Alternative Solvent for PD-680 Type II

DEPOT MAINTENANCE PROJECT as of 941129

Type: E
Accession Number: 57957
Code: Active

Narrative:

DOD facilities are experiencing problems in using PD-680 solvents for general maintenance procedures and clean-up operations. This petroleum based solvent is considered a hazardous waste, causing disposal difficulties. PD-680 Type II not only contains hazardous constituents and VOCs, but it is also a known carcinogen.

Status:

- The Naval Surface Warfare Center, Carderock Division, Annapolis, MD (CDNSWC) developed a multi-disciplinary approach by forming a task force of chemists, engineers, industrial hygienists, and systems analysts.
- The task force identified and evaluated alternative materials and process changes and coordinated with other government agencies and military commands.
-Sep 94PD-680 Type III is recommended as an interim substitute.
-Nov 94Based on preliminary review results, PD-680 Type III can replace PD-680 Type II in a majority of applications. A significant reduction of the use of PD-680 Type II can be achieved through elimination, substitution, and process changes.

Implementation Date: 1994-00-00
Initial Submission Date: 1994-08-09
Update Submission Date: 1994-10-12
Lead Service: Navy
Key Words: Solvents, PD-680
Point of Contact - Name: Robert Vozzella
Point of Contact - Organization: NAVSEA Code 900H
Point of Contact - Phone: DSN 684-1610, COM 207-438-1610, Fax ext 1298

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Last Updated: 10/29/96

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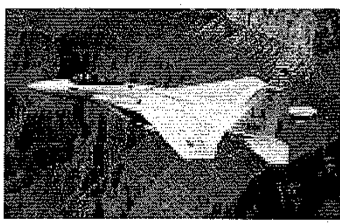
May 2000 VOLUME 5, NUMBER 2

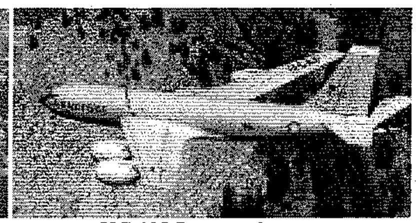
Aging Aircraft - Lessons Learned

A car more than 20 years old may be a classic but you likely would not take it on a long trip. In contrast, the backbone of the military aircraft fleet was built more than twenty years ago and is still performing their designed functions. In fact, KC-135 tankers entered service more than 40 years ago and the B-52H, C-130, T-37 and T-38 began their service 35-40 years ago. In the 25-35 year age group are the C-141 and C-5A transports and 20-25 years ago the F-15, A-10 and E-3 entered service.



F-15 Eagle

B-52 Stratofortress

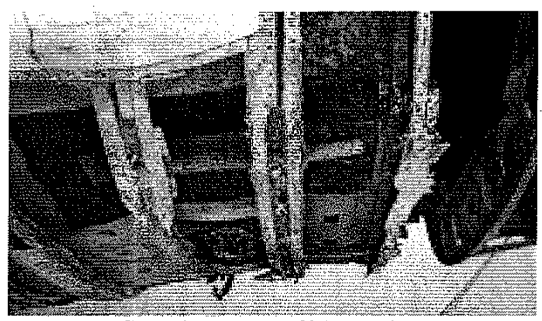


KC-135 Stratotanker

While these aging aircraft have been in service for many years, they are expected to serve for many more. Of the aircraft mentioned, only the C-141 and C-130E/H have a replacement in full production with the C-17 and C-130J respectively. Other aircraft replacements are in various development stages or have no replacements identified.

Flight hours and environmental exposure take their toll on aircraft. As expected, when mechanical equipment ages, detection and repair of normal wear, fatigue cracking and corrosion make up a larger portion of maintenance cost. In 1994 a US Air Force Scientific Advisory Board report noted that airframe corrosion is the is the single most costly maintenance problem for Air Force aging aircraft.

Military aircraft spend most of their life on the ground, often in warm humid environments and it is well known that metals with corrosion potential will eventually corrode in the presence of an electrolyte. Severe corrosion of an F-86 lower fuselage section shown in the photograph (right) shows the contributing effect of water. While this corrosion was likely due to neglect after the aircraft was deactivated there was clearly much less corrosion damage on the upper section of the fuselage where moisture did not accumulate.



Corrosion on a non-flight-worthy F-86 aircraft fuselage built in the late 40's

It is not practical to keep aircraft dry to avoid corrosion but factors that can be controlled are design configuration, material selection, part processing, assembly practices, protective coatings and maintenance. Much of the corrosion found on aging aircraft can be related to one or more of these factors.

NOTICE: Tech Notes has been transitioned to an electronic format and electronic delivery. To be added to Tech Notes distribution, please submit your e-mail address, as well as your company name and mail address, to: paul.e.rempes@boeing.com or Phone (314) 233-1541 or FAX (314) 233-8578.

The design phase is the first opportunity to minimize the potential for corrosion. Avoiding dissimilar material contact and designing structures with adequate drainage paths will greatly minimize the effects of moisture. Internal structural components should be designed in such a manner that they can be sealed to avoid moisture intrusion. However, it must be assumed that leaks will occur. When moisture gets inside, the design should permit it to escape quickly. Proper location of drain holes will remove gross moisture. Insulation and other materials that will retain moisture should be well protected from wetting or isolated from materials subject to corrosion.

Aircraft material selection is typically a compromise of strength, weight, corrosion resistance, producibility and cost. The majority of the structure of an older aircraft fleet is made of aluminum. Early aluminum alloys and some heat treatments such as 7075-T6 are no longer used. More corrosion resistant alloys have been developed and are in use on more recent designs.

Detail part surface treatments for aluminum, such as chromate conversion coating and anodizing, are the first level of corrosion protection. In addition to the inherent protection afforded by the surface treatment it also aids adhesion of the paint primers that can only protect if they are in intimate contact with the metal.

Assembly practices can inadvertently negate a good design. Typical assemblies with adequate and properly located drain holes also routinely specify fay and/or filet seals with polysulfide or similar sealant. The sealant can provide an excellent barrier to prevent water intrusion into a joint. However, if the sealant squeeze out during installation blocks the drain holes, the trapped water will likely result in corrosion.

Organic coatings, such as paint primers, are often the last corrosion protection applied to interior structures for the life of an aircraft. Spray applied paint primers containing chromate corrosion inhibitors have been used for over fifty years and have significantly improved since their introduction. The primer requirement for salt spray corrosion protection for current production Boeing fighter aircraft is twelve times that specified for use on the F-4 (a 1960s aircraft). The ability of primer to protect the structure depends not only on the quality of the primer, but also on correct surface preparation and primer application.

Maintenance cannot prevent normal wear and metal fatigue but it is a vital element in prolonging the life of an aircraft. Maintenance procedures can also negate effective designs in ways similar to the previously discussed assembly practices. In addition, during routine maintenance the original organic coatings and surface treatments are removed. Even with meticulous care it is not likely that the replacement finish will provide corrosion protection equal to the original system.

The challenges facing the military operators of an aging aircraft fleet will continue to grow as the average age of the fleet grows older. Also, most protective coatings and surface treatments currently used on aircraft contain hazardous materials that are or will be more highly regulated in the near future, driving the need for further material replacements or the use of more personal protective equipment.

For more info, contact Larry Triplett at (314) 232-2882, e-mail: larry.triplett@boeing.com

Latest Scoop on MIL-PRF-680 Degreasing Solvent

P-D-680 was a Federal Specification for dry cleaning and degreasing solvents. It was widely used by the Department of Defense in general cleaning applications. Numerous federal, state, and local environmental regulations impacted P-D-680 solvents as a hazardous waste, as an air pollutant, as a toxic substance, and as a flammable material. Another problem was that the specification was too general. MIL-PRF-680 for degreasing solvents replaced P-D-680 as of December of 1999.

P-D-680 solvents were classified into three types, primarily based upon the solvent's flash point. Type I had a minimum Flash Point of 100 F, Type II had 140 F, and Type III had 200 F. Up to 20% by volume of aromatics were allowed for Types I and II. Also, there were no vapor pressure limitations for Types I and II. Basically the MIL-PRF-680 is the P-D-680 specification with improvements which now classify the solvents into four types as compared to the previous three.

		MIL-PRF-680			
Characteristics	Type I	Type II	Type III	Type IV	
Flash Point, C	38-60	61-92	93-116	61-92	
Kauri-butanol value	27 to 45	27 to 45	27 to 45	27 to 45	
Aromatic content, vol%, max	1	1	1	1	
Dichlorobenzene, mg/L, max	0.5	0.5	0.5	0.5	
Benzene, mg/L, max	0.5	0.5	0.5	0.5	
Tetrachloroethylene, mg/L, max	0.7	0.7	0.7	0.7	
Trichloroethylene, mg/L, max	0.5	0.5	0.5	0.5	
Non-volatile residue, mg/100 mL, max	8	8	8	8	
Vapor Pressure, mm Hg @ 20 C, max.	7	2	0.4	2	
			P-D-680		
Characteristics	Type I	Type IA	Type II	Type IIA	Type III
Flash Point, C, min.	38	38	60	60	93.3
Kauri-Butanol value	29 to 45	29 to 45	29 to 45	29 to 60	27 to 45
Aromatics, max % by volume	20	1	20	1	1
Non-volatile residue (mg/100 ml), max.	10	2.5	10	2.5	10
Vapor pressure, Torr @ 20C, max.	-----	0.2	------	0.03	-------
Note: Types IA and IIA were created by the Navy (under interim amendment) for a low residue P-D-680					

Fig. 1 - Key Characteristics of MIL-PRF-680 vs. P-D-680

Figure 1 highlights the differences between the two. A new Type IV, d-limonene/hydrocarbon blend solvent, was added. The lower aromatic content limit of 1% by volume is required to reduce the toxicity of the solvent. Carcinogenic chemicals, such as benzene, are further restricted to a 0.5 mg/L maximum. A small amount is allowed so as not to eliminate all current materials from use. Previously only the P-D-680 Type III had a vapor pressure limit. In the new PRF specification, all four types have a vapor pressure acceptance limit to control VOC levels. The non-volatile residue limit was only slightly lowered in the new spec. Also, a soil cleaning test has been added to assess solvency of MIL-PRF-680 solvents.

