



TRI-SERVICES' POLLUTION PREVENTION OPPORTUNITY SOFTWARE SYSTEM

January 1996



**Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370**

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY HANDBOOK

*** DISCLAIMER ***

This document is intended to be used as a reference. All decisions to order or use any of the items contained within should be authorized through your official chain of command.

*** HEALTH & SAFETY CONCERNS ***

It is important to understand that some of the alternate chemicals or processes listed herein may be more “environmentally friendly” than the current method being used, but may pose health risks. These risks may involve additional personal protective equipment (PPE), added ventilation, etc. It is imperative that you contact your local industrial health specialist, your local health and safety personnel, and consult the appropriate MSDS prior to implementing any of these technologies.

This sentiment is further emphasized in OPNAVINST 5100.23D Section 0803.2 which states that: “Any changes in the workplace which could affect exposures should prompt reevaluation. The cognizant industrial hygienist shall establish procedures to ensure he/she is notified of any changes which could affect worker exposure to potential hazards.”

*** NOTE ***

If you or someone at your activity has information which could be incorporated into this document, please send your comments to:

Naval Facilities Engineering Service Center
Pollution Prevention Opportunities Comments
Code 423
1100 23rd Avenue
Bldg. 1500
Port Hueneme, CA 93043-4370

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What topics do you feel need to be added to future upgrades?

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COMMANDING OFFICER

NFESC, CODE 423

1100 23RD AVENUE

PORT HUENEME CA 93043-4370

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Data sheets listed in bold italics are currently being developed

INTRODUCTION

The purpose of the Tri-Service Pollution Prevention Opportunity Handbook is to identify available “off-the-shelf” pollution prevention (P2) technologies, management practices, and process changes that will reduce the amount of hazardous waste and solid waste being generated at DOD industrial facilities. The handbook was developed by the Naval Facilities Engineering Service Center (NFESC) under the direction of the Office of the Chief of Naval Operations (CNO-N451) and the Naval Facilities Engineering Command (NAVFAC). Input for the handbook was coordinated with the Air Force Center for Environmental Excellence (AFCEE) and the Army Environmental Center (AEC).

P2 techniques included in the handbook are presented in the form of technical data sheets. The data sheets are organized into the following categories:

- Metal Finishing
- Hazardous Waste Minimization
- Ozone Depleting Substances
- Painting
- Depainting
- Petroleum, Oils, and Lubricants
- Solid Waste
- Solvent Substitution
- Wastewater Treatment
- Storm Water Treatment
- Preproduction Technologies

Each data sheet presents information that includes:

- Service process code
- Applicable EPCRA targeted chemical(s)
- Overview
- Materials compatibility
- Safety and health
- Vendor listing (information provided here is not intended as an endorsement for any particular vendor’s services, products, hardware, or proprietary process).
- Benefits
- Disadvantages
- Economic analysis
- Approval authority
- Points of contact

The handbook will be updated semi-annually as NFESC, AFCEE, AEC, and others continue to investigate and develop new solid waste and hazardous waste management technologies. The handbook should be considered a preliminary source of information for identifying potential P2 techniques and providing contacts for gathering additional information.

P2 information can also be obtained from the Pollution Prevention Library on the Defense Environmental Network and Information Exchange (DENIX) bulletin board system. DENIX also includes a broad range of environmental information from the Navy, Air Force, Army, EPA, OSD, DLA, and other federal agencies. DOD personnel are encouraged to obtain a DENIX log-in for the most current, up-to-date environmental P2 information throughout DOD. To request a log-in, contact the DENIX Data Manager at (217) 373-6790.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ELECTRODIALYSIS TECHNOLOGY FOR ANODIZING BATH SOLUTIONS

Revision: 1/96
Process Code: Navy: ID-04-99; Air Force: MT03; Army: N/A
Opportunity: Reduction of the hazardous waste volume generated and the associated disposal costs
Applicable EPCRA Targeted Constituents: Sulfuric Acid, Aluminum

Overview: Electrodialysis is a process that will efficiently maintain a low metal ion concentration in the anodizing bath solution by transporting metal ions from the bath solution through a selective membrane into a capture media using an electrical current to induce flow.

When anodizing aluminum, for example, the bath solution is required to be changed out and disposed of when the aluminum concentration reaches 80-100 grams/liter. The spent solution contains high levels of sulfuric acid and aluminum, requiring neutralization and metals removal for a typically large volume prior to disposal.

Electrodialysis does not affect the anodizing process. It is simply a process that can indefinitely extend the useful life of the bath solution by maintaining a low concentration of metal ions. The capture media, catholyte, is not immune to the presence of the metal ions and forms a concentrated sludge. The sludge must be removed from the unit and the catholyte changed out on a regular basis to ensure effective metals removal from the anodizing bath solution. The recovered sludge is a hazardous waste containing high concentrations of metal that can be reclaimed by an outside company.

Materials

Compatibility: N/A

Safety and Health: Spent sulfuric acid waste can be extremely corrosive to skin tissue. Contact with the body can result in severe burns. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Reduction of hazardous waste volume and the associated disposal costs.
- Metals reclamation and reduction of liability if sludge is recovered by an outside company.
- Indefinite extension of anodizing bath solutions useful life.

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- Lower annual cost for chemical makeup & replacement.
- Improved production quality and consistent reproducibility of manufactured parts due to control of the metal ion concentration in the anodizing bath solution.

Disadvantages:

- Moderately high capital cost.
- Increase in the number of possible exposures with regard to the handling of hazardous waste.
- Ability to locate company that will recover and reclaim metals from the sludge.

Economic Analysis: The addition of an electro dialysis unit to an anodizing bath system can significantly reduce the volume of hazardous waste generated and the associated disposal costs. Variables affecting the capital cost, operation & maintenance costs, and the hazardous waste disposal costs with regard to the addition of an electro dialysis unit include:

- The frequency of pre-change bath solution replacement
- Cost to heat the bath solution after replacement
- The metal ion loading rate for the bath solution
- The metal ion removal rate of the electro dialysis unit
- Ability to locate an outside company to recover the generated sludge.

- Assumptions

- Volume of anodizing bath solution, 5000 gal.
- Volume of electro dialysis unit, 55 gal.
- Labor costs are equal for both methods
- Anodized bath solution requires 10% vol. sulfuric acid, \$200, and 10 oz/gal chromic acid, \$1500, per changeout
- Anodizing bath solution replaced once a year
- Anodizing bath make-up solution volumes and costs are negligible
- Electro dialysis solution, catholyte, is \$50 per 55 gal make-up.
- Catholyte replacement during the first six months of operation shall be weekly, thereafter, on a bi-weekly basis
- Annual energy costs for the electro dialysis unit:
 $(\$0.07/\text{KW}\cdot\text{hr})[(400 \text{ amp})(12 \text{ volt})\text{K}/1000](8 \text{ hr/day})(250 \text{ day/yr})$

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- Cost Comparison

	Annual Cost using current Technology	1 st Year Cost with new Technology ¹	Annual Cost with new Technology ²
Capital Costs	-	25000	-
Installation Costs	-	4000	-
Electrodialysis Energy Costs	-	672	672
Anodizing Bath Solution Replacement/Make-Up	1700	-	-
Catholyte Solution Replacement	-	1950	1300
Hazardous Waste Disposal Costs			
Anodizing Bath Solution	5000	-	-
Catholyte & Sludge	-	600	400
Hazardous Waste Volume Generated	5000 gal	2145 gal	1430 gal
Total	6700	32222	2372

Payback Period: 6.9 years

Annual Savings after Payback Period: \$4328

A smaller payback period and larger annual savings can be realized if the anodizing bath solution is changed-out at a higher rate than stated above prior to implementing the new technology.

¹ 57% Hazardous Waste Volume Reduction, 88% Reduction of Hazardous Waste Disposal Costs

² 71% Hazardous Waste Volume Reduction, 92% Reduction of Hazardous Waste Disposal Costs

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

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 (805) 982-4895, DSN: 551-4895

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Vendors: The following is a list of electro dialysis system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

IONSEP Corporation, Inc.
P.O. Box 258
Rockland, DE 19732
(302) 798-7402

Baker Brothers/Systems
44 Campanelli Parkway
Stoughton, MA 02072-0507
(617) 344-1700

Eco Tec
925 Brock Road South
Pickering (Toronto) Ontario, Canada L1W2X9
(905) 831-3400

ELECTROLESS NICKEL BATH LIFE EXTENSION

Revision: 1/96
Process Code: Navy: ID-04-02; Air Force: MT05; Army: N/A
Opportunity: Reduce the volume of hazardous waste generated and the associated disposal costs.
Applicable EPCRA Targeted Constituents: Nickel

Overview: Utilizing the Electroless Nickel (EN) bath life extension technology to augment current EN operations can increase the life of the plating bath at a typical naval facility up to ten-fold, reduce the volume of hazardous waste generated by up to 90 percent and the associated disposal costs. The EN bath life extension technology accomplishes this by performing two functions: 1) it removes the chemical by-products formed during the plating process, and 2) maintains the overall chemical balance of the EN plating bath (nickel concentration, pH, temperature) through the addition of bath chemicals (hypophosphite, reducing agents, complexing agents, and bath stabilizers). EN plating consists of a chemical process in which a reaction occurs to reduce nickel ions to metal which deposit onto the part. Current practice is to changeout the plating bath solution as it becomes loaded with contaminants that interfere with the plating process and dispose of it as hazardous waste. Typical EN wastestreams include orthophosphite, sulfate, and sodium ions.

Materials

Compatibility: N/A

Safety and Health: Nickel compounds can be irritating to the skin. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

- Benefits:**
- Decrease the volume of hazardous waste generated by up to 90% and the associated disposal costs
 - EN bath life can be increased up to ten-fold
 - EN bath will require minimal chemical additions versus six to twelve annual bath change-outs
 - Improved production quality due to stability of plating bath parameters and quick removal of bath impurities that can cause poor plating quality
 - Reduction of rework required due to poor plating quality

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- Disadvantages:**
- Moderately high capital costs
 - Increased handling and exposure to workers from the addition of plating bath chemicals

Economic Analysis: Variables affecting capital cost, operation & maintenance costs, and the hazardous waste disposal costs with regard to the addition of an EN bath life extension system include:

- Capacity and size of the plating bath
- Quantity of work to be processed
- Ability to stabilize bath characteristics and remove impurities.

- Assumptions for Cost Comparison
 - Volume of EN plating bath solution, 500 gal.
 - ENFINITY EN bath life extension technology will be implemented (Implementation requires the use of the vendors EN system in conjunction with the bath life extension technology)
 - Chemical replenishing costs based on plating thickness per square footage of work processed. The ENFINITY vendor estimates a process cost of \$1.97 per mil·ft² (1 mil = 0.001 inches)
 - No additional labor costs, savings associated with fewer bath change-outs will be offset by need to add chemicals, clean and recondition EN plating tank
 - Bath life extended 5-fold

• Cost Comparison

	EN Plating System	1st Year using EN Plating System with Bath Life Extension Technology	Subsequent Years using EN Plating System with Bath Life Extension Technology
Capital Costs (ENFINITY EN)	-	35000	-
EN Chemical Bath Make-Up @ \$1950 / 500 gal			
10 Change-Outs	19500	-	-
2 Change-Outs	-	3900	3900
Hazardous Waste Disposal Cost @ \$2000 / 500 gal			
10 Disposals	20000	-	-
2 Disposals	-	4000	4000
Total	39500	42900	7900

Payback Period: 1.1 years

Annual Savings after Payback Period: \$31,600

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Michael Viggiano, Code 423
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(805) 982-4895, DSN: 551-4895

Glen Gramham
Tinker Air Force Base
Air Logistic Center Oklahoma
DSN 336-5185

Vendors: The following is an Electroless Nickel plating system supplier. This is not meant to be a complete list, as there may be other suppliers of this type of equipment.

Stapleton Company
1350 W. 12th Street
Long Beach, CA 90813
(310) 437-0541

HIGH VELOCITY OXY-FUEL THERMAL SPRAY

Revision: 1/96
Process Code: Navy: ID-06-99; Air Force: MT03; Army: N/A
Substitute for: Hard Chrome Plating
Applicable EPCRA Targeted Constituent: Chromic Acid, Sulfuric Acid, Lead, Chromium, Nickel, and Copper

Overview: High Velocity Oxy-Fuel (HVOF) thermal spray technology is a dry process that produces a dense metallic coating whose desired physical properties are equal to or surpass those of hard chrome plating (HCP). These properties include wear resistance, corrosion resistance, low oxide content, low stress, low porosity, and high bonding strength to the base metal.

HVOF thermal spray uses a fuel (i.e., propylene, hydrogen, kerosene)/oxygen mixture in a combustion chamber. This combustion process melts a metal containing powder that is continually fed into a gun using a carrier gas (argon) and propels it at high speeds (3,000 - 4,000 ft/sec) towards the surface of the part to be coated. The high speeds of the spray coating produce a coating that can be used as an alternative to the HCP process. The metal powder is available in many compositions, including nickel, nichrome, inconel, chrome carbide, and tungsten carbide. Uniform coating thickness' of up to 0.250 inches can be achieved.

The only waste stream produced by HVOF is from the capture of the overspray. Current users either use a water curtain filter system or a dry high efficiency particulate air (HEPA) filter. Since the overspray contains only the pure metal or alloy, it is feasible to recycle or reclaim this waste stream.

Materials

Compatibility: N/A

Safety and Health: When working with fine particulate matter that consists of various compositions of different metals, inhalation is a primary concern. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

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- Benefits:**
- Surface coating physical properties are at least equal to those of HCP
 - Multiple choice of coating materials
 - Large volume reduction of hazardous waste and the associated disposal costs

- Disadvantages:**
- Line-of-sight process, can only coat the external surface of a part not the inner diameters
 - High capital cost
 - Process must be housed in a full enclosure of sufficient size to process parts that normally utilize HCP

Economic Analysis: The cost for implementing HVOF in lieu of continuing to use HCP to apply a surface coating to production parts depends on many variables, in particular the following:

- Quantity of work to be transferred from HCP
- Whether a robotic or manual system is used
- Type of capture system used
- Availability of space at the facility to house the HVOF enclosure

To better define these variables and some of the costs, the implementation of HVOF technology at an existing DOD facility (Air Logistic Center) as a replacement for 20% of the then current HCP production will be examined.

- Total number of HCP tanks at facility, 8
- Current disposal treatment for HCP waste streams is pretreatment at the Industrial Wastewater Treatment Plant (IWTP), unless the facility has a zero discharge rinse water recycling system installed, prior to release to the Public Owned Treatment Works (POTW)
- 20% of HCP production to be transferred to HVOF with an additional 15% planned in the future
- Manual system to be implemented, High Efficiency Particulate Air (HEPA) filter selected for overspray capture system, space is available to house the HVOF process
- Capital Cost plus Installation of HVOF equipment, \$100,000 - 120,000
- Capital Cost of HEPA filter System, approx. \$50,000
- Fuel mixture is Oxygen/hydrogen
- Metal powder for coating shall be Tungsten or Chromium Carbide, \$40-65 per pound
- No additional labor resources are required as the displaced workers will be trained for HVOF
- Training provided by the manufacturer of the HVOF equipment

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- No disposal costs for overspray, recovered metals are sold to a local refiner
- Finished product cost is dependent on the number of parts processed and the computed cost for consumables and labor per mil-ft² of coating (1 mil = 0.001 inches)
- Toxic air emissions from HCP bath containers reduced
- More than 90% volume reduction of rinse water that would have been generated using HCP for allocated work
- Annual savings will increase, while the payback period, air emissions, hazardous waste generation, and the associated disposal costs will continue to be reduced as more work is transferred to HVOF
- Estimated Payback Period: 1.5 years
- Estimated Annual Savings after Payback Period: \$70,000 at 20% production transfer to HVOF; \$200,000 at 35% production transfer to HVOF

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

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Naval Facilities Engineering Service Center
1100 23rd Avenue, Bldg. 1500
Port Hueneme, CA 93043-4370
(805) 982-4895, DSN: 551-4895

Leonard Hayes
OCALC/LPPE
3001 Staff Drive, 2B93 Room 20
Tinker Air Force Base, OK 73145-3034
(405) 736-2289, DSN: 336-2289

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Vendors: The following is a list of HVOF equipment manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

TAFA, Inc.
146 Pembroke Road
Concord, NH 03301
(603) 224-9585

Sulzer Metco (USA INC)
1972 Meijer Drive
P.O. Box 84310
Troy, MI 48084
(810) 288-1200

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NON-CYANIDE NICKEL STRIPPERS

Revision: 1/96
Process Code: Navy: ID-04-99; Air Force: MT03, Army: N/A
Substitute for: Cyanide Based Nickel Stripping Processes
Applicable EPCRA Targeted Constituents: Nickel, Cyanides, and Chlorine

Overview: Non-cyanide based metal stripping removes metal based coatings from production parts by dipping the parts in a bath solution, and rinsing. Using a non-cyanide based metal stripping process reduces the volume of hazardous waste generated and the associated disposal costs, and exposure of personnel to hazardous materials and wastes.

Until recently, the majority of stripping of metal coatings from production parts has been accomplished using cyanide based processes. Parts that require rework often need to remove previously applied metal coatings. Cyanide based processes are capable of removing many different metal coatings such as nickel (Ni), silver (Ag), copper (Cu), zinc (Zn), gold (Au), and other precious metals without damaging the surface of the part itself. The downside of cyanide-based stripping is that cyanides are hazardous to personnel, frequent bath solution change-outs due to a limited bath life, and the rinse streams generated from this process contain high concentrations of metals and cyanides. The rinse water generated requires treatment to remove the cyanides and metals at the Industrial Wastewater Treatment Plant (IWTP) before the water can be released to the Public Owned Treatment Works (POTW). The treatment process at the IWTP requires the use of toxic chemicals such as sulfuric acid, caustic, chlorine and other hazardous materials.

There are a number of commercially available non-cyanide metal stripping processes that can be implemented to replace cyanide-based metal stripping processes. These alternative metal strippers use amines, aromatic nitro compounds, protein based and other oxidizing chemicals. The following process parameters must be examined for any alternative before implementation can occur: stripping rate, corrosion of base metal, reaction with maskants, bath stability, and treatability of rinse waters or spent process bath material.

Materials

Compatibility: Due to the variability of non-cyanide based bath solutions, it is highly recommended that the activity reference the vendors data for specific incompatibilities between bath solution and other materials / chemicals.

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Safety and Health: Many components of a non-cyanide metal stripper are biodegradable and present minimal safety risks. However; several components do present splash, heat and vapor hazards. Bath solution temperatures range from room temperature to 180 °F, appropriate precautions shall be observed. Nickel compounds can be skin irritants. Proper personnel protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Elimination of a major source of cyanides
- Reduction of costs and materials required for cyanide treatment of rinse waters at IWTP
- Non-cyanide baths are also more stable and require less frequent change-out
- The removal of cyanides may enable the reclamation of metals from the bath solution and rinse water
- The same process equipment (tanks, heaters or coolant coils) that is currently used can be used in the non-cyanide based process

Disadvantages:

- Due to the variability of bath solutions available, it is possible that new waste streams may be created

Economic Analysis: Non-cyanide nickel strippers can be implemented using existing tanks, heaters, and ventilation systems. The only cost variable will be for the initial make up for the process bath, but that will be offset by the fact that non-cyanide baths have a much higher bath life than cyanide baths (2 to 3 times). Also, eliminating the cost (chemicals and labor) for the treatment of cyanide contaminated rinse waters will yield greater savings.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: The following is a list of non-cyanide nickel stripper system suppliers. This is not meant to be a complete list, as there may be other suppliers of this type of equipment.

B-9 Nickel Stripper
Metalx, Inc.
Route 10, Box 683
Lenoir, NC 28645
(704) 758-4997

Patstrip Ni-E
Patclin Chemical Co.
66 Alexander St.
Yonkers, NY 10701-2714
(914) 476-7000

Nickel-Sol
ElectroChemical, Inc.
5630 Pioneer Creek Drive
Maple Plain, MN 55359
(612) 479-2008

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SURFACE COATING BY PHYSICAL VAPOR DEPOSITION

Revision 1/96
Process Code: Navy: N/A; Air Force: MT03; Army: N/A
Substitute for: Certain electroplating processes like cadmium plating
Applicable EPCRA Targeted Constituents: N/A

Overview: Physical Vapor Deposition (PVD) comprises a group of surface coating technologies used for decorative coating, tool coating, and other equipment coating applications. It is fundamentally an evaporative coating process in which the basic mechanism is an atom by atom transfer of material from the solid phase to the vapor phase and back to the solid phase, gradually building a film on the surface to be coated.

There are three basic process categories considered as PVD technologies: ion plating, evaporation, and sputtering. All of which utilize the same three fundamental steps to develop a coating. Each of the PVD technologies generate and deposit material in a somewhat different manner, requiring equipment unique to each process. The three fundamental steps include:

1. Vapor phase generation from coating material stock by -
 - Evaporation
 - Sputtering
 - Chemical vapors and gases
2. The transfer of the vapor phase from source to substrate by -
 - Line-of-sight
 - Molecular flow
 - High partial pressure of coating material
 - Vapor ionization by creating a plasma
3. Deposition and film growth on the substrate

These steps can be independent or superimposed on each other depending on the desired coating characteristics. The final result of the coating/substrate composite is a function of each materials individual properties, the interaction of the materials and any process constraints that may exist.

The selection criteria for determining the best method of PVD is dependent on several factors;

1. Material to be deposited
2. Rate of deposition
3. Limitations imposed by the substrate, such as, the maximum deposition temperature
4. Adhesion of the deposition to the substrate

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5. Throwing power (rate and thickness distribution of the deposition process, i.e., the higher the throwing power, the better the process ability to coat irregularly-shaped objects with uniform thickness)
6. Purity of coating materials
7. Equipment requirements and their availability
8. Cost
9. Ecological considerations
10. Abundance of deposition material

PVD is a desirable alternative to electroplating and possibly some painting applications. PVD can be applied using a wide variety of materials to coat an equally diverse number of substrates using any three of the basic PVD technologies to deposit a number of desired finishes of variable thickness with specific characteristics.

The application of PVD surface coating technologies at large scale, high volume operations will result in the reduction of hazardous waste generated when compared to electroplating and other metal finishing processes that use large quantities of toxic and hazardous materials at major maintenance facilities.

Materials

Compatibility:

PVD coating processes are compatible with most metals and some plastics either as coatings or as substrates. However, temperature constraints may limit the degree to which dense coatings can be deposited on some plastics. Finally, PVD processes do not normally produce the kind of coatings that work well where lubrication is required. Thus, PVD coatings are not usually good choices for parts such as fasteners.

Safety and Health: The safety and health issues must be evaluated on a case-by-case basis. Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- The coatings are typically harder and more corrosion resistant than coatings applied by the electroplating process. Most coatings have high temperature and good impact strength, excellent abrasion resistance and are so durable that protective topcoats are almost never necessary.
- Ability to utilize virtually any type of inorganic and some organic coating materials on an equally diverse group of substrates and surfaces using a wide variety of finishes.
- More environmentally friendly than traditional coating process like electroplating and painting.
- More than one technique can be used to deposit a given film.

Disadvantages:

- Specific technologies can impose constraints; for example, line-of-sight transfer makes coating annular shapes practically impossible.

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- PVD technologies operate at very high temperatures and vacuums, requiring special attention by operating personnel.
- Requires a cooling water system to dissipate large heat loads.
- Selection of the best PVD technology may require some experience and/or experimentation.
- High capital costs

Economic Analysis: Economic considerations are probably the primary hindrance to conversion of more plating operations to any of the vapor deposition processes. A capital cost of several hundred thousand dollars is the order of magnitude for a new vapor deposition installation. Operating costs are, however, roughly equal to electroplating, although plating can be slightly less labor intensive.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Mr. Donald M. Mattox
Technical Director of the Society of Vacuum Coaters
Albuquerque, NM
(505) 856-7188, Fax (505) 856-6716
For ion plating expertise

Mr. Brad Christensen
Environmental Engineer
Commodities Directorate
Hill AFB, Utah
(801) 777-2341, DSN 777-2341

Has experience with a couple of aluminum ion vapor deposition systems that were installed to replace a cadmium plating operation. Large and small steel components are plated at this location.

