weight with Contaminant 2	40.5198	41.0474	39.6124		0.1173	0.1282	0.1443	
	Coupon Weight with Contaminant 2 after cleaning	40.4014	40.9177	39.4665		1.00937766	1.011700468	1.011088	1.010722
17	SW-8 Aircraft OzzyJuice					105	100.00%	40.55556	
	Contaminant 1								
	Coupon Number	28	29	30					
	Coupon Weight	41.235	40.6267	39.6219					
	Coupon Weight with Contaminant 1	41.371	40.7694	39.7613		0.136	0.1427	0.1394	
	Coupon Weight with Contaminant 1 after cleaning	41.2489	40.6315	39.626		0.89779412	0.966362999	0.970588	0.944915
	Contaminant 2								
	Coupon Number	4	5	6					
	Coupon Weight	39.6589	40.2682	40.3768					
	Coupon Weight with Contaminant 2	39.7869	40.3888	40.505		0.128	0.1206	0.1282	
	Coupon Weight with Contaminant 2 after cleaning	39.6602	40.2711	40.3776		0.98984375	0.975953566	0.99376	0.986519
18	SW-LF OzzyJuice					105	100.00%	40.55556	
	Contaminant 1								
	Coupon Number	31	32	33					
	Coupon Weight	40.5963	41.2718	41.2355					
	Coupon Weight with Contaminant 1	40.7366	41.4092	41.3731		0.1403	0.1374	0.1376	
	Coupon Weight with Contaminant 1 after cleaning	40.6035	41.2794	41.2435		0.9486814	0.944687045	0.94186	0.945076
	Contaminant 2								
	Coupon Number	7	8	9		Edges full of grease			
	Coupon Weight	40.0702	39.5563	41.1749					
	Coupon Weight with Contaminant 2	40.198	39.6961	41.3004		0.1278	0.1398	0.1255	
	Coupon Weight with Contaminant 2 after cleaning	40.0702	39.5595	41.1761		1	0.977110157	0.990438	0.989183
19	SW-3 OzzyJuice					105	100.00%	40.55556	
	Contaminant 1								
	Coupon Number	34	35	36					
	Coupon Weight	39.9973	40.6389	40.9988					
	Coupon Weight with Contaminant 1	40.1298	40.7831	41.1228		0.1325	0.1442	0.124	
	Coupon Weight with Contaminant 1 after cleaning	39.9977	40.6402	40.998		0.99698113	0.990984743	1.006452	0.998139
	Contaminant 2								
	Coupon Number	10	11	12					
	Coupon Weight	41.8035	40.895	41.1495					
	Coupon Weight with Contaminant 2	41.9293	41.0146	41.2718		0.1258	0.1196	0.1223	
	Coupon Weight with Contaminant 2 after cleaning	41.8028	40.8946	41.1489		1.00556439	1.003344482	1.004906	1.004605
20	Millennium					105	25%	40.55556	
	Contaminant 1								
	Coupon Number	37	38	39					
	Coupon Weight	41.277	41.4496	41.3498					
	Coupon Weight with Contaminant 1	41.3931	41.5546	41.4932		0.1161	0.105	0.1434	
	Coupon Weight with Contaminant 1 after cleaning	41.2888	41.4572	41.367		0.89836348	0.927619048	0.880056	0.902013
	Contaminant 2								
	Coupon Number	13	14	15					
	Coupon Weight	39.7608	40.1446	40.7904					
	Coupon Weight with Contaminant 2	39.891	40.2923	40.9274		0.1302	0.1477	0.137	
	Coupon Weight with Contaminant 2 after cleaning	39.7605	40.1446	40.7896		1.00230415	1	1.005839	1.002715

21	Soy Green Solvent (SG5000)					100	100%	37.77778		
	Contaminant 1									
	Coupon Number	40	41	42		Rinses very easily				
	Coupon Weight	40.9445	40.6183	40.5135						
	Coupon Weight with Contaminant 1	41.0884	40.7538	40.6302		0.1439	0.1355	0.1167		
	Coupon Weight with Contaminant 1 after cleaning	40.9453	40.6192	40.514		0.99444058	0.993357934	0.995716	0.994505	
	Contaminant 2									
	Coupon Number	16	17	18						
	Coupon Weight	41.4624	40.1007	41.358						
	Coupon Weight with Contaminant 2	41.5805	40.2208	41.5012		0.1181	0.1201	0.1432		
	Coupon Weight with Contaminant 2 after cleaning	41.4627	40.102	41.3583		0.99745978	0.989175687	0.997905	0.994847	
22	EnviroClear					100	100%	37.77778		
	Contaminant 1									
	Coupon Number	43	44	45		Rinses very easily				
	Coupon Weight	41.3443	40.4908	40.9675						
	Coupon Weight with Contaminant 1	41.4502	40.6338	41.1039		0.1059	0.143	0.1364		
	Coupon Weight with Contaminant 1 after cleaning	41.3435	40.4898	40.9673		1.0075543	1.006993007	1.001466	1.005338	
	Contaminant 2									
	Coupon Number	19	20	21						
	Coupon Weight	39.8039	41.2212	40.5695						
	Coupon Weight with Contaminant 2	39.9269	41.3608	40.6856		0.123	0.1396	0.1161		
	Coupon Weight with Contaminant 2 after cleaning	39.8025	41.2197	40.5687		1.01138211	1.010744986	1.006891	1.009673	
23	KT600C					112	16.67%	44.44444		
	Contaminant 1									
	Coupon Number	46	47	48						
	Coupon Weight	40.958	40.4045	40.9488						
	Coupon Weight with Contaminant 1	41.0609	40.5479	41.0856		0.1029	0.1434	0.1368		
	Coupon Weight with Contaminant 1 after cleaning	40.9617	40.4123	40.9572		0.96404276	0.945606695	0.938596	0.949415	
	Contaminant 2									
	Coupon Number	22	23	24						
	Coupon Weight	41.6373	41.2709	40.6427						
	Coupon Weight with Contaminant 2	41.7789	41.3958	40.7832		0.1416	0.1249	0.1405		
	Coupon Weight with Contaminant 2 after cleaning	41.6369	41.2693	40.6412		1.00282486	1.012810248	1.010676	1.00877	
24	Bio-Circle-L					100	100.00%	37.77778		
	Contaminant 1									
	Coupon Number	1	2	3						
	Coupon Weight	40.4014	40.9194	39.4666						
	Coupon Weight with Contaminant 1	40.5293	41.0522	39.5769		0.1279	0.1328	0.1103		
	Coupon Weight with Contaminant 1 after cleaning	40.4067	40.9205	39.4692		0.95856138	0.991716867	0.976428	0.975569	
	Contaminant 2									
	Coupon Number	48	47	46						
	Coupon Weight	40.947	40.4035	40.9568						
	Coupon Weight with Contaminant 2	41.089	40.5352	41.0828		0.142	0.1317	0.126		
	Coupon Weight with Contaminant 2 after cleaning	40.9463	40.4023	40.9561		1.00492958	1.009111617	1.005556	1.006532	
25	EnviroLogic - Partwasher Solution					100	10%	37.77778		
	Contaminant 1									
	Coupon Number	4	5	6						
	Coupon Weight	39.6582	40.2673	40.3758						
	Coupon Weight with Contaminant 1	39.7925	40.395	40.5162		0.1343	0.1277	0.1404		
	Coupon Weight with Contaminant 1 after cleaning	39.6817	40.288	40.4086		0.82501862	0.837901331	0.766382	0.809767	
	Contaminant 2									
	Coupon Number	45	44	43						
	Coupon Weight	40.9674	40.491	41.3443						
	Coupon Weight with Contaminant 2	41.0862	40.614	41.4653		0.1188	0.123	0.121		
	Coupon Weight with Contaminant 2 after cleaning	40.9973	40.5279	41.3613		0.7483165	0.7	0.859504	0.769274	

26	SoySolv II Plus					100	100.00%	37.77778	
	Contaminant 1								
	Coupon Number	7	8	9					
	Coupon Weight	40.0692	39.5568	41.1746					
	Coupon Weight with Contaminant 1	40.1987	39.6828	41.3075		0.1295	0.126	0.1329	
	Coupon Weight with Contaminant 1 after cleaning	40.0693	39.556	41.1742		0.9992278	1.006349206	1.00301	1.002862
	Contaminant 2								
	Coupon Number	42	41	40					
	Coupon Weight	40.5144	40.6189	40.945					
	Coupon Weight with Contaminant 2	40.6588	40.7558	41.0755		0.1444	0.1369	0.1305	
	Coupon Weight with Contaminant 2 after cleaning	40.5127	40.6175	40.9439		1.01177285	1.010226443	1.008429	1.010143
27	SoySolv II Plus					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	10	11	12					
	Coupon Weight	41.8036	40.8946	41.1512					
	Coupon Weight with Contaminant 1	41.9407	41.0195	41.2892		0.1371	0.1249	0.138	
	Coupon Weight with Contaminant 1 after cleaning	41.8026	40.8946	41.1492		1.00729395	1	1.014493	1.007262
	Contaminant 2								
	Coupon Number	39	38	37					
	Coupon Weight	41.3499	41.4502	41.2773					
	Coupon Weight with Contaminant 2	41.4931	41.5854	41.4048		0.1432	0.1352	0.1275	
	Coupon Weight with Contaminant 2 after cleaning	41.4137	41.4993	41.3343		0.55446927	0.63683432	0.552941	0.581415
28	Methyl Ethyl Ketone					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	13	14	15					
	Coupon Weight	39.7606	40.1455	40.7898					
	Coupon Weight with Contaminant 1	39.9019	40.2844	40.9009		0.1413	0.1389	0.1111	
	Coupon Weight with Contaminant 1 after cleaning	39.76	40.1435	40.7888		1.00424628	1.014398848	1.009001	1.009215
	Contaminant 2								
	Coupon Number	36	35	34					
	Coupon Weight	40.9976	40.6378	39.9966					
	Coupon Weight with Contaminant 2	41.1403	40.7696	40.1294		0.1427	0.1318	0.1328	
	Coupon Weight with Contaminant 2 after cleaning	41.0051	40.6436	40.0075		0.94744219	0.95599393	0.917922	0.940453
29	Mineral Spirits (Stoddard Solvent)					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	16	17	18					
	Coupon Weight	41.4624	40.101	41.3578					
	Coupon Weight with Contaminant 1	41.6011	40.2338	41.5023		0.1387	0.1328	0.1445	
	Coupon Weight with Contaminant 1 after cleaning	41.4619	40.0997	41.3563		1.0036049	1.009789157	1.010381	1.007925
	Contaminant 2								
	Coupon Number	33	32	31					
	Coupon Weight	41.2358	41.2719	40.5967					
	Coupon Weight with Contaminant 2	41.3676	41.3975	40.7405		0.1318	0.1256	0.1438	
	Coupon Weight with Contaminant 2 after cleaning	41.2351	41.2717	40.5961		1.00531108	1.001592357	1.004172	1.003692
30	Isopropanol					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	19	20	21					
	Coupon Weight	39.8027	41.2194	40.5671					
	Coupon Weight with Contaminant 1	39.9081	41.3384	40.6931		0.1054	0.119	0.126	
	Coupon Weight with Contaminant 1 after cleaning	39.8021	41.2182	40.5667		1.0056926	1.010084034	1.003175	1.006317
	Contaminant 2								
	Coupon Number	30	29	28					
	Coupon Weight	39.6202	40.6246	41.2348					
	Coupon Weight with Contaminant 2	39.7617	40.7496	41.3588		0.1415	0.125	0.124	
	Coupon Weight with Contaminant 2 after cleaning	39.7302	40.7164	41.3308		0.22261484	0.2656	0.225806	0.238007