The military's need for more environmentally compliant P-D-680 solvents, led to the formation of a tri-service (Army, Air Force, Navy, and DLA) working group. In Phase I of the working group's plan, they conducted user surveys for these solvents. Fifty-four responses were received from various military headquarters. Twenty-five percent of the users surveyed used P-D-680 Type I; 63% used Type II; and 12% used Type III. The users identified P-D-680 as an excellent degreaser, but knew that it had environmental problems, such as high VOCs, and was somewhat toxic, etc. The users also preferred hydrocarbon-based solvents to other types, which often did not perform as well.

Phase II of the tri-service group's plan was to conduct field validation tests for DoD maintenance cleaning applications and to revise the P-D-680 specification. Prior to this, 82 commercial solvents were evaluated to determine cleaning performance and environmental effects. The solvents were categorized into eight classifications, such as aqueous, terpene/hydrocarbon blend, petroleum distillate hydrocarbon, ester, etc. Only the petroleum distilled hydrocarbon solvents and the terpene/hydrocarbon solvents met the current P-D-680 performance requirements. Of the original 82 solvents, 23 were identified as candidate alternatives. The group published a technical report, TARDEC (U. S. Army Tank Automotive Research, Development and Engineering Center) No. 13643 – "Replacement of P-D-680 Solvents for General Maintenance of DoD Equipment".

For the actual field demonstration, eight solvents were selected and tested over a period of three months, using various existing soil cleaning methods (parts washers, ultrasonic cleaner, etc.). All candidate solvents performed well for all applications when compared to the P-D-680 solvents, and all candidate solvents can be potentially recycled. Six of the candidates were accepted by the Army Center of Health Promotion and Preventative Medicine. The citron odor of the terpene/hydrocarbon blend solvents was not a problem in open working areas. The group published two additional technical reports. They are TARDEC No. 13730 – "Field Demonstration for P-D-680 Solvent Replacement" and TARDEC No. 13751 – "Field Demonstration for P-D-680 Solvent Replacement (Part II)".

The P-D-680 specification was converted to a military performance specification, MIL-PRF-680. It's name was changed from dry cleaning and degreasing solvent to just degreasing solvent.

One of the most important things to remember about the MIL-PRF-680 solvents is that they are for general purpose degreasing applications and not for final cleaning applications, such as cleaning prior to painting or bonding.

The above information was presented by Dr. In-Sik Rhee at the Air Force Corrosion Program Conference, March 13-17, 2000.

For more information, contact Carol Greenaway at (314) 234-0061, e-mail: carol.a.greenaway@boeing.com

Glycol Ether Team 'Pride' Recognized

The Boeing St. Louis Glycol Ether Team recently completed an effort targeting these OSHA regulated chemicals in St. Louis and St. Charles operations. Product substitution to reduce or eliminate employee exposure to hazardous materials is the premier method of control recognized by OSHA and our DoD customer as well as the Safety and Health profession. Recognition of the reproductive effects of four Glycol Ethers, (CAS#s 110-80-5, 111-15-9, 109-86-4, and 110-49-6) has heightened pressure to decrease potential personnel exposure for Boeing employees. Tech Notes (Volume 3 Number 4, November 1998) gives more detail on the subject. An extensive search was done to determine if these four chemicals were in the thousands of production materials used at St. Louis. The search produced the need for two significant substitutions of less hazardous materials.

The Harpoon Program, which maintains a 10,000 gallon JP-10 storage tank, has agreed to substitute a less hazardous non-regulated JP-10 fuel deicer (diethylene glycol monoethyl ether) in place of a more hazardous material stringently regulated by OSHA (ethylene glycol monoethyl ether). The Glycol Ether team proposed this change to Harpoon engineering personnel, who successfully pursued the substitution project with their customer (JP-5 and JP-8 fuels were found to be free of the targeted glycol ethers).

Adhesion promoting primers, Dow Corning DC 1200 (Clear & Red) and DC 1204, applied prior to silicone sealant, required the second substitution. These materials are widely used by virtually all Programs; while they did not contain a glycol ether, they reacted upon application to produce a regulated glycol ether. The replacement material, Dow Corning P5200 (Red), does not contain or produce this hazardous chemical.

These are "real world" risk reductions based on the efforts of the Glycol Ether Team working in cooperation with Program and Surface Finish Team & Laboratory Team experts. Product substitution represents the best approach to risk reduction. Minimal inconvenience, interruption or expense to the Programs and Production Operations resulted from this effort.

Team members were recognized with individual Boeing Pride Program Achievement Awards on April 28, 2000.

For more information, contact Vaughn Meister at (314) 234-0179, e-mail: vaughn.e.meister@boeing.com

NAME	CAS/ 313 Category Codes	Section 302 (EHS) TPQ	Section 304 EHS RQ	CERCLA RQ	Section 313	RCRA CODE	CAA 112(r) TQ
Sodium cacodylate	124-65-2	100/10,000	100				
Dibromotetrafluoroethane	124-73-2				313		
Halon 2402	124-73-2				X		
Picrotoxin	124-87-8	500/10,000	500				
Tris(2,3-dibromopropyl) phosphate	126-72-7			10	313	U235	
2-Propenenitrile, 2-methyl-	126-98-7	500	1,000	1,000	X	U152	10,000
Methacrylonitrile	126-98-7	500	1,000	1,000	313	U152	10,000
Chloroprene	126-99-8			100	313		
Perchloroethylene	127-18-4			100	X	U210	
Tetrachloroethylene	127-18-4			100	313	U210	
Zinc phenolsulfonate	127-82-2			5,000	313c		
Potassium dimethyldithiocarbamate	128-03-0				313		
Sodium dimethyldithiocarbamate	128-04-1				313		
C.I. Vat Yellow 4	128-66-5				313		
Pyrene	129-00-0	1,000/10,000	5,000	5,000			
Warfarin sodium	129-06-6	100/10,000	100	100	313c		
1,4-Naphthoquinone	130-15-4			5,000		U166	
Dimethyl phthalate	131-11-3			5,000	313	U102	
Sodium pentachlorophenate	131-52-2				313		
Ammonium picrate	131-74-8			10		P009	
2-Cyclohexyl-4,6-dinitrophenol	131-89-5			100		P034	
Sodium o-phenylphenoxide	132-27-4				313		
Dibenzofuran	132-64-9			100	313		
1H-Isoindole-1,3(2H)-dione, 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-	133-06-2			10	X		
Captan	133-06-2			10	313		
Folpet	133-07-3				313		
Benzoic acid, 3-amino-2,5-dichloro-	133-90-4			100	X		
Chloramben	133-90-4			100	313		
o-Anisidine hydrochloride	134-29-2				313		
alpha-Naphthylamine	134-32-7			100	313	U167	
Benzeneamine, N-hydroxy-N-nitroso, ammonium salt	135-20-6				X		
Cupferron	135-20-6				313		
Dipropyl isocinchomeronate	136-45-8				313		
Thiram	137-26-8			10	313	U244	
Ziram	137-30-4			1*		P205	
Potassium N-methyldithiocarbamate	137-41-7				313		
Metham sodium	137-42-8				313		
Sodium methyldithiocarbamate	137-42-8				X		
Disodium cyanodithioimidocarbonate	138-93-2				313		
Nitrilotriacetic acid	139-13-9				313		
3,3'-Dimethyldiphenylmethane-4,4'-diisocyanate	139-25-3				313#		
4,4'-Thiodianiline	139-65-1				313		
Benzyl cyanide	140-29-4	500	500				
Pyridine, 2-methyl-5-vinyl-	140-76-1	500	500				
Ethyl acrylate	140-88-5			1,000	313	U113	
Butyl acrylate	141-32-2				313		
Dicrotophos	141-66-2	100	100				
Ethyl acetate	141-78-6			5,000		U112	
1,3-Dichloropropane	142-28-9			5,000			

Return to the MSDS Archive . . . Search Help
Enter a whole or partial NSN or 1-3 words or character strings from manufacturer's name, product name, or CAS number..
Try one word from the manufacturer's name and one from the product name to start. Searching hints

Find PD680 ◉ Partial words ○ NSN ○ Whole words only [Search]

FORSHAW CROWN CHEMICALS INC,DBA CROWN	-- PD680 TYPE 2	-- 6850-00-274-5421
PMP INDUSTRIES	-- PD680 TYPE 2	-- 6850-00-274-5421
PHIPPS PRODUCTS	-- PD680 TYPE 2	-- 6850-00-274-5421
PACKAGING SERVICES	-- PD680 TYPE 2	-- 6850-00-274-5421
UNION OIL OF CALIFORNIA UNION CHEMICAL	-- PD680A TYPE II	-- 6850-00-274-5421

RE: PERC Content of P-D-680 before 1990
John Stassi to: Cynthia Brown 03/24/2009 03:59 PM
Cc: Beth Wagner

History: This message has been forwarded.

Hi Cindy,

Here's an orphan document that contains a table showing p-d-680 content before 1988:

> WASTE MINIMIZATION OPPORTUNITIES FOR PETROLEUM-BASED SOLVENTS
> Ronald A. Vogel Kimberly G. Murray
> Lee Wan & Associates, Inc. Martin Marietta Energy Systems
> Oak Ridge, Tennessee 37830 Oak Ridge, Tennessee 37830
>
> EXCERPT:
> The most recent federal specification, **dated September 14, 1988**, specifies the characteristics for both types of PD 680A, as shown in Table 1.
> [table showing 500 ppm chlorine content in 1988 on page numbered 49]
> http://www.p2pays.org/ref/03/02117.pdf

I'll be looking for specifications for this solvent dating from further back than this one.