Vendors:

The following is a list of physical vapor deposition system suppliers. This is not meant to be a complete list, as there may be other suppliers of this type of equipment.

McDonnell Douglas
Pure Tech Inc., Carmel, NY

Source: Plating and Surface Finishing, Jan 1995, Journal of the American Electroplaters and Surface Finishers Society; *Handbook of Deposition Technologies for Films and Coatings*, Second Edition, 94, Noyes Publications, Park Ridge, New Jersey.

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SULFURIC/BORIC ACID ANODIZING

Revision: 1/96
Process Code: Navy: ID-04-99; Air Force: MT03; Army: N/A
Substitute for: Chromic Acid Aluminum Anodizing Process
Applicable EPCRA Targeted Constituents: Chromic Acid, Chromium.

Overview: The Sulfuric/Boric Acid Anodizing (SBAA) process is a direct replacement for the Chromic Acid Anodizing (CAA) process used on aluminum production pieces. The SBAA process consists of a sulfuric/boric acid anodizing bath and a chromate sealer bath. SBAA is a commercially available and tested process that provides a protective coating meeting all military and industrial specifications that the CAA process does.

The CAA process is currently used by all Naval Aviation Depots (NADEPs), Naval Shipyards, and other activities to apply a protective coating to aluminum parts used by many naval aircraft and ships. CAA generates chrome containing waste streams from the rinsing of parts and ventilation system washdowns. The resulting CCA rinse water requires the removal of metals at the Industrial Wastewater Treatment Plant (IWTP) prior to release to a Public Owned Treatment Works (POTW). The SBAA process has no chrome except for a small amount in a separate sealer tank (70 ppm compared to 74.9×10^3 ppm in CAA) that the parts need to be dipped into after the SBAA process; therefore, no chrome containing waste streams are generated from the rinsing of the parts and the ventilation system. The rinse water stills contain metals and acids that must be treated at the IWTP prior to release to a POTW.

The SBAA process was tested by the Naval Air Systems Command (NAVAIRSYSCOM) at NADEP North Island and has been approved by NAVAIRSYSCOM as an alternative to the CAA process. The SBAA process has since been implemented at NADEP North Island and NADEP Cherry Point. Mil-C-8625C (the Mil-Spec that governs all anodized coatings) is being revised to include the SBAA process as an additional option for aluminum anodizing.

Materials

Compatibility: N/A

Safety and Health: Sulfuric acid can be extremely corrosive to skin tissue. Contact with the body can result in severe burns. Boric acid can be a dermal and mucous membrane irritant. It is also a suspected teratogen and mutagen. Chromic acid can irritate the respiratory tract and mucous membranes,

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and is a known mutagen. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

- Benefits:**
- Replace a major source of Chromic Acid in the Navy
 - Significant reduction in the treatment of chromic acid at the IWTP
 - Reduction of toxic air emissions from the chromic acid process

- Disadvantages:**
- Still generates a hazardous waste stream requiring pre-treatment

Economic Analysis: Cost savings will depend largely on the volume of chromic acid contaminated rinse water generated, rinse water treatment costs, and the hazardous waste disposal costs for the heavy-metals-contaminated sludge. The cost to implement the SBAA process is minimal at a facility that currently utilizes CAA. Additional equipment requirements include:

- Sealer tank
- Immersion heater or steam line for the sealer tank
- Cooling coils for the SBAA to keep bath temperature below 80 °F
- Process Parameters and Assumptions for Cost Comparison
 - CAA, SBAA and sealer bath capacities: 2,800 gal each
 - Sulfuric/Boric Acid bath : 30-50 g of sulfuric acid per liter of bath fluid, 5-11 g of boric acid /l of bath fluid, 76-84 °F
 - Sealer bath : 26g of chromic acid per 100 gal of bath fluid, 190-200 °F
 - No differential in labor, permitting, training, etc. Personnel operating the CAA process can be trained to operate the SBAA equipment
 - Operating costs are equivalent for both processes with the exception of bath make-up costs

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- Cost Comparison

	CAA Process	SBAA Process First Year Costs	SBAA Process Annual Costs
Capital Costs			
Sealant Tank	-	2200	-
Sealant Tank Heater	-	2900	-
SBAA Tank Cooling Coils	-	1270	-
Operational Costs			
2800 gal Make Up for SBAA tank	-	6000	6000
2800 gal Make Up for Sealer tank	-	800	800
Chemical additions for CAA	2200	-	-
Treatment Costs			
Treatment costs from IWTP @ \$0.70/gal	70000	21000	21000
Total	72200	34170	27800

Payback period is approximately 6 months with first year savings of \$38,030. Subsequent annual savings are \$44,400.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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 NADEP North Island
 NAS North Island
 San Diego, California
 (619) 545-9757, DSN: 735-9757

Steve Spadefora
 Naval Air Warfare Center
 Aircraft Division
 Patuxent River, Maryland
 (301) 342-8007, DSN: 342-8007

Vendors:

A list of Sulfuric/Boric Acid Anodizing system manufacturers is not available at this time.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

HAZARDOUS MATERIAL AFFIRMATIVE PROCUREMENT POLICIES/PROCEDURES

Revision: 1/96
Process Code: Navy: SR-11-99; Air Force: MA01; Army: N/A
Substitute For: Non-Affirmative Procurement
Applicable EPCRA Targeted Constituents: Various

Overview: The United States Environmental Protection Agency (US EPA), as part of their hazardous waste minimization and pollution prevention initiatives, has developed a policy for "affirmative procurement" of various hazardous materials (HM). The objective of this policy is to significantly reduce the use of ozone-depleting substances, through the use of affirmative procurement practices. In so doing, the federal government seeks to become a leader in the world wide phaseout of these substances.

Executive Order 12843, entitled, "Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances," was issued on April 21, 1993, by President Clinton. The executive order is intended to reduce the federal government's procurement and use of substances that cause stratospheric ozone depletion, in accordance with the Montreal Protocol on Substances that Deplete the Ozone Layer, to which the United States is a signatory. The executive order includes the following provisions:

1. The federal agencies (including all military departments) shall, to the extent practicable:
 - a. conform their procurement policies and practices to the stratospheric ozone protection requirements included in Title VI of the Clean Air Act;
 - b. maximize the use of safe alternatives to ozone-depleting substances;
 - c. evaluate the present and future use of ozone-depleting substances, and evaluate their use of, and plans for recycling;
 - d. revise their procurement programs and practices to specify use of non ozone-depleting substances, to the extent economically practicable; and
 - e. exercise leadership and develop exemplary practices related to phasing out the use of ozone-depleting substances.
2. Defines ozone-depleting substances as those controlled internationally by the Montreal Protocol and nationally under Title VI of the Clean Air Act Amendments. This includes both Class I and Class II substances, as follows:

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- a. Class I substances includes chlorofluorocarbons, halons, carbon tetrachloride, and methyl chloroform.
 - b. Class II substances include hydrochlorofluorocarbons and any other substances so designated by the EPA by any subsequent regulations.
3. Federal Policy: The policy to be followed by federal agencies is to implement cost-effective programs to minimize the procurement of materials and substances that contribute to the depletion of stratospheric ozone, and give preference to the procurement of alternative chemicals, products, and manufacturing processes that reduce overall risks to human health and the environment by lessening the depletion of ozone in the upper atmosphere. This policy encourages federal agencies to conform their procurement policies to the general requirements of Title VI of the Clean Air Act Amendments. Key elements of the policy are as follows:
- a. Minimizing the procurement of products containing or manufactured with Class I substances, and maximizing the use of safe alternatives. Federal agencies should also be aware of the EPA phaseout schedule for Class II substances;
 - b. Amending existing contracts to be consistent with the phaseout schedule for Class I substances. Agencies should also be aware of the phaseout schedule for Class II substances in awarding new contracts;
 - c. Implementing practices which recognize the limited availability of Class I substances, such as reducing emissions and recycling ozone-depleting substances; ceasing the purchase of nonessential products containing ozone-depleting substances; and requiring that any new contracts provide that acquired products containing Class I or Class II substances be labeled in accordance with Section 611 of the Clean Air Act Amendments.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits:

- Significant reduction in the volume of ozone-depleting substances used
- Reduction in emissions generated from federal facilities
- Economic benefits (in many instances)

Disadvantages: N/A

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Economic Analysis: Completion of a rigorous economic analysis of the benefits of the affirmative procurement policies requires site-specific information regarding material usage, waste processing, waste volumes, and existing procurement practices.

Points of Contact: United States Environmental Protection Agency

Vendors: N/A

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HAZARDOUS MATERIAL SHELF LIFE MANAGEMENT

Revision: 1/96
Process Code: Navy: SR-11-99; Air Force: MA01; Army: N/A
Substitute for: Disposal of Expired Materials
Applicable EPCRA Targeted Constituents: Various

Overview: One of the most effective waste minimization programs that can be established is the active life-cycle management of hazardous materials before they become hazardous waste. An effective shelf life extension program is a critical part of life-cycle management. A significant portion of hazardous materials turned in for disposal is typically unused and still in its original packaging. The material is declared a waste when it has reached the end of its designated shelf life before being used.

Shelf life designations are either Type I or Type II. Type I materials comprise a small portion of hazardous materials (10 percent) and can not be extended. Type II materials are the majority of the hazardous materials and have an extendible shelf life. Shelf life can be extended by testing or inspection. These are further described below. The following definitions are presented:

Shelf-life Item. Item or material possessing deteriorative or unstable characteristics to the degree that a storage time period must be assigned to assure that item will perform satisfactorily in services. Shelf-life items are categorized into two types:

- (1) Type I. An item of supply which is determined through an evaluation of technical test data and/or actual experience to be an item with a definite non-extendible period of shelf-life. The single digit shelf-life code designating Type I material is a letter (A-S).
- (2) Type II. An item of supply having an assigned shelf-life time period that may be extended after completion of an inspection, test, or restorative action. The single digit shelf-life code designating Type II material is a number (1-9).

Acceptable Quality Level. The maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average.

Condition Code. A code assigned to classify material in terms of its readiness for issue and use, or to identify action underway to change the status of material. The condition codes used by stocking activities in

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shelf-life procedures are listed below. "Users" of the material normally do not downgrade condition codes in this manner. They leave the material in "A" condition until the shelf-life has expired.

When Shelf-life Remaining is:	Assign Condition Code:
More than six months	A
Three to six months	B
Less than three months	C
Expired, awaiting testing	J
Expired, awaiting disposal	H

Shelf-life Code. A code assigned to a shelf-life item to indicate its storage time period. Shelf-life codes are standard within the Department of Defense (DOD) and are published regularly. For example, items used by the Navy which have an assigned shelf-life code are listed monthly in NAVSUP PUB 4105 (List of Items Requiring Special Handling [LIRSH]).

TYPE I (NON-EXTENDIBLE)

(Shelf Life Action Codes are: UU, SA, SB, or S9)

0 - Non-Deteriorate

A - 1 Month

B - 2 Months

C - 3 Months

D - 4 Months

E - 5 Months

F - 6 Months

G - 9 Months

H - 12 Months

J - 15 Months

K - 18 Months

L - 21 Months

M - 24 Months

N - 27 Months

P - 30 Months

Q - 36 Months

R - 48 Months

S - 60 Months

X - Greater than 60 Months

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TYPE II (EXTENDIBLE)

(Shelf Life Action Codes are: CO, C_, CT, L_, RD, RN, RJ, T_, X_)

- 0 - Non-Deteriorate
- 1 - 3 Months
- 2 - 6 Months
- 3 - 9 Months
- 4 - 12 Months
- 5 - 18 Months
- 6 - 24 Months
- 7 - 36 Months
- 8 - 48 Months
- 9 - 60 Months
- X - Greater than 60 Months

Shelf-life Action Code (SLAC). A code assigned to a shelf-life item to specify the type of inspection, test, or restorative action to be taken when the item has reached the end of its designated shelf-life. It also specifies the allowed extension period for the item after the inspection, test, or restorative action has been completed. NAVSUP PUB 4105 promulgates the Shelf-life Action Code (SLAC) for items used by the Navy that have assigned shelf-life codes

The code describes action to be taken at the expiration of the Shelf Life period. The codes which include a (_) in the second position imply a period of time expressed by the Shelf Life Codes.

CO - Check/inspect/test in accordance with inventory manager's instructions.

C_ - Incorporate all mandatory changes, etc. If found satisfactory, reclassify to the number of months indicated after which the item is considered unsuitable for restoration to issuable status. Shelf life codes will be used to identify the number of months for which the item is reclassified (i.e., 7C2 indicates an item having normal shelf life of 3 years may be extended for 6 months after incorporation of changes).

CT - Incorporate all mandatory changes, perform minor adjustments required, clean and relubricate bearings, reassemble, test to post-overhaul standards, and correct any observed discrepancies. Items which pass tests shall be returned to stock as RFI. Exterior package marking of such items shall indicate the latest check and test date, and the original date of manufacture. Items which fail test shall be placed in "F" condition.

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- L_ - To be tested by the laboratory/activity in periodic increments after the initial time limit has expired. The letter or number following the "L" indicates increment in which laboratory tests are required. Example: 4L1 - After 12 months, and every 3 months thereafter, a sample should be submitted to the Laboratory/Activity for testing. If item fails test, take disposition action.
- RD - Replace all deteriorated and nonmetallic components subject to determination (disassemble and process to the level required to permit replacement of deteriorable items; test to post-overhaul standards and return to stock as RFI item with fully restored storage time limitations). Exterior package marking of such items shall indicate the latest date of overhaul.
- RN - Provides for equipment that has been tested with fluids indicated by specification MIL-F-7024A and has not subsequently been operated with other fluids. (Use for fuel metering equipment only.)
- RJ - This is assigned to fuel metering equipment which has been tested by other than MIL-F-7024A.
- SA - Salvage.
- SB - Request cannibalization/salvage instructions from inventory manager.
- S9 - Identification of safety items. A safety item designated by the Navy that is subject to a 5-year limitation when in applications involving the safety of personnel. Material in this category that is over 5 years old will not be used for repair or modification of personnel, drag, or special parachutes, or other uses directly involving personnel safety. Use advice code 2H, unless material is being used for cargo parachutes or other uses not involving personnel safety.
- T_ - Test: If the item passes, extend life by number of months indicated by the number following "T," after which process in accordance with Code RD.
- UU - Unsuitable for restoration to issuable status. At end of shelf life period, material will be disposed of in accordance with existing instructions.

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- X_ - Test: If passed, redate item to the number of months/years indicated by the shelf life code. If item fails tests, dispose of it in accordance with existing instructions. All material that exceeds the age from date of manufacture to the age indicated by the character following the letter "X" will be disposed of in accordance with existing instructions.
- 00 - Not deteriorative. (Must always be shown in field "Shelf Life" as "0.")

Shelf-life extension programs are the single most neglected aspect of shelf-life management. Organizations (users as well as suppliers) generally do not conduct in-house inspections of tests to extend the shelf-life of their material. They either don't extend shelf-life at all or rely on the monthly DOD Quality Status Listing (QSL) to tell them what shelf-life material can be extended and for how long. When the QSL is used, extension efforts often consist solely of re-marking material with the new expiration dates published in the QSL. There is nothing wrong with that, and it needs to be done, but the QSL primarily lists only DLA-managed items that require laboratory testing. Items that require only visual checks are not listed; neither are GSA-managed items. There is a DOD initiative underway to extend the QSL into a DOD listing that will include material managed by DLA and all military services. Unfortunately, it will be some time before it becomes fully integrated, and it will never list items that require only visual checks to do extensions.

In-house inspections and tests are adequate for most material. It is, however, often difficult for personnel to find descriptions of the specific inspections or tests required to extend the shelf-life of particular items. There is no single source of test information. GSA and all military services except the Navy have developed separate storage standards with extension criteria for the material they manage. Each DLA Inventory Control Point (ICP) has developed storage standards for material managed by the particular ICP. Every command should have a collection of those standards. Together, they represent the existing universe of shelf-life extension test and inspection guidelines. Individual product specifications are the only other source of inspection and test information. Storage Standard Points of Contact are listed in DOD 4140.27-M (Shelf-Life Item Management Manual).

The Navy has not yet developed storage standards for shelf-life extension inspections and tests on Navy-managed material. In the absence of specific guidelines, use common sense. For most Type II

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material, shelf-life extension tests are not complicated, do not require a laboratory, and can be done on the spot by anyone with a minimum amount of training. They are usually nothing more than visual checks for damage or deterioration.

Navy Item Managers refer callers to Fed-Std-793 (Depot Storage Standards) when asked what tests need to be conducted to extend the life of particular products. A sample of generic storage standards based on Fed-Std-793 is presented below. Personnel can use it to test most Type II hazardous materials in the absence of other specific instructions.

INSTRUCTIONS FOR SAMPLING AND INSPECTION/TEST

a. Sampling

- (1) Whenever possible, sampling shall be in accordance with MIL-STD-105, Inspection Level S-2, single sampling plan for normal inspection.
- (2) When on-hand quantities of the item are too low to allow statistically valid sampling, inspect/test enough of the material to give you confidence in the overall condition of the lot/batch.
- (3) Acceptable Quality Level: 4.0 percent defective.

b. Shelf-life Extension Criteria.

- (1) The material being inspected/tested shall be sampled as specified in paragraph a(1)-(3).
- (2) Unit, intermediate, and shipping containers shall be secure and free from leaks, rust or other contaminants, dents, bulges, or other distortion.
- (3) Unit containers will be securely sealed.
- (4) Container contents shall show no evidence of deterioration.
- (5) There shall be no evidence of reaction of the contents with the container.
- (6) Liquid products shall be homogeneous solutions with no separation, sediment, or other degradation of components.
- (7) Contents shall not have evaporated.
- (8) Solid materials (powders, etc.) shall be free-flowing with no significant water absorption or other contamination.
- (9) Aerosols/sprays will spray as designed.
- (10) Markings on all containers shall be securely attached, clear, and legible.
- (11) The material will perform its intended function.

c. Length of Shelf-life Extension. When the shelf-life of an item is extended, the new reinspection date will be as designated by the item's Shelf-Life Action Code (SLAC). The SLAC specifies the

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type of inspection, test, or restorative action required, and the extension period allowed after the inspection, test, or restorative action has been completed. The SLAC for a particular item can always be found on the item's issue/receipt documentation (DD 1348-1) and/or Material Movement Document (MMD). If the paperwork is not available, use a suitable reference such as NAVSUP PUB 4105 to find the Shelf-Life and Shelf-Life Action Codes for the item.

- d. Maximum Time the Shelf-Life Can Be Extended.
- (1) The shelf-life of Type I material can not be extended. The material goes to disposal at the end of its shelf life.
 - (2) The shelf-life of Type II material can be extended as many times as the required inspection/test shows that the material is still in usable condition. In order to minimize the disposal of functional material, stock points and end-users are authorized and encouraged to inspect/test shelf-life items by this standard or by practical, end-user-related tests to determine if the items still meet the intended use of that activity. The shelf-life may be extended as long as the item performs satisfactorily for the end-users needs.

STORAGE CONDITIONS

Adhesives and sealants must be stored in temperature and humidity controlled areas. Unless otherwise specified on the package label or marking, all other products may be stored in uncontrolled temperature and humidity locations.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits: A properly implemented shelf life management program will:

- Reduce disposal of expired hazardous materials
- Reduce reordering of additional hazardous materials to replace expired hazardous materials
- Enhance hazardous minimization/pollution prevention efforts

Disadvantages:

- Often difficult for personnel to find descriptions of specific tests or inspections required to extend shelf-life of an item

Approval

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Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Economic Analysis: The savings incurred through reduced disposal costs and reduced reordering of materials varies greatly depending on the situation.

Points of Contact: Ross Thompson
SUP 4521A
DSN 327-0312, (703) 607-0312

Vendors: N/A

Source: Shelf Life Management Chart from Hazardous Material Control & Management/HMIS CD ROM System.

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WASTE ANALYSIS PLAN

Revision: 1/96

Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A

Substitute for: Non-centralized, non-standard means of determining the characteristics of wastes in order to determine proper disposal

Applicable EPCRA Targeted Constituents: Various

Overview: A waste analysis plan serves to standardize and optimize the required testing of wastes so that all wastes at a site are properly characterized prior to disposal in a simple and efficient manner. A waste analysis plan establishes the characterization frequency and analytical requirements to be satisfied for every identified waste at the installation and provides guidance for handling new wastes.

1. Responsibilities for Characterization Prior to Disposal: The personnel that make decisions regarding waste characterization and disposal must be trained in the regulatory requirements of the Resource Conservation and Recovery Act (RCRA), and must know who establishes and enforces those regulations in the generator's location. The applicable hazardous waste regulatory program could be operated by a regional office of the Environmental Protection Agency (EPA) or by an EPA-approved state agency. In this data sheet, only references to federal regulations are provided. However, additional or alternative state regulations may apply. All state programs have the same basic regulatory requirements as the federal program, but may also have additional requirements. It is critical that state-specific regulations be reviewed before waste management plans are developed.

Waste management personnel must understand the details of the characterization requirements described below so that any required testing and analysis can be integrated into the waste analysis plan. In addition to determining if a waste is covered by the RCRA hazardous waste regulations, a waste's characterization must also be sufficient to determine what waste disposal options (neutralization or other treatment, landfilling, incineration) are available for that waste.

For any waste that requires sampling and testing to determine its characteristics, the following information must be developed:

- the required parameters for sufficient characterization,
- the tools required for sampling,
- the method used for sampling,
- the holding time of the sample,
- the laboratory analytical method to be used,
- the degree of detail in the reporting data and quality control, and

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- the maximum allowable concentration of the parameters of interest for the desired means of disposal.

2. Characterization by Generator Knowledge of a Listed Hazardous Waste: The circumstances associated with the generation of each waste determine what means of characterization is required. First, the waste must fit the definition of solid waste stated in 40 CFR 261.2 and not fit the definition of any exclusions listed in 40 CFR 261.4. Excluded wastes may be covered by other regulatory programs, or may be allowable in the municipal solid waste stream if not prohibited by the local solid waste ordinance.

If a waste is a solid waste (by RCRA definition), it may be a "listed hazardous waste," as specifically defined in 40 CFR 261 Subpart D (Parts 261.30 through 261.35). If the waste meets the definition of a "listed waste," based on the circumstances of the generation of the waste, then documented generator knowledge may be enough for a sufficient characterization to satisfy all disposal requirements. This also applies to a mix of a "listed waste" and another type of waste (per 40 CFR 261.3 [a] [2]), and also to a waste that is derived from a "listed waste" (per 40 CFR 261.3 [c] [2]). An example of a derived waste is the ash that remains from a listed hazardous waste that burned.

Each individual listed hazardous waste is assigned one or more waste type designations, based on the criteria of being ignitable (I), corrosive (C), reactive (R), toxicity characteristic (E), acutely hazardous (H), or toxic (T). Based on these characteristics, EPA specifies four hazardous waste lists, described below.

List Name	Designation	40 CFR Citation
Non-specific Source Wastes	F List	261.31
Specific Source Wastes	K List	261.32
Discarded Commercial Chemical Products - Acutely Hazardous	P List	261.33(e)
Discarded Commercial Products - Hazardous	U List	261.33(f)

In order to determine if a specific waste is included in one of these lists, the lists provided in 40 CFR Part 261 must be referenced. Acute hazardous waste includes not only the "P List" waste chemicals, but selected "F List" waste types marked in the regulation with an (H). (Note that rules for accumulating waste often have specific requirements to address acutely hazardous waste.)

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The waste analysis plan should include an updated description of each specific source of listed hazardous wastes generated at the installation.

3. Characterization by Sampling and Analysis of a Characteristic Hazardous Waste: If a waste is a solid waste (by RCRA definition), but does not meet the definition of any of the "listed hazardous wastes," it may still be considered a hazardous waste if the material exhibits any of the characteristics as defined in 40 CFR 261 Subpart C (Parts 261.20 through 24). Sampling and testing are required to determine the following hazardous characteristics:

- Ignitability (RCRA code D001)
- Corrosivity (RCRA code D002)
- Reactivity (RCRA code D003)
- Toxicity (RCRA codes D004 through D0043)

The suggested sampling procedures to create a representative sample of different specific waste forms (such as drummed liquid, saturated soil, etc.) are provided in an EPA guidance manual titled *Test Methods for Evaluating Solid Wastes*, EPA document SW846. The specific analytical laboratory testing methods for each hazardous characteristic are specified in 40 CFR 261 Subpart C by specific references to SW846.