31	Heavy Duty Cleaner				105	20%	40.55556		
	Contaminant 1								
	Coupon Number	22	23	24					
	Coupon Weight	41.6377	41.2701	40.6409					
	Coupon Weight with Contaminant 1	41.7565	41.3932	40.7777	0.1188	0.1231	0.1368		
	Coupon Weight with Contaminant 1 after cleaning	41.6364	41.2685	40.6415	1.01094276	1.012997563	0.995614	1.006518	
	Contaminant 2								
	Coupon Number	27	26	25					
	Coupon Weight	41.1358	40.9323	40.4862					
	Coupon Weight with Contaminant 2	41.273	41.0735	40.6008	0.1372	0.1412	0.1146		
	Coupon Weight with Contaminant 2 after cleaning	41.1351	40.9317	40.4845	1.00510204	1.004249292	1.014834	1.008062	
32	NZD Ultra Degreaser				70	100.00%	21.11111		
	Contaminant 1								
	Coupon Number	13	14	15					
	Coupon Weight	39.7599	40.1438	40.7893					
	Coupon Weight with Contaminant 1	39.88	40.2841	40.9166	0.1201	0.1403	0.1273		
	Coupon Weight with Contaminant 1 after cleaning	39.7593	40.1438	40.7886	1.00499584	1	1.005499	1.003498	
	Contaminant 2								
	Coupon Number	25	26	27					
	Coupon Weight	40.4856	40.9332	41.1367					
	Coupon Weight with Contaminant 2	40.6221	41.0535	41.2597	0.1365	0.1203	0.123		
	Coupon Weight with Contaminant 2 after cleaning	40.4947	40.9426	41.1437	0.93333333	0.921862012	0.943089	0.932762	
33	Spray-Nine AV-8				70	10	21.11111		
	Contaminant 1								
	Coupon Number	16	17	18					
	Coupon Weight	41.4624	40.1009	41.3584					
	Coupon Weight with Contaminant 1	41.5638	40.2452	41.4733	0.1014	0.1443	0.1149		
	Coupon Weight with Contaminant 1 after cleaning	41.5072	40.1461	41.3783	0.5581854	0.686763687	0.826806	0.690585	
	Contaminant 2								
	Coupon Number	28	29	30					
	Coupon Weight	41.2336	40.6257	39.6201					
	Coupon Weight with Contaminant 2	41.3508	40.7462	39.7439	0.1172	0.1205	0.1238		
	Coupon Weight with Contaminant 2 after cleaning	41.3487	40.7438	39.7419	0.01791809	0.019917012	0.016155	0.017997	
34	Spray-Nine AV-8 Low ph				130	10	54.44444		
	Contaminant 1								
	Coupon Number	19	20	21					
	Coupon Weight	39.8037	41.2193	40.5687					
	Coupon Weight with Contaminant 1	39.9073	41.3356	40.7133	0.1036	0.1163	0.1446		
	Coupon Weight with Contaminant 1 after cleaning	39.8073	41.2248	40.5776	0.96525097	0.952708512	0.938451	0.952137	
	Contaminant 2								
	Coupon Number	31	32	33					
	Coupon Weight	40.5961	41.2723	41.2361					
	Coupon Weight with Contaminant 2	40.7213	41.3899	41.3549	0.1252	0.1176	0.1188		
	Coupon Weight with Contaminant 2 after cleaning	40.6236	41.2788	41.244	0.78035144	0.944727891	0.933502	0.886194	
35	Sea Wash 8				130	5.00%	54.44444		
	Contaminant 1								
	Coupon Number	22	23	24					
	Coupon Weight	41.6383	41.27	40.6423					
	Coupon Weight with Contaminant 1	41.7479	41.4095	40.7875	0.1096	0.1395	0.1452		
	Coupon Weight with Contaminant 1 after cleaning	41.6431	41.2772	40.6494	0.95620438	0.948387097	0.951102	0.951898	
	Contaminant 2								
	Coupon Number	34	35	36					
	Coupon Weight	39.9956	40.6374	40.9974					
	Coupon Weight with Contaminant 2	40.11	40.7726	41.139	0.1144	0.1352	0.1416		
	Coupon Weight with Contaminant 2 after cleaning	39.9956	40.6362	40.9971	1	1.00887574	1.002119	1.003665	

36	Bean-e-doo Parts Washer Solvent					130	100%	54.44444		
	Contaminant 1									
	Coupon Number	43	44	45						
	Coupon Weight	41.3436	40.4901	40.9667						
	Coupon Weight with Contaminant 1	41.4564	40.6064	41.1018		0.1128	0.1163	0.1351		
	Coupon Weight with Contaminant 1 after cleaning	41.3435	40.4911	40.9663		1.00088652	0.991401548	1.002961	0.998416	
	Contaminant 2									
	Coupon Number	37	38	39						
	Coupon Weight	41.2774	41.4478	41.3494						
	Coupon Weight with Contaminant 2	41.4083	41.5844	41.4668		0.1309	0.1366	0.1174		
	Coupon Weight with Contaminant 2 after cleaning	41.278	41.4505	41.3528		0.99541635	0.980234261	0.971039	0.98223	
37	Agriplast					130	100%	54.44444		
	Contaminant 1									
	Coupon Number	46	47	48						
	Coupon Weight	40.9565	40.4037	40.947						
	Coupon Weight with Contaminant 1	41.0766	40.5517	41.0888		0.1201	0.148	0.1418		
	Coupon Weight with Contaminant 1 after cleaning	41.0161	40.452	40.9827		0.50374688	0.673648649	0.748237	0.641877	
	Contaminant 2									
	Coupon Number	40	41	42						
	Coupon Weight	40.9448	40.6186	40.5134						
	Coupon Weight with Contaminant 2	41.0697	40.7431	40.6454		0.1249	0.1245	0.132		
	Coupon Weight with Contaminant 2 after cleaning	40.9531	40.6237	40.5187		0.93354684	0.959036145	0.959848	0.95081	
38	(Bioact MSO equivalent)					110	25	43.33333		
	Contaminant 1									
	Coupon Number	24	23	22		very fine film left behind				
	Coupon Weight	40.6421	41.2716	41.6379						
	Coupon Weight with Contaminant 1	40.7515	41.4158	41.7545		0.1094	0.1442	0.1166		
	Coupon Weight with Contaminant 1 after cleaning	40.6421	41.2706	41.638		1	1.006934813	0.999142	1.002026	
	Contaminant 2									
	Coupon Number	25	26	27						
	Coupon Weight	40.4863	40.9328	41.1372						
	Coupon Weight with Contaminant 2	40.6116	41.073	41.2708		0.1253	0.1402	0.1336		
	Coupon Weight with Contaminant 2 after cleaning	40.4865	40.9348	41.1358		0.99840383	0.985734665	1.010479	0.998206	
39	SS-HD Parts Washer Formulation					110	100.00%	43.33333		
	Contaminant 1									
	Coupon Number	21	20	19						
	Coupon Weight	40.5689	41.2197	39.805						
	Coupon Weight with Contaminant 1	40.6955	41.3269	39.9157		0.1266	0.1072	0.1107		
	Coupon Weight with Contaminant 1 after cleaning	40.5759	41.2348	39.8132		0.94470774	0.859141791	0.925926	0.909925	
	Contaminant 2									
	Coupon Number	28	29	30						
	Coupon Weight	41.2349	40.6249	39.623						
	Coupon Weight with Contaminant 2	41.3778	40.7497	39.751		0.1429	0.1248	0.128		
	Coupon Weight with Contaminant 2 after cleaning	41.2334	40.6243	39.6195		1.01049685	1.004807692	1.027344	1.014216	
40	Silicon Wash Concentrate					140	16.67%	60		
	Contaminant 1									
	Coupon Number	18	17	16						
	Coupon Weight	41.3578	40.1017	41.4627						
	Coupon Weight with Contaminant 1	41.4844	40.2433	41.5753		0.1266	0.1416	0.1126		
	Coupon Weight with Contaminant 1 after cleaning	41.3825	40.157	41.5037		0.80489731	0.609463277	0.635879	0.683413	
	Contaminant 2									
	Coupon Number	31	32	33						
	Coupon Weight	40.5984	41.2741	41.2369						
	Coupon Weight with Contaminant 2	40.7421	41.4095	41.3643		0.1437	0.1354	0.1274		
	Coupon Weight with Contaminant 2 after cleaning	40.5987	41.2743	41.2361		0.99791232	0.998522895	1.006279	1.000905	

41	Axarel 58					150	100%	65.55556		
	Contaminant 1									
	Coupon Number	15	14	13		looked and felt completely clean				
	Coupon Weight	40.7901	40.1439	39.7623						
	Coupon Weight with Contaminant 1	40.9219	40.2879	39.9028		0.1318	0.144	0.1405		
	Coupon Weight with Contaminant 1 after cleaning	40.795	40.1473	39.7655		0.96282246	0.976388889	0.977224	0.972145	
	Contaminant 2									
	Coupon Number	34	35	36						
	Coupon Weight	39.9969	40.6378	40.9987						
	Coupon Weight with Contaminant 2	40.139	40.7696	41.132		0.1421	0.1318	0.1333		
	Coupon Weight with Contaminant 2 after cleaning	40.0014	40.6434	41.0029		0.96833216	0.957511381	0.968492	0.964779	
42	Optima 100 GP					148	10%	64.44444		
	Contaminant 1									
	Coupon Number	12	11	10						
	Coupon Weight	41.1495	40.8941	41.8043						
	Coupon Weight with Contaminant 1	41.2737	41.0146	41.9274		0.1242	0.1205	0.1231		
	Coupon Weight with Contaminant 1 after cleaning	41.1523	40.897	41.8069		0.97745572	0.97593361	0.978879	0.977423	
	Contaminant 2									
	Coupon Number	37	38	39						
	Coupon Weight	41.2774	41.4491	41.35						
	Coupon Weight with Contaminant 2	41.4116	41.579	41.4827		0.1342	0.1299	0.1327		
	Coupon Weight with Contaminant 2 after cleaning	41.2797	41.448	41.351		0.9828614	1.008468052	0.992464	0.994598	
43	Optima 2001 CR					148	10%	64.44444		
	Contaminant 1									
	Coupon Number	43	44	45						
	Coupon Weight	41.3453	40.4907	40.9677						
	Coupon Weight with Contaminant 1	41.464	40.6312	41.1095		0.1187	0.1405	0.1418		
	Coupon Weight with Contaminant 1 after cleaning	41.3441	40.4915	40.967		1.01010952	0.99430605	1.004937	1.003117	
	Contaminant 2									
	Coupon Number	40	41	42						
	Coupon Weight	40.9453	40.6181	40.5138						
	Coupon Weight with Contaminant 2	41.0911	40.7414	40.6391		0.1458	0.1233	0.1253		
	Coupon Weight with Contaminant 2 after cleaning	40.9437	40.6168	40.5126		1.01097394	1.01054339	1.009577	1.010365	
44	Vertrel CMS					Room	100%	21		
	Contaminant 1									
	Coupon Number	19	20	21						
	Coupon Weight	39.8042	41.2203	40.5696						
	Coupon Weight with Contaminant 1	39.9417	41.3437	40.6815		0.1375	0.1234	0.1119		
	Coupon Weight with Contaminant 1 after cleaning	39.8123	41.2314	40.5764		0.94109091	0.910048622	0.939231	0.930124	
	Contaminant 2									
	Coupon Number	1	2	3						
	Coupon Weight	40.4023	40.9186	39.469						
	Coupon Weight with Contaminant 2	40.5438	41.0607	39.6064		0.1415	0.1421	0.1374		
	Coupon Weight with Contaminant 2 after cleaning	40.402	40.9222	39.467		1.00212014	0.974665728	1.014556	0.997114	
45	Neugenic 4177					Room	100%	21		
	Contaminant 1									
	Coupon Number	22	23	24						
	Coupon Weight	41.638	41.2739	40.6426						
	Coupon Weight with Contaminant 1	41.7605	41.3907	40.7483		0.1225	0.1168	0.1057		
	Coupon Weight with Contaminant 1 after cleaning	41.6552	41.2777	40.6701		0.85959184	0.967465753	0.73983	0.855629	
	Contaminant 2									
	Coupon Number	4	5	6		Still had cleaning product on it after drying, very thick				
	Coupon Weight	39.6589	40.2678	40.3766						
	Coupon Weight with Contaminant 2	39.8003	40.4114	40.5113		0.1414	0.1436	0.1347		
	Coupon Weight with Contaminant 2 after cleaning	39.7962	40.4175	40.5566		0.02899576	-0.042479109	-0.336303	-0.116595	