I guess the question that arises is this: How many gallons of max 500 ppm perc (assuming chlorine content is all in that form) would have to be spilled to account for measured levels of perc in ground water beneath site?

A table entitled **Proposed Target Requirements for the Revision C of P-D-680 Specification** in this more recent publication:

> **HTIS BULLETIN Vol.9 No.3**
> **May - June 1999**
>
> **Environmentally Compliant P-D-680 Solvents**
> by Dr. In-Sik Rhee, TARDEC
> http://www.p2pays.org/ref/20/19926/p2_documents/htis_docs/MayJun99.htm

divides allowed chlorine content among various chlorinated hydrocarbons, including allowances for tetrachloroethylene.

Here is another old document, 1985, that talks about what sorts of solvents were used in DoD at that time for degreasing:

> **RECOVERY, REUSE, AND RECYCLE OF SOLVENTS**

Defense Environmental Leadership Project
1717 H Street N.W., Room 202
Washington, D.C. 20006 - 3901
(202) 653-1273, AV 294-1273
Richard W. Boubel, Ph.D., P.E.
December 1985

[excerpt, page 2]

SOLVENT USE BY DOD
[...]
Appendix C is a partial listing of solvents used by DoD.
Solvent usage by DoD facilities is extensive as to the quantity used but can be grouped into a short list as to the systems using the solvent:

Metal Cleaning - This includes processes such as degreasing before finishing, oil and grease removal for cleanup, protective surface removal, and cleaning of wheel bearings. **Both hydrocarbon solvents and halogenated solvents are used for metal cleaning. Examples are PD-680, 1,1,1 Trichloroethane, and Tetrachloroethylene (Perc).**

http://www.p2pays.org/ref/23/22271.pdf

Search this last document using 680 and you can see in Appendix C how many solvents with different National Stock Numbers but all with this P-D-680 name in were in use in 1985.

I found all of these documents on this website:
http://www.p2pays.org/

More later,

John Stassi / ASRC Management Services
Chemical Reference Librarian, EPA Headquarters & Chemical Libraries
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P-D-680
March 27, 1963

SUPERSEDING
Int. Fed. Spec. P-S-00661c(GSA-FSS)
June 13, 1962 and
Fed. Spec. P-S-661b
April 6, 1953

FEDERAL SPECIFICATION

DRY CLEANING SOLVENT

This specification was approved by the Commissioner, Federal Supply Services, General Services Administration, for the use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 **Scope.** This specification covers two types of petroleum distillates employed for dry cleaning of textile materials, and referred to industrially as "Stoddard Solvent" and as "140° F. Solvent".

1.2 **Classification.**

1.2.1 *Types.* Dry-cleaning solvent shall be of the following types, as specified:

Type I.—100°F. Solvent (Stoddard Solvent).

Type II.—140°F. Solvent.

2. APPLICABLE SPECIFICATIONS, STANDARDS, AND OTHER PUBLICATIONS

2.1 Specifications and Standards. The following specifications and standards, of the issues in effect on date of invitation for bids, form a part of this specification:

Federal Standards:

Fed. Std. No. 102—Preservation, Packaging, and Packing Levels.
Fed. Std. No. 123—Marking for Domestic Shipment (Civilian Agencies).
Fed. Test Method Std. No. 791—Lubricants, Liquid Fuels, and Related Products; Methods of Testing.

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications, Standards, and Handbooks and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

(Single copies of this specification and other product specifications required by activities outside the Federal Government for bidding purposes are available without charge at the General Services Administration Regional Offices in Boston, New York, Washington, D. C., Atlanta, Chicago, Kansas City, Mo., Dallas, Denver, San Francisco, and Auburn, Wash.

(Federal Government activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications, Standards, and Handbooks from established distribution points in their agencies.)

Military Standards:

MIL-STD-105—Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-129—Marking for Shipment and Storage.
MIL-STD-290—Packaging, Packing and Marking of Petroleum and Related Products.

(Copies of Military Specifications and Standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 **Other publications.** The following publications form a part of this specification. Unless otherwise indicated, the issues in effect on date of invitation for bids shall apply:

American Society for Testing and Materials Publication:

Part 7—Petroleum Products and Lubricants.

(Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia 3, Pennsylvania.)

Uniform Classification Committee Publication:

Uniform Freight Classification Rules.

(Application for copies should be addressed to Uniform Classification Committee, 202 Union Station, Chicago 6, Illinois.)

3. REQUIREMENTS

3.1 **Material.** The material shall be a petroleum distillate.

3.2 **Physical and chemical properties.** The physical and chemical properties of the solvents shall conform to the requirements specified in table I.

3.3 **Workmanship.** The dry cleaning solvent shall be clear, free from suspended matter and undissolved water as determined by visual inspection.

4. SAMPLING, INSPECTION, AND TEST PROCEDURES

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examinations and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

TABLE I. *Physical and chemical properties*

	Type I	Type II	Test Para.
Appearance	Clear, free from suspended matter, and undissolved water		4.4.2
Color, Saybolt, not greater than ...	21	21	
Odor	Sweet	Sweet	4.4.3
Corrosion of copper strip 212° F. for 3 hours	Slight tarnish[1]		
Distillation range:			
Initial boiling pt., min.	300° F.	350° F.	
50% distilled by vol., min.	350° F.	375° F.	
End point, max. .	410° F.	415° F.	
Distillation residue, max.	1.5%	1.5%	4.4.4
Acidity-reaction of residue to methyl orange	Neutral	Neutral	4.4.5
Doctor test	Negative	Negative	4.4.1
Flash Point, Tag Closed Cup, min.	100° F.	138° F.	4.4.1
Sulfuric acid absorption, max. ..	5%	5%	4.4.1

[1] Shall correspond to classification number 1 of ASTM designation D 130.

4.2 **Sampling.**

4.2.1 *Lot.* For purposes of sampling, a lot shall consist of solvents from one batch or tank offered for delivery at one time. If material cannot be identified by batch or tank, a lot shall consist of not more than 10,000 gallons offered for delivery at one time.

4.2.2 *Sampling for inspection of containers.* A random sample of filled containers shall be taken by the Government inspector in accordance with Military Standard MIL-

STD-105 at inspection level I and acceptable quality level — 2.5 percent defective to verify compliance with this specification in regard to fill, closure, marking, and other requirements not involving tests.

4.2.3 *Sampling for tests.* From each inspection lot (see 4.2.1), the inspector shall take two containers at random. From each of the two containers 1-quart specimens shall be taken and placed in separate, clean, dry, metal, or glass containers, and then sealed, marked, and forwarded to the testing laboratory designated by the procuring activity.

4.3 **Inspection of containers.** Each sample filled container shall be examined for defects of construction of the container and the closure, for evidence of leakage, and for unsatisfactory markings; each filled container shall be weighed to determine the amount of contents. Any container in the sample having one or more defects, or under required fill, shall be rejected and if the number of defective containers in any sample exceeds the acceptance number for the appropriate sampling plan of MIL-STD-105, the lot represented by the sample shall be rejected.

4.4 **Test procedures**

4.4.1 *Physical and chemical properties.* These determinations shall be made in accordance with the methods specified in table II.

4.4.2 *Appearance.* Examine the solvent for undissolved water, sediment and suspended matter by the use of transmitted light.

4.4.3 *Odor.* If the odor is questionable the following test shall be performed. Desized and laundered bleached cotton cloth of 3.6 to 4.0 ounces per square yard shall be used for this test. The cloth when lightly steamed shall have no odor except that of clean cotton cloth. The cloth shall be conditioned at 50 to 80 percent R.H. and 65° to 90°F. for 4 hours. A piece of the conditioned cloth approximately 12 inches square shall be placed in 100 milliliters of solvent so as to be completely submerged, and allowed to soak for 5 minutes. The cloth shall then be removed, drained, but not squeezed or extracted and hung at room temperature for 2 hours. The cloth shall then be dried in a stream of fresh air heated to 140° to 160° F. (60° to 71°C.) for 1 hour. The odor of the dried cloth when steamed over boiling water for 4 to 5 seconds, shall not differ from that of an untreated sample similarly steamed.

TABLE II. *Test procedures*

	Applicable method in Fed. Test Method Std. No. 791	Test method paragraph	Requirement paragraph
Appearance	—	4.4.2	Table I
Color	101.6	—	Table I
Odor	—	4.4.3	Table I
Copper Corrosion	5325.2	—	Table I
Distillation			
Distillation range	1001.9		Table I
Distillation residue		4.4.4	Table I
Acidity	—	4.4.5	Table I
Doctor test	5203.2	—	Table I
Flash point	1101.5	—	Table I
Sulfuric Acid Absorption	(See Note)	—	

Note: Determine according to ASTM D484-52.

4.4.4 *Distillation residue.* Pour the distillation residue from the flask into a small cylinder graduated to 0.1 milliliter. Cool, measure and record the volume as residue.

4.4.5 *Acidity.* Make this test immediately after recording the volume of distillation residue. Transfer the cooled residue to a test tube, add three volumes of distilled water, and shake the tube thoroughly. Allow the mixture to separate and remove the aqueous layer to a clean test tube by means of a pipette. Add 1 drop of 0.1 percent aqueous solution of methyl orange. A pink or red color indicates the presence of mineral acid.

5. PREPARATION FOR DELIVERY

For civil agency procurement, the definitions and applications of the levels of packaging and packing shall be in accordance with Fed. Std. No. 102.

5.1 Packaging and packing.

5.1.1 *Levels A and B.* The solvent shall be packaged and packed in accordance with MIL-STD-290 as specified for the applicable level (see 6.2).

5.1.2 *Level C.* Commercial unit and bulk containers shall be packed so as to be acceptable by common or other carriers for safe transportation to point of destination specified in shipping instruction at the lowest transportation rate.