To develop a waste analysis plan, a standard method of sampling and laboratory analysis for each waste should be selected based on the guidance provided in SW846 (or other applicable EPA guidance manuals) and the background knowledge of the generator. Every analysis does not have to be performed for every waste if the generator can provide documented support that certain compounds are unlikely to be present.

4. Determining the Frequency of Characterization: Per 40 CFR 264.13 (a)(3), "Waste analysis must be repeated as often as necessary to ensure that it is accurate and up to date." This means that an analysis of a waste is necessary whenever any of the following circumstances occur:

- the generator is aware of a change in the process that produces the waste,
- the generator is aware that a waste was tainted by inadvertent mixing with another waste,
- the receiving TSD facility determined through analysis that the waste no longer matches the expected characteristics, or
- there is a change to the hazardous waste regulations that apply to that waste.

**Materials
Compatibility:**

N/A

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Safety and Health: N/A

Benefits: The development and correct use of a waste analysis plan can:

- Help to avoid the unnecessary expense of disposing of non-hazardous wastes using hazardous waste disposal methods or contractors
- Help to avoid regulatory violations that can result in large fines and negative public exposure for the mismanagement or improper disposal of hazardous waste
- Minimize the time and money required for sufficient characterization of wastes and selection of proper disposal methods

Disadvantages:

- Personnel must be specially trained to make decisions regarding waste characterization and disposal and to develop these decisions into a plan

Economic Analysis: Savings incurred through the use of a waste analysis plan are dependent upon site specific details.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: The Hazardous Technical Information Services (HTIS) helpline (phone [800] 848-4847), the RCRA hotline (phone [800] 424-9346), agencies associated with environmental compliance within each branch of the U.S. military, and environmental compliance specialists at each U.S. military installation can provide technical assistance necessary to develop an installation-specific waste analysis plan.

Vendors: A guide for developing a formalized, installation-specific waste analysis plan is available through the National Technical Information Service (phone [703] 487-4660) or the U.S. Government Printing Office (phone [202] 512-1800). Request the *EPA Guidance Manual: Waste Analysis At Facilities That Generate, Treat, Store, and Dispose of Hazardous Wastes*, document number PB94-963903, April 1994.

The EPA guidance manual titled *Test Methods for Evaluating Solid Wastes*, EPA document SW846, is available through the U.S. Government Printing Office (phone (202) 512-1800)

HAZARDOUS MATERIALS SHELF LIFE OPTIMIZATION

Revision: 1/96
Process Code: Navy: SR-11-99; Air Force: MA01; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: All

Overview: Management of hazardous materials is dependent on several conditions, one of the most important being the material's expected usable lifetime, or "shelf life." A material's shelf life is a function of a number of factors such as intrinsic degradation rate, storage conditions, packaging, exposure to air, etc. The effective management of hazardous materials has become an economic, as well as an environmental, necessity, because once a hazardous material's shelf life is exceeded, it is no longer usable for its intended purpose. At that point in time, the hazardous material becomes a hazardous waste. Proper disposal is not only difficult and expensive, but may cause some long-term environmental impact. Moreover, new material needs to be procured to replace that lost by expiration of the shelf life.

One of the goals of a hazardous materials management program should be to accurately determine a material's shelf life so that materials can be managed more effectively. This data sheet provides information on the basic aspects of a shelf life optimization program.

Hazardous materials include many widely-used chemical products, such as adhesives, lubricants, paints, oils, and sealants. Any such product remaining at the time of its shelf life code expiration has to be either tested for suitability for continued use or be disposed as hazardous waste and replaced with new material. In order to reduce hazardous waste generation and save money, the U.S. Navy is evaluating its hazardous materials management system and "shelf life code" assignments to determine which materials can have their shelf life codes lengthened without compromising safety, quality, or usability.

"Shelf life" is not synonymous with "shelf life code." Shelf life is the actual useful life of a hazardous material, whereas shelf life code is the period assigned to that hazardous material by the procuring service that indicates the time period before quality testing is required to verify that the material has not degraded beyond its usefulness. This means that the period of a material's shelf life code should be less than or, at most, equal to its actual shelf life. There is also a distinction between "lengthen" and "extend" that is important in understanding the shelf life optimization concept in precise terms. A shelf life code can be "lengthened" after technical review of the material's specification,

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composition, storage condition, degradation rate, etc. In contrast, the shelf life code of a specific batch or lot of material can be “extended” only after quality testing has indicated that it has some more useful life left.

Most chemical products acquired by the Navy either have very conservative shelf life codes or were assigned a shelf life code without an adequate underlying technical basis. The goal of shelf life code optimization is to use a scientific basis to assign a shelf life code so that a product’s useful life can be lengthened (shelf life code approaches the material’s actual shelf life) and, thus, material usage can be optimized without compromising use or requiring excessive and costly quality testing.

A product’s shelf life code can not simply be derived from any scientific formula; rather, it should be based on a technical evaluation of the degradation mode of each of the product’s constituents, as well as its packaging and storage conditions. Furthermore, sound engineering judgment based on these data and other information, such as scientific literature, manufacturer’s data, DOD material testing, and military specifications, along with product use and experience, should be combined to determine the product’s optimum shelf life.

Not all products require prompt re-evaluation of their shelf life codes. Products should be prioritized for re-evaluation. The initial focus should be on products that contain hazardous materials, have short shelf lives, and have high disposal or replacement costs.

Individuals can be assigned to review specific products, but each individual’s recommendations should undergo a peer review process in which a team scrutinizes the data and recommendations, and then has the final authority to determine a product’s shelf life code.

Implementation of measures that will improve management of hazardous materials with respect to shelf life code lengthening are:

- Procurement of chemicals in smaller lots so that all the material can be used by the shelf life code expiration
- Reduce inventory of material
- Just-in-time procurement of material
- Improve storage conditions of chemicals

Materials

Compatibility:

Materials compatibility considerations are a key part of the analysis of each individual chemical product. This should include not only storage container compatibility, but also storage conditions such as temperature,

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humidity, atmosphere, light exposure, and mutual compatibility of chemical constituents of products.

Safety and Health: Safety and health are important considerations when evaluating shelf life extension of a given material. While these considerations are primarily material specific, they should also be viewed in the broader areas of storage, distribution, and use of multiple products in a common area.

Materials that are used in critical applications within the DOD, especially those operations where use of aged material could jeopardize the safety or health of DOD personnel, are assigned more conservative shelf life codes.

Consult your local health and safety personnel, and the appropriate MSDS for specific precautions..

Benefits: A shelf life code review and management program will :

- Reduce the total amount of chemicals purchased
- Reduce generation of hazardous waste
- Require less procuring, handling, shipping, and storage of chemicals and wastes because of decreased need for new materials and reduced generation of waste materials

Disadvantages: N/A

Economic Analysis: The savings incurred through shelf-life management of hazardous materials depend on how the program is organized at each activity. Reduced material purchases and waste disposed must be determined on an individual basis to assess the economic benefit of a shelf-life program.

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Jim Lewis
Defense General Supply Center
(804) 279-4140 or DSN 695-4140

Vendors: N/A

Source(s): Parsons ES study for the Navy on "Hazardous Materials Shelf Life Code Specification."

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HAZARDOUS WASTE CONTAINER LABELING, STORAGE, AND TRANSPORTATION

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute For: Unsafe Or Sub-Standard Handling Of Hazardous Wastes At The Generating Location
Applicable EPCRA Target Constituents: Various

Overview: The proper handling techniques for containers of hazardous wastes are defined within the Resource Conservation and Recovery Act (RCRA) regulations. Specific requirements depend on the available facilities, the volume of waste typically generated, and the desired mode of hazardous waste handling and transportation.

The personnel that make decisions regarding hazardous waste containers, labeling, storage, and transportation must be trained in the regulatory requirements of RCRA, and must know who establishes and enforces those regulations in the generator's location. The applicable hazardous waste regulatory program could be operated by a regional office of the Environmental Protection Agency (EPA) or by an EPA-approved state agency. In this data sheet, only references to federal regulations are provided. However, additional or alternative state regulations may apply. All state programs have the same basic regulatory requirements as the federal program and should be consulted prior to establishing any procedures.

This data sheet addresses the generator's requirements for container type, marking, and labeling. For the purpose of this datasheet, an installation may have more than one waste-generating site. Proper preparation of hazardous wastes for off-site transport must be performed by trained personnel in accordance with the Hazardous Materials Transportation Act regulations provided in 49 CFR Subchapter C (Parts 171 through 177). Often times, the hazardous waste transporter will be responsible for providing compliance with 49 CFR 171-177.

1. Container Storage

In general, hazardous waste may be stored in accordance with one of three sets of regulatory requirements. The requirements for an "initial accumulation area" (also called a "satellite accumulation area"); the requirements of a "less-than-90-day storage area;" or the requirements for a permitted treatment, storage, or disposal (TSD) facility must be satisfied for each location where hazardous waste is stored.

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Fulfilling the requirements for a TSD facility is a complicated and demanding task that is far beyond the requirements for storing wastes from a single waste-generating process at an installation with multiple waste-generating sites. By comparison, the requirements for an "initial accumulation area" or a "less-than-90-day storage area" are much less complex and still provide an area that is suitable for many waste-generating situations.

The regulatory limit for accumulating hazardous waste at an "initial accumulation area" is volume-based (no more than 55 gallons allowed, in most cases), while the limit for accumulating hazardous waste at a "less-than-90-day storage area" is time-based (no longer than 90 days of storage allowed, in most cases). When the corresponding limit is reached at either type of storage area, the waste must then be transferred. Hazardous waste from an "initial accumulation area" can be moved to an on-site "less-than-90-day storage area," or a permitted TSD facility. Hazardous waste from a "less-than-90-day storage area" can only be moved to a permitted TSD facility.

An "initial accumulation area" must be located at or near the waste-generating activity and be under the direct supervision of the operator of the activity. In accordance with 40 CFR 262.34 (c):

- No more than 55 gallons of hazardous waste or 1 quart of acutely hazardous waste may be accumulated at an "initial accumulation area." There is no time limit on how long it takes for waste to be accumulated up to the volume limit.
- Once the volume limit is exceeded, the generator must mark the hazardous waste container with that date, and transfer that waste out of the area within 3 days.

A "less-than-90-day storage area" must be located on site at the installation and be managed in accordance with the following requirements from 40 CFR 262.34 (a).

- Any volume of hazardous waste can be collected and stored in acceptable containers or tanks (or drip pads, in the case of equipment that contains hazardous waste), providing no accumulated hazardous waste remains in storage for more than 90 days.
- A container holding hazardous waste must always be kept closed during storage except when it is necessary to add or remove waste.
- The container must not be handled in a manner which will cause it to leak.

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- If the container holding the waste leaks, the waste must be transferred to a new container.
- The containers must be inspected at least weekly for leaks and signs of corrosion.
- Containers holding ignitable or reactive waste must be located at least 50 feet from the installation property line.
- Containers of incompatible waste must be separated by means of a dike, berm, wall, or other structure.
- A "less-than-90-day storage area" must have communication, alarm, and fire-fighting systems in accordance with 40 CFR Part 265 Subpart C (265.30 through 37). This regulation also defines the required aisle space between containers.
- A "less-than-90-day storage area" must have a contingency plan with established emergency procedures in accordance with 40 CFR Part 265 Subpart D (265.50 through 56).
- The personnel that operate a "less-than-90-day storage area" must receive training in accordance with 40 CFR Part 265.16.
- A "less-than-90-day storage area" must have a waste analysis plan in accordance with 40 CFR Part 268.7(a)(4).

If a container of hazardous waste is kept at a "less-than-90-day storage area" for the purpose of collecting small quantities of waste over time, the 90-day storage limit for that container begins with the original addition of waste. If a filled container of hazardous waste from an "initial accumulation area" arrives at a "less-than-90-day storage area," the 90-day limit for that container began when the volume limit of 55 gallons (or 1 quart of acute hazardous waste) was first exceeded at the "initial accumulation area."

2. Container Selection

A container used to collect hazardous waste at an "initial accumulation area" or a "less-than-90-day storage area" must meet the following requirements (per 40 CFR 262.34).

- The waste being placed in the container must be compatible with the container. The operator of the "initial accumulation area" can confirm the compatibility of a stored material and a container material by referencing any of a variety of handbooks or manuals on the subject, such as Table 23-3 of the *Chemical Engineering Handbook* by Perry and Chilton. The MSDS may also be helpful in identifying suitable storage conditions. Under many circumstances, the only commonly handled wastes not compatible with a steel container are highly corrosive wastes, such as waste acids, which must be stored in a plastic or plastic-lined container.

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- If wastes from more than one specific source are intended to share the same container, and mixing of the wastes does not violate applicable disposal requirements, then the compatibility of the mixed wastes with each other and the compatibility of the mix with the container must be confirmed prior to this type of storage. Similarly, a waste can not be stored in a container that has previously stored a different waste with which it is incompatible.

3. Container Labeling

For an "initial accumulation area" (per 40 CFR 262.34 [c]):

- Containers must be marked with the words "Hazardous Waste" and with other words which identify the contents of the container.

For a "less-than-90-day storage area" (per 40 CFR 262.34 [a]):

- The storage container must be labeled with the words "Hazardous Waste" and a description of the waste.
- Containers that accumulate waste while being stored must be clearly marked with the date when the container began accumulating waste.
- Containers that arrive from an "initial accumulation area" must be clearly marked with the date when the container became full.

4. On-Site Movement of Containers

As stated in 40 CFR 263.10 (b), "These regulations [for permitted transportation of hazardous waste via air, water, or public highway] do not apply to on-site transportation of hazardous waste by generators or by owners or operators of permitted hazardous waste management facilities." However, it is recommended that standard safety guidelines for the handling of hazardous waste be implemented for on-site transportation activities. Typical standard operating procedures are as follows.

- Prior to transport, the hazardous waste container must be completely closed and sealed. Bungs must be tightened, and lids must be in place with bolt rings tightened.
- Prior to transport, the container must be inspected to ensure that it can be safely transported without risk of spills or leaks. If a container is damaged, corroded, or otherwise structurally inadequate, the waste must be transferred to a new container or placed in an approved overpack drum prior to moving.

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- The transfer of a container between an area and a vehicle must be accomplished using appropriate equipment in a way as to minimize the possibility of an accident or spill.
- Other installation-specific documentation may be required at the time of transfer.

Materials

Compatibility: See section on “container selection” above.

Safety and Health: Consult your local safety and health personnel for specific precautions.

Benefits:

- Containers that are properly selected, labeled, and handled will minimize the risk of releasing hazardous waste that might lead to facility damage, personal injury, or pollution of the environment.

Disadvantages:

- Personnel may require “re-training” to learn to modify their regular work habits.

Economic Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: The Hazardous Technical Information Services (HTIS) helpline (phone [800] 848-4847), RCRA hotline ([800] 424-9346), agencies associated with environmental compliance within each branch of the U.S. military, and environmental compliance specialists at each U.S. military installation can provide assistance in determining the proper container, labeling, storage, and transport requirements for a hazardous waste with known characteristics.

Vendors: N/A

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HAZARDOUS MATERIAL/HAZARDOUS WASTE MANAGEMENT

Revision: 1/96
Process Code: Navy: SR-11-99, ID-25-99; Air Force: MA01, HW01; Army: N/A
Substitute For: Traditional, Non-Centralized Hazardous Material/Waste Management Approaches
Applicable EPCRA Targeted Constituents: N/A

Overview: The Navy Hazardous Material Control & Management (HMC&M) Program was established in 1989 in response to the increased attention being focused on environmental issues, both in the United States and internationally. This program focuses on the reduction of hazardous material (HM) usage and the subsequent generation of hazardous waste (HW) associated with HM usage. As implementation of the HMC&M program got underway, an early initiative was development of a strategy to achieve significant reductions in the use of HM and the generation of HW. Historically, the Navy managed HM in much the same manner as most non-hazardous consumable material. There was no centralized mechanism of procuring HM or maintaining HM inventory control and management. This led to the proliferation of redundant capacities of HM, as well as unnecessary generation of HW resulting from excess quantities being handled.

As a means to eliminate many of the problems associated with traditional HM management practices, the Commanding Officer (CO) of Naval Air Weapons Station (NAWS), Point Mugu, California, decided to implement a program to consolidate the inventory management of HM through a single organization known as the Hazardous Material Minimization Center (HAZMINCEN). This center served the entire base and was the central element in the development of the plan for life cycle micro-management of HM at the base, which was termed the Consolidated Hazardous Material Reutilization and Inventory Management Program (CHRIMP).

Major Features of CHRIMP (as executed at Point Mugu):

1. Establishment of a HAZMINCEN to consolidate the inventory management of hazardous material into a single organization to serve the entire base.
2. Started by consolidating material from the Aircraft Maintenance Department (AMD). Set up system of credits and billings to control inventory and purchase of all HM by the department. Also established delivery system to respond to work order requests for material and to pick up any unused portions of HM.
3. Customer service was a key element of the HAZMINCEN. System was set up to eliminate as much paperwork as possible. Only a

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phone call was necessary to draw material. Efficient inventory management techniques were also essential to ensure material is on hand when needed, which was vital in the efforts to eliminate proliferation of locally purchased HM to meet an immediate requirement.

4. Established a recycling center on the base to collect all types of recyclable material including aluminum and tin cans, plastics, paper (many kinds), glass, cardboard, copper wire, and scrap metal (ferrous and non-ferrous).
5. Hazardous Inventory Control System (HICS) provided on-line visibility of inventory levels and provided the capability to process material requisitions, receipts, and issues. The system uses bar code technology to allow the user to create container bar-codes for each issue that uniquely identifies each container (see detailed description at end of section).
6. HAZMINCEN Startup Procedures:
 - a. All HM on site turned in to central storage area.
 - b. All material with shelf life greater than 6 months was bar-coded and entered into inventory.
 - c. All material with shelf life less than 6 months was donated to the community.
 - d. Small percentage of material which couldn't be used was sent to an approved waste transfer facility.
 - e. Reusable materials were consolidated and stored in approved containers.
 - f. All stocked HM is regularly checked to verify that supplies are sufficient.
 - g. Reorders are made regularly to replenish depleted supplies.
7. Typical HM processing steps:
 - a. Call for HM request is received at the Central Order Desk.
 - b. The HM order is immediately entered into the computer.
 - c. Order Clerk notifies stock manager of order.
 - d. Stock manager locates HM, retrieves amount for order, and delivery.
 - e. Guaranteed delivery time is within 45 minutes of order. Average delivery time is 30 minutes.
 - f. Performed daily roundup loop to pick up accumulated HM at customer locations, thus relieving them of responsibility and associated with tracking and storing HM.

costs

Description of HICS Program

The Hazardous Inventory Control System (HICS) is a computer-based program which formed the key element of the hazardous material management program at Point Mugu NAWS. HICS was developed to replace the manual INDEX system formerly used to manage HM. It

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includes the capability to process material requisitions, receipts, and HM issues. The HICS program uses bar code technology to allow the user to create container bar-codes for each issue that uniquely identifies each container. This feature is significant in that it establishes accountability for the HM that is issued and prevents unauthorized disposal of empty or partially filled containers. Another important element of the HICS program is that HM data collection is automatically performed, which allows for informed management decisions regarding HM purchasing and stockpiling policies. This type of information, combined with the ease in which it can be processed, was not available with the former HM management programs.

The Navy issued a CHRIMP manual in 1994 that includes HICS software and User's Guide. This package outlines the methodology for implementing a HICS-based centralized inventory management program. The HICS program has also been recently enhanced to provide networking capability. This will enable the regional FISC to query other HICS inventories to determine availability of reuse material. In addition, each regional FISC will be able to access inventory data from each HAZMINCEN within their region, as well as all other HAZMINCENs throughout the Navy. This capability will be instrumental in optimizing the HM inventories and usage, and will allow the fullest utilization of all HM that is procured. Furthermore, the HICS program can be incorporated into a more complex HM data collection system undergoing prototyping throughout the Navy to enhance compliance with the Pollution Prevention Act (PPA) and the Emergency Preparedness and Community Right-To-Know Act (EPCRA) requirements.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits:

Achievements of the HAZMINCEN at Point Mugu include:

- Total cost avoidance benefits in excess of \$1 million
- Hundreds of hours saved each month per customer in dealing with HM.
- Thousands of gallons of HM each month that no longer have to be shipped off site for costly disposal.
- Thousands of dollars less per month in hazardous waste disposal costs.
- Thousands of dollars less in HM procurement costs.
- Numerous safety benefits with proper HM storage centralized.

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Community recognition for job well done / numerous public relations benefits.

- Additional benefits include reduced landfill and waste disposal costs, reduced costs for replenishment of waste disposal containers and supplies, reduced labor hours, and significantly reduced volumes of HM on hand.
- Solid Waste Recycling Center Program
 - Program run using sailors and County Work Release personnel who use program to pay for community service duty; thus, no cost incurred to taxpayers.
 - Recycling center processes plastics, glass, newspaper, metal, and cardboard.
 - Money generated by center is used for base recreation fund.
 - Last year (1993) center recycled over 1/2 million pounds of scrap material.
 - Customers of the center vary from small local businesses to large, nationwide companies.

Disadvantages: N/A

Economic Analysis: The cost benefits of a properly established hazardous material/hazardous waste management program vary depending on the situation and should be assessed individually. As shown in the Point Mugu example, cost savings may be quite substantial and obtainable with the proper management strategies in place.

Approval Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Points of contact at Point Mugu Naval Air Weapons Station (NAWS) include the following:

Commander Edward Payne
Department of the Navy
Naval Supply System Command
1931 Jefferson Davis Highway
Arlington, VA 22241-5360
(703) 607-1440, Fax: (703) 607-0250

HAZMAT Pharmacy at Andrews AFB
SMSgt Lawrence Scott
DSN 858-9323, (301) 981-9323

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HAZMART Pharmacy at Nellis AFB
USAF WTC/EVW
4551 Devlin Drive
Nellis AFB, NV 89191-6546
Captain Michael E. McDonald
Chief Pollution Prevention
(702) 652-6098, (DSN) 682-4352, Fax (702) 682-2021

Points of Contact to get your name on the distribution list to receive the quarterly HMC&M/HMIS on CD ROM, call the appropriate Point of Contact below:

Army:

MACOM approval is required to receive 6050.5-LR. Provide justification and publication account number to the appropriate MACOM control office for approval. Medical staff activities that are not part of a MACOM should submit to US Army Medical Command. Engineer staff and field operating activities submit to US Army Corps of Engineers. All other staff and field operating activities that do not report to a MACOM submit to DCSLOG, Attn: DALO-SMP (R. George), Washington, DC 20310-0546.

Any questions regarding the distribution should be addressed to Ms. Sandy Gorba DSN 795-6622 or (717) 895-6622.

Air Force:

Commander

Attn Anna Willis AL OEMB
US Air Force
2402 E. Drive
Brooks AFB TX 78235-5114
DSN 240-6159, (210) 536-6159

Navy and Marine Corps:

Commander

Attn 4521C Bob Law
Navy Supply Systems Command
1931 Jefferson Davis Highway Ste 612
Arlington VA 22241-5360
DSN 327-0312, (703) 607-0312

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Defense Logistics Agency:

Attn SHP HAZMAT COORD Peter Shen
Defense General Supply Center
8000 Jefferson Davis Highway
Richmond VA 23297-5685
DSN 695-5735, (804) 279-5735

Other Federal Agencies and General Public:

Commanding Officer
Attn CD-ROM Team
NCTAMS LANT
9625 Moffett Avenue
Norfolk, VA 23511-2784
(804) 445-9192

Vendors:

In addition to the HICS software system developed specifically for use by the Navy and other DOD branches, there are several commercial vendors of hazardous material inventory control and related environmental management software. This list is not intended to be a complete listing of software vendors.