46	Simple Green					Room	100%	21	
	Contaminant 1								
	Coupon Number	25	26	27					
	Coupon Weight	40.4897	40.9331	41.1371					
	Coupon Weight with Contaminant 1	40.6025	41.052	41.2732		0.1128	0.1189	0.1361	
	Coupon Weight with Contaminant 1 after cleaning	40.5053	40.9518	41.1666		0.86170213	0.842724979	0.783248	0.829225
	Contaminant 2								
	Coupon Number	7	8	9					
	Coupon Weight	40.0703	39.5571	41.1757					
	Coupon Weight with Contaminant 2	40.2112	39.6998	41.3103		0.1409	0.1427	0.1346	
	Coupon Weight with Contaminant 2 after cleaning	40.1938	39.6839	41.2933		0.12349184	0.111422565	0.1263	0.120405

47	Green 4 Kleen					Room	12%	21	
	Contaminant 1								
	Coupon Number	28	29	30					
	Coupon Weight	41.2348	40.6296	39.6206					
	Coupon Weight with Contaminant 1	41.3792	40.7626	39.734		0.1444	0.133	0.1134	
	Coupon Weight with Contaminant 1 after cleaning	41.2959	40.6784	39.6859		0.57686981	0.633082707	0.424162	0.544705
	Contaminant 2								
	Coupon Number	10	11	12					
	Coupon Weight	41.8034	40.8958	41.1518					
	Coupon Weight with Contaminant 2	41.9254	41.0326	41.2866		0.122	0.1368	0.1348	
	Coupon Weight with Contaminant 2 after cleaning	41.9253	41.0326	41.2859		0.00081967	0	0.005193	0.002004

48	Daraclean					131	25%	55	
	Contaminant 1								
	Coupon Number	31	32	33					
	Coupon Weight	40.6006	41.273	41.2366					
	Coupon Weight with Contaminant 1	40.7128	41.3939	41.3607		0.1122	0.1209	0.1241	
	Coupon Weight with Contaminant 1 after cleaning	40.6006	41.2801	41.2481		1	0.94127378	0.907333	0.949536
	Contaminant 2								
	Coupon Number	13	14	15					
	Coupon Weight	39.7605	40.1446	40.7896					
	Coupon Weight with Contaminant 2	39.8938	40.2554	40.9221		0.1333	0.1108	0.1325	
	Coupon Weight with Contaminant 2 after cleaning	39.7589	40.143	40.788		1.012003	1.014440433	1.012075	1.01284

49	EXP 1300					145	4%	63	
	Contaminant 1								
	Coupon Number	34	35	36					
	Coupon Weight	39.9978	40.6388	40.998					
	Coupon Weight with Contaminant 1	40.1312	40.7642	41.1147		0.1334	0.1254	0.1167	
	Coupon Weight with Contaminant 1 after cleaning	40.0204	40.6489	41.0141		0.83058471	0.919457735	0.862039	0.870694
	Contaminant 2								
	Coupon Number	16	17	18					
	Coupon Weight	41.4647	40.1016	41.358					
	Coupon Weight with Contaminant 2	41.5875	40.2242	41.4873		0.1228	0.1226	0.1293	
	Coupon Weight with Contaminant 2 after cleaning	41.4615	40.0997	41.3563		1.02605863	1.015497553	1.013148	1.018235

50	Cleanaire 1200					160	3.0%	71.11111	
	Contaminant 1								
	Coupon Number	39	38	37					
	Coupon Weight	41.3513	41.4488	41.2786					
	Coupon Weight with Contaminant 1	41.4723	41.5861	41.4152		0.121	0.1373	0.1366	
	Coupon Weight with Contaminant 1 after cleaning	41.352	41.4535	41.2775		0.99421488	0.96576839	1.008053	0.989345
	Contaminant 2								
	Coupon Number	48	47	46					
	Coupon Weight	40.948	40.4037	40.9575					
	Coupon Weight with Contaminant 2	41.0805	40.5258	41.0808		0.1325	0.1221	0.1233	
	Coupon Weight with Contaminant 2 after cleaning	40.9467	40.4025	40.9565		1.00981132	1.00982801	1.00811	1.00925

51	Natural Orange					160	0.5%	71.11111		
	Contaminant 1									
	Coupon Number	18	17	16		discolored rest of submerged coupon				
	Coupon Weight	41.356	40.0997	41.4614						
	Coupon Weight with Contaminant 1	41.4755	40.2135	41.5636		0.1195	0.1138	0.1022		
	Coupon Weight with Contaminant 1 after cleaning	41.3596	40.1012	41.465		0.96987448	0.986818981	0.964775	0.973823	
	Contaminant 2									
	Coupon Number	45	44	43						
	Coupon Weight	40.9696	40.4918	41.346						
	Coupon Weight with Contaminant 2	41.0982	40.6097	41.4826		0.1286	0.1179	0.1366		
	Coupon Weight with Contaminant 2 after cleaning	40.9892	40.5119	41.3553		0.84758942	0.829516539	0.931918	0.869675	
52	PowerKleen III					160	2.2%	71.11111		
	Contaminant 1									
	Coupon Number	15	14	13						
	Coupon Weight	40.7882	40.1431	39.7593						
	Coupon Weight with Contaminant 1	40.9125	40.2522	39.8921		0.1243	0.1091	0.1328		
	Coupon Weight with Contaminant 1 after cleaning	40.8011	40.1582	39.7654		0.89621883	0.861594867	0.954066	0.90396	
	Contaminant 2									
	Coupon Number	42	41	40						
	Coupon Weight	40.5142	40.6192	40.9475						
	Coupon Weight with Contaminant 2	40.6472	40.7488	41.0828		0.133	0.1296	0.1353		
	Coupon Weight with Contaminant 2 after cleaning	40.5132	40.6186	40.9444		1.0075188	1.00462963	1.022912	1.011687	
53	Aero Wash 4					160	10%	71		
	Contaminant 1									
	Coupon Number	36	35	34						
	Coupon Weight	40.9999	40.6393	39.9969						
	Coupon Weight with Contaminant 1	41.1011	40.7546	40.1278		0.1012	0.1153	0.1309		
	Coupon Weight with Contaminant 1 after cleaning	40.9988	40.6377	39.9968		1.01086957	1.013876843	1.000764	1.008503	
	Contaminant 2									
	Coupon Number	1	2	3						
	Coupon Weight	40.4042	40.9235	39.4685						
	Coupon Weight with Contaminant 2	40.534	41.0675	39.6085		0.1298	0.144	0.14		
	Coupon Weight with Contaminant 2 after cleaning	40.4015	40.9179	39.4664		1.02080123	1.038888889	1.015	1.024897	
54	Aero wash 4					160	20.0%	71.11111		
	Contaminant 1									
	Coupon Number	33	32	31						
	Coupon Weight	41.2371	41.2742	40.5983						
	Coupon Weight with Contaminant 1	41.342	41.4234	40.7447		0.1049	0.1492	0.1464		
	Coupon Weight with Contaminant 1 after cleaning	41.2352	41.2738	40.5967		1.01811249	1.002680965	1.010929	1.010574	
	Contaminant 2									
	Coupon Number	4	5	6						
	Coupon Weight	39.6619	40.2706	40.378						
	Coupon Weight with Contaminant 2	39.7902	40.401	40.5127		0.1283	0.1304	0.1347		
	Coupon Weight with Contaminant 2 after cleaning	39.6578	40.2677	40.376		1.03195635	1.022239264	1.014848	1.023014	
55	Flightline 2					160	10.0%	71.11111		
	Contaminant 1									
	Coupon Number	30	29	28						
	Coupon Weight	39.6238	40.6299	41.2412						
	Coupon Weight with Contaminant 1	39.7673	40.7566	41.3663		0.1435	0.1267	0.1251		
	Coupon Weight with Contaminant 1 after cleaning	39.6215	40.6281	41.237		1.01602787	1.014206788	1.033573	1.021269	
	Contaminant 2									
	Coupon Number	7	8	9						
	Coupon Weight	40.071	39.5604	41.1762						
	Coupon Weight with Contaminant 2	40.2054	39.6973	41.3092		0.1344	0.1369	0.133		
	Coupon Weight with Contaminant 2 after cleaning	40.0694	39.557	41.1744		1.01190476	1.024835646	1.013534	1.016758	

56	Flight line 2					160	20.0%	71.11111	
	Contaminant 1								
	Coupon Number	27	26	25					
	Coupon Weight	41.1396	40.9354	40.4876					
	Coupon Weight with Contaminant 1	41.247	41.0762	40.6287		0.1074	0.1408	0.1411	
	Coupon Weight with Contaminant 1 after cleaning	41.1365	40.9342	40.4901		1.02886406	1.008522727	0.982282	1.006556
	Contaminant 2								
	Coupon Number	10	11	12					
	Coupon Weight	41.8047	40.8959	41.1516					
	Coupon Weight with Contaminant 2	41.9214	41.0269	41.2792		0.1167	0.131	0.1276	
	Coupon Weight with Contaminant 2 after cleaning	41.803	40.8946	41.149		1.01456727	1.009923664	1.020376	1.014956
57	Acetone					ambient	100.0%	21	
	Contaminant 1								
	Coupon Number	4	5	6					
	Coupon Weight	39.6576	40.2669	40.3759					
	Coupon Weight with Contaminant 1	39.7946	40.3911	40.488		0.137	0.1242	0.1121	
	Coupon Weight with Contaminant 1 after cleaning	39.6583	40.2681	40.3763		0.99489051	0.990338164	0.996432	0.993887
	Contaminant 2								
	Coupon Number	1	2	3					
	Coupon Weight	40.4009	40.9171	39.466					
	Coupon Weight with Contaminant 2	40.5173	41.0536	39.6029		0.1164	0.1365	0.1369	
	Coupon Weight with Contaminant 2 after cleaning	40.4779	41.0081	39.5627		0.33848797	0.333333333	0.293645	0.321822

Appendix C

Test Data Sheet – Revised Results

Description of Tables

While the cleaning efficiency tests were being conducted, all experimental observations were recorded directly on an Excel spreadsheet with a laptop computer in the cleaning laboratory. This section of the appendix contains all of the revised data collected during execution of the cleaning efficiency tests. The information contained in these tables is explained below with the use of an actual example, Test #41.

During Test #41, the cleaning compound Axarel 58 was used, as indicated in the top row of the table below. The number appearing to the left of the compound name, 41, is the test number. The numbers to the right of the compound name (150, 100%, and 65.55556) indicate the temperature (degrees F), concentration (% by volume), and temperature (degrees C) of the cleaning solution used in the test, respectively. Directly below these numbers, a comment ("looked and felt completely clean") appears.

Directly below the compound name, two sections are presented, colored pink and yellow. The pink section represents Contaminant # 1; the yellow section represents Contaminant #2. For each contaminant, three test coupons were used. The test coupon number and its clean bare weight after a thorough final cleaning is recorded in the white section in between the colored rows (in the case of test coupons #22 - #27, the initial weight of the test coupon was used as the precleaned weight for Tests #1 - #8, as explained in the body of this report). Then, directly below these rows, the weight of the test coupon loaded with contaminant before and after cleaning is recorded. For example, for Contaminant #1, the first test coupon used was #15. It had a clean bare weight of 40.7883 grams after a thorough final cleaning. After the test coupon was loaded with Contaminant #1, it weighed 40.9219 grams before it was cleaned, and 40.7950 grams after it was cleaned.

Test coupon #15, which was used for Contaminant #1, therefore saw a reduction in mass of 0.1336 grams before and after cleaning in Axarel 58, which corresponds to a cleaning efficiency of 0.9498503, or about 94.99%. These numbers can be found on the right hand side of the table. Test coupon #14 saw a reduction in mass of 0.1448 grams; test coupon #13, 0.1436 grams. The average cleaning efficiency for all three coupons for Contaminant #1 is the mean of the cleaning efficiencies for test coupons #15, #14, and #13, and is equal to 0.958991 (or about 95.90%) and is highlighted in pink. . The values for Contaminant #2 are located in similar positions on the table.