5.2 Marking.

5.2.1 *Civil agencies.* In addition to any special marking required by the contract or order, marking for shipment shall be in accordance with Fed. Std. No. 123.

5.2.2 *Military agencies.* In addition to any special marking required by the contract or order, marking for shipment shall be in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The product is intended for use as a dry-cleaning solvent.

6.1.1 Type I is intended for use as a comparatively safe dry-cleaning solvent.

6.1.2 *Type II is intended for use in dry-cleaning plants where a solvent with a higher flash-point is desirable as an additional safety factor.*

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number and date of this specification.

(b) Type of solvent required (see 1.2).

(c) Size of containers and level of protection required (see 5.1 and 5.2).

6.3 Purchase unit. The solvent shall be purchased by volume, the unit being a U.S. gallon of 231 cubic inches at 60°F. (15.6°C.). The volume may be determined by dividing the net weight, in pounds, by the weight per gallon.

6.4 Transportation description. Transportation descriptions and minimum weights applicable to this commodity are:

Rail:

Chemicals, not otherwise indexed by name.

Carload minimum weight 24,000 pounds, subject to Rule 34, Uniform Freight Classification.

Motor:

Chemicals, not otherwise indexed.

Truckload minimum weight 24,000 pounds, subject to Rule 115, National Motor Freight Classification.

6.5 Certification. Solvent delivered in cans, drums, or tank cars shall either be accompanied by an official gager's certificate showing the net contents of each container and also the temperature of the contents at the time of gaging or shall be subject to gaging by the Government inspector. In the absence of a statement of the temperature at the time of gaging on the official gager's certificate, or in case the barrels show evidence of loss by leakage or other shortages, the delivery shall be subject to *re-inspection* and re-gaging by the Government inspector.

Notice. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

MILITARY INTERESTS:

Army—MU MR GL

Navy—Sh

Air Force—MAAMA

Copies of this specification may be purchased for 5 cents each.

THE RIGHT P-D-680 REPLACEMENTS

THE SEARCH CONTINUES

Regulatory agencies are closely scrutinizing P-D-680 use in areas where Naval Air Systems Command (NAVAIR) facilities operate. Recent developments in finding viable non-toxic P-D-680 alternatives have come about rapidly, so read on to find out about allowable substitutes, applications, and how they will impact operations.

Concerns About P-D-680

P-D-680, commonly referred to as "dry cleaning solvent," is a petroleum-based chemical widely used throughout NAVAIR as a cleaner for aircraft bearings, hydraulic system assemblies, weapons, and engine components. Right now we use three types of P-D-680 – Types I, II and III, which vary according to their flashpoints. A typical Aviation Intermediate Maintenance Department (AIMD) uses approximately 1,500 gallons of P-D-680 (Types II and III) annually. Similar amounts are estimated for the Marine Air and Logistic Squadrons (MALS) throughout the Marine Corps.

There are a number of concerns about the safe and consistent use of P-D-680, as Types I and II may contain toxic substances and Hazardous Air Pollutants (HAPS) although Type III does not. In addition to these concerns, certain Air Pollution Control Districts (APCDs) in California will soon require a limitation of volatile organic compound (VOC) content of solvents used in immersion tanks to 50gm/l or less, or otherwise require sophisticated airtight cleaning systems. We anticipate this pending requirement to impact the San Joaquin Valley air district by January 2002. The South Coast APCD already has such a rule in place, and may lower the VOC limit to 25gm/l. In the future, we expect these stringent limits to impact all Navy operations in California, and eventually the entire United States.

The New P-D-680 Specification

The P-D-680 specification was recently revised and is superceded with MIL-PRF-680. This new specification differs from the old in several aspects, the first being the introduction of one new type of petroleum solvent with non-toxic compositions. Of these new solvents, Type IV has the same flashpoint as that of the old Type II (140 degrees Fahrenheit) and may contain d-limonene co-solvents with a citrus odor. According to the United States Army, the custodian of the newly issued MIL-PRF-680 specification, all four of these new solvents are not classified under EPA lists as being toxic or hazardous. These new solvents are recyclable, and better yet, their performance is fully equivalent to the formerly qualified P-D-680 solvents. (For further information, consult R U 232043Z TECHNICAL ADVISORY MESSAGE #101, REPLACEMENT OF P-D-680. The Army Petroleum Center point of contact is Cathy Freeman, DSN 977-5868, and commercial 717-770-5868).

Compliance in California

While the new MIL-PRF-680 solvents are non-toxic, they have about the same VOC content as P-D-680. Therefore, to address current regulations and future compliance issues in the APCDs in California, solvent immersion cleaning processes are the primary focus of an Aviation Pollution Prevention Technology (APPTec) Project. A project team is identifying and prioritizing P-D-680 usage throughout the Fleet, and will be concentrating on providing approved substitutions via Organizational, Intermediate, and Depot-level manual changes.

Substitutes for solvent cleaning of aviation bearings, aircraft engine components, hydraulics, and weapons are currently being evaluated. The substitutes may be traditional non-solvent cleaners that are already approved via NAVAIR general series manuals, such as the Aircraft Cleaning and Corrosion Control manual (NA 01-1A-509). Alternatively, the substitutes may be new materials that are being qualified by on-going evaluation projects. In both cases, approved substitutions will be implemented as these new materials are qualified. There are requirements for P-D-680 identified in maintenance manuals that may simply be eliminated. In those cases where solvent cleaning is the most appropriate for the component and an approved substitute is not thoroughly approved, alternative low/no emission equipment will be investigated to allow the user to continue to use P-D-680 materials to perform critical required maintenance.

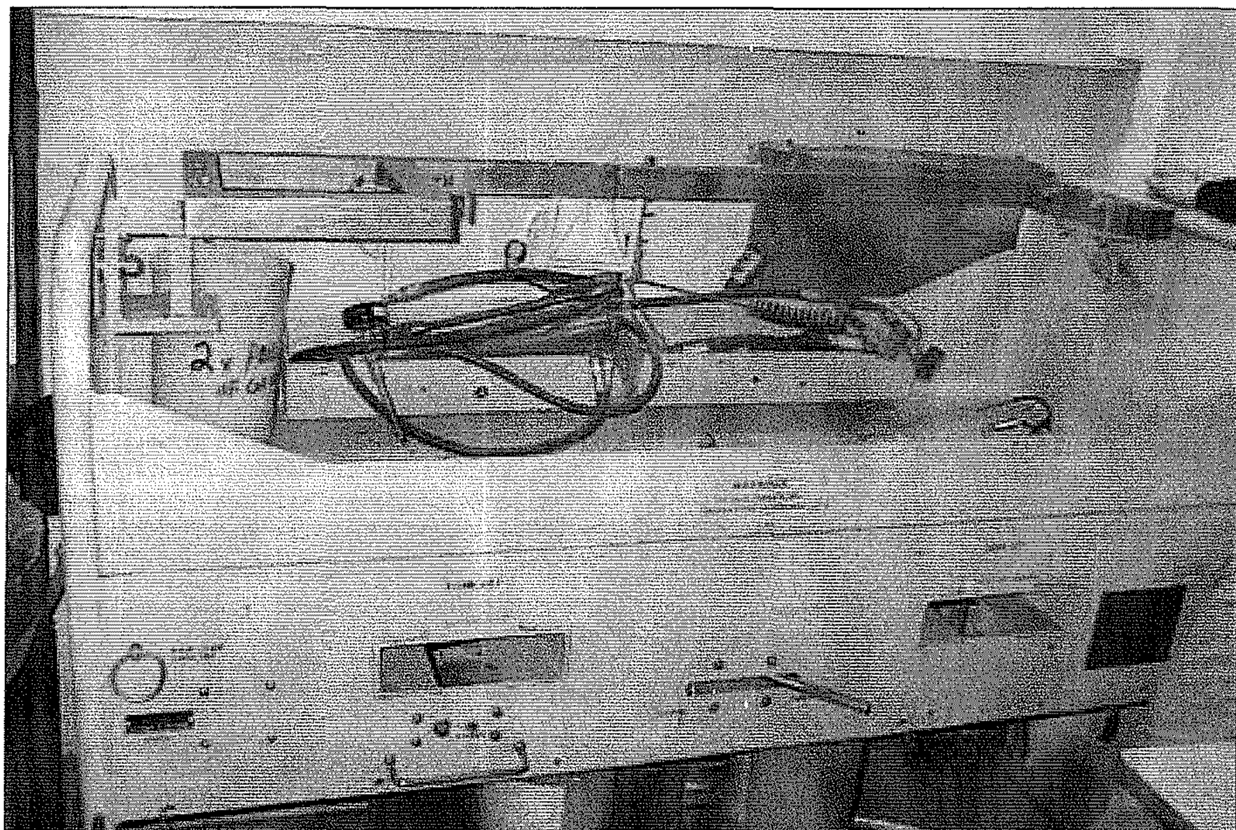
In the Interim

There are many commercial vendors contacting Fleet maintainers to "sell" their products as the "environmentally compliant answer to P-D-680." However, it is important for the Fleet to continue to use the approved maintenance materials that are listed in either NAVAIR 01-1A-509 or specific weapon system manuals. If your manual refers to P-D-680 Type II or III, then Mil-PRF-680 Type II or III is an equivalent material that you may use.

If you have questions as to whether or not a cleaner is approved for use within NAVAIR, please feel free to contact any member of the P-D-680/APPTec team listed on the following page.