Chemical Safety

1301 S. 46th Street

Building 180

Richmond, CA 948904

(510) 231-9490, Fax: (510) 233-8926

Products/Services Offered: Environmental Management Systems (EMS) comprehensive hazardous materials tracking and reporting system capable of handling environmental compliance and management requirements from inventories and wastes to employee training. The EMS Modular system includes a variety of software selections including: Facility Module (for facility management and safety), Inventory Module (for chemical inventory reporting, purchasing, and management), MSDS Module (for MSDS management), Human Resource Module (for employee training, industrial hygiene monitoring, incident/accident tracking, and OSHA reporting), Waste Module (for waste manifest management, hazardous waste reporting, waste permit tracking, hazardous waste handling, etc.), Air Emissions Module (for Form R reporting), and Inventory Collection System (ICS).

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Primatech Inc.

445 Hutchinson Avenue, Suite 200

Columbus, OH 43235

(614) 841-9800, Fax: (614) 841-9805

Products/Services Offered: Primatech's HAZWARE programs are PC-based systems that were developed for specific aspects of hazardous material management and hazards analysis. Programs available include: HAZOP-PC (for performing Hazard and Operability studies), AUDIT-PC (for assisting in performing process safety audits, and other environmental auditing functions), WHAT IF-PC (for guiding the performance of a hazard analysis using "What If" question), FMEA-PC (for addressing possible equipment failures and potential hazards), PHA-PC (provides preliminary review leading to a detailed hazard analysis study, also provides risk management technique for screening and comparing hazards), and MANAGE-PC (for managing the implementation of recommendations resulting from hazard analysis studies). In addition to software applications, Primatech also offers specialized consulting and training services in risk, safety, and reliability.

Logical Technology, Inc. (LTI)

5113 N. Executive Drive

Peoria, IL 61614

(800) 3-PEORIA, (800) 373-6742

Products/Services Offered: Logical Technology, Inc. is an information management services firm that specializes in cost-effective regulatory compliance and office automation. LTI software programs include: CCM (Chemical Compliance Monitor, which is a compilation of chemical regulatory and advisory lists), TMS ("The MSDS Solution," an easy access, menu-driven package for managing MSDSs), The Directory (an electronic file cabinet for plans, procedures, and reports), Logitrac (material tracking system for all hazardous materials from purchase to disposal), and HAZMIN (Hazardous Materials Information Network, which combines the features of Logitrac with a comprehensive product review process). LTI provides custom-designed software packages to meet individual customer's needs.

PRINTED CIRCUIT BOARD RECYCLING

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute For: Disposal Of Waste Printed Circuit Boards As Hazardous Waste
Applicable EPCRA Targeted Constituents: Copper, Gold, Lead, Mercury, Platinum, Silver

Overview: Printed circuit boards are a common component of many electronic systems built for both military and commercial applications. Printed circuit boards are typically manufactured by laminating dry film on clean copper foil, which is supported on a fiberglass plate matrix. The film is exposed with a film negative of the circuit board design, and an etcher is used to remove unmasked copper foil from the plate. Solder is then applied over the unetched copper on the board. Depending upon the use and design of the particular printed circuit board, various other metals may be used in the manufacturing process, including lead, silver, gold, platinum, and mercury. Printed circuit boards are potentially a difficult waste material to process, since they generally have no usefulness once they are removed from the electrical component in which they were installed, and they typically consist of materials that classify them as a hazardous or "special" waste stream. They must be segregated and handled separately from other non-hazardous solid waste streams. Printed circuit boards that are handled as waste materials must be processed using any one of several available disposal options. Not only are these options expensive, they require a significant amount of effort and handling by the generator. Furthermore, since some of these disposal options do not include destruction of the waste circuit boards, the generator also retains much of the liability associated with improper handling or disposal.

As an alternative to off-site disposal, printed circuit boards can be handled and processed to recover the value of the raw materials that are used to produce the boards. There are several companies that offer recycling services as an alternative to off-site disposal of obsolete printed circuit boards. These services will generally process the boards by systematically removing raw materials of value from the board matrix. This includes metals such as silver, lead, copper, and gold. Depending upon the volume and characteristics of the printed circuit boards processed through a particular vendor, the raw materials will be recovered and the salvage value returned to the generator.

Typically, the vendor will provide a waste material profile form, which will be used by the generator to describe the nature, quantity, and additional characteristics of the circuit boards to be processed. Once the vendor approves of the processing arrangement, the generator will

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prepare the circuit boards for shipment. The handling and transportation methods used will depend on the volume of material, distance to be shipped, and vendor requirements.

Materials

Compatibility:

This should generally not be a consideration, since virtually all of the components of printed circuit boards are stable, solid materials when handled under normal circumstances. There may be some concern associated with printed circuit boards that contain unstable and/or toxic components such as mercury, certain forms of lead, and some electronic components that are attached to the boards. The waste recycling vendor should be contacted if there are any potential concerns regarding material compatibility which may be encountered during shipment or processing of the circuit boards.

Safety and Health: There are minimal safety and health concerns regarding circuit board recycling. For specific precautions consult your local health and safety personnel.

Benefits:

Recycling printed circuit boards has various benefits including:

- Recovered value of raw materials reclaimed from processing the circuit boards
- Savings resulting from the elimination of a potential hazardous waste or "special" waste stream
- Reduction of potential generator liability associated with improper handling and/or disposal procedures
- Generators can boost public relations by publicizing efforts made to bolster recycling initiatives at their facilities

Disadvantages:

- Market value of the reclaimed metals can fluctuate abruptly
- Boards containing inherently toxic or hazardous materials such as mercury may have little or no recyclable value

Economic Analysis: The economics of printed circuit board recycling will be determined by many factors, including the characteristics of the boards to be recycled, market value of the reclaimed components/raw materials, volume of boards being recycled, and conditions of the hazardous waste/solid waste market. Boards containing valuable metals, such as gold or silver, which can be readily reclaimed will be the easiest and most economically beneficial to recycle. Boards which contain inherently toxic or hazardous materials (e.g., mercury) may have little or no recyclable value and be precluded from consideration in a recycling program.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Wallace Eakes
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-4882, DSN: 551-4882, Fax (805) 982-4832

Vendors: Clean Harbors, Inc.
Customer Services Representative
Central Customer Service
Quincy, Massachusetts
(800) 533-5900

Chemical Waste Management
Customer Service Representative
Central Customer Service
3003 Butterfield Road
Oakbrook, IL 60521
(800) 843-3604

BFI Industrial Waste Services
Customer Service Representative
Central Customer Service
(800) 289-4310

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RECYCLING PHOTO/X-RAY PROCESSING AND PRINTING WASTES

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute For: Disposal Of Spent Photographic And X-Ray Processing And Printing Solutions
Applicable EPCRA Targeted Constituents: Heavy/Toxic Metals Including Cadmium, Hexavalent Chromium, Cyanide, Lead, Mercury, and Silver; Organics

Overview: Disposal of spent photographic and X-ray processing and printing solutions is expensive and difficult. The wastes generated by these processes typically contain elevated concentrations of heavy metals, organic compounds, and other toxic constituents unacceptable for direct discharge to a sewer system. In addition, as a result of the specialized characteristics of these solutions, they generally have very little, if any, value other than for their intended application. There are, however, various technologies that can be applied to treat certain solutions prior to disposal and/or to recover constituents of the waste streams which have value (e.g. silver recovery from specific photographic process wastes).

Silver may cause a material to be classified as a RCRA-hazardous waste by the Toxicity Characteristic Leaching Procedure (TCLP) (40 CFR 261.24). However, for a material to be a RCRA-hazardous waste, it must first fit the definition of a solid waste under RCRA (40 CFR 261).

Per a July 16, 1990, letter from Sylvia Lowrance (EPA) to Ralph Eschborn, the EPA considers spent photographic solutions as "spent materials," which is a subcategory of solid wastes (40 CFR 261.2 [c], Table 1). Further interpretation is provided by a February 28, 1994, letter from Michael Shapiro (EPA) to Scott Donovan:

"Provided that economically significant quantities of silver are reclaimed from the [spent] solution, [then] the generation, transport, and storage prior to reclamation of the solutions is not subject to the general RCRA Subtitle C requirements for recyclable materials... but rather a different set of regulatory requirements specified at 40 CFR Part 266 Subpart F [40 CFR 266.70]." In addition, "Under RCRA Subtitle C regulation [and 40 CFR 261.2 (c), Table 1.], characteristic sludges being reclaimed are not within the definition of solid waste."

In summary, 40 CFR 266.70 states that persons who generate, transport, or store recyclable materials that are reclaimed to recover economically significant amounts of gold, silver, platinum, or any combination of these must apply for an EPA or EPA-approved state generator

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identification number, and must also use the EPA or EPA-approved state manifest system to document all off-site transportation of solutions destined for reclamation of precious metals. However, once reclaimed, the silver is exempt from all hazardous waste regulations. Also, if the resulting treated liquid does not exceed the RCRA toxicity characteristic limits for silver (5 mg/L) or any other TCLP compound, then it is considered to be a non-hazardous material.

There are various technologies for recovering/recycling materials from spent photographic and X-ray processing and printing waste solutions. The most concentrated silver-containing waste in film and image processing is spent or excess fixer bath solution. In a typical film developing operation, fixer solution is continuously added to maintain solution strength. As a result, there is generally an overflow of fixer from the bath. The concentration of silver in the overflow may vary greatly depending on the type and amount of film processed, frequently exceeding 5 grams per liter. Because of this high silver concentration, silver recovery from the fixer solution is cost effective.

When the film is moved from the fixer to the rinse, it carries a small amount of silver which is removed by the rinse water. Rinse waters contain low concentrations of silver, ranging from less than 1 milligram per liter (mg/L) to greater than 5 mg/L. Although there is little economic benefit to recovering silver from rinse water, environmental regulations prohibit discharge of untreated rinse water if the silver concentration exceeds regulatory limits. Nearly all the silver in photographic wastes is bound up in silver thiosulfate complexes, which are highly stable. However, federal, state, and local regulations governing silver-containing wastes do not distinguish between different forms of silver.

There are several technology categories that are used for silver recovery, including precipitation, ion exchange, reductive exchange, electrolytic recovery, reverse osmosis, and electrodialysis. The specific technology to be applied for a particular waste stream will be based on the waste characteristics, volume, and treatment objectives. For example, if reduction of silver concentrations to meet wastewater effluent limitations is the primary treatment objective, then a technology which achieves extremely high silver recovery from the waste stream is probably not a cost-effective application. On the other hand, in cases where silver recovery is of primary importance, then application of a highly efficient system, such as reverse osmosis or ion exchange, makes sense. The following paragraphs provide brief descriptions of various technologies used for treating silver-laden waste streams. Although this discussion centers on the application of these technologies for silver

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treatment and/or recovery, these technologies are also effective in addressing additional waste constituents, as described herein.

1. **Waste Stream Heavy Metal Precipitation:** Hydroxide precipitation of metal-laden wastewater is a common technology that has been proven effective for several decades. The concept of this technology includes adjustment of the waste stream pH to a level at which the targeted metal is least soluble and will readily precipitate from solution. Precipitated solids are agglomerated, allowed to settle out, and then withdrawn from the treatment unit as a metal hydroxide sludge. Since the optimal treatment pH for various targeted metal species ranges from about pH 7 to over pH 12, most hydroxide precipitation systems are only effective in co-precipitating two, or perhaps three, different metals. As a result, most metal wastewater treatment systems which deal with multiple metal species include some means to segregate the waste stream flow trains, to more effectively address specific metals. Hydroxide precipitation of silver is effective, although it is not widely utilized, due to unfavorable economics and lower recovery efficiencies than competitive technologies.

Silver is frequently precipitated from metal wastewater as silver chloride, which is extremely insoluble. Thus, silver can be selectively removed from a mixed metal wastestream without prior segregation or co-precipitation interference. Should alkaline conditions exist in the silver treatment wastestream, resulting in co-precipitation of additional metal species, the precipitated metal sludges can be acid washed to leave the insoluble silver chloride compound. Alternative silver precipitation processes, such as the patented process developed by Eastman Kodak, are available. These processes rely on the use of magnesium sulfate and lime. The silver then precipitates as a mixed sulfate-oxide and is recovered from the settled sludge.

Sulfide is also widely used and is one of the oldest technologies for silver recovery in the photographic film processing industry. Hydrosulfite precipitation results in formation of both free silver and sulfide, with a more compact precipitate with favorable settling qualities. Disadvantages of this method include relatively high chemical costs and the need for supplemental heat input.

Precipitation is not commonly used to recover silver from film processing operations, nor is it commonly used to process liquid wastes to meet discharge limits.

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2. Ion Exchange: Ion exchange is commonly used for silver recovery from liquid wastestreams. One patented process exists which involves silver recovery from dilute photographic processing wash water by passage through a mixture of basic ion exchange resins. Silver retained on the resin is recovered through either elution of silver salts from the resin bed or by direct resin incineration and pure silver recovery. An ion exchange system for silver cyanide rinsewaters has also been developed, which consists of a five-column unit. In the first column, a cation exchange resin converts the silver cyanide to a silver hydrogen cyanide complex. The second column contains an anion exchange resin, which removes the silver cyanide. The elutant from the second column is then treated with sodium or potassium cyanide to recover the silver as either sodium or potassium silver cyanide. The additional three columns are used to achieve additional cyanide removal.

Another application of ion exchange technology for silver recovery utilizes a Type I, strong base gel anion resin to selectively remove silver from waste rinses. The dissolved silver is present as a negatively charged thiosulfate anionic complex which exchanges with sulfate ions on the anion resin. The resin bed is then rinsed with 2 percent sulfuric acid to precipitate the silver collected on the resin. The effluent from this rinse is then collected, neutralized, and discharged. This system is capable of reducing silver concentrations in the treated effluent to between 0.1 and 2.0 mg/L. After a sufficient number of cycles through the resin bed, the ion exchange capacity of the resin bed to remove silver will be exhausted. At this time, the resin is sent to a silver refiner for incineration and silver recovery.

Automated ion exchange columns units generally cost several thousand dollars and are practical only for large processing facilities. An ion exchange column is not suitable for high concentrations of silver, but may work well for recovering silver from fixer bath overflows that are diluted with rinse waters.

3. Metallic Replacement: This method utilizes iron metal (typically steel wool) to react with silver thiosulfate solution in photo processing fixer solutions and rinse waters. The iron replaces the silver in solution, while the silver settles out as a solid, for subsequent removal. The silver-laden waste solution is passed through a container filled with steel wool as a means of contacting the silver with the iron. The typical system consists of two chemical cartridges installed in series. The silver concentration in the treated effluent is generally below 5 mg/L. There are three disadvantages of this system: silver is recovered as a sludge, which is more difficult

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and expensive to process than alternative technologies; chemical recovery cartridges can not be reused and, thus, must be replaced when exhausted; and the cartridge effluent wastestream contains high iron concentrations. The advantage to this technology is that it is low cost, readily available, and requires no energy or special plumbing connections.

4. **Electrolytic Silver Recovery:** In this method, silver-laden solutions are passed through a system containing an anode-cathode array, which applies a controlled current. As the solution flows through the system, silver in virtually pure form is plated on the cathode. Once a sufficient quantity of silver has been accumulated on the cathode, the silver is recovered. Two disadvantages of the electrolytic recovery method are the relatively high capital costs and the lower treatment efficiency (typical silver effluent concentrations are in the range of 100 to 200 ppm). In common practice, electrolytic and metallic replacement systems are used in series, whereby the electrolytic unit will remove up to 90 percent of the silver in the influent, with the metallic replacement system removing most of the remaining silver in solution. However, even when these two technologies are used in combination, they still are not capable of achieving silver effluent concentrations to well below 5 ppm. Ion exchange or other alternative technologies must be implemented if extremely low effluent silver concentrations are consistently required.

Electrolytic recovery systems can also be used "in-line" for silver recovery in fixer solutions. Since much of the silver is recovered during the in-line process, often the only final treatment required is a metallic replacement cartridge system. Another benefit of in-line silver recovery is that less silver is carried into the wash water, since the concentration in the fixer bath is maintained at a lower concentration.

5. **Reverse Osmosis:** This method uses high pressure to force a liquid solution through a semipermeable membrane, which will separate larger molecule substances, such as salts and organic compounds, from smaller molecular substances, such as water. Reverse osmosis (RO) is capable of removing up to 90 percent of silver thiosulfate complexes (the most common silver compound present in most photo processing solutions) from wash water. Along with silver, RO is effective in removing almost all other chemicals in solution. On this basis, RO is used to recover such photo processing chemicals as color couplers and ferrocyanide. An additional benefit of RO treatment is that, due to its high removal efficiencies, treated wash

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water may be suitable for reuse in final rinses. Once silver has been removed from the wash water, it can be recovered using such means as chemical precipitation, metallic replacement, or electrolytic recovery. The primary disadvantage of RO compared to alternative silver recovery technologies is the high capital investment required. As a result, its principal application is for treating wash water solutions to reduce silver concentrations to acceptable levels for discharge.

Materials

Compatibility: N/A

Safety and Health: These materials must be handled with caution. Skin absorption is the main health concern. Chemicals like lead are experimental tetatogens and carcinogens. Proper personal protective equipment is highly recommended.

Consult your local health and safety personnel prior to implementing any of these technologies.

Benefits:

Recycling and/or recovery of photographic and X-ray processing and printing solutions can:

processes

- Reduce the volume of hazardous waste generated from these

costs

- Reduce the cost of chemical usage
- Reduce or eliminate hazardous waste handling/treatment/disposal

Result in a net positive economic return (especially for silver recovery)

Disadvantages:

- These processes can be costly if not selected in conjunction with a specific treatment plan or goal

Economic Analysis: Economics depends on site-specific information including system characteristics, waste volumes, and treatment objectives. In general, the higher volume and the higher concentration of the process solution being handled, the more cost effective implementation of a reuse/recovery system becomes. For low volume operations, installation of a metallic replacement system is typically a cost effective alternative. Installation of an electrolytic recovery unit becomes economical for higher processing volumes, since the capital installation cost will be more than offset by the savings incurred from fewer changeouts of metallic replacement cartridges. In-line electrolytic recovery units will reduce silver refining costs since the collected silver is in a form that is more readily recoverable. In cases where low effluent silver concentrations are required, installation of an ion exchange system may be necessary. However, the capital investment and chemical handling

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costs associated with this method are higher than for alternative technologies.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Your installation can obtain silver recovery units from the Defense Reutilization and Marketing Office. To obtain information on their services, contact Ms. LaVona E. Remakel, DSN 246-6655.

Contact 1st Lt. Timothy G. Bossetti, US Army Environmental Hygiene Agency, DSN 923-6205, for more information about the US Army study of silver recovery technologies.

Vendors:

There are many companies that offer products and/or services which deal with the technologies described in this data sheet. A list of representative contacts is presented below. This is not intended to be a complete listing.

Eastman Kodak Company
Department 412-L
Rochester, NY 14650-0532
(800) 242-2424

Ion Exchange Treatment

Resin Tech, Inc.
615 Deer Road
Cherry Hill, NJ 08034
(609) 354-1152

Osmonics, Inc.
5951 Clearwater Drive
Minnetonka, MN 55343-8990
(612) 933-2277

Silver Recovery Equipment

Rhodes/American Steel Wool Mfg. Co.
2825 W. 31st. St.
Chicago, IL 60623
(312) 247-6000, (800) 621-8934

Silver Treatment Systems, Inc.
20 Aegean Drive

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Methuen, MA 01844
(508) 682-6407

Silver Solutions, Inc.
P.O. Drawer 1064
Yazoo City, MS 39194
(601) 746-7470

Durawool, Inc.
P.O. Box 254
Queens Village, NY 11428
(718) 776-5800

Silver Refiners & Scrap Purchasers

Martin Metals, Inc.
1319 Wilson St.
Los Angeles, CA 90021
(213) 627-7755

Specialty Metals Refining Co.
10 Bay Street, Dept. 10712
Westport, CT 06880
(203) 372-0481, (800) 426-2344

MRP Co., Inc.
P.O. Box 343
Cockeysville, MD 21030
(410) 666-2775

Eastern Smelting & Refining Corp.
37-39 Bubier St.
Lynn, Massachusetts

Americana Precious Metals Div.
217 Paterson Ave.
East Rutherford, NJ 07073

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SOFTWARE TO EVALUATE THE PROFITABILITY OF POLLUTION PREVENTION INVESTMENTS USING METHOD OF “TOTAL COST ASSESSMENT”

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Conventional Financial Analysis
Applicable EPCRA Targeted Constituents: N/A

Overview: “Total cost assessment (TCA)” is a method to eliminate unjustified and misleading financial barriers in consideration of pollution prevention processes and projects. The TCA method’s focus is on the “true” profitability of proposed projects and differs from conventional financial analysis in four ways:

- Cost, savings, and revenue summaries include indirect items like compliance, training, testing, liability, and affect on product and corporate image, all typically neglected from project analysis.
- Costs and savings are directly allocated to specific process and product accounts rather than to overhead accounts.
- Time horizons for calculating returns on investment are extended to capture longer-term benefits.
- Other profitability measures include the time value of money for evaluating long-term costs and savings.

Using the TCA method, the Tellus Institute has completed several major studies including 1) a study for the EPA Division of Pollution Prevention entitled, “Total Cost Assessment: Accelerating Industrial Pollution Prevention through Innovative Project Financial Analysis,” and 2) a study for the New Jersey Department of Environmental Protection and Energy entitled, “Alternative Approaches to the Financial Evaluation of Industrial Pollution Prevention Investments.” Furthermore, Tellus has incorporated the TCA method into its software, “P2/FINANCE.”

P2/FINANCE is spreadsheet software designed to guide companies in data collection and rigorous financial evaluation of potential pollution prevention projects. As a starting point or a complement to a company’s existing project evaluation procedure, P2/FINANCE assures that pollution prevention projects have accurate financial representation and receive due consideration when capital budgeting is done. In addition, the program can compare the costs of current practices to various alternatives based on a number of criteria: liability, cost, debt, interest and tax rates, inflation, and depreciation.

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The program is available in either Microsoft Excel 4.0 or Lotus 1-2-3 for MS-DOS 3.1 (or higher) formats, and comes complete with a User's Manual and user support, if desired. A mouse and color screen are optional, but do simplify operation of the program. For larger groups and organizations, one day training on TCA and P2/FINANCE is available.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits:

- TCA focuses on true profitability of proposed projects
- TCA method is more detailed than conventional financial analysis for pollution prevention projects

Disadvantages:

- Users may need to set aside time to educate themselves on the TCA method so that they will understand how to plan an analysis (plug in the appropriate variables) for accurate results

Economic Analysis: The software is available free of charge for all U.S. government agencies. For those without a licensing agreement, a demo diskette and user's manual can be purchased for \$35.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Tellus Institute for Resource and Environmental Strategies
11 Arlington Street
Boston, MA 02116-3411
(617) 266-5400, Fax (617) 266-8303
Ms. Angela Dierks

Tellus Institute's "P2/FINANCE" software is licensed by the U.S. EPA. It is available free of charge to all U.S. government agencies by calling the EPA's Pollution Prevention Information (P2I) Clearinghouse at (202) 260-1023. The P2I Clearinghouse will mail a diskette of the desired version (Lotus 3.4a and Excel 4.0) upon request. For those without a licensing agreement, a demo diskette and user's manual are available from Tellus for \$35. Details about the complete licensing agreements for individuals and organizations, which may include training and follow-up support, are also available from Tellus.

Vendors: See Points of Contact.

Source: The Tellus Institute's P2/FINANCE documentation.

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SPILL PREVENTION TECHNIQUES

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: A key component of an integrated approach to pollution prevention is to minimize accidental and incidental releases of toxic and hazardous materials to the atmosphere. These releases usually result in not only a waste of material, but also in the generation of contaminated soil, absorbent material, and contaminated product that has to be treated and disposed. A structured plan is absolutely necessary to assure control of systems and to verify that the goal of zero spills can be achieved.