41	Axarel 58					150	100%	65.55556	
	Contaminant 1								
	Coupon Number	15	14	13		looked and felt completely clean			
	Coupon Weight	40.7883	40.1431	39.7592					
	Coupon Weight with Contaminant 1	40.9219	40.2879	39.9028		0.1336	0.1448	0.1436	
	Coupon Weight with Contaminant 1 after cleaning	40.795	40.1473	39.7655		0.9498503	0.970994475	0.956128	0.958991
	Contaminant 2								
	Coupon Number	34	35	36					
	Coupon Weight	39.9954	40.6366	40.9972					
	Coupon Weight with Contaminant 2	40.139	40.7696	41.132		0.1436	0.133	0.1348	
	Coupon Weight with Contaminant 2 after cleaning	40.0014	40.6434	41.0029		0.95821727	0.94887218	0.957715	0.954935

TEST #

						Temperature	Concentration		
1	Armakleen M-Aero					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	48	47	46					
	Coupon Weight	40.9466	40.4023	40.956					
	Coupon Weight with Contaminant 1	41.0701	40.5399	41.0786		0.1235	0.1376	0.1226	
	Coupon Weight with Contaminant 1 after cleaning	40.9474	40.4031	40.9578		0.99352227	0.994186047	0.985318	0.991009
	Contaminant 2								
	Coupon Number	1	2	3					
	Coupon Weight	40.4009	40.9171	39.466					
	Coupon Weight with Contaminant 2	40.5318	41.0424	39.5778		0.1309	0.1253	0.1118	
	Coupon Weight with Contaminant 2 after cleaning	40.4019	40.9186	39.4666		0.99236058	0.988028731	0.994633	0.991674
2	Aquaworks MM Dip Concentrate					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	45	44	43					
	Coupon Weight	40.9663	40.4895	41.343					
	Coupon Weight with Contaminant 1	41.0852	40.6275	41.4926		0.1189	0.138	0.1496	
	Coupon Weight with Contaminant 1 after cleaning	40.9672	40.4919	41.3459		0.99243061	0.982608696	0.980615	0.985218
	Contaminant 2								
	Coupon Number	4	5	6					
	Coupon Weight	39.6576	40.2669	40.3759					
	Coupon Weight with Contaminant 2	39.7826	40.3896	40.4878		0.125	0.1227	0.1119	
	Coupon Weight with Contaminant 2 after cleaning	39.6606	40.2691	40.3774		0.976	0.98207009	0.986595	0.981555
3	Armakleen M100					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	42	41	40					
	Coupon Weight	40.5128	40.6175	40.9439					
	Coupon Weight with Contaminant 1	40.6413	40.7501	41.0689		0.1285	0.1326	0.125	
	Coupon Weight with Contaminant 1 after cleaning	40.5175	40.6293	40.9476		0.96342412	0.911010558	0.9704	0.948278
	Contaminant 2								
	Coupon Number	7	8	9					
	Coupon Weight	40.069	39.556	41.1742					
	Coupon Weight with Contaminant 2	40.2037	39.6711	41.2771		0.1347	0.1151	0.1029	
	Coupon Weight with Contaminant 2 after cleaning	40.0697	39.557	41.1765		0.99480327	0.991311903	0.977648	0.987921
4	US-2003					160	10.00%	71.11111	
	Contaminant 1								
	Coupon Number	39	38	37					
	Coupon Weight	41.3486	41.4476	41.276					
	Coupon Weight with Contaminant 1	41.4986	41.5699	41.4144		0.15	0.1223	0.1384	
	Coupon Weight with Contaminant 1 after cleaning	41.3564	41.4593	41.2859		0.948	0.904333606	0.928468	0.926934
	Contaminant 2								
	Coupon Number	9	11	12					
	Coupon Weight	41.1742	40.8939	41.1483					
	Coupon Weight with Contaminant 2	41.2961	41.0094	41.2601		0.1219	0.1155	0.1118	
	Coupon Weight with Contaminant 2 after cleaning	41.1748	40.8946	41.149		0.99507793	0.993939394	0.993739	0.994252
5	Bean-e-doo Parts Washer Solvent					160	50%	71.11111	
	Contaminant 1								
	Coupon Number	27	26	25					
	Coupon Weight	41.3739	41.1622	40.6909					
	Coupon Weight with Contaminant 1	41.4789	41.2728	40.8177		0.105	0.1106	0.1268	
	Coupon Weight with Contaminant 1 after cleaning	41.3747	41.1654	40.6949		0.99238095	0.971066908	0.968454	0.977301
	Contaminant 2								
	Coupon Number	14	15	24					
	Coupon Weight	40.1431	40.7883	40.7896					
	Coupon Weight with Contaminant 2	40.2656	40.8988	40.8953		0.1225	0.1105	0.1057	
	Coupon Weight with Contaminant 2 after cleaning	40.1456	40.7905	40.7907		0.97959184	0.980090498	0.989593	0.983092

6	Gold Matrix					160	100%	71.11111	
	Contaminant 1								
	Coupon Number	30	29	28					
	Coupon Weight	39.6195	40.6244	41.2333					
	Coupon Weight with Contaminant 1	39.7589	40.7472	41.3757		0.1394	0.1228	0.1424	
	Coupon Weight with Contaminant 1 after cleaning	39.6223	40.6271	41.2403		0.97991392	0.978013029	0.950843	0.96959
	Contaminant 2								
	Coupon Number	19	20	21					
	Coupon Weight	39.8025	41.2185	40.5666					
	Coupon Weight with Contaminant 2	39.9232	41.3439	40.6783		0.1207	0.1254	0.1117	
	Coupon Weight with Contaminant 2 after cleaning	39.8031	41.2192	40.5673		0.995029	0.994417863	0.993733	0.994393

7	Citrusoy Super High Flash					160	100%	71.11111	
	Contaminant 1								
	Coupon Number	33	32	31					
	Coupon Weight	41.2347	41.2714	40.5959					
	Coupon Weight with Contaminant 1	41.3724	41.4039	40.7173		0.1377	0.1325	0.1214	
	Coupon Weight with Contaminant 1 after cleaning	41.2387	41.2749	40.5984		0.97095134	0.973584906	0.979407	0.974648
	Contaminant 2								
	Coupon Number	16	17	13		Left greasy residue			
	Coupon Weight	41.4611	40.0992	39.7592					
	Coupon Weight with Contaminant 2	41.5915	40.2134	39.8888		0.1304	0.1142	0.1296	
	Coupon Weight with Contaminant 2 after cleaning	41.4997	40.131	39.7939		0.70398773	0.721541156	0.732253	0.719261

8	Clean Safe 7448-05					160	11.11%	71.11111	
	Contaminant 1								
	Coupon Number	25	26	27		Foamy and left black residue on entire coupon seem			
	Coupon Weight	40.6909	41.1622	41.3739					
	Coupon Weight with Contaminant 1	40.7971	41.2951	41.5168		0.1062	0.1329	0.1429	
	Coupon Weight with Contaminant 1 after cleaning	40.4999	40.9432	41.1429		2.79849341	2.64785553	2.616515	2.687621
	Contaminant 2								
	Coupon Number	24	23	22					
	Coupon Weight	40.7896	41.3683	41.7335					
	Coupon Weight with Contaminant 2	40.9293	41.514	41.8623		0.1397	0.1457	0.1288	
	Coupon Weight with Contaminant 2 after cleaning	40.6509	41.281	41.6468		1.9928418	1.59917639	1.673137	1.755052

8	Clean Safe 7445-05					160	11.11%	71.11111	
	Contaminant 1								
	Coupon Number	28	29	30					
	Coupon Weight	41.2333	40.6244	39.6195					
	Coupon Weight with Contaminant 1	41.3871	40.7654	39.7637		0.1538	0.141	0.1442	
	Coupon Weight with Contaminant 1 after cleaning	41.2377	40.6312	39.6233		0.97139142	0.95177305	0.973648	0.965604
	Contaminant 2								
	Coupon Number	21	20	19					
	Coupon Weight	40.5666	41.2185	39.8025					
	Coupon Weight with Contaminant 2	40.6991	41.354	39.9448		0.1325	0.1355	0.1423	
	Coupon Weight with Contaminant 2 after cleaning	40.5674	41.2191	39.8031		0.99396226	0.995571956	0.995784	0.995106

10	Oleocal ME-130					160	100.00%	71.11111	
	Contaminant 1								
	Coupon Number	31	32	33					
	Coupon Weight	40.5959	41.2714	41.2347					
	Coupon Weight with Contaminant 1	40.7402	41.3921	41.3772		0.1443	0.1207	0.1425	
	Coupon Weight with Contaminant 1 after cleaning	40.5983	41.2742	41.2394		0.98336798	0.976801988	0.967018	0.975729
	Contaminant 2								
	Coupon Number	18	17	16		Still greasy			
	Coupon Weight	41.3559	40.0992	41.4611					
	Coupon Weight with Contaminant 2	41.4896	40.2307	41.6044		0.1337	0.1315	0.1433	
	Coupon Weight with Contaminant 2 after cleaning	41.3971	40.1123	41.4831		0.69184742	0.900380228	0.846476	0.812901

11	SoySolv II					160	100.00%	71.11111	
	Contaminant 1								
	Coupon Number	34	35	36					
	Coupon Weight	39.9954	40.6366	40.9972					
	Coupon Weight with Contaminant 1	40.1129	40.7724	41.1482		0.1175	0.1358	0.151	
	Coupon Weight with Contaminant 1 after cleaning	39.9958	40.6364	40.9975		0.99659574	1.001472754	0.998013	0.998694
	Contaminant 2								
	Coupon Number	15	14	13					
	Coupon Weight	40.7883	40.1431	39.7592					
	Coupon Weight with Contaminant 2	40.9326	40.2808	39.9041		0.1443	0.1377	0.1449	
	Coupon Weight with Contaminant 2 after cleaning	40.7892	40.1443	39.7601		0.99376299	0.991285403	0.993789	0.992946
12	Armakleen HP-2					160	7.50%	71.11111	
	Contaminant 1								
	Coupon Number	37	38	39					
	Coupon Weight	41.276	41.4476	41.3486					
	Coupon Weight with Contaminant 1	41.4171	41.5546	41.4578		0.1411	0.107	0.1092	
	Coupon Weight with Contaminant 1 after cleaning	41.2791	41.4501	41.3506		0.97802977	0.976635514	0.981685	0.978783
	Contaminant 2								
	Coupon Number	12	11	10					
	Coupon Weight	41.1483	40.8939	41.8025					
	Coupon Weight with Contaminant 2	41.2916	41.0263	41.9426		0.1433	0.1324	0.1401	
	Coupon Weight with Contaminant 2 after cleaning	41.1492	40.8949	41.803		0.99371947	0.99244713	0.996431	0.994199
13	ArmaKleen M-400					160	7.5	71	
	Contaminant 1								
	Coupon Number	40	41	42					
	Coupon Weight	40.9439	40.6175	40.5128					
	Coupon Weight with Contaminant 1	41.0759	40.7353	40.656		0.132	0.1178	0.1432	
	Coupon Weight with Contaminant 1 after cleaning	40.9873	40.6513	40.5642		0.67121212	0.713073005	0.641061	0.675116
	Contaminant 2								
	Coupon Number	9	8	7					
	Coupon Weight	41.1742	39.556	40.069					
	Coupon Weight with Contaminant 2	41.3192	39.6836	40.2079		0.145	0.1276	0.1389	
	Coupon Weight with Contaminant 2 after cleaning	41.1755	39.5568	40.0709		0.99103448	0.993730408	0.986321	0.990362
14	Aquaworks MPC concentrate					160	7.5	71	
	Contaminant 1								
	Coupon Number	43	44	45		still contam left but weighed 0			
	Coupon Weight	41.343	40.4895	40.9663					
	Coupon Weight with Contaminant 1	41.4492	40.6098	41.0901		0.1062	0.1203	0.1238	
	Coupon Weight with Contaminant 1 after cleaning	41.3444	40.4908	40.9678		0.98681733	0.989193682	0.987884	0.987965
	Contaminant 2								
	Coupon Number	6	5	4					
	Coupon Weight	40.3759	40.2669	39.6576					
	Coupon Weight with Contaminant 2	40.5062	40.381	39.8019		0.1303	0.1141	0.1443	
	Coupon Weight with Contaminant 2 after cleaning	40.376	40.2672	39.658		0.99923254	0.997370727	0.997228	0.997944
15	Breakthrough					70	100%	21.11111	
	Contaminant 1								
	Coupon Number	46	47	48					
	Coupon Weight	40.956	40.4023	40.9466					
	Coupon Weight with Contaminant 1	41.0975	40.5118	41.0775		0.1415	0.1095	0.1309	
	Coupon Weight with Contaminant 1 after cleaning	40.9575	40.4031	40.9483		0.98939929	0.992694064	0.987013	0.989702
	Contaminant 2								
	Coupon Number	3	2	1					
	Coupon Weight	39.466	40.9171	40.4009					
	Coupon Weight with Contaminant 2	39.5882	41.0493	40.5332		0.1222	0.1322	0.1323	
	Coupon Weight with Contaminant 2 after cleaning	39.4665	40.918	40.4016		0.99590835	0.993192133	0.994709	0.994603