POCs:

- Stacey Luker
- NADEP Cherry Point
  - 252-464-8142
  - DSN: 451-8142
  - lukerss@navair.navy.mil
- Tim Woods
- NADEP North Island
  - 619-545-9757
  - DSN: 735-9757
  - woodstr@navair.navy.mil
- Dayle Dierks
- NAWCAD Patuxent River
  - 301-342-8058
  - DSN: 342-8058
  - dierksda @navair.navy.mil
- Gerald Roth
- NADEP Jacksonville
  - 904-542-3444
  - DSN: 942-3444
  - rothgp@navair.navy.mil
- Jim Ambrosino
- NAES Lakehurst
  - 732-323-7904
  - DSN: 624-7904
  - ambrosinoja @navair.navy.mil
- Steve Wright
- Point Mugu
  - 805-484-6488
  - DSN: 893-6488
  - wrights@navair.navy.mil



Specialized P-D-680 Cleaning Equipment

News Publications

Topic: RSS Feed

Bye-bye P-D-680

PS: The Preventive Maintenance Monthly , May, 2005

- Email
- Print

Mechanics, P-D-680 cleaning solvents have been around a long time. As of right now, P-D-680 Types I, II and III are cancelled and have been replaced with environmentally safer cleaning solvents.

Aviation and ground support users, do not order P-D-680 of any type from the supply system. Instead, order MIL-PRF-680, the safer cleaning solvents with the following NSNs:

When using these hazardous solvents, be cautious. The flash points are 100[degrees]F for Type I, 140[degrees]F for Type II and 200[degrees]F for Type III. Use all safety precautions when using flammable liquids.

Wear the appropriate protective gear, such as face shield, rubber gloves and a respirator if required by your local environmental SOP.

Related Results

- BNET Daily Dispatch: Yahoo, Doral, Comcast, and KFC
- Give Your Treo a Battery Boost
- Moving West, Chase Needs WaMu's Branches
- Fred Hassan, Schering's $30 Million Man
- Predictify Test

MIL-PRF-680 Type I

NSN 6850-01-474-	Size
2302	1 gal
2309	5 gal
2313	55 gal

MIL-PRF-680 Type II

NSN 6850-	Size
01-474-2319	1 gal
00-246-6112	5 gal
01-474-2317	5 gal
01-474-2719	55 gal

EXCELLENT INSTALLATIONS

DEPARTMENT OF DEFENSE

UNITED STATES OF AMERICA

THE FOUNDATION OF DEFENSE

RECOVERY, REUSE AND RECYCLE OF SOLVENTS

DECEMBER 1985

DEFENSE ENVIRONMENTAL LEADERSHIP PROJECT

VP
7

RECOVERY, REUSE, AND RECYCLE OF SOLVENTS

Defense Environmental Leadership Project

1717 H Street N.W., Room 202

Washington, D.C. 20006 - 3901

(202) 653-1273, AV 294-1273

Richard W. Boubel, Ph.D., P.E.

December 1985

INDEX

INTRODUCTION

Sol-vent (sol'vent, solv)n 1. Chem. a. The component of a solution that is present in excess or that undergoes no change of state. b. A liquid capable of dissolving another substance, "The American Heritage Dictionary," Second College Edition.

The broad term, "Solvents," covers a wide spectrum of chemicals used for many purposes. 80 percent of all manufacturing companies use solvents. The quantity of solvents used by the Department of Defense (DoD) is exceeded only by the quanity of fuel, when organic chemicals are inventoried. The generation of waste solvents, with their subsequent disposal, is one of the most significant hazardous waste problems of the services today.

In past years, waste solvents were disposed of in the manner most convienient to the user of the solvent. Little thought was given to economics or environmental effects. Solvents were considered as expendable supplies. Today, because of the regulations concerning disposal of hazardous wastes plus the economics of solvent disposal and replacement, solvent recovery, reuse, and recycle (R^3) is mandated as DoD policy.

- R^3 is practiced to assure compliance with regulations. These regulations may be DoD or other governmental units such as the U.S. Environmental Protection Agency (EPA) or state or local agencies.

- R^3 eliminates concern for future liability, groundwater contamination, etc.

- R^3 is most successfully practiced by the facility which generates the waste. If no other facility or agency is involved, the total responsibility remains with the generating facility.

- R^3 eliminates the need for the permits and other paper work necessary to dispose of large volumes of hazardous waste. The solvent stays in a logical cycle instead of being continually supplied, used, and disposed of.

- R^3 results in cost savings that are real and impressive. Even for solvents costing a dollar or two per gallon, the total disposal cost may be as high as $10 per gallon. Previously, the true disposal costs were hidden from the user because they are paid by the Defense Reutilization and Marketing Office (DRMO), not the facility.

- Some DRMO's were selling used solvents for a few cents on the dollar of their original cost. If it was economical for off-facility recyclers to deal in used solvents, it stands to reason that R^3 by the facility itself will be economical.

DEPARTMENT OF DEFENSE USED SOLVENT ELIMINATION PROGRAM

Recognizing a need to improve DoD solvent disposal practices, a Used Solvent Elimination (USE) program was initiated by Assistant Secretary of Defense, Dr. Lawrence J. Korb, on 10 January 1984. The USE program has the goal of eliminating by October 1, 1986, disposal of recyclable solvents as wastes. Appendix A is a summary of the USE program.

The specific guidance for the USE program states the intent of DoD:

The preferred disposition of used solvents is recycling either on or off the generating installation, using solvent reclamation equipment. Even relatively small systems can pay back the intial capital investment in a few years. Disposal of most non-chlorinated solvents (e.g., mineral spirits) by burning as a fuel replacement to extract the heating value is an acceptable form of recycle. Burning solvents for disposal purposes only is not acceptable.

An alternative means of solvent disposal is sale through a Defense Reutilization and Marketing Office. This should be used only if there are overriding reasons which rule out recycle. To ensure that recycling is used where feasible, decisions to dispose of solvents through a DRMO must be reviewed by higher headquarters. The review must be accomplished by knowledgeable personnel, with appropriate technical assistance if required. The higher headquarters must be a flag officer command.

Disposal of oganic solvents as waste is not acceptable except for that small fraction of the total solvent waste stream which cannot be recycled (i.e., the still bottoms and sludges) or for small volumes (less than 400 gallons per year, total, of all solvents generated at one installation). Disposal of small volumes of waste must be by sale to a resource recovery facility or by transfer to an approved hazardous waste disposal facility.

DEPARTMENT OF DEFENSE INCENTIVE PROGRAM FOR HAZARDOUS WASTE REDUCTION/RECYCLING

The Defense Environmental Leadership Project (DELP), is promoting and supporting the Productivity Enhancing Capital Investment (PECI) program which is administered by the Defense Productivity Program Office (DPPO). The PECI program provides up-front money to fund capital investments, such as solvent stills and collection systems, and provides incentives to allow the use of the benefits, in excess of the cost, to be used as discrtionary funds by the installation commander. Appendix B explains this incentive program and also contains the DoD Instruction on the PECI program. Because of the favorable pay-back potential of many solvent R^3 systems, the PECI program not only enables rapid purchase of the system but can return much more money to the base commander than the present practice of sales through the DRMO.

SOLVENT USE BY DOD

The key to successful solvent R^3 is complete segregation throughout the entire solvent use cycle. Do not mix solvents, do not contaminate solvents with water or foreign material, and make sure that solvent containers are properly labled (Solvent name, new or used, contact point for responsibility, contaminent etc.) Appendix C is a partial listing of solvents used by DoD.

Solvent usage by DoD facilities is extensive as to the quantity used but can be grouped into a short list as to the systems using the solvent:

Metal Cleaning - This includes processes such as degreasing before finishing, oil and grease removal for cleanup, protective surface removal, and cleaning of wheel bearings. Both hydrocarbon solvents and halogenated solvents are used for metal cleaning. Examples are PD-680, 1,1,1 Trichloroethane, and Tetrachloroethylene (Perc).

6810-00-584-4070	ASTM D 846	XYLENE, TECH
6810-00-616-9188	MIL-D-6998	DICHLOROMETHANE
6810-00-663-9417	O-M-232	METHANOL, TECH
6810-00-664-0275	O-T-620	TRICHOLROETHANE, TECH
6810-00-664-0388	O-T-620	TRICHOLROETHANE, TECH
6810-00-664-5278	TT-N-97	NAPHTHA, AROMATIC
6810-00-805-9798	O-C-940	CYCLOHEXYLAMINE, TECH
6810-00-819-1128	O-T-236	TETRACHLOROETHYLENE, TECH
6810-00-823-8011	O-E-760	ALCOHOL, DENATURED
6810-00-855-1158	TT-I-735	ISOPROPYL, ALCOHOL, TECH
6810-00-855-6160	TT-I-735	ISOPROPYL, ALCOHOL, TECH
6810-00-922-0866	MIL-E-50011	MONOETHANOLAMINE, TECH
6810-00-926-8993	TT-I-735	ISOPROPYL ALCOHOL, TECH
6810-00-944-2124	O-E-760	ALCOHOL, DENATURED
6810-00-955-6489	O-E-760	ALCOHOL, DENATURED
6810-00-968-6181	O-E-760	ALCOHOL, DENATURED
6810-01-013-2541	O-T-236	TETRACHOROETHYLENE, TECH
6810-01-089-5514	MIL-I-85470	INHIBITOR, ICING, FUEL SYSTEM
6810-01-097-2020	O-T-236	TETRACHLOROETHYLENE, TECH
6810-01-099-3435	O-T-236	TETRACHLOROETHYLENE, TECH
6810-01-745-5201	O-C-940	CYCLOHEXYLAMINE, TECH
6830-00-104-2654	MIL-M-12218	MONOBROMOTRIFLUOROMETHANE, TECH
6830-00-181-7324	MIL-M-12218	MONOBROMOTRIFLUOROMETHANE, TECH
6830-00-227-0441	BB-F-1421	MONOCHLORODIFLUOROMETHANE, TECH
6830-00-269-4300	BB-F-1421	DICHLOROETERATFLUOROETHANE, TECH
6830-00-285-5887	MIL-B-38741	BROMOCHLORODIFLUOROMETHANE, TECH
6830-00-543-6623	MIL-M-12218	MONOBROMOTRIFLUOROMETHANE, TECH