Spills are caused by a number of common factors, but the most likely causes are:

- Mechanical failure
- Personnel error
- Fires and explosions
- Power failures, and
- Natural disasters such as tornadoes, earthquakes, and hurricanes

Since the great majority of spills result from the first two factors, which, to a large extent, also control the third factor, proper design and prevention measures can greatly reduce the incidence of spills. The following suggested measures go a long way toward laying the foundation for a system that will minimize occurrence of accidental spills:

- Good design
- Explicit and detailed operating and maintenance procedures
- Thorough training of all personnel
- Conscientious and timely maintenance of equipment and facilities
- Strict job responsibility and accountability
- Redundant process control and alarm monitoring systems

Other proactive and reactive processes should be implemented to minimize the occurrence, reoccurrence, and severity of spills that do occur. This includes investigating all spills to determine root cause; performing process hazard analyses to look at factors such as chemical interactions, maximum material inventories, materials compatibility, and failure scenarios; and developing spill action plans to be followed in the event of a spill. In addition, physical barriers should be used to contain spills and minimize environmental damage (contamination of soil,

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groundwater, or leakage into sewers or surface waters) in the event of a release. Such physical barriers include neutralizing agents and containment devices (booms) strategically located to be quickly deployed in the event of a spill.

Monitoring Systems

Knowledge and decision making are critical to taking appropriate action when an unusual circumstance presents itself. Instrumentation is the key to obtaining fast and accurate knowledge of the status of the process. Furthermore, redundancy of instrumentation is a vital component of any good spill prevention system. All critical instruments, such as drum or tank level sensors, should be duplicated, preferably with an instrument using a different means of sensing to avoid a double failure.

Control and accuracy of inventory by material balance may also indicate a spill is occurring. Alarm setpoints should be chosen to minimize false alarms while maintaining adequate response for true failures.

Piping Systems

Pipelines are often the site of major spills, typically because of equipment failure. Guidelines for designing, maintaining, and operating pipelines are as follows:

- A standard identification system should be developed for all pipelines to assure proper and accurate indication of the product flowing within each and every line. All lines should be marked and their markings maintained.
- Any product fill line entering a tank below the liquid level should have a check valve and isolation valve combination located close to the receiving tank in order to prevent massive backflow or siphoning of the material out of the tank. The isolation valve permits easy maintenance of the check valve as well as tight shutoff in the event of a transfer shutoff.
- Underground pipelines should be avoided. If lines must be underground, they should have protective coatings and wrappings, as well as cathodic protection to minimize corrosion. In addition, a section of the underground line should be exposed and inspected annually until the entire length of the line has been inspected over a period of years. Then the process should be continued from the original starting point.
- If a pipeline is taken out of service for an extended period of time, it should be marked, blind flanged, and isolated at both ends.
- Pipelines supported just off the ground, especially those using wood or makeshift shoes, should be avoided. Pipelines should be routed in designated pipe racks with standard pipe shoes at each support point.

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- Stress analysis should be done for all piping subject to thermal cycling to avoid overstress and rupture during a cycle.
- Designers should minimize the number of inaccessible valves and flanges. All connects should undergo at least a regular quarterly visual inspection, at which time an assessment can be made of the general condition of the line, its support structure, and other components.
- Elevated pipe bridges should be used for road crossings and designed for the tallest regular vehicle traffic. Exceptional vehicular traffic should be notified of the crossing heights in order to allow time to make alternative arrangements.
- Pumping systems should be located in close proximity to storage tanks.
- Baffles, hard coatings, high alloys, long bends, or other means of abrasion resistant designs should be used for abrasive or erosive liquids.

Bulk Storage

- Underground tank use should be avoided unless adequate measures have been taken to assure integrity of the vessel by a combination of careful design, quality construction, conscientious maintenance, continuous monitoring, and periodic inspection.
- Material storage should only be done in vessels designed and constructed to meet the requirements of the stored material. Additionally, all vessels should be subjected to integrity testing by the most appropriate non-destructive means, e.g., x-ray, dye penetrant, etc. All tanks should also undergo hydrostatic testing as a new tank and following maintenance work.
- Thickness testing should be done periodically and compared to the vessel's original thickness to track reduction due to corrosion.
- Tank farms for large volume storage should have a spill containment volume (e.g., pits, dikes, or curbs) equal to 110% of the volume of the largest tank.
- Drainage of rainwater from containment areas should be restricted to in-plant treatment, unless assurances such as locked valves, careful analysis of water, and monitoring of pumpouts are carried out.
- Fail-safe engineering designs should be used on all tanks: high and low audible alarms with redundancy directed to a constantly manned control station and high level pump cut-offs or valve shutoffs to stop flow at a predetermined liquid level to prevent overfilling of tanks.
- Visible product seeps or leaks from seams, cracks, or gaskets should be followed by immediate corrective action.
- Analytic devices (e.g., pH sensors) should be installed in wastewater sumps or other collection point for early warning of spilled material.

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Materials

Compatibility: Compatibility of materials should always be checked before putting a pipeline, vessel, or piece of mechanical equipment into service. This includes not only the bulk materials of each item, but also the gaskets, o-rings, coatings, liners, and seals. Consider cleanout conditions, especially high temperature conditions, which may cause two materials compatible at a lower temperature to be incompatible at an elevated temperature.

Safety and Health: Consult your local health and safety personnel for assistance in developing a spill prevention plan where needed.

Benefits: The benefits of spill prevention are:

- Raw materials and finished products are not wasted, lost or disposed
- Damage to the environment is minimized if product losses are minimized
- Treatment and disposal costs are minimized and salable and useable product is maximized

Disadvantages: N/A

Economic Analysis: Spill prevention systems have definite costs; unfortunately, spill avoidance and the major costs and hazards that never manifest themselves are difficult, if not impossible, to quantify when trying to justify a spill prevention project on its economic merits. Sometimes historical cost data from past spills can be used in cost avoidance arguments. In any event, the costs and benefits of spill prevention systems must be weighed for each individual case.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Wayne Blodgett
Code 424
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-2635, DSN 551-2635, Fax (805) 982-4832

Vendors: N/A

THE CLEAN-IN-PLACE (CIP) METHOD TO MINIMIZE HAZARDOUS WASTE

Revision: 1/96
Process Code: Navy: ID-03-99; Air Force: CL04; Army: Not available
Substitute for: Hydroblasting, chemical cleaning, and solvent cleaning
Applicable EPCRA Targeted Constituents: N/A

Overview: Clean-In-Place (CIP) is a method designed to “automatically” clean pipes and process equipment without the time and labor requirement of manually dismantling equipment components. Long-term, CIP is less expensive and more consistent than conventional manual cleaning methods. CIP is not a substitute for toxic solvents, but rather, a more efficient way to use them.

CIP is more of a design method than a cleaning process. The CIP method works “automatically” by eliminating the places where residue can accumulate. This is achieved by placing pipes at an angle to the horizontal (minimum 3%) to improve drainage and by using instruments and valves that connect flush to pipes, eliminating “dead legs” (places where residues can be trapped). CIP is perhaps best applied to batch process operations because the amount of residual product from a batch can contaminate subsequent batches and given the frequency of these operations, the CIP method is ideally suited to fast turnarounds and to achieving a high degree of piping and equipment cleanliness.

The CIP method can be improved with specially designed process equipment, piping, and fittings which have ducts and spray balls for cleaning the equipment internally. As of July 1994, only diaphragm valves have been used with CIP; ball and slide valves can be modified with injection ports for use with CIP, but this makes them very complex.

To enhance the CIP method, use a CIP cleaning system which consists of a centralized control unit with satellite spray-washing and rinsing units to clean the process equipment, pumps, valves, and pipes. Also, use gear pumps with a low “dead” volume (where “dead” volume refers to the amount of void space that does not drain freely and as a consequence can be difficult to clean because material is stagnant and then dries or polymerizes). Mechanical drives have internal parts which have void spaces where residue can be deposited; these must be removed for cleaning, so for difficult applications with rotating equipment such as agitators, magnetic drives should be used.

The CIP cleaning system is procured as a package consisting of a recirculation system: storage tank, pump, heat exchanger, and rotary

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strainer; a chemical feeder which makes the cleaning solutions; a cleaning system with spray balls and piping to supply and return the various solutions; solution-return tanks; and control instrumentation. After the chemical process is complete, activate the CIP cleaning system to clean and rinse the equipment, the cleaning can even be integrated into the process program.

Materials

Compatibility: As the CIP cleaning system does not alter the actual chemicals used for cleaning, material compatibility should not be an issue.

Safety and Health: Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: For most process plants, the use of CIP systems increases overall capital costs by about 10%. However, the return on investment due to lower labor, raw material, and energy costs can mean pay back in less than a year.

Disadvantages: Requires redesigning the current system.

Economic Analysis:

N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendor: The following is a company that can assist you in setting up the Clean-in-Place technology. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Hartel Corp.
201 North Marx Street
Ft. Atkinson, WI 53578
Mr. Gene Bond (414) 563-8461

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NUMBERING SYSTEM FOR CFCS, HCFCS, AND HALONS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: The common names for class I and class II ODSs are derived from each compound's chemical formula. Because the common names can be relatively long, numbering systems were devised to more simply describe each compound.

A numbering system describing chlorofluorocarbons (CFCs), which are class I ODSs, and hydrochlorofluorocarbons (HCFCs), which are class II ODSs, has been developed to simply and systematically name each compound. The numbering system for both classes of compounds is the same (except for a slightly different numbering system used to describe the Halons and also the prefix before each number, which is simply CFC- or HCFC-, depending on the class to which that particular compound belongs). For CFCs and HCFCs, the ones digit (last) indicates the number of fluorine atoms in each molecule, the tens digit represents the number of hydrogen atoms in each molecule plus one, and the hundreds digit represents the number of carbon atoms in each molecule minus one. For example, trichlorotrifluoroethane is a CFC that has three fluorine atoms, no hydrogen atoms, and two carbon atoms in each molecule; hence, the designation CFC-113. Since there are two carbon atoms and thus six sites available for halogens (chlorine or fluorine only, no bromine) and hydrogens, the number of chlorine atoms is determined by the difference between the total number of sites available and the sum of the hydrogen and fluorine atoms. In this case, $6 - (0 + 3) = 3$, or the number of chlorine atoms.

The Halon numbering system uses four digits. It is similar, but also a bit simpler, since the Halons, like the CFCs, are totally halogenated, lacking any hydrogen atoms. The numbering system uses a simple count of the number of atoms of each element in the molecule from the ones digit to the thousands digit: bromine (Br), chlorine (Cl), fluorine (F), and carbon (C), respectively. For example, the bromochlorodifluoromethane molecule has one bromine atom, one chlorine atom, two fluorine atoms, and one carbon atom; hence, the designation Halon 1211 or CF_2ClBr .

It is possible to derive the common name or chemical formula of most of these compounds. The numbered names have a lower case letter following the ones digit. This letter indicates a particular isomer or arrangement of the molecule, but no other specific information to further establish the compound's exact identity.

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Materials

Compatibility: N/A

Safety and Health: N/A

Benefits: N/A

Disadvantages: N/A

Economic Analysis: N/A

Approval

Authority: N/A

Points of Contact: Ms. Sally Rand
USEPA Significant New Alternatives Policy (SNAP) program
(202) 233-9739.

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Du Pont Fluorochemical Products Information
(800) 582-5606

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R-502 ALTERNATIVE

Revision: 1/96
Process Code: Navy: SR-04-02; Air Force: FA03; Army: OTG
Substitute for: Refrigerant R-502
Applicable EPCRA Targeted Constituents: N/A

Overview: R-404a is an EPA Significant New Alternatives Policy (SNAP, Subpart G of 40 CFR Part 82) program approved substitute for R-502, which is a mixture of Class II (HCFCs) used primarily in large commercial and industrial refrigeration applications, such as cold storage warehouses, commercial ice machines, industrial process refrigeration units, and refrigerated transports.

R-404a is a near azeotropic mixture of the following refrigerants: HFC-125 (44%), HFC-143a (52%), and HFC-134a (4%). These refrigerants are all hydrofluorocarbons (HFCs), and thus are not on either the Class I nor the Class II lists of ozone depleting substances (ODSs). R-404a was developed as a long-term replacement for refrigeration equipment currently using primarily R-502. R-404a provides similar energy efficiencies and capacities, but with a lower discharge temperature and slightly higher discharge pressure. It is acceptable for both new equipment and retrofit equipment; however, triple flushing is sometimes necessary for retrofit equipment so that most (>95% by weight) of the mineral oil lubricant is removed (allowable residual mineral oil is highly dependent on system configuration and operating conditions). Flushing can usually be accomplished after removing and recovering the existing refrigerant by simply draining the existing mineral oil either from an oil drain plug or by removing the compressor and draining from the suction line. In most small systems, 90-95% of the lubricant can be removed from the system in this manner. Larger systems may require multiple drainage points, particularly if there are low spots around the evaporator. In systems with an oil separator, any lubricant in the separator should also be drained. In all cases, measure the volume of lubricant removed and compare to the compressor/system specifications to assure that >95% of the lubricant has been removed. If >95% of the mineral oil lubricant has not been removed, flushing will be required (if the system shows poor heat transfer, the mineral oil residual is typically still too high). Equipment using R-404a requires polyol ester lubricating oil, so flushing consists of selecting a polyol ester lubricant with a viscosity similar to the existing lubricant and charging an amount of polyol ester oil equal to the amount of mineral oil removed. Recharge the system with the recovered R-502 in order to achieve thorough mixing of the two lubricants (48 to 72 hours of operation may be required). Repeat this procedure twice more, but on the last charge

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of fresh polyol ester oil, recharge the system with R-404a instead of the recovered R-502. Note - special care should be taken when handling polyol ester lubricants due to their tendency to absorb water; minimize contact with air and keep in a sealed container.

The following precautions regarding R-404a use should also be noted:

- 1) Because R-404a is a blend, any leaks in a system may allow components of the blend to bleed off at different rates, leaving behind an altered blend that may mask system problems during troubleshooting and failures. Leak detection and prevention should be maintenance priorities, especially when running systems with refrigerant mixtures.
- 2) Service ports and valves on retrofit systems should be well marked and identified to assure the refrigerant type is known by all service and maintenance personnel.
- 3) The chemical compatibility of plastics and elastomers should be considered before retrofitting. Gaskets, shaft seals, and o-ring materials should be reviewed with the equipment manufacturer before retrofitting.
- 4) Use of HFCs is subject to the no-venting prohibition under the Clean Air Act Amendments, Section 608 (c) (2), which takes effect November 15, 1995, at the latest.

For most retrofit systems, the optimum charge of R-404a will be 85-90% of the weight of the equipment manufacturers recommended R-502 charge.

**Material
Compatibility:**

N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of Class II ODSs going into the environment.

Disadvantages: N/A

Economic Analysis: N/A

**Approval
Authority:**

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Air Conditioning and Refrigeration Institute
(703) 524-8800

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Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Ms. Allison Minton or Mr. Bob Luksic
Technical Information Specialists
Du Pont Fluorochemicals
(800) 242-4618, (800) 582-5606, or (800) 441-9442.

Note: Du Pont tradename for R-404a is SUVA[®] HP-62. Du Pont can also supply a copy of "Du Pont Refrigerants Document Cross Reference Listing," 13 APR 94.

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PURCHASE RESTRICTIONS ON CFC-CONTAINING APPLIANCES

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: CFC-Containing Residential Appliances
Applicable EPCRA Targeted Constituents: CFC-12 (dichlorodifluoromethane)

Overview: Given the production phase-out of Class I CFCs, any purchases of new appliances would ideally be those having CFC-free refrigerants. Refrigerators using HFC-134a are just coming to market, but portable room air conditioners use predominantly R-22, an HCFC and Class II ODS (with a lower ozone depleting potential than CFCs and scheduled for phaseout beginning 2015) and are not yet being replaced with an HFC substitute.

DOD policy is to avoid purchase of new equipment containing CFCs. However, residential refrigerators and portable room air conditioners have not yet been mass produced using ODS-free refrigerants. Nevertheless, production of HFC refrigerators is expected soon, and purchases should be directed toward those new products if at all possible. If this is not possible, then purchase a refrigerator using an HCFC; otherwise, an ODS waiver will be required for purchase of any item containing a CFC. Procurement of portable room air conditioners containing HCFC-22 does not require a waiver and will most likely be allowed until the year 2000.

Materials

Compatibility: N/A

Health and Safety: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

Economic Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: E.I. Du Pont de Nemours Corporation
(302) 999-3129

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Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Whirlpool Corporation, Consumer Assistance Center
(800) 253-1301 or (800) 437-9616
2000 North State Rte. 63 Benton Harbor, MI 49022

SERP (Super Efficient Refrigerator Program) Line of ODS-free refrigerators
Models ED-22 and ED-25, uses HFC-134a.
SERP refrigerators are sold through utility companies.

The following manufacturers were not yet producing ODS free small appliances as of 30 Dec 93:

- General Electric, (800) 626-2000
- Amana, (800) 843-0304
- Frigidaire/Westinghouse, (800) 451-7007 • Subzero, (800) 222-7820

(614) 861-1350

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AEROSOL CAN PUNCTURING AND CRUSHING

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: OTG
Substitute for: N/A
Applicable EPCRA Targeted Constituents: ODS Propellants

Overview: Aerosol cans are difficult to dispose when still filled with product. There are several devices on the market that can puncture aerosol cans that are not empty.

Aerosol can puncturing devices are available to safely puncture, depressurize, and empty aerosol cans not completely discharged during use. The devices safely puncture the cans, capturing their contents and emptying them for easy recycling or disposal. Spray nozzles are typically removed as well. Puncturing is not required by law, nor is it considered treatment; however, some regulatory agencies may consider an unpunctured aerosol can to exhibit the characteristic of reactivity, as heat or external pressure can cause detonation if the can is partially or completely filled. The law only requires the container to be “empty,” where “empty” is defined as “removing all wastes that can be removed using practices commonly employed to remove materials from that type of container; and no more than 1 inch of residue remains on the bottom of the container; or no more than 3% by weight of the total container capacity remains within the container (if the container is <110 gallons in size).” Furthermore, a container that has held a compressed gas is considered empty when the pressure in the container approaches atmospheric. Containers meeting these “empty” criteria are not hazardous waste and can be disposed of as non-hazardous waste.

In some states, like California, volatile organic carbon (VOC) venting is regulated. Since some propellants are frequently VOCs, for example butane, the puncturing operation could result in release of these compounds to the environment. To address this problem some devices, such as the AEROSOLV unit by Katec, provide an activated carbon adsorption canister to capture any VOCs released from the punctured can. However, the carbon has to be replaced and disposed of periodically and is not intended to adsorb CFCs.

Disposal is not the only option for handling used aerosol cans; at least one company, Macon Iron and Metal in the Atlanta area, will accept aerosol cans for recycling. Customers are, however, required to sign an indemnity agreement stating the aerosol cans are empty.

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Materials

Compatibility: N/A

Safety and Health: As aerosol cans are under pressure, it is important to use the proper personal protective equipment and to ensure that personnel are properly trained. Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduces the difficulty of recycling or properly disposing of aerosol cans not completely discharged during normal use.

Disadvantages: N/A

Economic Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Sources of can puncturing systems:

Katec Inc.

P.O. Box 3399

Virginia Beach, VA 23454

(800) 843-6808

Manufacturer of the AEROSOLV Aerosol Can Puncturing system

Mr. Mike Campbell.

Herkules Corporation

8230 Goldie, Wald Lake, MI 48390

(800) 444-4351 or (810) 960-7100

Manufacturer of the AFC-2 Puncturing and Crushing Unit.

Sources of can crushing systems:

C.S. Bell

170 W. Davis St.

P.O. Box 291, Tiffin, OH 44883

(419) 448-0791.

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Drew-It Corporation
P.O. Box 10111
Greenville, SC 29603
(803) 292-6376

International Compactor Inc.
P.O. Box 5918
Hilton Head Island, SC 29938,
(800) 423-4003

Can recycler:
Macon Iron and Metal
(912) 743-6773
Mr. Evan Koplín

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**NON-CHLOROFLUOROCARBON ALTERNATIVES FOR AIR CONDITIONING
AND REFRIGERATION**

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Air Conditioning and Refrigeration using chlorofluorocarbons
Applicable EPCRA Targeted Constituents: CFC-11, CFC-12, CFC-113, and CFC-114

Overview: CFCs and HCFCs have been used as refrigerants since the 1930s. Because of their ozone depleting effect and the eventual phaseout of the production of these chemicals, development of alternative refrigerants and refrigeration and air conditioning processes are becoming increasingly important.

Air conditioning and refrigeration use the principle of vapor compression to achieve a cooling effect. This process has long relied on CFCs and HCFCs as the refrigerant materials of choice for use in the vapor compression process. The discovery of their probable effect on the ozone layer has resulted in the development of alternative processes, as well as development of new refrigerants.

The first substitute refrigerants for CFCs and HCFCs have been developed and are known as hydrofluorocarbons (HFCs), since they do not contain any chlorine atoms, HFCs are already beginning to be used. Due to the concern for future regulation of HFCs for global warming, other processes are being looked at to replace them in the long-term.

Applications for:

- Vapor compression using hydrocarbons, ammonia, carbon dioxide, or water: Ammonia-refrigerated warehouses and industrial processes; Hydrocarbons - industrial applications and more recently small appliances; Water - above 0 degrees C applications only, such as air conditioning; Carbon dioxide - stationary air conditioning, and potentially automobile air conditioning in the future; Being used in small appliances in many parts of the world, but not in the U.S.
- Evaporative cooling (direct and indirect): Residential and industrial air conditioning systems
- Gas expansion: Transport of perishable substances
- Absorption: Industrial processes with excess waste heat but also needing refrigeration, gas fired systems are often used in remote areas where electrical costs are high or the supply of electricity will not meet demand, often used in conjunction with electrically powered vapor compression systems to reduce peak load power demands
- Stirling Cycle: Practical only for small applications

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- Air (Joule) Cycle: Not practical in many applications due to high power requirements
- Thermoelectric Cooling: Small applications, not economically viable in most larger applications due to its low efficiency, often used in specialty applications where low noise or high reliability is desirable e.g. on submarines
- Magnetic Cooling: Without cost considerations and very low temperature requirements

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- **Vapor compression using hydrocarbons, ammonia, carbon dioxide, or water** - zero ozone depletion potential (ODP), zero global warming potential (GWP) (except negligible for carbon dioxide and hydrocarbons), widely available, and good thermal properties.
- **Evaporative cooling (direct and indirect)** - zero ODP and GWP, high efficiency in dry climates, provides humidity, improves indoor air quality, high air flow rates, commercially available, life cycle is cost effective, adaptable to various energy sources
- **Gas expansion** - zero ODP and GWP, simple mechanical design, and low capital costs
- **Absorption** - zero ODP and GWP, can use waste heat, reliable (few moving parts), commercially available, most economically viable when waste heat is available
- **Adsorption** - zero ODP and GWP, energy efficient, can use waste heat
- **Stirling Cycle** - zero GWP, can be used over wide temperature range, theoretically high efficiency
- **Air (Joule) Cycle** - zero ODP and GWP, non-toxic, non-flammable, low installation and maintenance costs
- **Thermoelectric Cooling** - zero GWP, immediately available, high reliability, small, no moving parts, wide cooling range (-100 to +125 degrees C)
- **Magnetic Cooling** - zero ODP and GWP
- **Thermoacoustic Cooling** - zero ODP and GWP, no moving parts

Disadvantages:

- **Vapor compression using hydrocarbons, ammonia, carbon dioxide, or water** - Ammonia and hydrocarbons are flammable, ammonia is toxic, and water and carbon dioxide systems are generally bigger and more expensive.