16	California Parts Washer Solution					105	20%	40.55556	
	Contaminant 1								
	Coupon Number	25	26	27					
	Coupon Weight	40.4848	40.9319	41.1353					
	Coupon Weight with Contaminant 1	40.6144	41.0784	41.2504		0.1296	0.1465	0.1151	
	Coupon Weight with Contaminant 1 after cleaning	40.4857	40.9331	41.1366		0.99305556	0.991808874	0.988705	0.99119
	Contaminant 2								
	Coupon Number	1	2	3					
	Coupon Weight	40.4009	40.9171	39.466					
	Coupon Weight with Contaminant 2	40.5198	41.0474	39.6124		0.1189	0.1303	0.1464	
	Coupon Weight with Contaminant 2 after cleaning	40.4014	40.9177	39.4665		0.99579479	0.995395242	0.996585	0.995925
17	SW-8 Aircraft OzzyJuice					105	100.00%	40.55556	
	Contaminant 1								
	Coupon Number	28	29	30					
	Coupon Weight	41.2333	40.6244	39.6195					
	Coupon Weight with Contaminant 1	41.371	40.7694	39.7613		0.1377	0.145	0.1418	
	Coupon Weight with Contaminant 1 after cleaning	41.2489	40.6315	39.626		0.88671024	0.951034483	0.954161	0.930635
	Contaminant 2								
	Coupon Number	4	5	6					
	Coupon Weight	39.6576	40.2669	40.3759					
	Coupon Weight with Contaminant 2	39.7869	40.3888	40.505		0.1293	0.1219	0.1291	
	Coupon Weight with Contaminant 2 after cleaning	39.6602	40.2711	40.3776		0.97989172	0.965545529	0.986832	0.977423
18	SW-LF OzzyJuice					105	100.00%	40.55556	
	Contaminant 1								
	Coupon Number	31	32	33					
	Coupon Weight	40.5959	41.2714	41.2347					
	Coupon Weight with Contaminant 1	40.7366	41.4092	41.3731		0.1407	0.1378	0.1384	
	Coupon Weight with Contaminant 1 after cleaning	40.6035	41.2794	41.2435		0.94598436	0.941944848	0.936416	0.941448
	Contaminant 2								
	Coupon Number	7	8	9		Edges full of grease			
	Coupon Weight	40.069	39.556	41.1742					
	Coupon Weight with Contaminant 2	40.198	39.6961	41.3004		0.129	0.1401	0.1262	
	Coupon Weight with Contaminant 2 after cleaning	40.0702	39.5595	41.1761		0.99069767	0.975017844	0.984945	0.983553
19	SW-3 OzzyJuice					105	100.00%	40.55556	
	Contaminant 1								
	Coupon Number	34	35	36					
	Coupon Weight	39.9954	40.6366	40.9972					
	Coupon Weight with Contaminant 1	40.1298	40.7831	41.1228		0.1344	0.1465	0.1256	
	Coupon Weight with Contaminant 1 after cleaning	39.9977	40.6402	40.998		0.9828869	0.975426621	0.993631	0.983981
	Contaminant 2								
	Coupon Number	10	11	12					
	Coupon Weight	41.8025	40.8939	41.1483					
	Coupon Weight with Contaminant 2	41.9293	41.0146	41.2718		0.1268	0.1207	0.1235	
	Coupon Weight with Contaminant 2 after cleaning	41.8028	40.8946	41.1489		0.99763407	0.994200497	0.995142	0.995659
20	Millennium					105	25%	40.55556	
	Contaminant 1								
	Coupon Number	37	38	39					
	Coupon Weight	41.276	41.4476	41.3486					
	Coupon Weight with Contaminant 1	41.3931	41.5546	41.4932		0.1171	0.107	0.1446	
	Coupon Weight with Contaminant 1 after cleaning	41.2888	41.4572	41.367		0.89069172	0.910280374	0.872752	0.891242
	Contaminant 2								
	Coupon Number	13	14	15					
	Coupon Weight	39.7592	40.1431	40.7883					
	Coupon Weight with Contaminant 2	39.891	40.2923	40.9274		0.1318	0.1492	0.1391	
	Coupon Weight with Contaminant 2 after cleaning	39.7605	40.1446	40.7896		0.99013657	0.989946381	0.990654	0.990246

21	Soy Green Solvent (SG5000)					100	100%	37.77778		
	Contaminant 1									
	Coupon Number	40	41	42		Rinses very easily				
	Coupon Weight	40.9439	40.6175	40.5128						
	Coupon Weight with Contaminant 1	41.0884	40.7538	40.6302		0.1445	0.1363	0.1174		
	Coupon Weight with Contaminant 1 after cleaning	40.9453	40.6192	40.514		0.99031142	0.987527513	0.989779	0.989206	
	Contaminant 2									
	Coupon Number	16	17	18						
	Coupon Weight	41.4611	40.0992	41.3559						
	Coupon Weight with Contaminant 2	41.5805	40.2208	41.5012		0.1194	0.1216	0.1453		
	Coupon Weight with Contaminant 2 after cleaning	41.4627	40.102	41.3583		0.98659966	0.976973684	0.983482	0.982352	
22	EnviroClear					100	100%	37.77778		
	Contaminant 1									
	Coupon Number	43	44	45		Rinses very easily				
	Coupon Weight	41.343	40.4895	40.9663						
	Coupon Weight with Contaminant 1	41.4502	40.6338	41.1039		0.1072	0.1443	0.1376		
	Coupon Weight with Contaminant 1 after cleaning	41.3435	40.4898	40.9673		0.99533582	0.997920998	0.992733	0.99533	
	Contaminant 2									
	Coupon Number	19	20	21						
	Coupon Weight	39.8025	41.2185	40.5666						
	Coupon Weight with Contaminant 2	39.9269	41.3608	40.6856		0.1244	0.1423	0.119		
	Coupon Weight with Contaminant 2 after cleaning	39.8025	41.2197	40.5687		1	0.991567112	0.982353	0.991307	
23	KT600C					112	16.67%	44.44444		
	Contaminant 1									
	Coupon Number	46	47	48						
	Coupon Weight	40.956	40.4023	40.9466						
	Coupon Weight with Contaminant 1	41.0609	40.5479	41.0856		0.1049	0.1456	0.139		
	Coupon Weight with Contaminant 1 after cleaning	40.9617	40.4123	40.9572		0.94566254	0.931318681	0.923741	0.933574	
	Contaminant 2									
	Coupon Number	22	23	24						
	Coupon Weight	41.6365	41.269	40.6408						
	Coupon Weight with Contaminant 2	41.7789	41.3958	40.7832		0.1424	0.1268	0.1424		
	Coupon Weight with Contaminant 2 after cleaning	41.6369	41.2693	40.6412		0.99719101	0.997634069	0.997191	0.997339	
24	Bio-Circle-L					100	100.00%	37.77778		
	Contaminant 1									
	Coupon Number	1	2	3						
	Coupon Weight	40.4009	40.9171	39.466						
	Coupon Weight with Contaminant 1	40.5293	41.0522	39.5769		0.1284	0.1351	0.1109		
	Coupon Weight with Contaminant 1 after cleaning	40.4067	40.9205	39.4692		0.95482866	0.974833457	0.971145	0.966936	
	Contaminant 2									
	Coupon Number	48	47	46						
	Coupon Weight	40.9466	40.4023	40.956						
	Coupon Weight with Contaminant 2	41.089	40.5352	41.0828		0.1424	0.1329	0.1268		
	Coupon Weight with Contaminant 2 after cleaning	40.9463	40.4023	40.9561		1.00210674	1	0.999211	1.000439	
25	EnviroLogic - Partwasher Solution					100	10%	37.77778		
	Contaminant 1									
	Coupon Number	4	5	6						
	Coupon Weight	39.6576	40.2669	40.3759						
	Coupon Weight with Contaminant 1	39.7925	40.395	40.5162		0.1349	0.1281	0.1403		
	Coupon Weight with Contaminant 1 after cleaning	39.6817	40.288	40.4086		0.82134915	0.835284934	0.766928	0.807854	
	Contaminant 2									
	Coupon Number	45	44	43						
	Coupon Weight	40.9663	40.4895	41.343						
	Coupon Weight with Contaminant 2	41.0862	40.614	41.4653		0.1199	0.1245	0.1223		
	Coupon Weight with Contaminant 2 after cleaning	40.9973	40.5279	41.3613		0.74145121	0.691566265	0.850368	0.761128	

26	SoySolv II Plus					100	100.00%	37.77778	
	Contaminant 1								
	Coupon Number	7	8	9					
	Coupon Weight	40.069	39.556	41.1742					
	Coupon Weight with Contaminant 1	40.1987	39.6828	41.3075		0.1297	0.1268	0.1333	
	Coupon Weight with Contaminant 1 after cleaning	40.0693	39.556	41.1742		0.99768697	1	1	0.999229
	Contaminant 2								
	Coupon Number	42	41	40					
	Coupon Weight	40.5128	40.6175	40.9439					
	Coupon Weight with Contaminant 2	40.6588	40.7558	41.0755		0.146	0.1383	0.1316	
	Coupon Weight with Contaminant 2 after cleaning	40.5127	40.6175	40.9439		1.00068493	1	1	1.000228
27	SoySolv II Plus					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	10	11	12					
	Coupon Weight	41.8025	40.8939	41.1483					
	Coupon Weight with Contaminant 1	41.9407	41.0195	41.2892		0.1382	0.1256	0.1409	
	Coupon Weight with Contaminant 1 after cleaning	41.8026	40.8946	41.1492		0.99927641	0.994426752	0.993612	0.995772
	Contaminant 2								
	Coupon Number	39	38	37					
	Coupon Weight	41.3486	41.4476	41.276					
	Coupon Weight with Contaminant 2	41.4931	41.5854	41.4048		0.1445	0.1378	0.1288	
	Coupon Weight with Contaminant 2 after cleaning	41.4137	41.4993	41.3343		0.54948097	0.624818578	0.54736	0.573887
28	Methyl Ethyl Ketone					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	13	14	15					
	Coupon Weight	39.7592	40.1431	40.7883					
	Coupon Weight with Contaminant 1	39.9019	40.2844	40.9009		0.1427	0.1413	0.1126	
	Coupon Weight with Contaminant 1 after cleaning	39.76	40.1435	40.7888		0.99439383	0.997169144	0.99556	0.995707
	Contaminant 2								
	Coupon Number	36	35	34					
	Coupon Weight	40.9972	40.6366	39.9954					
	Coupon Weight with Contaminant 2	41.1403	40.7696	40.1294		0.1431	0.133	0.134	
	Coupon Weight with Contaminant 2 after cleaning	41.0051	40.6436	40.0075		0.94479385	0.947368421	0.909701	0.933955
29	Mineral Spirits (Stoddard Solvent)					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	16	17	18					
	Coupon Weight	41.4611	40.0992	41.3559					
	Coupon Weight with Contaminant 1	41.6011	40.2338	41.5023		0.14	0.1346	0.1464	
	Coupon Weight with Contaminant 1 after cleaning	41.4619	40.0997	41.3563		0.99428571	0.99628529	0.997268	0.995946
	Contaminant 2								
	Coupon Number	33	32	31					
	Coupon Weight	41.2347	41.2714	40.5959					
	Coupon Weight with Contaminant 2	41.3676	41.3975	40.7405		0.1329	0.1261	0.1446	
	Coupon Weight with Contaminant 2 after cleaning	41.2351	41.2717	40.5961		0.99699022	0.997620936	0.998617	0.997743
30	Isopropanol					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	19	20	21					
	Coupon Weight	39.8025	41.2185	40.5666					
	Coupon Weight with Contaminant 1	39.9081	41.3384	40.6931		0.1056	0.1199	0.1265	
	Coupon Weight with Contaminant 1 after cleaning	39.8021	41.2182	40.5667		1.00378788	1.002502085	0.999209	1.001833
	Contaminant 2								
	Coupon Number	30	29	28					
	Coupon Weight	39.6195	40.6244	41.2333					
	Coupon Weight with Contaminant 2	39.7617	40.7496	41.3588		0.1422	0.1252	0.1255	
	Coupon Weight with Contaminant 2 after cleaning	39.7302	40.7164	41.3308		0.22151899	0.265175719	0.223108	0.236601