6830-00-597-6663	MIL-D-4540	DIBROMODIFLUOROMETHANE, TECH
6830-00-882-1794	BB-S-1419	SULFUR HEXAFLUORIDE, TECH
6830-00-965-2309	MIL-B-38741	BROMOCHLORODIFLUOROMETHANE, TECH
6830-00-965-9647	MIL-M-12218	MONOBROMOTRIFLUOROMETHANE, TECH
6830-00-985-7283	BB-S-1419	SULFUR HEXAFLUORIDE, TECH
6830-00-985-7284	MIL-D-4540	DIBROMODIFLUROMETHANE, TECH
6830-00-171-5854	MIL-B-38741	BROMOCHLORODIFLUOROMETHANE, TECH
6850-00-033-8851	MIL-C-81302	CLEANING COMPOUND, SOLVENT
6850-00-060-5312	MIL-I-276861	INHIBITOR, ICING, FUEL SYSTEM
6850-00-097-9632	O-L-298	LITHOGRAPHIC BLANKET-ROLLER WASH
6850-00-167-4701	MIL-C-81302	CLEANING COMPOUND, SOLVENT
6850-00-174-1806	MIL-A-11755	ANTIFREEZE
6850-00-181-7933	MIL-A-46153	ANTIFREEZE
6850-00-181-7940	MIL-A-46154	ANTIFREEZE
6850-00-209-7947	O-C-1889	CLEANING COMPOUND SOLVENT
6850-00-249-8029	MIL-C-372	CLEANING COMPOUND RIFLE BORE
6850-00-264-5771	MIL-C-7024	CALIBRATING FLUID, AIRCRAFT FUEL SYSTEM
6850-00-264-9037	P-D-680	DRY CLEANING SOLVENT
6850-00-264-9066	MIL-C-6864	CLEANING COMPOUND, SOLVENT
6850-00-269-8388	MIL-C-7024	CALIBRATING FLUID, AIRCRAFT FUEL SYSTEM
6850-00-274-5421	P-D-680	DRY CLEANING SOLVENT
6850-00-280-1751	MIL-T-81772	THINNER ALIPAHTIC POLYURETHANE COAT
6850-00-281-1985	A-A-711	DRY, CLEANING SOLVENT
6850-00-281-3042	P-C-111	CARBON REMOVING COMPOUND
6850-00-285-4321	MIL-C-25107	CARBON REMOVING COMPOUND
6850-00-285-8011	P-D-680	DRY CLEANING SOLVENT
6850-00-285-8012	P-D-680	DRY CLEANING SOLVENT

6850-00-291-0964	O-L-298	LITHOGRAPHIC BLANKET-ROLLER WASH
6850-00-292-9700	O-C-1824	CLEANING COMPOUND SOLVENT
6850-00-292-9701	O-C-1824	CLEANING COMPOUND SOLVENT
6850-00-543-7801	MIL-C-19853	CARBON REMOVING COMPOUND
6850-00-550-7453	MIL-C-19853	CARBON REMOVING COMPOUND
6850-00-551-3694	MIL-C-6864	CLEANING COMPOUND, SOLVENT
6850-00-558-1248	MIL-A-8243	DEICING-DEFROSTING AND ANTI-ICING F
6850-00-576-9842	MIL-C-25107	CARBON REMOVING COMPOUND
6850-00-584-4685	MIL-A-8243	DEICING-DEFROSTING AND ANTI-ICING F
6850-00-619-7715	O-C-1889	CLEANING COMPOUND SOLVENT
6850-00-637-6135	P-D-680	DRY CLEANING SOLVENT
6850-00-656-0810	MIL-C-7024	CALIBRATING FLUID, AIRCRAFT FUEL SYSTEM
6850-00-664-1409	A-A-870	ANTIFREEZE
6850-00-664-1409	O-A-548	ANTIFREEZE
6850-00-681-5688	MIL-C-81302	CLEANING COMPOUND, SOLVENT
6850-00-753-4806	MIL-C-372	CLEANING COMPOUND, RIFLE BORE
6850-00-753-5061	MIL-I-27686	INHIBITOR, ICING, FUEL SYSTEM
6850-00-754-2670	MIL-F-27351	CALIBRATING FLUID, AIRCRAFT FUEL SYSTEM
6850-00-764-6999	O-L-298	LITHOGRAPHIC BLANKET-ROLLER WASH
6850-00-803-6420	MIL-C-25107	CARBON REMOVING COMPOUND
6850-00-823-7934	P-D-680	DRY CLEANING SOLVENT
6850-00-901-0591	MIL-A-8243	DEICING-DEFROSTING AND ANTI-ICING F
6850-00-905-9098	MIL-H-81829	HEAT TRANSFER FLUID
6850-00-941-5045	O-C-1889	CLEANING COMPOUND SOLVENT
6850-00-952-7185	O-C-1889	CLEANING COMPOUND SOLVENT
6850-00-965-2323	P-C-111	CARBON REMOVING COMPOUND
6850-00-965-2356	MIL-F-38299	FLUID, PURGING, PRESERVING, FUEL SYSTEM

SAFETY-KLEEN 105 SOLVENT RECYCLED
MATERIAL SAFETY DATA SHEET FOR USA AND CANADA

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: SAFETY-KLEEN 105 SOLVENT RECYCLED

SYNONYMS: Parts Washer Solvent; Petroleum Distillates; Petroleum Naptha; Naptha, Solvent; Stoddard Solvent; Mineral Spirits.

PRODUCT PART NUMBERS: 6614, 6617, 1011662, 1014662.

PRODUCT USE: Cleaning and degreasing metal parts.
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 MEDICAL: TRANSPORTATION (SPILL): emergency use only. If you desire non-emergency 1-800-752-7869 1-800-468-1760 product information, please call a phone number listed below.

SUPPLIER: Safety-Kleen Systems, Inc.
5400 Legacy Drive
Cluster II, Building 3
Plano, Texas 75024
USA
1-800-669-5740

TECHNICAL INFORMATION: 1-800-669-5740, Press 1 then Extension 7500

MSDS FORM NUMBER: 82310	**ISSUE:** November 27, 2002
ORIGINAL ISSUE: April 8, 1976	**SUPERSEDES:** March 24, 2000
PREPARED BY: Product MSDS Coordinator	**APPROVED BY:** MSDS Task Force

 SAFETY-KLEEN 105 SOLVENT RECYCLED MATERIAL SAFETY DATA SHEET FOR USA AND CANADA

SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS

OSHA PEL				ACGIH TLV®					
WT%	NAME	SYNONYM	CAS NO.	TWA	STEL	TWA	STEL	LD	LC
99 to 100	Distillates (petroleum), hydrotreated lighte	N.Av.	64742-47-8 500d	ppm	N.Av.	100d ppm	N.Av.	>5000g, c	>5500d, h mg/m3/4 hours
0 to 0.2*	Tetrachloroethene	Perchloroethylene; Tetrachloroethylene	127-18-4	100 ppm	200 ppm (ceiling)	25 ppm	100 ppm	2629a,f	34200b mg/m3/8 hours

WASTE MINIMIZATION OPPORTUNITIES FOR PETROLEUM-BASED SOLVENTS

Ronald A. Vogel
Lee Wan & Associates, Inc.
Oak Ridge, Tennessee 37830

Kimberly G. Murray
Martin Marietta Energy Systems
Oak Ridge, Tennessee 37830

INTRODUCTION

Petroleum-based solvent is the solvent of choice at the Department of Defense (DoD) facilities. At nonindustrial-type activities, it is used for parts cleaning, degreasing, and corrosion prevention. Usually referred to as PD 680, petroleum-based solvent is most often found in small vat-type operations. Typically, a military facility may use 500 to 35,000 gal of petroleum-based solvent annually, and it is usually the second largest facility waste stream after waste oil and fuel. Because of its widespread use and its large associated waste volume, petroleum-based solvent is a primary candidate for waste minimization efforts.

Petroleum-based solvent is used for parts cleaning to remove dirt, grime, grease, oil, hydraulic fluid, fuel, other lubricants, other solvents, and wet paint. This solvent easily cuts or dissolves all of the above materials holding them in solution or allowing them to form a settled sludge. Petroleum-based solvent is used in the repair and maintenance of most weapons and their associated systems. A sample of some of the shops in which petroleum-based solvent is used includes motor pools, small arms maintenance, wheel and tire shops, hydraulic system shops, generator shops, jet engine shops, heating plants, ground support equipment shops, office equipment repair shops, and wash racks.

Petroleum-based solvent generally is referenced by the military by its federal specification number, PD 680. Within the PD 680 designation are Type I, Type II, and Type III solvents, which are differentiated by their respective flashpoints. PD 680, Type I, has been called Stoddard Solvent, naphtha, dry cleaning solvent, and mineral spirits. The Type II solvent has also been called dry cleaning solvent and mineral spirits. Type III has only been specified since July 1990, and is differentiated from Type II by its flashpoint and viscosity. While the flashpoint is the characteristic which differentiates the types, chemical constituents cause the difference in flashpoint. PD 680, Type I, primarily contains aliphatic organic carbon molecules of six to eight carbon atoms. PD 680, Type II, contains aliphatic chains of 8 to 12 carbon atoms. Additionally, the specification allows up to 20% aromatic compounds. Aliphatic naphtha containing 100% aliphatic compounds meets the PD 680, Type I, specification.