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- **Evaporative cooling (direct and indirect)** - high equipment costs and service requirements; usually works poorly in high humidity climates, new techniques such as indirect evaporative cooling and use of desiccants are expanding evaporative cooling into more humid climates; retrofits difficult for existing vapor compression systems
- **Gas expansion** - low efficiency, high refrigerant costs, limited applications
- **Absorption** - less efficient than vapor compression, LiBr can be toxic
- **Adsorption** - low cooling efficiency, large equipment, high cost, not available in short term
- **Stirling Cycle** - low demonstrated efficiency, significant materials development required
- **Air (Joule) Cycle** - low efficiency, high power requirements
- **Thermoelectric Cooling** - low efficiency, not efficient enough for large applications
- **Magnetic Cooling** - very high costs, low efficiency, superconducting materials required, high magnetic fields require shielding
- **Thermoacoustic Cooling** - low efficiency, still requires long term development

Economic Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Alternative Fluorocarbons Environmental Acceptability Study
The West Tower, Suite 400
1333 H Street NW, Washington D.C. 20005
(202) 898-0906, FAX (202) 798-1206

Oak Ridge National Laboratory
Oak Ridge, TN 37831-2008
(615) 574-0576, FAX (615) 574-9338

Vendors: N/A

ALTERNATIVES TO CFC-12 AS A TRACER GAS FOR LEAK DETECTION

Revision: 1/96
Process Code: Navy: ID-14-99; Air Force: MN01; Army: Not available
Substitute for: CFC-12
Applicable EPCRA Targeted Constituent: CFC-12

Overview: In order to detect leaks in pressure vessels, refrigeration systems, and various other equipment, the equipment can either be pressurized or evacuated and tested for leaks. Instruments sensitive to certain types of gas are then used to pinpoint leaks in the vessel or system. The repair of small leaks leads to greater safety and lower product losses, which result in lower costs. Past practice has often been to pressurize a piece of equipment with a refrigerant, such as CFC-12, and then use one of a wide range of refrigerant leak detectors to snoop for leaks. However, chlorofluorocarbons (CFCs) are significant contributors to ozone depletion, and are therefore being phased out of production. Alternatives to CFCs for leak detection are available for testing the integrity of high-pressure equipment and systems.

Several options are available to replace CFC-12 as a leak-detection agent. Options include, a refrigerant and nitrogen/air mixture, a refrigerant alone, or simply an inert gas. Some standard leak detection equipment can detect all leak-detection agent alternatives. Leak detectors primarily designed to qualitatively indicate the presence or absence of leak-detection agents are used to pin point leaks. Equipment is available that will detect specific concentrations; however, this equipment is very expensive and is not necessary for locating system leaks. Replacement compounds are described briefly below. Detection equipment and special leak detection systems for refrigeration units are described in detail in the Pollution Prevention Opportunity Data Sheet, "Leak Detection and Emission Reduction of Refrigerants from Refrigeration Systems."

Replacement Compounds

Refrigerant Tracer: In order to use testing equipment presently available, a refrigerant and air, or a refrigerant and nitrogen mixture is cycled through a system to check for leaks. The reason for having refrigerant present in the leak-detection agent is that it's the presence of refrigerant makes a leak readily detected.

Inert Gases: Use of inert gases for leak detection can be similar to using a refrigerant-based tracer. Inert gases like helium or argon can be used,

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although special detectors are required. Nitrogen or compressed air can also be used.

Others Methods

(Soap) Bubble Test: A simple leak test can be performed by applying a soap solution to potential leak sources and observing for bubbles

Dye: Dyes can be applied to suspect areas or mixed into other materials in order to better locating leaking areas.

Electronic Leak Detectors: Electronic leak detectors can identify the presence of specific refrigerants or gases, and can give a reading on the relative size of the leak. These detectors have movable probes that are effective in areas where a soap bubble test would be difficult.

Hydrostatic testing: Hydrostatic testing uses compressed water as the leak detection agent. This method has limited applicability for leak detection in refrigeration systems and is used primarily for pressure vessels and piping systems.

Manometer: Manometers can be used to measure minute changes in pressure across evaporators or condenser coils. While a manometer cannot determine exact locations of leaks, it can identify the section of equipment where refrigerant is being lost.

Materials

Compatibility:

Most refrigerants are very inert and have relatively low toxicity. However, some are rather toxic, and others can degrade into toxic materials if they decompose; for example, by exposure to a flame. Therefore, leak testing should never present gas concentrations above the compound's permissible exposure limits unless proper personal protective equipment is used. In addition, chemical compatibility with leak detection equipment should always be checked with the original equipment manufacturer to safeguard components such as gaskets, o-rings, and valve packing.

Safety and Health:

Cylinders which contain nitrogen or compressed air are pressurized to extremely high levels (2,500 to 3,000 psig). Handle all high-pressure gas cylinders with extreme care! Secure all gas cylinders prior to use by chaining or tying to a column or other rigid support.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any leak detection method or product.

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Benefits: The principle benefit is the ability to use an alternative to CFC-12. There are also secondary benefits, such as the rapid determination and repair of leaks before equipment is put into service can greatly reduce the amount of refrigerant or product lost. This should result in not only reduced environmental effects, but also cost savings from reduced losses and fewer service outages.

Disadvantages: The only disadvantage would be the extra time it takes to adapt the current processes over to a new testing procedure. However, this is to be expected in any process improvement change.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: US EPA's Stratospheric Ozone Hotline
(800) 296-1996

Mr. Al Day
Air Force Technical Authority for USTs
HQ AFCESA/DM
DSN 523-6357, (904) 283-6357

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

American Gas and Chemical Corp.
Northside, New Jersey
(201) 767-7300

CEA Instruments, Inc.
Emerson, New Jersey
(201) 967-5660

Source(s): PA Technical Inquiry: 2210, *Practical Air-Conditioning Equipment Repair*, Anthony J. Caristi, McGraw-Hill Book Company, 1991; *Fluorocarbon Refrigerants Handbook*, Ralph C. Downing, Prentice Hall Publishers, 1988; and PA files 2094, 2113, 2772, and 2864.
"Doing Inventory Control Right for Underground Storage Tanks," EPA Publication, Nov 93.
"Straight Talk on Tanks," EPA Publication, Aug 90.
"Standard Test Procedures for Evaluating Leak Detection Methods: Non-volumetric Tank Tightness Testing Methods," EPA Publication, Mar 90.
"Standard Test Procedures for Evaluating Leak Detection Methods: Volumetric Tank Tightness Testing Methods," EPA Publication Mar 90.
"Leak Detection Methods," 7th edition, EPA Publication Feb 94.

AEROSOL COOLING SPRAY SUBSTITUTES FOR CFC-12 AND HCFC-22

Revision: 1/96
Process Code: Navy: ID-22-99; Air Force: AD04; Army: ELM
Substitute for: CFC-12 and HCFC-22
Applicable EPCRA Targeted Constituents: CFC-12

Overview: Halocarbon (halogenated carbon based molecules, primarily carbons with bromine, chlorine, or fluorine atoms as part of their molecular structure) aerosol cooling sprays have long been used for troubleshooting circuit boards; however, EPA regulations no longer allow the sale of either product for this purpose. Several alternatives are available that do not use halocarbons.

Circuit boards with suspected thermally intermittent components are typically tested with CFC-12 or HCFC-22 during troubleshooting. EPA regulations have banned these materials from this application. The alternatives that are readily available and also environmentally innocuous are the following:

- 1) Vortex cooling involves use of a vortex tube powered by compressed air. This typically small, hand-held device uses shop air (8 to 15 SCFM @ 80-125 psig) passed through a vortex chamber to produce a cooling effect. Outlet temperatures of approximately -30 degrees F are produced. However, the supply air must be both clean and dry for proper operation of the vortex tube.
- 2) Liquid nitrogen from a dispenser flask can be used to spray at the component; however, care must be taken when using the nitrogen gun, as component temperatures can reach -270 degrees F. Cost is around \$500.
- 3) HFC-134a can also be used as a freeze spray in place of CFC-12 and HCFC-22, if compressed air and nitrogen are unavailable. However, HFC-134a sprays have shown to produce higher levels of electrostatic discharge than either CFC-12 or HCFC-22. One way to apparently overcome this problem is by adding small quantities of alcohol to the spray. Others are investigating small reusable grounding devices. In either case, check with the manufacturer before using.
- 4) The "Sno Gun" is another electrical component cleaner. "Sno Guns" are used to clean and freeze electronic equipment with carbon dioxide, which is not an ODS, but does contribute to global warming since carbon dioxide is a greenhouse gas. Although not yet specifically approved for use by the Air Force, product testing and evaluation is ongoing.

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Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ozone depleting substances going into the environment

Disadvantages: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Economic

Analysis: N/A

Points of Contact: Navy CFC & Halon Clearinghouse, (703) 769-1883

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Manufacturer's of vortex tubes:
ITW Vortec
10125 Carver Rd.
Cincinnati, Ohio 45242
(513) 891-7475 or FAX (513) 891-4092

Mr. Jeff Sloan
Manufacturer of the "Sno Gun"
Va-Trans Systems Inc.
(619) 423-4555

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HALON 1211 REPLACEMENTS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Halon 1211
Applicable EPCRA Targeted Constituents: Halon 1211

Overview: Halon 1211 is a widely used fire suppression and explosion protection agent applied as a streaming agent and, for example, has been the fire extinguishing agent of choice for portable fire extinguishers in C-130 aircraft. However, it also has one of the higher ozone depletion potentials (or ozone layer depleting effects) of any compound, and thus its production and use are being curtailed and eventually eliminated. Nevertheless, Halon 1211 is still approved for use, but only in mission-critical applications. In addition, each application requires a waiver for procurement of replacement Halon 1211, and its procurement must come from the DLA Halon reserve, since its production has already been phased out. Furthermore, any existing non-mission-critical applications must be decommissioned and allocated to the Halon reserve's stockpile.

There are several Halon 1211 substitutes approved by the EPA's Significant New Alternatives Policy (SNAP) program; though none is an ideal replacement, they are acceptable subject to specific use conditions as cited in 40 CFR 82 Appendix A to Subpart G, "Substitutes Subject to Use Restrictions and Unacceptable Substitutes." The following substitutes are listed:

- HBFC-22B1 (an interim substitute at best, since its high ozone depletion potential qualifies it for phased out production by January 1, 1996), Surfactant Blend A, HCFC Blend B, carbon dioxide, dry chemical, Aqueous Film Forming Foam (AFFF), or perfluorohexane, (C₆F₁₄), although perfluorohexane is not regarded as an acceptable alternative for use by any of the branches of the DOD.

Note: Since the SNAP approved alternatives for Halon 1211 have narrow use limits, extreme care must be taken when converting, retrofitting, or redesigning Halon 1211 systems.

Halon 1211 is a brominated, chlorinated fluorocarbon used primarily for fire suppression and explosion prevention. Because it is a severe ozone depleting substance, there is a serious effort to eliminate its use by developing and finding qualified substitutes. The EPA has developed a list of acceptable alternatives as an initiative of the SNAP program. Presently, there are several approved alternatives to Halon 1211. Nevertheless, it is critical that any alternative's applicability be verified, given the long list of qualifications and use conditions to which each

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alternative is subject. The variation in use conditions is mainly a result of physical property differences. A substitute compound may not be as effective in extinguishing a fire, and so a higher concentration of the extinguishing agent is required. High gas concentrations also increase the sensitivity of personnel to cardiotoxicity and reduce available oxygen content; as a result, many of the use conditions require personnel evacuation in 30 seconds or less, a critical and sometimes impossible requirement to meet.

Each and every alternative for any application should be carefully reviewed for applicability to the use conditions. For example, an aqueous foam can not be used for explosion protection. For the halocarbon alternatives, oxygen displacement and cardiotoxicity are the primary concerns.

The main factors to weigh when considering conversion to a Halon 1211 alternative are the following:

- 1) Are there non-halocarbon alternatives that would work for the application, such as dry chemical, carbon dioxide, or foam systems? If not, what are the halocarbon alternatives?
- 2) Is the candidate substitute EPA SNAP approved?
- 3) Has the candidate substitute been tested by a nationally recognized testing organization such as Underwriters Laboratories (UL) or Factory Mutual (FM)?
- 4) Does the candidate substitute conform with the National Fire Protection Association Standard for Clean Agent Extinguishing Systems (NFPA Standard 2001)?
- 5) Does the candidate substitute have zero ozone depletion potential and low global warming potential? If not, it may also be targeted for replacement sometime in the future; for example, any HCFC substitute will eventually be phased out over the next 20 years per the Montreal protocol on ozone depleting substances.
- 6) Is the existing equipment compatible with the candidate substitute? If not what are the performance compromises, costs, and retrofit requirements?

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Switching from Halon 1211 to an approved alternative will reduce the amount of ozone depletion chemical going into the environment. The switch may also provide a non-global warming agent or one with a

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lower global warming potential. Careful consideration of the choices is necessary in order to select the optimal alternative.

Disadvantages: N/A

**Approval
Authority:**

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

**Economic
Analysis:**

Use of pollution prevention funds for replacement of Halon fire extinguishing systems with non-Halon based systems is not authorized if the reason for conversion is that the existing system has reached the end of its life expectancy.

Points of Contact:

Captain Robert Tetla
Halon Replacement Program
Occupied Areas, Wright Laboratories (WR/FIVCF)
DSN 523-3746, (904) 283-3746

Mr. Milford Puckett
Air Force Civil Engineering Support Agency (AFCESA)
Fire Protection, DSN 523-6152, (904) 283-6152

Mr. Tom Lorman
HQ AFMC/LGSH
DSN 787-3078, (513) 257-3078

Vendors:

The following list is not meant to be complete, as there are other manufacturers of this product.

Fike, Kidde-Fenwal and Ansul and 3M product CEA 614 (also known as perfluorohexane) which is not now a DOD approved substitute for Halon 1211

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HALON 1301 REPLACEMENTS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Halon 1301
Applicable EPCRA Targeted Constituents: Halon 1301

Overview: Halon 1301 is a widely used fire suppression and explosion protection agent applied in the total flooding manner. It also has one of the highest ozone depletion potentials (or ozone depleting effects) of any compound, and thus its production and use are being curtailed and eventually eliminated. There are several substitutes approved by the EPA's Significant New Alternatives Policy (SNAP) program, although none of them are truly ideal replacements and are all acceptable subject only to specific use conditions as cited in 40 CFR 82 Appendix A to Subpart G, "Substitutes Subject to Use Restrictions and Unacceptable Substitutes." The following substitutes are listed:

- HBFC-22B1 (an interim substitute at best, since its high ozone depletion potential qualifies it for phased out production by January 1, 1996),
- HCFC-22,
- HCFC-124,
- HCFC Blend A,
- HFC-23,
- HFC-125,
- HFC-134a,
- HFC-227ea, and
- Perfluorobutane (C₄F₁₀).

Note: since all SNAP approved HCFCs and HFCs alternatives for Halon 1301 have very narrow use limits, extreme care must be taken when converting, retrofitting, or redesigning Halon 1301 systems, especially those for normally occupied areas. In new buildings, non-halocarbon alternatives should be considered: water mists, foams, or carbon dioxide (for unoccupied space applications only). Other products are in the testing stage; for example, C₃F₇H (FM-200), HFC-23, and the iodine analog of bromine containing Halon 1301, CF₃I (Halon 13001). Halon 1301 is, nevertheless, still approved for mission critical uses, but its procurement must come from the DLA Halon bank, since its production has already been phased out.

Halon 1301 is a brominated fluorocarbon used primarily for fire suppression and explosion prevention. Because it is a severe ozone depleting substance, there is a serious effort to eliminate its use by developing and finding qualified substitutes. The EPA has

developed a list of acceptable alternatives as an initiative of the

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SNAP program. Although there are a number of approved alternatives to Halon 1301, it is critical that any alternative's applicability be verified, given the long list of qualifications and use conditions to which each alternative is subject. This wide variation in use conditions is mainly a result of physical property differences. Some of these compounds are not as effective in extinguishing a fire, and so a higher concentration of the gas is required. High gas concentrations also increase the sensitivity of personnel to cardiotoxicity and reduce available oxygen content; as a result, many of the use conditions require personnel evacuation in 30 seconds or less, a critical and sometimes impossible requirement to meet. Each and every alternative for any application should be carefully reviewed for applicability to the Use Conditions. For example, HFC-227ea can not be used in normally occupied areas at concentrations greater than 10.5%. In areas not normally occupied by people, HFC-227ea concentrations greater than 10.5% are allowed, provided that any personnel can escape the area within 30 seconds after discharge of the gas; furthermore, the area shall be secured so that unprotected personnel are prevented from entering the area during discharge. Again, oxygen displacement and cardiotoxicity are the primary concerns. The main factors to weigh when considering conversion to a Halon 1301 alternative are the following:

- 1) Are there non-halocarbon alternatives that would work for the application, such as water mist or foam systems? If not, what are the halocarbon alternatives?
- 2) Is the candidate substitute EPA SNAP approved?
- 3) Has the candidate substitute been tested by a nationally recognized testing organization such as Underwriters Laboratories (UL) or Factory Mutual (FM)?
- 4) Does the candidate substitute conform with the National Fire Protection Association Standard for Clean Agent Extinguishing Systems (NFPA Standard 2001)?
- 5) Does the candidate substitute extinguishing agent have zero ozone depletion potential and low global warming potential? If not it may also be targeted for replacement sometime in the future; for example, any HCFC substitute will eventually be phased out over the next 20 years per the Montreal protocol on ozone depleting substances.
- 6) Is the existing equipment compatible with the candidate substitute? If not, what are the performance compromises, costs, and retrofit requirements?

**Materials
Compatibility:**

N/A

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Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Switching from Halon 1301 to an HCFC reduces the ozone depletion potential of the extinguishing agent, but does not eliminate it. Switching to an HFC (all chlorine sites on the carbon molecule are fluorine substituted) or a perfluorocarbon (all available sites on the carbon molecule are fluorine substituted) provides a non-ozone depleting substitute, but also provides a gas with a not insignificant global warming potential, particularly the perfluorocarbons. Careful consideration of the choices is necessary in order to select the optimal alternative.

Disadvantages: N/A

Economic Analysis: Use of pollution prevention funds for replacement of Halon fire extinguishing systems with non-Halon based systems is not authorized if the reason for conversion is that the existing system has reached the end of its life expectancy.

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Captain Robert Tetla
Halon Replacement Program
Occupied Areas, Wright Laboratories (WR/FIVCF)
DSN 523-3746, (904) 283-3746

Mr. Fred Walker
Fire Protection Engineer
HQ AFCESA/DFE
DSN 523-6315, (904) 283-6315

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Fike Kidde-Fenwal, and Ansul

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HALON REDISTRIBUTION/RECOVERY/RECYCLING/RECLAIMING

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: Halon 1211 (Bromochlorodifluoromethane),
Halon 1301 (Bromotrifluoromethane)

Overview: Halon 1211 and 1301 are widely-used fire-suppression and explosion-protection agents. However, both Halon 1211 and Halon 1301 have extremely high ozone-depletion potentials; therefore, production has been halted and use is being curtailed until existing supplies are exhausted.

Halon 1301 and Halon 1211 are still approved for use, but only in mission-critical applications such as flight-line fire fighting and ship-and shore-based crash and rescue operations. In addition, each mission-critical application requires a waiver for procurement of replacement Halon, and its procurement must come from the Defense Logistics Agency (DLA) Halon reserve, since purchase of new product is now impossible. Furthermore, any existing non-mission-critical applications must be decommissioned and allocated to the DLA Halon reserve's stockpile. Conservation of Halons is necessary to preserve existing supplies until replacement products and systems can be implemented. Actual use should be restricted to real incidents requiring fire suppression. Routine testing of systems for proper operation with the Halon product is discouraged.

However, the price of reclaimed Halon should start to drop as "approved" alternatives become available and large companies satisfy their Halon needs. Surplus Halon is likely to be resold, since Halon cannot be destroyed economically. Thus, redistribution, recovery, recycling, and reclamation are all methods of meeting future Halon demand. Recycling is the process of removing contaminants (oils, nitrogen, particulates, moisture) by refrigeration and filtration so that the Halon can again be used in a fire suppression system. Reclaiming involves reprocessing the Halon to new product specifications through filtration, distillation, refrigeration, and vaporization.

Halon Redistribution: Both E/M Corporation, a subsidiary of Great Lakes Chemical Corporation, and Automatic Suppression Systems of South Holland, Illinois, provide a recycling service to restore contaminated Halon back to Mil-Spec quality, as well as a market for Halon 1301 and Halon 1211 resale to distributors. The steps required to recover Halon include the following:

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- 1) Verify that cylinders contain Halon 1301, Halon 1211, or other Halons.
- 2) Transfer Halon to blow-down tank for storage.
- 3) Recycle Halon through a recycling system to remove contaminants or reclaim the Halon so that it meets all necessary specifications.
- 4) Verify that the reclaimed Halon meets the necessary specifications.
- 5) Return Halon to storage cylinders.

In order to recycle Halon, certain components are required. The pumping system must be able to quickly and efficiently (99 percent efficiency to prevent the escape of Halon into the atmosphere) move the Halon liquid and vapor from the storage tank to processing equipment. Operating pressures range from 360 to 600 psig for pressurized cylinders down to a vacuum of 10 to 20 inches of mercury for cylinders which will be opened to the atmosphere. The recycling system should include modules for 1) removing contaminants by filtration and 2) removing nitrogen by condensing the Halon and venting the nitrogen. Filters should be replaceable without the release of Halon. In general, the two modules can run automatically and are not labor intensive.

Typically, limited Halon supplies are restricted to the following critical use applications. These criteria are only suggested guidelines and do not represent EPA legislation:

- Where a potential for fatalities or serious injuries exists.
- Where hazardous material processes could result in an environmental release with potential for fatalities, serious injuries, serious environmental incident, adverse public opinion, or fire/explosion.
- Where damage will exceed \$50 million.
- When severe economic impact will result due to interruption of sales.

For more detailed information on Halon 1211 and 1301 alternatives, see the Pollution Prevention Opportunity Data Sheets, "Halon 1211: Uses, Restrictions and Replacements," and, "Halon 1301: Uses, Restrictions and Replacements."

Materials

Compatibility:

Halons are very inert and not deleterious to most elastomers, metals, or electronic systems. Halons do decompose to a small degree during a fire extinguishing event, releasing some hydrofluoric acid gases. However, the concentrations are so small (several hundred to several thousand ppm) and the gases so readily dispersed that material compatibility is not normally a concern, even if materials left in the enclosed space are sensitive to the acid gases/decomposition products of Halons. Damage is more often caused by the smoke, ash, and soot of the fire.

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Safety and Health: Both dry chemical and perfluorocarbons have low order toxicities. However, care should be taken when handling any of these chemicals. Proper personal protective equipment is always recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Production of both Halon 1301 and Halon 1211 has been stopped, and any existing material will most likely be used for its originally intended purpose. Currently, there is no good method of converting Halon 1301 or Halon 1211 into other compounds or destroying them. Careful use of the material for mission-critical applications will conserve current supplies and prolong the time over which the material enters the environment, thus lessening the immediate impact on the ozone layer.

Because there is no universal drop-in replacement, and many of the approved substitutes also have undesirable characteristics like high global warming potentials, careful consideration is necessary in order to select the optimum alternative and achieve the maximum benefit.

Disadvantages: N/A

Economic Analysis: N/A

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Captain Robert Tetla
Halon Replacement Program
Occupied Areas
Wright Laboratories (WR/FIVCF)
DSN 523-3746, (904) 283-3746

Mr. Fred Walker
Fire Protection Engineer
HQ AFCESA/DFE
DSN 523-6315, (904) 283-6315

US EPA Stratospheric Ozone Information Hotline, (800) 296-1996
US EPA Halon Program Manager (202) 233-9193
Halon Recycling Corporation, (800) 258-1283, (202) 223-6166

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Navy CFC and Halon Clearinghouse, (703) 769-1883
DLA Halon Bank, (804) 279-4525
National Fire Protection Association (NFPA), (800) 344-3555
National Association of Fire Equipment Distributors, (312) 644-6610
Fire Suppression Systems Association, (410) 931-8100
Fire Equipment Manufacturers Association, (216) 241-7333
Underwriters Laboratories, (708) 272-8800

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

DuPont Fluorochemicals
(302) 992-2177, FAX (302) 992-2836
Barley Mill Plaza 13-2150
P.O. Box 80013
Wilmington, DE 19880-0013
Former manufacturer of Halon 1301
Mr. Daniel Moore
Market Development Manager for Halon Replacements

The following vendors can provide complete fire suppression systems:

Ansul Fire Protection
1240 Iroquois Drive, Suite 102
Napierville, IL 60563-8537
(708) 305-5700, Fax (708) 305-3360
Also supplies IG-541
Mr. David Pelton

Automatic Suppression Systems, Inc.
130 Armory Drive
South Holland, IL 60473-2817
(800) 310-7644 or (708) 333-4130
Recovery and reclamation of Halon
Mr. George A. Krabbe
President/CEO

Source(s):

- Solomon, J., "Halon Redistribution," *1994 International CFC and Halon Alternatives Conference*, p. 426-427, October 1994.
- Krabbe, G., "Halon Recovery and Reclaim Technology from the Viewpoint of the Installers/Distributors," *1994 International CFC and Halon Alternatives Conference*, p. 428-435, October 1994.
- Huston, P., "The Modular Concept of Halon 1301 Recovery/Recycling/Reclaiming," *1994 International CFC and Halon Alternatives Conference*, p. 436-441, October 1994.