31	Heavy Duty Cleaner					105	20%	40.55556	
	Contaminant 1								
	Coupon Number	22	23	24					
	Coupon Weight	41.6365	41.269	40.6408					
	Coupon Weight with Contaminant 1	41.7565	41.3932	40.7777		0.12	0.1242	0.1369	
	Coupon Weight with Contaminant 1 after cleaning	41.6364	41.2685	40.6415		1.00083333	1.004025765	0.994887	0.999915
	Contaminant 2								
	Coupon Number	27	26	25					
	Coupon Weight	41.1353	40.9319	40.4848					
	Coupon Weight with Contaminant 2	41.273	41.0735	40.6008		0.1377	0.1416	0.116	
	Coupon Weight with Contaminant 2 after cleaning	41.1351	40.9317	40.4845		1.00145243	1.001412429	1.002586	1.001817
32	NZD Ultra Degreaser					70	100.00%	21.11111	
	Contaminant 1								
	Coupon Number	13	14	15					
	Coupon Weight	39.7592	40.1431	40.7883					
	Coupon Weight with Contaminant 1	39.88	40.2841	40.9166		0.1208	0.141	0.1283	
	Coupon Weight with Contaminant 1 after cleaning	39.7593	40.1438	40.7886		0.99917219	0.995035461	0.997662	0.99729
	Contaminant 2								
	Coupon Number	25	26	27					
	Coupon Weight	40.4848	40.9319	41.1353					
	Coupon Weight with Contaminant 2	40.6221	41.0535	41.2597		0.1373	0.1216	0.1244	
	Coupon Weight with Contaminant 2 after cleaning	40.4947	40.9426	41.1437		0.92789512	0.912006579	0.932476	0.924126
33	Spray-Nine AV-8					70	10	21.11111	
	Contaminant 1								
	Coupon Number	16	17	18					
	Coupon Weight	41.4611	40.0992	41.3559					
	Coupon Weight with Contaminant 1	41.5638	40.2452	41.4733		0.1027	0.146	0.1174	
	Coupon Weight with Contaminant 1 after cleaning	41.5072	40.1461	41.3783		0.55111977	0.678767123	0.809199	0.679695
	Contaminant 2								
	Coupon Number	28	29	30					
	Coupon Weight	41.2333	40.6244	39.6195					
	Coupon Weight with Contaminant 2	41.3508	40.7462	39.7439		0.1175	0.1218	0.1244	
	Coupon Weight with Contaminant 2 after cleaning	41.3487	40.7438	39.7419		0.01787234	0.019704433	0.016077	0.017885
34	Spray-Nine AV-8 Low ph					130	10	54.44444	
	Contaminant 1								
	Coupon Number	19	20	21					
	Coupon Weight	39.8025	41.2185	40.5666					
	Coupon Weight with Contaminant 1	39.9073	41.3356	40.7133		0.1048	0.1171	0.1467	
	Coupon Weight with Contaminant 1 after cleaning	39.8073	41.2248	40.5776		0.95419847	0.946199829	0.925017	0.941805
	Contaminant 2								
	Coupon Number	31	32	33					
	Coupon Weight	40.5959	41.2714	41.2347					
	Coupon Weight with Contaminant 2	40.7213	41.3899	41.3549		0.1254	0.1185	0.1202	
	Coupon Weight with Contaminant 2 after cleaning	40.6236	41.2788	41.244		0.77910686	0.937552743	0.922629	0.879763
35	Sea Wash 8					130	5.00%	54.44444	
	Contaminant 1								
	Coupon Number	22	23	24					
	Coupon Weight	41.6365	41.269	40.6408					
	Coupon Weight with Contaminant 1	41.7479	41.4095	40.7875		0.1114	0.1405	0.1467	
	Coupon Weight with Contaminant 1 after cleaning	41.6431	41.2772	40.6494		0.94075404	0.941637011	0.941377	0.941256
	Contaminant 2								
	Coupon Number	34	35	36					
	Coupon Weight	39.9954	40.6366	40.9972					
	Coupon Weight with Contaminant 2	40.11	40.7726	41.139		0.1146	0.136	0.1418	
	Coupon Weight with Contaminant 2 after cleaning	39.9956	40.6362	40.9971		0.9982548	1.002941176	1.000705	1.000634

36	Bean-e-doo Parts Washer Solvent					130	100%	54.44444	
	Contaminant 1								
	Coupon Number	43	44	45					
	Coupon Weight	41.343	40.4895	40.9663					
	Coupon Weight with Contaminant 1	41.4564	40.6064	41.1018		0.1134	0.1169	0.1355	
	Coupon Weight with Contaminant 1 after cleaning	41.3435	40.4911	40.9663		0.99559083	0.986313088	1	0.993968
	Contaminant 2								
	Coupon Number	37	38	39					
	Coupon Weight	41.276	41.4476	41.3486					
	Coupon Weight with Contaminant 2	41.4083	41.5844	41.4668		0.1323	0.1368	0.1182	
	Coupon Weight with Contaminant 2 after cleaning	41.278	41.4505	41.3528		0.98488284	0.97880117	0.964467	0.97605
37	Agriplast					130	100%	54.44444	
	Contaminant 1								
	Coupon Number	46	47	48					
	Coupon Weight	40.956	40.4023	40.9466					
	Coupon Weight with Contaminant 1	41.0766	40.5517	41.0888		0.1206	0.1494	0.1422	
	Coupon Weight with Contaminant 1 after cleaning	41.0161	40.452	40.9827		0.50165837	0.667336011	0.746132	0.638376
	Contaminant 2								
	Coupon Number	40	41	42					
	Coupon Weight	40.9439	40.6175	40.5128					
	Coupon Weight with Contaminant 2	41.0697	40.7431	40.6454		0.1258	0.1256	0.1326	
	Coupon Weight with Contaminant 2 after cleaning	40.9531	40.6237	40.5187		0.92686804	0.950636943	0.955505	0.944337
38	Bioact MSO equivalent					110	25	43.33333	
	Contaminant 1								
	Coupon Number	24	23	22		very fine film left behind			
	Coupon Weight	40.6408	41.269	41.6365					
	Coupon Weight with Contaminant 1	40.7515	41.4158	41.7545		0.1107	0.1468	0.118	
	Coupon Weight with Contaminant 1 after cleaning	40.6421	41.2706	41.638		0.98825655	0.989100817	0.987288	0.988215
	Contaminant 2								
	Coupon Number	25	26	27					
	Coupon Weight	40.4848	40.9319	41.1353					
	Coupon Weight with Contaminant 2	40.6116	41.073	41.2708		0.1268	0.1411	0.1355	
	Coupon Weight with Contaminant 2 after cleaning	40.4865	40.9348	41.1358		0.98659306	0.979447201	0.99631	0.98745
39	SS-HD Parts Washer Formulation					110	100.00%	43.33333	
	Contaminant 1								
	Coupon Number	21	20	19					
	Coupon Weight	40.5666	41.2185	39.8025					
	Coupon Weight with Contaminant 1	40.6955	41.3269	39.9157		0.1289	0.1084	0.1132	
	Coupon Weight with Contaminant 1 after cleaning	40.5759	41.2348	39.8132		0.92785105	0.849630996	0.905477	0.89432
	Contaminant 2								
	Coupon Number	28	29	30					
	Coupon Weight	41.2333	40.6244	39.6195					
	Coupon Weight with Contaminant 2	41.3778	40.7497	39.751		0.1445	0.1253	0.1315	
	Coupon Weight with Contaminant 2 after cleaning	41.2334	40.6243	39.6195		0.99930796	1.000798085	1	1.000035
40	Silicon Wash Concentrate					140	16.67%	60	
	Contaminant 1								
	Coupon Number	18	17	16					
	Coupon Weight	41.3559	40.0992	41.4611					
	Coupon Weight with Contaminant 1	41.4844	40.2433	41.5753		0.1285	0.1441	0.1142	
	Coupon Weight with Contaminant 1 after cleaning	41.3825	40.157	41.5037		0.79299611	0.59888966	0.62697	0.672952
	Contaminant 2								
	Coupon Number	31	32	33					
	Coupon Weight	40.5959	41.2714	41.2347					
	Coupon Weight with Contaminant 2	40.7421	41.4095	41.3643		0.1462	0.1381	0.1296	
	Coupon Weight with Contaminant 2 after cleaning	40.5987	41.2743	41.2361		0.98084815	0.979000724	0.989198	0.983015

41	Axarel 58					150	100%	65.55556	
	Contaminant 1								
	Coupon Number	15	14	13		looked and felt completely clean			
	Coupon Weight	40.7883	40.1431	39.7592					
	Coupon Weight with Contaminant 1	40.9219	40.2879	39.9028		0.1336	0.1448	0.1436	
	Coupon Weight with Contaminant 1 after cleaning	40.795	40.1473	39.7655		0.9498503	0.970994475	0.956128	0.958991
	Contaminant 2								
	Coupon Number	34	35	36					
	Coupon Weight	39.9954	40.6366	40.9972					
	Coupon Weight with Contaminant 2	40.139	40.7696	41.132		0.1436	0.133	0.1348	
	Coupon Weight with Contaminant 2 after cleaning	40.0014	40.6434	41.0029		0.95821727	0.94887218	0.957715	0.954935
42	Optima 100 GP					148	10%	64.44444	
	Contaminant 1								
	Coupon Number	12	11	10					
	Coupon Weight	41.1483	40.8939	41.8025					
	Coupon Weight with Contaminant 1	41.2737	41.0146	41.9274		0.1254	0.1207	0.1249	
	Coupon Weight with Contaminant 1 after cleaning	41.1523	40.897	41.8069		0.96810207	0.974316487	0.964772	0.969063
	Contaminant 2								
	Coupon Number	37	38	39					
	Coupon Weight	41.276	41.4476	41.3486					
	Coupon Weight with Contaminant 2	41.4116	41.579	41.4827		0.1356	0.1314	0.1341	
	Coupon Weight with Contaminant 2 after cleaning	41.2797	41.448	41.351		0.97271386	0.99695586	0.982103	0.983924
43	Optima 2001 CR					148	10%	64.44444	
	Contaminant 1								
	Coupon Number	43	44	45					
	Coupon Weight	41.343	40.4895	40.9663					
	Coupon Weight with Contaminant 1	41.464	40.6312	41.1095		0.121	0.1417	0.1432	
	Coupon Weight with Contaminant 1 after cleaning	41.3441	40.4915	40.967		0.99090909	0.985885674	0.995112	0.990635
	Contaminant 2								
	Coupon Number	40	41	42					
	Coupon Weight	40.9439	40.6175	40.5128					
	Coupon Weight with Contaminant 2	41.0911	40.7414	40.6391		0.1472	0.1239	0.1263	
	Coupon Weight with Contaminant 2 after cleaning	40.9437	40.6168	40.5126		1.0013587	1.005649718	1.001584	1.002864
44	Vertrel CMS					Room	100%	21	
	Contaminant 1								
	Coupon Number	19	20	21					
	Coupon Weight	39.8025	41.2185	40.5666					
	Coupon Weight with Contaminant 1	39.9417	41.3437	40.6815		0.1392	0.1252	0.1149	
	Coupon Weight with Contaminant 1 after cleaning	39.8123	41.2314	40.5764		0.9295977	0.896964856	0.914708	0.913757
	Contaminant 2								
	Coupon Number	1	2	3					
	Coupon Weight	40.4009	40.9171	39.466					
	Coupon Weight with Contaminant 2	40.5438	41.0607	39.6064		0.1429	0.1436	0.1404	
	Coupon Weight with Contaminant 2 after cleaning	40.402	40.9222	39.467		0.99230231	0.96448468	0.992877	0.983221
45	Neugenic 4177					Room	100%	21	
	Contaminant 1								
	Coupon Number	22	23	24					
	Coupon Weight	41.6365	41.269	40.6408					
	Coupon Weight with Contaminant 1	41.7605	41.3907	40.7483		0.124	0.1217	0.1075	
	Coupon Weight with Contaminant 1 after cleaning	41.6552	41.2777	40.6701		0.84919355	0.928512736	0.727442	0.835049
	Contaminant 2								
	Coupon Number	4	5	6		Still had cleaning product on it after drying, very thick			
	Coupon Weight	39.6576	40.2669	40.3759					
	Coupon Weight with Contaminant 2	39.8003	40.4114	40.5113		0.1427	0.1445	0.1354	
	Coupon Weight with Contaminant 2 after cleaning	39.7962	40.4175	40.5566		0.0287316	-0.042214533	-0.334564	-0.116016