The federal specification calls for Type I to have a flashpoint of 38°C (or 100.4°F) and Type II to have a flashpoint of 60°C (or 140°F). The Type II flashpoint solvent was specified for regulatory and safety reasons. The most recent federal specification, dated September 14, 1988, specifies the characteristics for both types of PD 680A, as shown in Table 1. An amendment to the September specification describes Type III solvent with a

Table 1. Dry cleaning and degreasing solvent properties

Characteristic	Type I	Type II
Flashpoint, °C	38.0	60.0
Distillation, °C:		
Initial boiling point, minimum	149	177
50% recovered, maximum	Report	Report
Dry point, °C	208	211
Aniline point, °C	57 to 74	57 to 74
Kauri-butanol value	29 to 45	29 to 45
Allowable constituents (percent by volume*):		
a. Solvent with olefinic or cyclo-olefinic unsaturation, maximum	5	5
b. Aromatic compounds with eight or more carbon atoms, except ethyl-benzene, maximum	8	8
c. Total of ethylbenzene, toluene, and branched chain ketones, maximum	20	20
d. Total of a + b + c	20	20
Total chlorine content (ppm), maximum	500	500
Apparent specific gravity	0.754 to 0.820	0.754 to 0.820
Nonvolatile residue (mg/100 mL) maximum	10	10
Color, minimum	25	25
Odor[b]	Characteristic and nonresidual	Characteristic and nonresidual
Corrosion, copper, maximum'	2A	2A
Acidity	Neutral	Neutral
Doctor test	Negative	Negative

'These maximum limits are as defined in Rule 102, South Coast Air Quality Management District regulations.

[b]Samples of PD 680 having satisfactory odor characteristics are to be used as reference standards.

'Test for three hours at 100°C.

flashpoint greater then 200 °F and viscosity of 6 seconds. While there are many National Stock Numbers (NSNs) for Type I and Type II PD 680, none have been assigned for Type III.

Petroleum-based solvent waste is considered for waste minimization opportunities because of its regulatory status. Under regulations promulgated under the auspices of Resource Conservation and Recovery Act (RCRA), PD 680, Type I, is characteristically hazardous waste under the characteristic of ignitability (40 CFR 261.21). PD 680, Type I, has a flashpoint of 100°F, considerably less than the 139°F maximum flashpoint for defining the waste as ignitable. PD 680, Type II, was specifically developed to remove PD 680 waste from the hazardous category by ensuring its flashpoint was >140°F. As a waste, it remains nonhazardous if the flashpoint is unaltered during use. Type III solvent, assuming it is not mixed with listed solvents, is not hazardous because of its high flashpoint. However, the author has not seen any data on whether it is under the Toxicity Characteristic Leaching Procedure (TCLP) limits of 5 ppm for benzene. If it is above this level, the Type III is characteristically hazardous because of toxicity.

State regulations regarding petroleum-based solvent vary. While most states follow basic RCRA regulations, few have specific requirements that affect petroleum-based solvent waste. For instance, California regulates recyclable hazardous waste, which includes hydrocarbon solvents such as hexanes, Stoddard Solvent, benzene, toluene, and paint thinner [California Hazardous Waste Regulation 66796(b)(2)(c)]. No differentiation by flashpoint is made. As a result, all PD 680 waste in the state of California is hazardous regardless of its flashpoint.

Petroleum-based solvent and its subsequent waste products, because of their very nature, causes waste disposal problems. Regardless of the hazardous classification of a petroleum-based solvent, proper disposal is necessary. Disposal onto the ground or through direct burial and discharge to sewage systems, surface water, or groundwater is either prohibited, unsafe, or an unsound practice. Proper disposal of the waste is, therefore, mandatory and justifies waste minimization actions. Proper disposal is also somewhat regulatory driven. Because of regulatory requirements, a petroleum-based solvent waste with a flashpoint >140°F can be burned much more easily for energy recovery than a characteristic hazardous waste. Determination of a waste's flashpoint is crucial to determining possible disposal action.

Because flashpoint is critical to disposal action, it is necessary to test waste for flashpoint that may be borderline under RCRA criteria. For this reason PD 680, Type II, which by specification is borderline, should be either tested or disposed of as a hazardous waste. Because sampling, testing, and analysis is expensive and time consuming, most military hazardous waste managers choose to dispose of PD 680, Type II, as a hazardous waste.

Petroleum-based solvent presents other problems to the military hazardous waste manager. Contamination of the waste solvent with TCLP toxic metals is often a problem. Chromium, lead, or cadmium contamination is often found in waste petroleum solvent. Lead comes from fuels, paints, and engine sludges; chrome can leach from metals, paint, and shop chemicals; and cadmium has been shown to be a contaminant in bearing and office machine cleaning. TCLP-toxic metals can be removed from a waste solvent using filtration or a chemical process such as precipitation or ion exchange, but the process is usually expensive and not economically justified.

Lower flashpoint petroleum-based solvent is a safety problem. Naphtha, because of its low flashpoint, is very volatile and will ignite easily. Additionally, the fumes emitted can present a health hazard if proper ventilation is not provided. A vat cover is necessary to protect against this hazard and to prevent excessive evaporative loss. Likewise, evaporation can cause problems complying with the provisions in the new Clean Air Act.

A petroleum-based solvent, because it carries the "solvent" nomenclature, is too often grouped and mixed with other solvent waste. These other solvents include halogenated and other listed solvents. When this occurs, the petroleum-based solvent becomes a listed waste and must be disposed of accordingly [40 CFR 261.3(a)(iv)]. This can severely limit both potential disposal and minimization options.

The term "solvent" has a bad connotation when disposal is considered. Waste petroleum solvent is often viewed in the same context as waste halogenated solvent. Disposal of waste petroleum solvent with waste oil can be difficult because reclaimers fear contamination with listed solvents. In most states, high-flashpoint (>140°F) petroleum-based solvent waste can be sold to a reclaimer for recycling or recycled by burning for energy recovery. Many reclaimers are hesitant to accept any kind of waste solvent.

The largest impediment in the military for minimizing use and waste production of petroleum-based solvent is technical operations specifications. Maintenance of complex weapon systems is usually directed by specific written directions called technical orders (TOs) or technical manuals. Because the weapon systems are extremely expensive, only proven maintenance procedures are allowed. These procedures are not flexible and often specify one specific material-for a given procedure. Deviation from the TO or TM is not allowed and is carefully policed by in-service quality assurance (QA)/quality control (QC) programs. TOs and TMs often specify PD 680 Type I or Type II as a cleaning/degreasing solvent and allow no substitution. This system rigidity often hampers waste minimization option development.

WASTE MINIMIZATION TECHNIQUES

Most of the techniques that can be used to minimize a specific waste stream apply to minimizing petroleum-based solvent waste. They include segregation, substitution, treatment, reuse, and recycling. Petroleum-based solvent waste can be minimized at all stages in the process including material purchase, use, and disposal.

Proper segregation of petroleum-based solvent is essential *to* most waste minimization efforts in that this isolates petroleum-based solvent from other solvent waste and further isolates petroleum-based solvent by flashpoint, making recycling, treatment, and reuse of petroleum-based solvent much simpler. Segregation plans provided to military activities usually recommend separate categories including:

- nonhalogenated fluids with a flashpoint below 100°F,
- nonhalogenated fluids with a flashpoint between 101 and 140°F,
- waste petroleum solvents with a flashpoint above 141°F,
- waste oil,
- waste fuel by types, and
- halogenated solvents.

The above-listed segregation categories separate PD 680 solvent from low-flashpoint naphtha (a recycling consideration), and PD 680, Type I, from nonhazardous (RCRA definition) petroleum-based solvent (a resource recovery consideration).

The most widely used waste minimization technique for petroleum-based solvent is substitution. Numerous substitute materials have become available and can be broadly categorized as follows: (1) flashpoint, (2) d-limonene, (3) detergent, (4) acetate-ester or (5) others. The flashpoint substitution involves using a substitute petroleum-based solvent with a flashpoint of 143°F or higher. This allows for disposal of the waste in most states as nonhazardous waste and also allows for easy burning on-site for energy recovery. Examples of this substitute are ZEP's Dyna 143, Penetone's Formula 724, and Kerr McGee's Kermac 140. Disadvantages of this approach are special handling of the waste is still required and in some states it may still be a hazardous waste (i.e., California). Higher flashpoint solvent represents an increased cost over PD 680, Type II, from 10 to 30%. The recently specified Type III solvent, which is nonhazardous in *most* states, is only manufactured by *two* companies, has no NSNs assigned and is, thus, difficult for the military user to procure. While a soon to be issued general supplement to many TO's will allow its use as a substitute for Type II solvent, that authorization will take some time to reach users.

Another substitution that has become common is the use of d-limonene-based solvent. A natural extract from lemons, the solvent emits a strong lemon odor. Usually mixed with water at a 1:3 to a 1:7 ratio, the waste is biodegradable, nonhazardous (assuming no metals contamination), and can be discharged to a sanitary sewage treatment facility. Purchase cost at a 1:5 dilution is competitive with PD 680, Type II. This solvent has been shown to be an effective oil and grease remover. Examples of d-limonene-based solvents are Penetone's Citrikleen HD and Rochester Midland's SE 377c. While this substitute is widely used and very effective, it does have some significant negative properties, especially in military-related applications. These include corrosiveness to steel after moderate exposure, extremely high biological/chemical oxygen demand (BOD_5/COD) loading when biologically treated, and possible hydrogen embrittlement problems. Oil and grease will separate from d-limonene solvent and should be removed and separately disposed. D-limonene solvent has found widespread application in aircraft wheel and tire shops and in automotive heavy equipment repair shops.

Compounds which are basically detergents with additives have been used as replacements for PD 680. Various brand names containing various ingredients have shown only limited applicability in vat-type operations. Some have been used successfully for degreasing and parts washing for noncritical equipment such as small internal-combustion engine parts. The area where these products have shown the most promise is on wash racks. PD 680, Type II, is often used to wash aircraft and heavy vehicles. It provides excellent performance for removing baked-on grease and hydraulic fluid. Unfortunately, the waste is either caught in an oil/water separator, sent to a sewage treatment plant, or released to the environment. Detergent replacements have been used with some success. Personnel protection is a must as dermatitis often results from exposure to a detergent strong enough to replace PD 680. The dermatitis is caused by the high alkalinity found in all of these detergents. Some examples of detergents used to replace PD 680 are Calla 800 and 850, manufactured by Baker Performance Chemicals, Inc.; Clepo Plus 5, manufactured by the Fredric Gumm Chemical Company; and Mega 680; manufactured by Sheldon Industries. Drawbacks from using detergents include mediocre performance, corrosive potential to steel in vat operations, and foaming problems in sewage treatment facilities.