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ODS-FREE PORTABLE HAND-HELD FIRE EXTINGUISHERS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Halon fire extinguishers
Applicable EPCRA Targeted Constituents: Halon 1211 and Halon 1301

Overview: Portable hand-held Halon fire extinguishers have been one of the standard types of fire extinguishers in common use. An ODS-free substitute must be found to replace the Halon units. There is an Air Force ban on the purchase of Halons (since 1 Jan 93), but not the use of existing Halon systems. Purchase of additional Halons would require that a waiver be granted by the appropriate authority based on the need and the availability of ODS-free alternatives. Use of Halons must conform to DOD policy, which essentially limits their use to mission-critical applications. Existing non-mission-critical Halon applications must find a substitute and convert from the Halon-based system. For example, Halon 1301 is used in aircraft simulators, but those non-mission-critical systems must eventually be modified to use an alternate fire extinguishing agent in accordance with current USAF policy. Furthermore, many automatically-activated Halon extinguishing systems have been deactivated and can now only be triggered manually. In the event of a discharge, the systems are not to be recharged with Halon. The onboard systems will be replaced when an acceptable substitute is available. ODS-free hand-held fire extinguishers are available; for example, carbon dioxide units or those with surfactant blends such as Cold Fire™. Reporting requirements for the Halon which is used in fire extinguishing systems must be in accordance with AFI 32-7080. The DoD-wide policy is currently being developed; it will be similar to AFI 32-7080 and it will be published in Apr 95.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduces the amount of ozone depleting substances going into the environment.

Disadvantages: N/A

Economic Analysis:

N/A

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Milt Puckett
Fire Protection Directorate
Headquarters Air Force Civil Engineering Support Agency (HQ AFCESA/DF) DSN 523-6152, (904) 283-6152 regarding shipment and disposition of portable fire extinguishers.

Captain Robert Tetla
Wright Laboratories (WL/FIVCF)
DSN 523-3746, (904) 283-3746

Mr. Terry Black
HQ AFMC/ENX
DSN 787-0349, (513) 257-0349

Mr. Duane Morgan
Chief of Fire Protection for Air Mobility Command
(618) 256-2547

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

FireFreeze, marketer of Cold Fire™, FAX (201) 627-2982. Available in an aerosol version intended primarily for use on small, startup fires. The surfactant is propelled by compressed air. It is approved for Class A and B fires only. It contains water and is, therefore, not suitable for use on Class C (electrical fires). It is non-toxic and non-corrosive, as well as biodegradable.

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REFRIGERANT TRACKING SOFTWARE

Revision: 1/96

Process Code: Navy: N/A; Air Force: N/A; Army: N/A

Substitute for: N/A

Applicable EPCRA Targeted Constituents: CFC-11, CFC-12, CFC-113, CFC-114

Overview: Software has been developed to track ozone-depleting substance (ODS) inventories, servicing dates, quantities, refrigerant types, system capacities, leak frequencies, and component failures. There are several programs available.

The Army Corps of Engineers has developed a two-level program to manage refrigerants; it is called Refrigerant Management System (RMS). RMS is designed to keep track of the addition and removal of refrigerants and refrigerant services performed on each piece of Air Conditioning and Refrigeration (AC&R) equipment. The Personal Computer (PC) based software consists of two modules, level 1 and level 2. Level 1 is for AC&R technicians/operators to keep records of refrigerant services performed on AC&R equipment. Level 2 is a database of refrigerant transactions (additions or subtractions); it is an inventory of AC&R equipment and a database of refrigerant services performed on AC&R equipment. RMS prepares transaction reports summarizing refrigerant services performed; output is in ASCII text format. RMS is available on floppy disks from the US Army Construction Engineering Research Laboratory (USACERL) in Champaign, Illinois. At present, there is no charge for the software.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The software should improve equipment leak integrity and reduce refrigerant use by providing a more complete maintenance history, identifying problem areas, and reducing variations between scheduled maintenance. This should reduce the number and frequency of major equipment failures and the large losses of refrigerant associated with failures on a large scale. It should also allow forecasting of requirements so that more accurate quantities of Class I ODSs can be procured from the Defense Logistics Agency. In addition, reclamation and recycling can be better coordinated with routine maintenance needs

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so that DOD policy to reduce ODS consumption becomes a built-in function.

Disadvantages: N/A

Economic Analysis: N/A

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Kim Grinn
U.S. Army Construction Engineering Research Laboratory (USACERL)
P.O.Box 9005
Champaign, IL 61826-9005
(217) 373-6790
(Request Corps of Engineers program disks)

Air Conditioning Contractors of America
1712 New Hampshire Avenue, NW
Washington, DC 20009
(202) 483-9370
FAX (202) 234-4721

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

OZ₃ Software, Division of Environmental Support Solutions,
210 N. Center, Suite 101, Mesa, AZ 85201,
(602) 964-5043, Fax (602) 834-4319,
Tim McConnaughey, Account Manager
Internet address: oz3@indirect.com

Source: PA Technical Inquiry 2151.

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RESTRICTIONS ON THE USE OF HYDROFLUOROCARBONS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: CFCs and HCFCs
Applicable EPCRA Targeted Constituents: CFCs

Overview: HFCs are being developed to replace CFCs and HCFCs for use primarily in refrigeration and air conditioning equipment. There are currently no restrictions on their use; however, a Clean Air Act regulation is forthcoming that will prohibit venting of HFCs.

HFCs are the next generation of refrigerants. They will substantially replace all the CFCs and HCFCs, since they do not have ozone depletion potential. At the present time, there are no restrictions regarding their use; however, a "no venting" regulation, per the Clean Air Act Amendments in 58 FR 92, Section 608(c)(2) page 28664, is scheduled to take effect 15 Nov 95 that will require users to recover HFCs and other alternative (to CFCs) refrigerants when servicing equipment, because although they are not ozone depleting substances, they are greenhouse gases and have global warming potential.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduction in the amount of ODSs going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: USEPA's Stratospheric Ozone Information Hotline, (800) 296-1996

Vendors: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

RECOVERY/RECYCLING OF CFC-12 AND HFC-134a

Revision: 1/96
Process Code: Navy: SR-04-02; Air Force:FA03 ; Army: Not available
Substitute for: Refrigerant venting
Applicable EPCRA Targeted Constituents: CFC-12

Overview: Numerous refrigerant recovery systems are now on the market to enable recovery of refrigerants and thus avoid the former common practice of refrigerant venting during routine servicing. In fact, CFC-12 recovery is required by law, and HFC-134a recovery will be mandatory as of 15 Nov 95.

A number of different companies manufacture refrigerant recovery systems for CFC-12 and HFC-134a (also known as R-12 and R-134a). Models vary in cost, capability, ease of use, and efficiency. In every case, each model is certified for the recovery of a specific refrigerant. Mixing of refrigerants affects their chemical properties, affecting not only their potential reuse but also the capacity and ability of the equipment recovering them. Therefore, every recovery system should be dedicated to reclamation of the refrigerant it was designed to recover.

R-134a can be ordered by the following NSNs:

6830-01-370-6207	45 lb container
6830-01-370-6208	45 lb container
6830-01-370-6209	132 lb container
6830-01-370-8756	132 lb container
6830-01-380-4960	30 lb disposable container

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs like R-12 and global warming gases like R-134a going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: For further information see the USAF Management and Equipment Evaluation Program (MEEP) for Transportation and Civil Engineering (AFR 77-5), "Consolidated Status Report," prepared by 615 SMSQ/LGTV, 16 Dec 92 - 15 Jun 93.

Mr. Cliff Meyers, Chemist, DSN 695-3995.

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Van Steenburgh Engineering Laboratories Inc.
(303) 696-0113

Jameskamm Technologies
(800) 676-3013

Refrigerant Recovery Systems, Inc.
(800) 327-9142

Refrigerant Technologies, Inc.
(800) 468-2321

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ODS-FREE CORROSION INHIBITORS/MOISTURE DISPLACERS

Revision: 1/96
Process Code: Navy: ID-23-99; Air Force: FA01; Army: ELM
Substitute for: MIL-C-85054 per Technical Order 1E-3A-23 for use on E-3A Aircraft and MIL-C-81309 per Technical Order 21M-AIM9L-2, NSN 8030-00-938-1947

Applicable EPCRA Targeted Constituents: CFC-113

Overview: ODSs have seen wide use as corrosion inhibitors and moisture displacers. Corrosion inhibitors and moisture displacers typically use ODS formulations.

Moisture displacement is one of the key factors in preventing and inhibiting corrosion. ODSs have long served in corrosion inhibitor product formulations functioning not only to displace moisture, but also serving as the propellant for aerosol products. However, ODS-free replacements are becoming available. One such product now available is AV-30 (NSN 6850-01-355-3387) made by Dinol International.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduces the amount of ODSs going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Ms. Jaun Gwynn
E-3A Systems Engineer
Oklahoma City Air Logistics Center (OC-ALC/LAKRA)
DSN 336-3343, (405) 736-3343

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Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Dinol International is the manufacturer of AV-30 (NSN 6850-01-355-3387).

Mr. Dave Wicks
L.S. Starrett Co.
24500 Detroit Rd., Cleveland, Ohio 44145
(216) 835-0001

L.S. Starrett Co. is the manufacturer of M-1, a corrosion inhibitor/moisture displacer available in ODS-free aerosol form.

Alox Corporation
(716) 282-1295

Mr. Anthony Murty
Non-aerosol ODS-free formulations of corrosion inhibitors are available in 5 or 55 gallon containers

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ODS-FREE COOLING/FREEZING PRODUCT

Revision: 1/96
Process Code: Navy: ID-22-99; Air Force: AD04; Army: ELM, LOP
Substitute for: ODS containing cooling products and freezing products
Applicable EPCRA Targeted Constituents: ODSs

Overview: ODSs have seen use in many different applications, including that of cooling agents. However, this direct application of CFCs does not lend itself to CFC recovery, and given the imminent production ban, alternatives need to be substituted.

In compressed gas form, CFCs are effective cooling agents; for example, for heat sensitive electronics or for testing anti-icing instruments like the probe on F-16 aircraft engine intakes. When the pressurized CFC is directed at the component or point of desired cooling and let down to atmospheric pressure, a cooling effect takes place due to the isoenthalpic expansion of the compressed gas. Recovery of the spent gas is difficult; therefore, alternatives must increasingly be substituted.

Various ODS-free products have been developed by several manufacturers for cooling applications, such as heat sensitive avionics, electrical, and computer components.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

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Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Mr. Marlin Winsel, Sales Representative

GC Thorsen, Inc.

1801 Morgan Street, Rockford, IL 61102

(815) 968-9661

Manufacturer of Series 2 Freeze Mist, part number 19-8410, NSN 6830-01-335-5741

Mr. Erroll Jackson, Sales Representative

Chemtronics, Inc.

(770) 424-4888

Manufacturer of "E-Series Freez-it 2000" which comes in two sizes of spray container, 10 oz., part number ES1050, and 15 oz., part number ES1550

Ms. Judy Quiaby, Technical Services Department.

Miller-Stephenson Chemical Company

(203) 743-4447

Manufacturer of "Quik-Freeze," part number MS-242N

Mr. Jeff Sloan

Va-Tran Systems, Inc.

(619) 423-4555, Manufacturer of "Sno Gun," a carbon dioxide freezing agent

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ODS-FREE LEAK DETECTOR FOR FUEL CELLS

Revision: 1/96
Process Code: Navy: ID-14-99; Air Force: IN07; Army: ELM
Substitute for: Product listed under Technical Order T.O. 1-1-3 NSN 6850-00-909-3123 (powder form), NSN 6850-01-130-2451 (aerosol form)
Applicable EPCRA Targeted Constituents: CFCs (chlorofluorocarbons)

Overview: The NSNs listed above are approved for leak detection in fuel cells; however, both forms of the product contain CFCs and are no longer manufactured. New products are undergoing performance testing, but no officially approved replacements have yet been selected. Nevertheless, interim approval for the products in testing may be requested from your command. Otherwise, fuel cell leak checks will have to be done visually until the new products are officially approved.

Non-destructive testing products are often dyes formulated with solvents, typically CFCs. The specific leak detecting products referenced above contain CFCs. As Class I ODSs, these solvents are subject to an imminent production ban (1 Jan 96). As a result, the manufacturer of these leak detecting products has already eliminated CFC use in their process. They did this by stopping production of the leak test products altogether. In addition, the manufacturer is unfortunately not developing any replacements. The Office of Primary Responsibility (OPR) is performance testing alternatives, but formulation changes may be needed before any products are officially approved. Any approved products will be added to the Qualified Products List.

Several products have had favorable test results; however, none are officially approved as of 31 Dec 94. Field units should request interim approval from their respective commands until a substitute is officially approved. If interim approval for one of the test products is not obtained, visual inspection will have to be relied upon to monitor fuel cell integrity.

The most promising replacements being tested are made by Keystone Aniline Corp.:

	Part Number
Keystone Oil Red OE Powder	60602650
Keystone Liquid Oil Red HF	60642950

Keystone Oil Red OE Powder is in fact a powder, and Keystone Liquid Oil Red HF is an oil formulation. These products should only be used if

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ODS-FREE SUBSTITUTE FOR GENERAL PURPOSE AEROSOL LUBRICANT

Revision: 1/96
Process Code: Navy: ML-99-99; Air Force: FA01; Army: CLD, ELM, PST, VHM
Substitute for: WD-40
Applicable EPCRA Targeted Constituents: ODSs

Overview: Several general purpose lubricants/penetrants without ODS in their formulations are now available for all-purpose use. All purpose lubricants/penetrants are available in aerosol form to replace ODS formulations.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

**Economic
Analysis:**

N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Break Free, Inc.
1035 South Linwood Avenue
Santa Anna, CA
(714) 953-1900
Manufacturer of Break Free CLP
Mr. Donald Yoder
Military Sales and Service

ODS-FREE AIRCRAFT COMPONENTS CLEANING - OVERVIEW

Revision: 1/96
Process Code: Navy: ID-01-00, ID-22-01, ID-23-99; Air Force: CL01; Army: CLD
Substitute for: Methyl chloroform (MCF) and Trichlorotrifluoroethane (CFC-113)
Applicable EPCRA Targeted Constituents: Methyl Chloroform (MCF), Also Known as 1,1,1-Trichloroethane and Trichlorotrifluoroethane

Overview: Chlorofluorocarbon (CFC) solvents, including MCF and CFC-113, are used extensively for cleaning metal, electronic, and precision parts during aircraft maintenance procedures. These solvents are also used in applications such as coatings, adhesives, lubricant carriers, and mold release agent carriers. However, CFC-113 and MCF are EPA Class I ozone-depleting substances (ODSs) and have been banned from production as of January 1, 1996. DoD policy is that CFCs and Halons can only be used for mission critical applications. Fortunately, numerous ODS-free alternatives are now available to replace CFC-113 and MCF. In many instances solvent use can even be reduced or eliminated

Cleaning for aircraft maintenance can, for the most part, be divided into three categories: metal, electronics, and precision cleaning. Metal cleaning refers to the removal of oil or grease from metal parts during maintenance and repair procedures. Landing gear and control surfaces fall under metal cleaning. Electronics cleaning includes the removal of flux from soldered operations. Encompassing both metal and electronics cleaning, the term “precision cleaning” is not as much a function of the component being cleaned, as it is of the level of cleanliness required. Components typically requiring precision cleaning are those with close tolerances, complex geometries, or sensitive to contamination. There are aircraft components that fall into all three categories.

The following suggestions are directed primarily at typical aircraft maintenance functions.

Cleaning Applications

The first step in eliminating the use of CFCs in aircraft maintenance is to characterize all cleaning steps. What parts need to be cleaned? What is the substrate and contaminant being cleaned? How clean does the part need to be? By identifying the cleaning needs, a proper alternative can be chosen. Certain materials are subject to corrosion, swelling, deformation, and damage to coatings and adhesives if the proper cleaning alternative is not chosen. Complexity of the part dictates whether vapor degreasing or aqueous cleaning should be used. Vapor

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degreasing works best for cleaning complex parts. Some cleaning steps may be identified that can be reduced, consolidated, or eliminated.

Most aircraft cleaning falls into two general cleaning processes: cold cleaning and vapor degreasing. In cold cleaning processes, parts are cleaned by either immersion and soaking, spraying, or wiping with ambient temperature solvents. The vapor degreasing process uses a boiling solvent to effect cleaning. A volatile solvent such as CFC-113 or MCF is heated in a reservoir below a suspended part. Solvent vapors rise to the top of the cleaning vessel and are condensed into droplets. The solvent droplets fall onto the part, dissolving contaminants. As the droplets collect and fall, contaminants are carried off the part and into the solvent reservoir. Since the contaminants are generally low or non-volatile, solvent vapors remain essentially pure; effective cleaning is maintained despite the increasing contamination of the solvent reservoir.

The following table lists cleaning operations and alternatives associated with aircraft maintenance. Detailed information concerning the elimination of CFC-113 and MCF, as well as explanations about many alternative cleaning agents and techniques available, such as aqueous, semi-aqueous, aliphatic hydrocarbon, and chlorinated and organic solids systems, can be found in the Pollution Prevention Opportunity Data Sheets listed above.

Cleaning Application	Current Cleaning method w/ CFC-113 or MCF	Alternative Cleaning Method
Aircraft Exterior Surface	Aerosol Spray or Hand Wipe	Aqueous Cleaning - Alkaline Solution (Light Soil Removal) Semi-Aqueous Cleaning - Aliphatic Naphtha/Alkaline (Moderately Heavy Soil Removal) Semi-Aqueous Cleaning - Aliphatic Naphtha/Alkaline (Heavy Soil Removal) Semi-Aqueous Cleaning - Terpene Aliphatic Hydrocarbon Cleaning - Mineral Spirits
Landing Gear	In-Shop Overhaul: Vapor Degreasing or Aerosol Spray On-the-Aircraft Maintenance: Aerosol Spray	Aqueous Cleaning - Alkaline Solution Semi-Aqueous Cleaning - Mineral Spirits Aqueous Cleaning - Alkaline Solution Aliphatic Hydrocarbon Cleaning - Mineral Spirit
Engine or Engine Modules	Vapor Degreasing Immersion Vapor Degreasing Vapor Degr. or Hand Wipe Immersion	Aqueous Cleaning - Heated Tank Aliphatic Hydrocarbon Cleaning - Mineral Spirit Aqueous Cleaning - Alkaline Solution, Heated Tank Aqueous Cleaning - Alkaline Solution, Heated Tank Aqueous Cleaning - One Step Heavy-Duty Alkaline Solution Aqueous Cleaning - Four Step Heavy-Duty Alkaline Solution

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Cleaning Application	Current Cleaning method w/ CFC-113 or MCF	Alternative Cleaning Method
	Vapor Degr. or Hand Wipe	Aqueous Cleaning - Alkaline Solution
	Vapor Degreasing	Blasting - High Pressure Steam/Water Chlorinated Solvent Cleaning - Trichloroethylene
Engine or Engine Modules: Assembled and Partially Assembled Parts	Aerosol Spray or Hand Wipe	Aqueous Cleaning - Alkaline Solution
Flight Control Surfaces	Aerosol Spray or Hand Wipe	Aqueous Cleaning - Alkaline Solution
		Aliphatic Hydrocarbon Cleaning - Mineral Spirit Organic Solvent Cleaning - Methyl Ethyl Ketone or Acetone
Electrical Equipment	Aerosol Spray	Aqueous Cleaning - Alkaline Solution, Ultrasonic Organic Solvent Cleaning - Isopropyl Alcohol
Hydraulic Lines	Hand Wipe or Vapor Degr.	Aqueous Cleaning - Water Base Soap Solution
Aircraft Seat Covers and Curtains/Draperies	Dry Cleaning	Chlorinated Solvent Cleaning - Perchloroethylene
Prior to Coating: Polyurethane	Hand Wipe	Organic Solvent Cleaning - Methyl Ethyl Ketone or Blends
Prior to Coating: Chromate Conversion	Hand Wipe	Organic Solvent Cleaning - Methyl Ethyl Ketone or Blends
Prior to Coating: Other	Varied	Semi-Aqueous Cleaning - Aliphatic Naphtha/Alkaline Organic Solvent Cleaning
Prior to Adhesive Bonding	Spray or Hand Wipe	Organic Solvent Cleaning - Isopropyl Alcohol
	Hand Wipe	Semi-Aqueous Cleaning - Terpene
Prior to Fluorescent Penetrant Inspection	Aerosol Spray or Hand Wipe	Chlorinated Solvent Cleaning - Trichloroethylene
		Organic Solvent Cleaning - Methyl Ethyl Ketone
During Fluorescent Penetrant Inspection	Aerosol Spray or Hand Wipe	Organic Solvent Cleaning - Isopropyl Alcohol, Methyl Ethyl Ketone, or Acetone
Prior to Reassembly	Hand Wipe or Immersion	Hydrocarbon Cleaning
Prior to Welding		Organic Solvent Cleaning - Methyl Ethyl Ketone or Acetone
Prior to Painting	Aerosol Spray or Hand Wipe	Organic Solvent Cleaning - Methyl Ethyl Ketone and Toluene

Materials

Compatibility:

Materials compatibility depends on the alternative solvent/procedure implemented. Considerations can include corrosion, damage to coatings and adhesives, and swelling and deformation (especially for organic substitutes: alcohols, ketones, ethers, chlorinated solvents, etc.). Testing will reveal damage.

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Safety and Health: Organic Solvents can be extremely flammable/combustible. Use only in areas with good ventilation. Aliphatic hydrocarbons are also flammable and have low occupational exposure limits. Consult the MSDS of particular solvents to ensure that solvent is used properly and all necessary safety requirements (i.e., personal protective equipment, increased ventilation, fire fighting equipment) can be met. In addition, consult your local Industrial Health specialist, local health and safety personnel, and the SNAP comments prior to converting to any replacement product.

Benefits: Reduce the amount of ozone-depleting substances and EPCRA-targeted chemicals going into the environment.

Disadvantages: Whenever a new cleaning procedure is implemented, there will be a certain amount of “down time” while the technicians learn the new process. However, this is to be expected in any process improvement.

Economic Analysis: Because cleaning circumstances are so variable, the economic feasibility of substitute processes and chemicals needs to be evaluated for each application prior to conversion.

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Dave Gauntt
Code 4.3.4.1
NAWC Aircraft Division
Warminster, PA 18974-0591
DSN 441-2189, (215) 441-2189

Ms. Nina Bonnelycke - Solvent Specialist, SNAP Program
Office of Stratospheric Ozone Protection - US EPA
(202) 233-9079

National Defense Center for Environmental Excellence
(800) 282-4392

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Vendors: See Pollution Prevention Opportunity Data Sheet, "Alternative Cleaning Process and Product Vendor List," for an extensive list of equipment and product vendors.

Source(s): ICOLP Manual, *Eliminating CFC-113 and Methyl Chloroform in Aircraft Maintenance Procedures*, 1993.

Hume, Bob, "Ozone Depleting Substances," *NAVAIR 4th Annual Pollution Prevention & Technology Exchange Conference*, p. 415-446, May 26, 1994.