46	Simple Green				Room	100%	21	
	Contaminant 1							
	Coupon Number	25	26	27				
	Coupon Weight	40.4848	40.9319	41.1353				
	Coupon Weight with Contaminant 1	40.6025	41.052	41.2732	0.1177	0.1201	0.1379	
	Coupon Weight with Contaminant 1 after cleaning	40.5053	40.9518	41.1666	0.82582838	0.834304746	0.773024	81.11%
	Contaminant 2							
	Coupon Number	7	8	9				
	Coupon Weight	40.069	39.556	41.1742				
	Coupon Weight with Contaminant 2	40.2112	39.6998	41.3103	0.1422	0.1438	0.1361	
	Coupon Weight with Contaminant 2 after cleaning	40.1938	39.6839	41.2933	0.12236287	0.110570236	0.124908	11.93%
47	Green 4 Kleen				Room	12%	21	
	Contaminant 1							
	Coupon Number	28	29	30				
	Coupon Weight	41.2333	40.6244	39.6195				
	Coupon Weight with Contaminant 1	41.3792	40.7626	39.734	0.1459	0.1382	0.1145	
	Coupon Weight with Contaminant 1 after cleaning	41.2959	40.6784	39.6859	0.570939	0.609261939	0.420087	53.34%
	Contaminant 2							
	Coupon Number	10	11	12				
	Coupon Weight	41.8025	40.8939	41.1483				
	Coupon Weight with Contaminant 2	41.9254	41.0326	41.2866	0.1229	0.1387	0.1383	
	Coupon Weight with Contaminant 2 after cleaning	41.9253	41.0326	41.2859	0.00081367	0	0.005061	0.20%
48	Daraclean					25%	55	
	Contaminant 1							
	Coupon Number	31	32	33				
	Coupon Weight	40.5959	41.2714	41.2347				
	Coupon Weight with Contaminant 1	40.7128	41.3939	41.3607	0.1169	0.1225	0.126	
	Coupon Weight with Contaminant 1 after cleaning	40.6006	41.2801	41.2481	0.9597947	0.928979592	0.893651	92.75%
	Contaminant 2							
	Coupon Number	13	14	15				
	Coupon Weight	39.7592	40.1431	40.7883				
	Coupon Weight with Contaminant 2	39.8938	40.2554	40.9221	0.1346	0.1123	0.1338	
	Coupon Weight with Contaminant 2 after cleaning	39.7589	40.143	40.788	1.00222883	1.000890472	1.002242	100.18%
49	EXP 1300					4%	63	
	Contaminant 1							
	Coupon Number	34	35	36				
	Coupon Weight	39.9954	40.6366	40.9972				
	Coupon Weight with Contaminant 1	40.1312	40.7642	41.1147	0.1358	0.1276	0.1175	
	Coupon Weight with Contaminant 1 after cleaning	40.0204	40.6489	41.0141	0.81590574	0.903605016	0.85617	85.86%
	Contaminant 2							
	Coupon Number	16	17	18				
	Coupon Weight	41.4611	40.0992	41.3559				
	Coupon Weight with Contaminant 2	41.5875	40.2242	41.4873	0.1264	0.125	0.1314	
	Coupon Weight with Contaminant 2 after cleaning	41.4615	40.0997	41.3563	0.99683544	0.996	0.996956	99.66%
50	Cleanaire 1200				160	3.0%	71.11111	
	Contaminant 1							
	Coupon Number	39	38	37				
	Coupon Weight	41.3486	41.4476	41.276				
	Coupon Weight with Contaminant 1	41.4723	41.5861	41.4152	0.1237	0.1385	0.1392	
	Coupon Weight with Contaminant 1 after cleaning	41.352	41.4535	41.2775	0.97251415	0.957400722	0.989224	97.30%
	Contaminant 2							
	Coupon Number	48	47	46				
	Coupon Weight	40.9466	40.4023	40.956				
	Coupon Weight with Contaminant 2	41.0805	40.5258	41.0808	0.1339	0.1235	0.1248	
	Coupon Weight with Contaminant 2 after cleaning	40.9467	40.4025	40.9565	0.99925317	0.998380567	0.995994	99.79%

51	Natural Orange				160	0.5%	71.11111	
	Contaminant 1							
	Coupon Number	18	17	16	discolored rest of submerged coupon			
	Coupon Weight	41.3559	40.0992	41.4611				
	Coupon Weight with Contaminant 1	41.4755	40.2135	41.5636	0.1196	0.1143	0.1025	
	Coupon Weight with Contaminant 1 after cleaning	41.3596	40.1012	41.465	0.96906355	0.982502187	0.961951	97.12%
	Contaminant 2							
	Coupon Number	45	44	43				
	Coupon Weight	40.9663	40.4895	41.343				
	Coupon Weight with Contaminant 2	41.0982	40.6097	41.4826	0.1319	0.1202	0.1396	
	Coupon Weight with Contaminant 2 after cleaning	40.9892	40.5119	41.3553	0.82638362	0.813643927	0.911891	85.06%
52	PowerKleen III				160	2.2%	71.11111	
	Contaminant 1							
	Coupon Number	15	14	13				
	Coupon Weight	40.7883	40.1431	39.7592				
	Coupon Weight with Contaminant 1	40.9125	40.2522	39.8921	0.1242	0.1091	0.1329	
	Coupon Weight with Contaminant 1 after cleaning	40.8011	40.1582	39.7654	0.89694042	0.861594867	0.953348	90.40%
	Contaminant 2							
	Coupon Number	42	41	40				
	Coupon Weight	40.5128	40.6175	40.9439				
	Coupon Weight with Contaminant 2	40.6472	40.7488	41.0828	0.1344	0.1313	0.1389	
	Coupon Weight with Contaminant 2 after cleaning	40.5132	40.6186	40.9444	0.99702381	0.991622239	0.9964	99.50%
53	Aero Wash 4				160	10%	71	
	Contaminant 1							
	Coupon Number	36	35	34				
	Coupon Weight	40.9972	40.6366	39.9954				
	Coupon Weight with Contaminant 1	41.1011	40.7546	40.1278	0.1039	0.118	0.1324	
	Coupon Weight with Contaminant 1 after cleaning	40.9988	40.6377	39.9968	0.98460058	0.990677966	0.989426	98.82%
	Contaminant 2							
	Coupon Number	1	2	3				
	Coupon Weight	40.4009	40.9171	39.466				
	Coupon Weight with Contaminant 2	40.534	41.0675	39.6085	0.1331	0.1504	0.1425	
	Coupon Weight with Contaminant 2 after cleaning	40.4015	40.9179	39.4664	0.99549211	0.994680851	0.997193	99.58%
54	Aero wash 4				160	20.0%	71.11111	
	Contaminant 1							
	Coupon Number	33	32	31				
	Coupon Weight	41.2347	41.2714	40.5959				
	Coupon Weight with Contaminant 1	41.342	41.4234	40.7447	0.1073	0.152	0.1488	
	Coupon Weight with Contaminant 1 after cleaning	41.2352	41.2738	40.5967	0.99534017	0.984210526	0.994624	99.14%
	Contaminant 2							
	Coupon Number	4	5	6				
	Coupon Weight	39.6576	40.2669	40.3759				
	Coupon Weight with Contaminant 2	39.7902	40.401	40.5127	0.1326	0.1341	0.1368	
	Coupon Weight with Contaminant 2 after cleaning	39.6578	40.2677	40.376	0.9984917	0.994034303	0.999269	99.73%
55	Flightline 2				160	10.0%	71.11111	
	Contaminant 1							
	Coupon Number	30	29	28				
	Coupon Weight	39.6195	40.6244	41.2333				
	Coupon Weight with Contaminant 1	39.7673	40.7566	41.3663	0.1478	0.1322	0.133	
	Coupon Weight with Contaminant 1 after cleaning	39.6215	40.6281	41.237	0.9864682	0.972012103	0.97218	97.69%
	Contaminant 2							
	Coupon Number	7	8	9				
	Coupon Weight	40.069	39.556	41.1742				
	Coupon Weight with Contaminant 2	40.2054	39.6973	41.3092	0.1364	0.1413	0.135	
	Coupon Weight with Contaminant 2 after cleaning	40.0694	39.557	41.1744	0.99706745	0.992922859	0.998519	99.62%

56	Flight line 2				160	20.0%	71.11111	
	Contaminant 1							
	Coupon Number	27	26	25				
	Coupon Weight	41.1353	40.9319	40.4848				
	Coupon Weight with Contaminant 1	41.247	41.0762	40.6287	0.1117	0.1443	0.1439	
	Coupon Weight with Contaminant 1 after cleaning	41.1365	40.9342	40.4901	0.98925694	0.984060984	0.963169	97.88%
	Contaminant 2							
	Coupon Number	10	11	12				
	Coupon Weight	41.8025	40.8939	41.1483				
	Coupon Weight with Contaminant 2	41.9214	41.0269	41.2792	0.1189	0.133	0.1309	
	Coupon Weight with Contaminant 2 after cleaning	41.803	40.8946	41.149	0.99579479	0.994736842	0.994652	99.51%

57	Acetone				ambient	100.0%	21	
	Contaminant 1							
	Coupon Number	4	5	6				
	Coupon Weight	39.6576	40.2669	40.3759				
	Coupon Weight with Contaminant 1	39.7946	40.3911	40.488	0.137	0.1242	0.1121	
	Coupon Weight with Contaminant 1 after cleaning	39.6583	40.2681	40.3763	0.99489051	0.990338164	0.996432	99.39%
	Contaminant 2							
	Coupon Number	1	2	3				
	Coupon Weight	40.4009	40.9171	39.466				
	Coupon Weight with Contaminant 2	40.5173	41.0536	39.6029	0.1164	0.1365	0.1369	
	Coupon Weight with Contaminant 2 after cleaning	40.4779	41.0081	39.5627	0.33848797	0.333333333	0.293645	32.18%

Appendix D

Case Study – Explanation of Excessively High Cleaning Efficiencies

Case Study

Test coupon #8 was used in six separate test trials – 3, 13, 18, 26, 46, and 55. Before running any cleaning trials, the test coupon was precleaned using the procedure set forth in mil spec MIL-PRF-29602A. Before the test coupon was used for any cleaning efficiency tests, it weighed 39.5566 grams. The mass of the test coupon, after being cleaned according to the mil spec procedure in addition to an ultrasonic wash, was equal to the following values before using it in the following tests:

Test #	Mass, grams
3	39.5566
13	39.5576
18	39.5563
26	39.5568
46	39.5571
55	39.5604

It should be noted that the cleaning procedure used in the mil spec – which calls for solvent wiping with acetone until the wipe is free of visual residue – was not sufficient to thoroughly clean the test coupon between some test trials. This was particularly evident between test trials #46 and #55, as it was 3.3 mg heavier for test trial #55. The cleaning chemistry in test trial #55 was a superior product that was able to clean the test coupon thoroughly, and it removed residual contamination that had not been removed prior to the start of the test, with the result that it weighed 39.5570 grams after the test trial, or 3.4 mg less than the precleaned mass at the start of the cleaning efficiency test. Because the cleaned test coupon weight with contaminant was less than the precleaned test coupon weight at the start of test trial #55, it appeared that this product had a cleaning efficiency equal to 102.48%, which cannot occur unless aluminum degradation or other substrate loss has occurred. The excess value of 2.48% is well above that level of error attributable to inaccuracies in linearity of the analytical balance, which could only account for an excess value of 0.32%. This latter value assumes that the test coupon weighs approximately 40 grams, and the degree of accuracy of the scale is +/- 0.2 mg.