A recently announce group of solvents to replace the petroleum based solvents are the acetate-ester based formulations. This group is typified by the Exon Exxate Family or Aliphatic ester blends. A military specification is in the process of being prepared for this group of solvents and may eventually be specified in applicable TOs to allow their use as a substitute for PD 680. The acetate ester group of solvents is characterized by high flashpoint, low volatility, slight odor and good cleaning effectiveness. Another potential group of solvents which also holds promise are the paraffin and cycloparaffin formulations. It should be noted that both groups have narrow boiling ranges making batch distillation an attractive recycling alternative.

The final category of potential substitutes for petroleum-based solvent is the "others" grouping. This group consists of products of unknown formulations that have been used to clean and remove grease and oil. Examples of the unknown group are Mirachem 100 and Simple Green. Common characteristics of these products are biodegradability, miscibility with water, and they cut oil and grease. Advertising literature often claims the products are the perfect substitute for halogenated and petroleum-based solvents. In practice, these products have limited application because they are aqueous-based and corrosion potential exists. Additionally, there may be some embrittlement problems. The major problem, however, is technical data does not allow use of these products. There has been specific direction prohibiting use of these compounds from service policy makers.

General chemicals that have or could be used as replacements for petroleum-based solvent include caustic (NaOH), butyl cellosolve, monoethanolamine, ethanolamine, and monoethanolamine monobutyl ether. The hazards and disposal problems associated with each chemical, along with its limited usefulness, have reduced the utility of these substitutes. Caustic is obviously not compatible with aluminum parts and the others can require special handling as waste.

Treatment is a minimization option for petroleum-based solvent that is often used. Treatment can extend solvent life and includes sludge removal and filtration. Canister filtering systems often come installed on vats. However, the filters are usually removed and not replaced during use. The result is that most military-operated vats are not filtered. Filtering can extend vat content life by 50 to 60%, depending on the filter system used. Filter systems can be integral to the vat or portable. The amount of filtering and the type of contaminants to be removed will dictate filter material, size, and pore size. A negative aspect to filtering is that the waste filters usually have to be treated as a hazardous waste. Frequent maintenance of the system is also necessary.

Waste exchange systems have found some applicability at military facilities. For bearing cleaning, PD 680 is changed often to meet very rigid specifications for particulate contamination. This "waste" PD 680 can be reused for general parts cleaning and degreasing. Most PD 680 vats are used until the solvent no longer performs to the level expected by the operator. The change-out decision is usually arbitrary. A method to determine change-out requirements is needed.

On-site recycling of petroleum-based solvent has been tried at numerous installations. Simple batch-type distillation is difficult to achieve because of the heterogeneous nature of the material. PD 680, by its specification, contains several types of organic compounds including aliphatic and aromatic compounds. Because of this variety, simple batch distillation is difficult. Adding a vacuum system to a batch unit improves performance. The distillate, regardless of feedstock used, will be the lower flashpoint product. A 65 to 70% recovery rate can normally be expected, and still bottoms result in a waste that may be hazardous. Operation of a distillation unit requires trained manpower and constant surveillance.

A method for minimizing petroleum-based solvent that has been successfully used is burning the waste for energy recovery. This option is normally recommended in conjunction with substitution to a high-flashpoint (>140°F) petroleum-based solvent. When combined, these options allow for burning of nonhazardous petroleum-based solvent waste in any boiler system using No. 2 heating oil. No. 2 heating oil and waste petroleum solvent have been found to be compatible. This option has proven to be very useful in cases where technical data and tight quality specifications limit substitution and treatment options. At some DoD installations, this option has been recommended for 50% of the PD 680, Type II, waste. An added benefit is the Btu value of the waste, which can offset fuel costs. It is normally estimated that waste petroleum solvent has 70% of the Btu content of virgin fuel oil.

No discussion of waste minimization for petroleum-based solvent would be complete without a discussion of rent-a-solvent programs. Foremost among the vendors of this type of service is the Safety-Kleen Corporation. The service normally consists of a vendor-supplied vat that is emptied and filled at specified intervals. The waste solvent is manifested off facility as part of the invoice. The waste solvent is recycled off-site at the vendor's facility and returned as fresh solvent at a later date. The service eliminates user handling of feedstocks and waste and provides some assurance that the waste is recycled properly. Costs of the service compared to life-cycle costs of PD 680 are essentially equivalent on a per-unit basis. Two problems noted from this type of service are the tendency to increase the amount of solvent used and a programmatic problem of waste accounting. Solvent is supplied from vendors such as Safety-Kleen on a specified periodic basis. The tendency by the vendor is to attempt to provide as much solvent as possible at minimum change-out intervals. The result is a net increase in usage and waste generation, often *doubling* the waste stream. This, coupled with DoD's lack of recognition of off-site recycling in their mandated 50% waste reduction program, results in a net programmatic increase in waste generation for the facility.

Numerous management options are available to reduce petroleum-based solvent waste generation. They include front-end controls such as rationing, surcharging, purchase control, and reporting requirements. Incentive programs such as publicity campaigns and training can also reduce waste generation rates.

SUMMARY OF FINDINGS

To illustrate possible waste minimization opportunities at military installations, the combined results from waste minimization studies accomplished at twelve Air Force Bases was reviewed. These bases were:

Command	Base
Strategic Air Command	Barksdale AFB, Louisiana
	Beale AFB, California
	Carswell AFB, Texas
	Castle AFB, California
	K.I. Sawyer AFB, Michigan
	Loring AFB, Maine
	Plattsburg AFB, New York
Air Training Command	Keesler AFB, Mississippi
	Lowry AFB, Colorado
	Randolph AFB, Texas
Military Airlift Command	Charleston AFB, South Carolina
	Hurlburt Field AFB, Florida

A review of the waste minimization reports indicates that a combined total of over 55,000 gallons of PD 680 is disposed of annually by the twelve bases (Table 2). Using the various waste minimization techniques described previously, the volume of waste PD 680 disposed of as hazardous could be reduced by about 43,170 gal/year (Table 3).

The establishment of the cost reduction listed in Table 3 deserves some explanation. For each base, the cost reduction was calculated as follows:

Gross Savings = (Average Disposal Cost x Reduction)
Additions = Feedstock Savings
Deductions = Increases Material Cost + Increased Operational Cost
Net Savings - Gross Savings - Deductions

In the above equations, the average disposal cost is a weighted average of the disposal cost for waste solvent. Reduction is the annual reduction in waste production estimated in the waste minimization reports. Average disposal cost ($/gal) times reduction (gal) gives the total amount of money saved by avoiding disposal. Feedstock savings occur when waste minimization activities extend the use of a solvent and, therefore, allow a decrease in the amount of solvent that must be purchased. Increased material cost occurs when substitutions (such as the use of high flashpoint solvent) result in a higher purchase price than the solvent in use. And, finally, increased operational costs may vary from a procedural change which requires more energy or manpower increases the operational cost of a procedure. An average disposal cost of $4,20/gal was calculated for the solvent from the twelve bases in the study. By multiplying this number by the reduction shown in Table 3, the savings from disposal cost reduction (the gross savings) becomes $181,314/year. Since the net savings is $169,426/year, it is obvious that , although the deductions are greater than the feedstock savings, they are a small percentage of the gross savings.

The liability savings produced by a waste minimization program are less defined that the cost savings listed above and could not be accurately estimated from available data. Programic costs in the DoD Installation Restoration Program have been considerable, and are estimated to be greater then 600 million dollars in FY 1991. Much of this cost was incurred as the result of using and disposing of solvents including petroleum based solvents. Potential liability savings from using the waste minimization techniques described in this paper are considerable.

CONCLUSION

Waste petroleum-based solvent is very amenable to waste minimization efforts. No single approach is best. Selection of an option depends on the process operation, amount of solvent used, process restrictions, costs, and intangible factors. Each minimization evaluation is distinct. Petroleum-based solvent waste can be minimized using many of the different techniques.

Table 2. Petroluem-based Solvent-Waste Minimization Recommendations at Twelve Air Force Bases

Shop	Cost reduction ($)	Volume reduction (gal)
Vehicle Maintenance	10078	3301
Aerospace Ground and Equipment	17344	2938
Wheel & Tire	20477	6364
Aircraft Wash Rack	44374	13480
Propulsion Shop	7956	2064
Munitions Maintenance	6190	2400
Central Heating Plant	10372	1655
Auto Hobby Shop	17671	3492
Pneudraulics	9529	2778
Fuels Management	0	0
Refueling Maintenance	2711	560
Aerorepair	4598	576
Operational Maintenance	6000	800
Fire Control	2074	919
Other	10052	1843
Total	169426	43170

Table 3. Waste Minimization Results From Twelve Air Force Bases

Base Name	Waste Production (gal/yr)	Waste Reduction (gal/yr)	Savings ($)	Capital Investment ($)
Barksdale	7245	3775	8600	0
Beale	4577	2762	9454	420
Carswell	7381	6741	51038	21002
Castle	9089	8304	26945	2147
K.I. Sawyer	5302	3970	3965	1450
Loring	1205	1205	2410	0
Plattsburg	2813	2803	14888	2000
Keesler	1410	1400	5500	0
Lowry	630	630	280	0
Randolph	1755	1255	11050	6000
Charleston	6204	5421	27210	0
Hurlburt	8120	5146	8086	3547
Total	55731	43412	169426	36566
Average	4644	3618	14119	3947