At the conclusion of testing, all test coupons underwent a very thorough final cleaning, well beyond that required by the mil spec, using multiple cleanings in ultrasonic tanks, manual scrubbing with acetone, and wiping with cleanroom wipes. The last step of this final cleaning process was an ultrasonic wash followed by a rinse with no wiping, so as to eliminate the presence of wiper bits on the sharp edges of the coupon. The final weight of the bare, cleaned test coupon #8 was 39.5560 grams. This correlates to a cleaning efficiency of 99.29% for test #55, which is a reasonable value.

Conclusion: the precleaning procedure established in the mil spec is less effective in removing contaminants than some of the chemistries evaluated in this project. As a result, nominal cleaning efficiencies in some cases exceed 100% when using the calculation established in the mil spec. In order to correct this deficiency, only one value

should be used for the precleaned test coupon mass for all trials, which should be the value obtained from the very thorough cleaning procedure used at the conclusion of cleaning efficiency testing. The cleaning procedure in the mil spec should also be modified and expanded to ensure that all contaminants are removed from the test coupons.

Appendix E

Contact Information for Selected Cleaning Chemistries

Contact Information for Selected Cleaning Chemistries

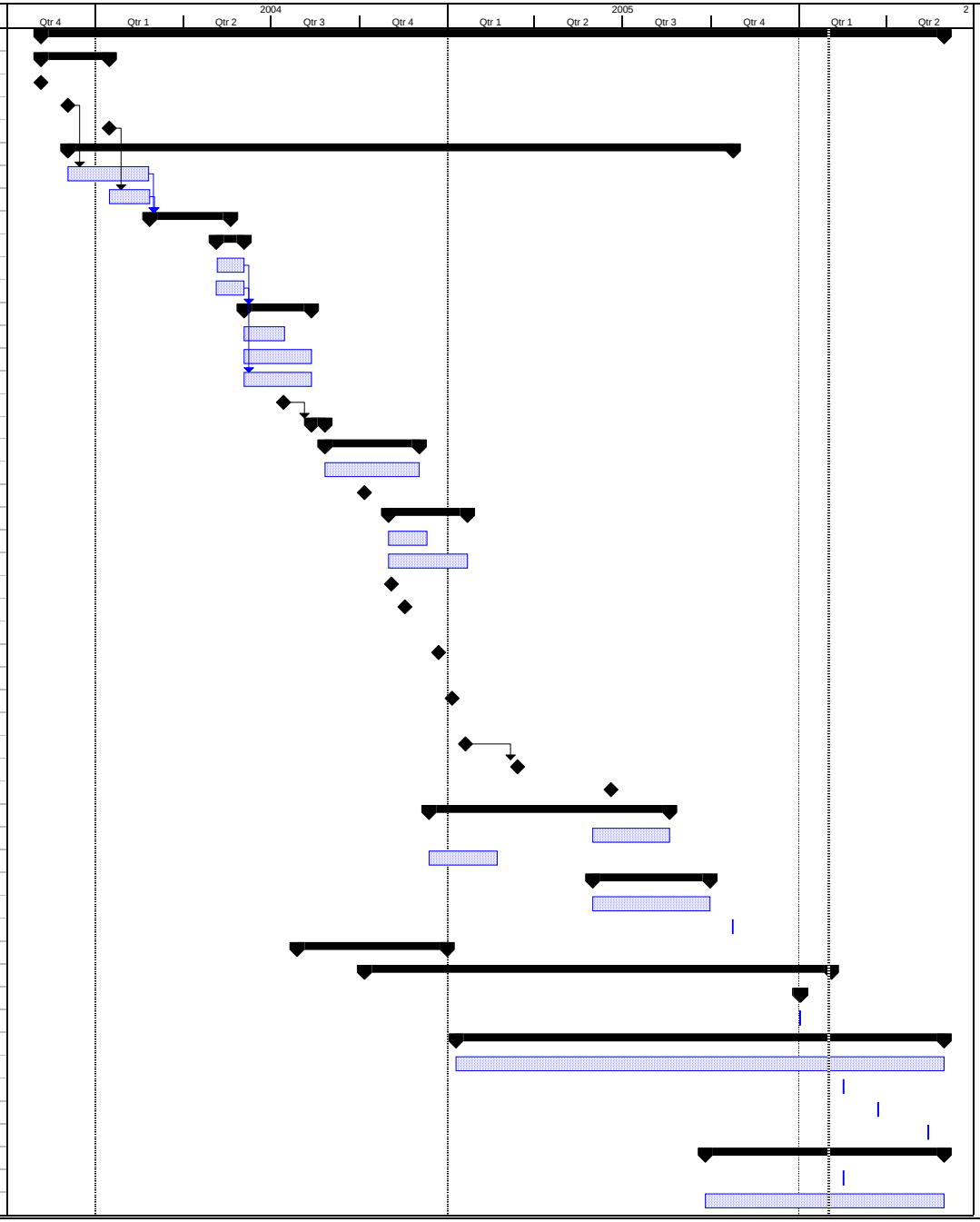
As stated in the body of this report, several cleaning chemistries were evaluated in this project that did not appear the original test matrix provided by NASA to NC3R. These cleaning chemistries can be obtained by contacting the following individuals at the following phone numbers.

Test #	Chemistry name	Supplier name	Average Cleaning Efficiency %	Rank -	Contact Name -	Contact Phone Number -
43	Optima 2001 CR	Global Specialty Products	99.67%	4	Davood Faghani	(609) 518-7577
54	Aerowash 4	Rochester Midland	99.43%	6	Grant Matta	(585) 336-2281
53	Aerowash 4	Rochester Midland	99.20%	11	Grant Matta	(585) 336-2281
56	Flightline 2	Rochester Midland	98.69%	15	Grant Matta	(585) 336-2281
55	Flightline 2	Rochester Midland	98.65%	16	Grant Matta	(585) 336-2281
50	Cleanaire 1200	Rochester Midland	98.55%	19	Grant Matta	(585) 336-2281
42	Optima 100 GP	Global Specialty Products	97.65%	26	Davood Faghani	(609) 518-7577
48	Daraclean	Magnaflux	96.46%	31	N/A	(847) 657-5300
32	NZD Ultra Degreaser	Global Specialty Products	96.07%	33	Davood Faghani	(609) 518-7577
52	Powerkleen III	Mart Corporation	94.95%	37	John Freeborn	(800) 543-6278
44	Vertrel CMS	Dupont	94.85%	38	Harris Towne	(860) 827-0626
49	EXP 1300	Brulin	92.76%	41	Andy Chadwick	(585) 467-6823
51	Natural Orange	Giant Cleaning Systems	91.09%	42	Pat McCormick	(585) 385-1390
34	Low pH Conc Cleaner	Spray-Nine	91.08%	43	David Crosbie	(800) 477-7299
57	Acetone	(various)	65.79%	51	(commonly available)	
46	Simple Green	Sunshine Makers	46.52%	53	(commonly available)	
45	Neugenic 4177	Rochester Midland	35.95%	54	Grant Matta	(585) 336-2281
33	Spray-Nine AV-8	Spray-Nine	34.88%	55	David Crosbie	(800) 477-7299

APPENDIX E
PROJECT SCHEDULE

NASA AP2 Coatings and Depainting Project Schedule 07/08/03

ID	Task Name	Start	Finish
1	**Parts Washer Alternatives Project**	Thu 11/6/03	Wed 5/31/06
2	**Identification**	Thu 11/6/03	Fri 1/16/04
3	Project Telecon 1	Thu 11/6/03	Thu 11/6/03
4	Project Telecon 2	Thu 12/4/03	Thu 12/4/03
5	Project Telecon 3	Fri 1/16/04	Fri 1/16/04
6	**Technical**	Thu 12/4/03	Mon 10/24/05
7	**Identify Current Parts Washers**	Thu 12/4/03	Wed 2/25/04
8	**Performance Guidelines Draft #1 Review**	Fri 1/16/04	Thu 2/26/04
9	**Technical Telecon #1**	Fri 2/27/04	Thu 5/20/04
12	**Technical Telecon #2**	Thu 5/6/04	Thu 6/3/04
13	Performance Standards Review	Fri 5/7/04	Thu 6/3/04
14	Downselect Parts Washers Based on Standards	Thu 5/6/04	Thu 6/3/04
15	**Technical Telecon #3**	Fri 6/4/04	Thu 8/12/04
16	Develop - 1st Draft (Strawman) Consumer Guide	Fri 6/4/04	Thu 7/15/04
17	Begin Selection of Demonstration Sites	Fri 6/4/04	Thu 8/12/04
18	Select Parts Washers and Cleaners for Demonstrations	Fri 6/4/04	Thu 8/12/04
19	**Technical Telecon #4**	Thu 7/15/04	Thu 7/15/04
20	**Technical Telecon #5**	Fri 8/13/04	Thu 8/26/04
22	**Technical Telecon #6**	Fri 8/27/04	Thu 12/2/04
23	Ship Parts Washers to Demonstration Sites	Fri 8/27/04	Thu 12/2/04
24	**Technical Telecon #7**	Thu 10/7/04	Thu 10/7/04
25	**Technical Telecon #8**	Mon 11/1/04	Fri 1/21/05
26	Setup Parts Washers and Cleaners at Demonstration Sites	Mon 11/1/04	Fri 12/10/04
27	Begin Demonstration of Parts Washers	Mon 11/1/04	Fri 1/21/05
28	**Technical Telecon #9**	Thu 11/4/04	Thu 11/4/04
29	**Technical Telecon #10**	Thu 11/18/04	Thu 11/18/04
30	**Technical Telecon #11**	Thu 12/23/04	Thu 12/23/04
31	In-Brief Interviews Complete	Thu 12/23/04	Thu 12/23/04
32	**Technical Telecon #12**	Thu 1/6/05	Thu 1/6/05
33	Mid-Point Interviews Complete	Thu 1/6/05	Thu 1/6/05
34	**Technical Telecon #13**	Thu 1/20/05	Thu 1/20/05
35	Out-Brief Interviews Complete	Thu 1/20/05	Thu 1/20/05
36	**Technical Telecon #14**	Tue 3/15/05	Tue 3/15/05
37	**Technical Telecon #15**	Mon 6/20/05	Mon 6/20/05
38	**Technical Telecon #16**	Mon 12/13/04	Fri 8/19/05
39	**Draft Consumer Guide**	Wed 6/1/05	Fri 8/19/05
40	**Laboratory Testing of Cleaning Materials**	Mon 12/13/04	Mon 2/21/05
41	**Technical Telecon #17**	Wed 6/1/05	Fri 9/30/05
42	**Draft Consumer Guide (After Testing Results)**	Wed 6/1/05	Fri 9/30/05
43	**Technical Telecon #18**	Mon 10/24/05	Mon 10/24/05
44	**Business**	Thu 7/29/04	Fri 12/31/04
46	**Alternative Dem/Val**	Thu 10/7/04	Fri 2/3/06
56	**Process Change Authorization**	Mon 1/2/06	Mon 1/2/06
57	**(Not applicable to this project; only baseline testing)**	Mon 1/2/06	Mon 1/2/06
58	**Implementation**	Mon 1/10/05	Wed 5/31/06
59	Implementation	Mon 1/10/05	Wed 5/31/06
60	**Final Teleconference**	Thu 2/16/06	Thu 2/16/06
61	Distribute Consumer Guide to JS3 Working Group	Fri 3/24/06	Fri 3/24/06
62	Distribute Consumer Guide at NASA's Annual Environmental Meeting	Mon 5/15/06	Mon 5/15/06
63	**Evaluation / Feedback**	Mon 9/26/05	Wed 5/31/06
64	Distribute Evaluation Questionnare at Final Teleconference	Thu 2/16/06	Thu 2/16/06
65	Assessment of Project & Recommendations for Follow-on	Mon 9/26/05	Wed 5/31/06



Project: propsl
Date: Tue 1/31/06

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | External Milestone | Deadline
Progress | Summary | Rolled Up Milestone | Split | Project Summary | External Milestone