Clark, Ken, "Low Solvent Cleaners and Corrosion Preventive Compounds," *NAVAIR 4th Annual Pollution Prevention & Technology Exchange Conference*, p. 589-592, May 26, 1994

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Ecolink, Inc.
Mr. Tom Womack
Southern Regional Manager
Sentry Chemical Company
1481 Rock Mountain Blvd.
Stone Mountain, GA 30083
(800) 886-8240
Manufacturer of Pen-T(22) Super Penetrant

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granted interim approval, and then only in accordance with the manufacturer's product instructions.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Gary Foy, WR-ALC/LKJE, DSN 468-6630, (912) 926-6630

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

CFC-free products:

Keystone Aniline Corp.
2501 W. Fulton St.
Chicago, IL, 60612
(800) 522-4393

CFC-containing products:

Courtaulds Aerospace
(800) 237-6649

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R-500 SERIES REFRIGERANTS: OVERVIEW

Revision: 1/96

Process Code: Navy: SR-04-02; Air Force: FA01; Army: Not available

Substitute for: R-500 Series Refrigerants

Applicable EPCRA Targeted Constituents: Dichlorodifluoromethane (CFC-12), Chlorotrifluoromethane (CFC-13), Dichlorotetrafluoroethane (CFC-114), and Chloropentafluoroethane (CFC-115)

Overview: Mixtures of refrigerants are used in special applications where a specific physical property of the refrigerant mixture is more desirable or is not available by using one of the pure compounds. Often, these refrigerant mixtures or blends contain an ozone-depleting substance (ODS). This is the case for most of the R-500 blends because they are formulated using one chlorofluorocarbon (CFC) and either a hydrochlorofluorocarbon (HCFC) or a hydrofluorocarbon (HFC). Given the imminent production ban and the scheduled use phaseout of CFCs, alternatives have to be substituted.

R-500 series refrigerants are refrigerant blends that have been developed and used for many applications. The 500 series refrigerants are all refrigerant mixtures made up of two components, a CFC and an HFC or an HCFC (except for the new generation of the series R-507, which is a mixture of two HFCs). The mixtures are as follows:

- R-500, azeotropic mixture of 73.8% CFC-12 and 26.2% HFC-152a (1,1-difluoroethane)
- R-501, mixture of CFC-12 and HCFC-22 (chlorodifluoromethane)
- R-502, azeotropic mixture of 51.2 % CFC-115 and 48.8% HCFC-22
- R-503, azeotropic mixture of 59.9% CFC-13 and 40.1% HFC-23 (trifluoromethane)
- R-504, mixture of CFC-115 and HCFC-132 (dichlorodifluoroethane)
- R-505, mixture of CFC-12 and HCFC-31 (chlorofluoromethane)
- R-506, mixture of CFC-114 and HCFC-31
- R-507, azeotropic mixture of 50% HFC-125 (pentafluoroethane) and 50% HFC-143a trifluoroethane), is a new ODS-free replacement for R-502

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Replacements for the R-500 series refrigerants depend on the application, but there are numerous EPA Significant New Alternatives Policy (SNAP) program-approved substitutes, both products and processes, for most applications now using R-500, R-502, and R-503. For a list of the approved alternatives to these three blends, see the Pollution Prevention Opportunity Data Sheet, "US EPA's Significant New Alternatives Policy (SNAP) Program." The EPA SNAP list is from Table 1 of 59 FR 13146, and also Appendix A to Subpart G of 40 CFR 82. Also see the Pollution Prevention Opportunity Data Sheets on, "R-500: Uses, Restrictions, and Replacements," "R-502: Uses, Restrictions, and Replacements," or, "R-503: Uses, Restrictions, and Replacements," for more detailed information about applications and substitutes for the individual blends.

Acceptable replacements for R-501, 504, 505, and 506 have not yet been identified by the EPA.

Materials

Compatibility:

Although refrigerant development has focused on relatively inert and non-toxic compounds, some products are not compatible with certain lubricants, plastics, and elastomers, while others exhibit a moderate degree of toxicity. Always check with the original equipment manufacturer to verify material compatibility.

Safety and Health:

Refrigerants tend to be relatively non-toxic; however, see the individual Pollution Prevention Opportunity Data Sheets for more specific information about the acceptable alternatives and their material compatibility concerns. Also, consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDSs before converting to any of the alternative products or processes.

Benefits:

Reduce the amount of ozone-depleting substances going into the environment.

Disadvantages:

N/A

Economic

Analysis:

N/A

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Points of Contact: US EPA Stratospheric Ozone Hotline
(800) 296-1996

Mr. Jeffrey Levy
Refrigerant Specialist
Office of Stratospheric Ozone Protection
US EPA
(202) 233-9727

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Allied-Signal, Inc.
Fluorocarbons
P.O. Box 1053
Morristown, NJ 07962-1053
(800) 631-8138, FAX (201) 455-6395
Manufacturer of R-500 series refrigerant replacements

DuPont Fluorochemicals
Ms. Allison Minton, (800) 582-5606, or Mr. Bob Luksic, (800) 242-4618
Technical Information Specialists
Manufacturer of R-500 series refrigerant replacements

*Source(s): PA Technical Inquiries: 2065, 2984, and 3136.
Allied-Signal fluorocarbon product information.*

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

REFRIGERANT RECOVERY/RECYCLING/RECLAMATION

Revision: 1/96

Process Code: Navy: N/A; Air Force: N/A; Army: N/A

Substitute for: N/A

Applicable EPCRA Targeted Constituents: R-11, R-12, R-113, R-114, and R-115

Overview: Refrigerants can be conserved in several ways including recovery, recycling, and reclaiming. Each process requires specialized equipment certified by the EPA. As CFCs are phased out of production, recovery, recycling, and reclaiming will become the primary source of CFCs for use in existing systems.

Recovery and Reuse: Recovery is the process of removing a refrigerant from the system, storing it in a cylinder, and returning it to the system after all repairs have been made. While cleaning the refrigerant may be a good idea, the refrigerant can often be returned to the system without being tested or processed in any way. If the refrigerant is removed from the job site, it must meet the criteria of the Air Conditioning and Refrigeration Institute (ARI) Standard 700-93, a system of monitoring the maximum contaminant levels and physical properties of the refrigerant.

Refrigerant should always be placed in a properly-marked cylinder that has been evacuated to reduce contamination (primarily air and moisture). The quality of the refrigerant can be tested using any number of refrigerant test kits on the market. By using recovered refrigerant, several assumptions are made: 1) The refrigerant is in good condition, 2) The refrigerant meets all EPA standards, 3) Minimal refrigerant has been lost, and 4) The recovered refrigerant will meet the requirements of the original equipment manufacturer.

Recycling: Recycling is the process of cleaning the refrigerant by oil separation and filtration before it is returned to the system. Recycling is best suited for small amounts of refrigerants like those contained in most motor vehicle air-conditioning and home air-conditioning systems. The refrigerant is returned to the system in better condition than a simple recovery or re-use operation.

Off-Site Reclaiming: Used in case of extreme contamination, off-site reclamation is the process of refining a refrigerant so that it meets or exceeds specifications. The refrigerant must meet ARI 700-93 standards. Many reclaiming facilities will provide clients with the equipment necessary for recovering and transporting the refrigerant. Advantages are many: the facility takes full responsibility for the refrigerant quality, no taxes apply to reclaimed refrigerants, and the refrigerant is available for use in the future in a "like new" condition.

Recovery/Reclamation Specifications

The EPA has approved equipment to capture and recycle refrigerants from air conditioning systems during repair or decommissioning. Section 609 of the Clean Air Act Amendments, "Approved Refrigerant Recycling Equipment," 23Aug94, lists approved systems and manufacturers of refrigerant recycling equipment. Also, the Underwriters Laboratories has a directory of certified equipment, "Certified Commercial Refrigerant Recovery/Recycling Equipment Directory," 21Mar93.

Recovery Methods: To expedite the process, recover the refrigerant liquid first, then recover the vapor. Some equipment is vulnerable to compressor damage as a result of improper removal of the refrigerant. Check with the original equipment manufacturer for proper evacuation procedures. For large systems such as chillers and industrial units, a liquid refrigeration pump is used for removing the refrigerant. All recovery and recycling equipment must meet ARI Standard 740.

Most refrigerant recovery equipment has epoxy-lined steel ASME-rated tanks and electrically-powered vacuum pumps, compressors, and fan-cooled condensers. Many recovery units are capable of processing a number of the most commonly used refrigerants without changes in equipment settings or operational procedures between batches (note: refrigerants cannot be mixed). The machine should be cleaned between batches if dirty, but no other special changes are necessary. The units achieve recovery by high vacuum (~27 in. Hg vacuum), recycling by filtration, and reclamation by distillation at processing capacities of 4 to 7 lb/min. Trailers are available for transporting the machines.

Recycling Methods: If the quality of the refrigerant is in question, recycle the recovered refrigerant so that it meets ARI Standard 700-93 with respect to moisture, acids, boiling-point residues, and other contaminants. Follow the listed steps to recharge the system after recycling the refrigerant:

1. Install new liquid line filter-dryers and required suction line filter-dryers.
2. Leak test the system using a gas such as dry nitrogen by pressurizing the system with the gas and measuring the pressure and time required for the test pressure to decrease (without makeup).
3. Recharge the system with the necessary amount of refrigerant.

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Materials

Compatibility: Chlorofluorocarbon refrigerants are generally very inert chemicals with good materials compatibility. However, if introducing a new material to an existing system or a different refrigerant to an existing system, always check with the original equipment manufacturer to verify compatibility.

Refrigerants should not be mixed. Not only are they very difficult to separate, but mixing results in radically different properties compared to the individual gases and may result in equipment damage.

Safety and Health: High pressure gases should always be handled with great care. Most refrigerants are inert and have very low toxicity. Nonetheless, some are quite toxic, and some of the hydrocarbon refrigerants are flammable. Be aware of the refrigerants being recovered, their hazards, their safe handling procedures, and their permissible exposure limits. Monitors may be considered for use with some refrigerants (e.g., HCFC-123), especially when working in a confined space, clean room or other space with limited ventilation. Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDSs prior to implementing any of these recovery, recycling, or reclaiming processes.

Benefits: Recovering, recycling, and reclamation of CFC refrigerants can extend the useful life of existing CFC-containing equipment by avoiding retrofits and by delaying the purchase of new ODS-free equipment due to a CFC refrigerant scarcity. A secondary benefit results from minimizing costs and maximizing efficiencies compared to retrofitting. Finally, re-use of existing refrigerant will prolong the time period over which the existing ozone-depleting and/or global-warming gases are emitted into the atmosphere, and so should therefore reduce the environmental impact of these refrigerants.

Disadvantages: It is important to have properly trained technicians, to insure that the process is performed in accordance with the proper guidelines. This will require initial and follow-up training.

Economic Analysis:

The cost of a typical recovery/recycle system is approximately \$4,000. High pressure recovery reclamation systems are approximately \$17,000, and the low pressure recovery/reclamation systems range in price from about \$28,000 to \$32,000.

Recovery charge for refrigerant sent to a manufacturer's facility is on the order of \$0.35/lb. Reclamation charges range from \$1.25 to \$1.75/lb, depending on the type of refrigerant. Combining recovery and reclamation adds approximately \$0.25/lb of refrigerant in addition to the

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reclamation charge. For small quantities (of less than 1,000 lb) there is often a \$50/hr charge with a 6-hour minimum. The following refrigerants can be usually be processed: CFC-11, CFC-12, HCFC-22, CFC-113, CFC-114, HCFC-123, HFC-134a, HCFC-141, HCFC-141b, R-500, and R-502.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

U.S. EPA Stratospheric Ozone Hotline
(800) 296-1996

Underwriters Laboratory
Research Triangle Park, North Carolina
(919) 549-1855

Vendors:

The following list is not meant to be complete, as there are other manufacturers of this product.

For Recycling and Reclamation Equipment:

Jameskamm Technologies
Toledo, Ohio
(800) 676-3013

National Refrigeration Products, Inc.
Pennsylvania
(800) 352-6951
Mr. Brian Peckjian

For refrigerant container information:

Worthington Cylinder Corporation
Subsidiary of Worthington Industries
P.O. Box 391
1085 Dearborn Drive
Columbus, OH 43085
(614) 438-3013, FAX (614) 438-3083

Source(s): *Refrigerant Management: The Recovery, Recycling, and Reclaiming of CFCs*, Billy C. Langley, Delmar Publishers Inc., 1994.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET
U.S. EPA's SIGNIFICANT NEW ALTERNATIVES POLICY (SNAP) PROGRAM

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Class I and Class II ozone-depleting substances
Applicable EPCRA Targeted Constituents: Class I and Class II ozone-depleting substances

Overview: Section 612 of the Clean Air Act stipulates that the EPA create a list of acceptable chemical and process alternatives to Class I and Class II ozone-depleting substances. The list, created in March of 1994, includes substitutes for major industry applications such as aerosols, adhesives, coatings, inks, foam blowing, fire suppression, refrigeration, solvents, sterilants, and tobacco expansion. As a result of the SNAP list, the Clean Air Act makes it illegal to replace any Class I or Class II substance with an alternative that has been identified as hazardous to human or environmental health when acceptable alternatives are available. Any person can petition the EPA for inclusion of certain alternatives on future revised lists of approved substitutes. The framework of the SNAP program is included in Subpart G of 40 CFR Part 82. The original SNAP listing separates alternatives by industry application. Revisions from August 1994, September 1994, and January 1995 are included as revisions at the end of the original SNAP listings. The latest updated list is available from the Stratospheric Protection Hotline relating generic names to trade names.

Material

Compatibility: Materials compatibility is based on the alternative procedure or chemical implemented. Considerations include the possibility of corrosion, swelling, deformation, and damage to coatings and adhesives. Testing will reveal particular types of damage to parts: stress, embrittlement, and total immersion corrosion.

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDSs prior to implementing any of these recovery, recycling, or reclaiming processes.

Benefits: Reduce the amount of ozone-depleting substances and EPCRA-targeted chemicals going into the environment.

Disadvantages: Potential substitutes not listed on the SNAP list may or may not actually be acceptable. Check with the Stratospheric Ozone Protection Hotline for the latest information from the EPA, especially for recent decisions or where a decision about a particular potential substitute is pending.

Economic

Analysis: Any SNAP-listed substitute process or chemical needs to be evaluated for a given application in order to determine the economic impact a specific substitution will have. Regardless of any substitute's cost, taxes on CFCs will continue to rise.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: For more information about the SNAP list and its latest revisions, SNAP notification forms, and SNAP notification guidance manual:
Stratospheric Protection Hotline (800) 296-1996
Monday - Friday, 10:00 a.m. - 4:00 p.m. (Eastern) or
SNAP Coordinator at (202) 233-9739

Copies of SNAP Federal Register notice available from:
Government Printing Office Order Desk
(202) 512-1800, SNAP citation March 18, 1994

The International Cooperative for Environmental Leadership, (202) 737-1419, is a non-profit organization made up of technical associations, corporations, and governmental agencies exchanging information on ozone layer protection, ODSs, and alternative technologies. ICOLP has developed seven different guidance manuals on ODS replacement products and processes, each including case studies and extensive vendor lists.

Office of Stratospheric Ozone Protection
U.S. EPA
SNAP Coordinator
(202) 233-9152

Ms. Nina Bonnelycke
Solvents and Aerosols Specialist
SNAP Program
Office of Stratospheric Ozone Protection
U.S. EPA
(202) 233-9079

Vendors: See ICOLP above.

Source: United States Environmental Protection Agency, Office of Air and Radiation Stratospheric Protection Division SNAP program, March

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ODS-FREE DRINKING FOUNTAINS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: CFC containing drinking fountains
Applicable EPCRA Targeted Constituents: CFC-12 (dichlorodifluoromethane)

Overview: The refrigerants used in drinking fountains to chill the water are typically CFCs. However, there are several companies that have developed CFC-free refrigeration units for their drinking fountains. At least two companies offer CFC-free refrigeration units as part of their drinking fountain products. Both use a non-ozone depleting chemical called HFC-134a (also known as R-134a), which is a hydrofluorocarbon. While R-134a is a non-ozone depleting refrigerant, it is, also a greenhouse gas and has a global warming potential. Thus, these units must be serviced by certified refrigeration technicians and are subject to the “non-venting rule” for Class I and Class II ODS replacements per the Clean Air Act Amendments as stated in 58 FR 92, Section 608(c)(2) page 28,664, scheduled to take effect as of 15 Nov 95.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Ms. Kris Arnold
Haws Company
(510) 525-5801

EBCO Company
(614) 861-1350

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE NON-FLAMMABLE CONTACT CEMENT

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: ODS-containing contact cement and also flammable contact cement formulations

Applicable EPCRA Targeted Constituents: ODSs, Toluene

Overview: Contact cement has many uses for general construction and maintenance of wooden housing fixtures. Many formulations are either flammable or contain ODSs. Alternatives are available that are both ODS-free and non-flammable.

ODS-free and non-flammable formulations of contact cement are available to directly replace the old formulations, although in most cases they are slower drying than the ODS or flammable formulations. DAP, Inc. has developed an alternative water-based product (UPC number 25202) available in 1-pint cans.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment and improve safety of shop or repair facilities by reducing presence of flammable materials.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

DAP, Inc., (513) 667-4461

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE PRODUCT SUBSTITUTE FOR ADHESIVE EA 9446

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: NSN 8040-01-175-9193 per Technical Order 1F-16C-3-1, Lockheed specification P6190-1, "Adhesive Acrylic Tough Peel, Fast Curing," indicates both Dexter Hysol product EA 9446 (preferred) and Lord Corp. product Versilock 201/Accelerator conform to these specifications.

Applicable EPCRA Targeted Constituents: Carbon Tetrachloride

Overview: Adhesive EA 9446 is used on F-16 aircraft; however, it contains ODSs. An approved substitute is available, but while ODS-free, it does contain some suspected carcinogens. Dexter Hysol is not planning any changes in product formulation due to the small amount of carbon tetrachloride contaminating the product.

The Lord Corporation product Versilock 201/Accelerator 4 is ODS-free, but the accelerator contains two suspected carcinogens: trichloroethylene (15%) and methylene chloride (70%). Given these components, this product must be used under carefully controlled conditions.

EA 9446 is the preferred adhesive under Technical Order 1F-16C-3-1 for use on F-16 aircraft. It does, however, contain trace amounts of carbon tetrachloride, not an ingredient per se, but an impurity contaminating the process during the formulation of the product.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Points of Contact: Captain Dan Bulloch
Ogden Air Logistics Center
F-16 Aircraft Structures (OO-ALC/LAAS)
DSN 458-5195

Mr. Bob Wolf
Lockheed Martin
Materials/Processes Division
(817) 777-2138

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Lord Corporation
Manufacturer of Versilock201/Accelerator 4
Mr. John Misterovich
(814) 868-3611

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE COMPUTER KEYBOARD DUSTER PRODUCTS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: NSN 1430-01-205-6877 "Dust Off"
Applicable EPCRA Targeted Constituents: CFCs

Overview: Dust cleaners for electronic equipment are now being formulated without ODSs. Products developed to clean dust off of computer keyboards and similar equipment have been typically formulated using ODSs. New products are available that are ODS-free. However, some products may be using the hydrofluorocarbon (HFC) tetrafluoroethane, HFC-134a (also known as R-134a), as a replacement. While R-134a is not an ODS, it is a greenhouse gas and has a global warming potential. Venting of products using R-134a should be avoided.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Economic Analysis:

N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Mr. Jimmy Witcher or Mr. Jim Wadell, Sales Representatives
Tech Spray, Inc.

P.O. Box Amarillo, TX 79015-0949
(800) 858-4043 or (806) 372-8523

Sells "Envi-Ro-Tech Duster," part number 1671-10S; designed for cleaning electrical components, it is 100% HFC-134a

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Micro Care Corporation
34 Ronzo Road, Bristol, CT 06010-7792
(860) 585-7912

Mr. Steve Blake, Customer Service
Inmac Corp.
(800) 547-5444

Sells 12 oz. cans of "Office Duster 3" which is 100% compressed air.
Minimum order: \$50, which in this case is 4 cans

Other possible electrical equipment cleaners as listed in the Defense
General Supply Center document "Environmentally Safe Chemical
Alternatives:"

- Lectra Clean II, CRC Industries, Inc., NSN 6850-01-382-5783, 20 oz. can.
- Electron, Ecolink Inc., NSN 6850-01-371-8048, 15oz. aerosol.
- Electron 22, Ecolink Inc., NSN 6850-01-371-8049, 22 oz. pump.
- Citra-Safe, Inland Technologies, NSN 6850-01-378-0616, 15oz. can.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE SUBSTITUTE FOR INK CLEANER

Revision: 1/96
Process Code: Navy: MS-99-99, ID-01-00, ID-22-01, ID-23-99; Air Force: CL01;
Army: CLD
Substitute for: A&M Multigraphics Co. Order Number 83-1-77004
Applicable EPCRA Targeted Constituents: ODSs

Overview: Ink cleaners for printing presses often contain ODSs as part of the formulation. ODS-free substitutes are now becoming available.

ODS-free substitutes for printing press ink cleaners are now available. They are typically slower acting and also slower drying, but they are more environmentally friendly. Before selecting a product, be ready to answer the following questions so that the best choice of products is made:

- What is the size of the printing press(es), in inches?
- Are the presses web or sheet fed?
- Are the presses offset lithographic or flexographic?
- Is the ink used soy, water, or petroleum based?
- Is the volatile organic content of the cleaner critical?

A & M Multigraphics ODS-free products:

Power Clean (1 gal. container of liquid), Order # 83-6-105452

Power Clean (5 gal. container of liquid), Order # 83-5-105453

International Specialty Products:

Printsolve Ink Remover, NSN 6850-01-383-2064

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Mr. Bill Murphy
Environmental Engineering Department
A&M Multigraphics
(708) 398-1900

Mr. Frank Tamasy
West Pentone
(800) 631-1652, Ext. 7734

Ms. Bianca Thayer
International Specialty Products
(800) 283-4823, Ext. 5466 or (505) 899-4350

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE LIQUID CARBURETOR CLEANER

Revision: 1/96
Process Code: Navy: SR-02-99; Air Force: AD07; Army: VHM
Substitute for: Clear R Carb Carburetor Cleaner
Applicable EPCRA Targeted Constituents: ODSs, Toluene, Xylene

Overview: An ODS-free and EPA 17 chemical-free carburetor cleaner called 2005 Gum-Solve Liquid Carburetor Cleaner is available as a substitute for Clear R Carb cleaner, which contains ODSs as well as toluene and xylene. Carburetor cleaners have typically been formulated using solvents that were very effective in dissolving gums and varnish buildups typically found in carburetors after long use. These solvents are either ODSs or EPA 17 listed, and as a result are no longer considered acceptable for open use such as carburetor cleaners. Several alternative cleaners are now available, including PENRAY's ODS-free and EPA 17-free 2005 Gum-Solve Liquid Carburetor Cleaner. Also available under NSNs 6850-01-085-1423 and 2940-00-123-7195 are ODS-free carburetor cleaners that have small percentages of toluene and/or xylenes.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduces the amount of ODSs and EPA 17 chemicals entering the environment.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

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Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Mr. Joe Caraso
PENRAY Co.
440 Dennison Court
Wheeling, IL 66609
(708) 459-5000

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE TUBELESS TIRE REPAIR KIT

Revision: 1/96
Process Code: Navy: SR-02-99; Air Force: AD07; Army: VHM
Substitute for: NSN 2640-00-922-6921, which contains methyl chloroform
Applicable EPCRA Targeted Constituents: Methyl chloroform (1,1,1 trichloroethane)

Overview: Tubeless tire repair kits typically have an adhesive that contains ODSs. There are alternatives available for these kits. Adhesives often contain ODSs, such as those used in tubeless tire repair kits. There are alternatives, such as the PEMCO 282 tubeless tire repair kit. PEMCO 282 is ODS-free.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Barnes/Adams PSP, Inc.
Mr. Larry Barnes, PEMCO 282
(412) 287-6711

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE LUBRICANT/ANTI-SEIZING COMPOUND

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: NSN 8030-00-111-6266 per Technical Order 1F116A-3-78JE-00-21
Applicable EPCRA Targeted Constituents: ODSs

Overview: Anti-seizing compounds are normally used on engine hardware (nuts and bolts) to lubricate and prevent seizing of the components due to corrosion or dirt buildup. An industry standard product made by FEL-PRO called C-300 was renamed Moly Dry Film, and its formulation contains no ODSs.

FEL-PRO Moly Dry Film (formerly FEL-PRO C-300) is a combination lubricant and anti-seizing compound used on PW-F100-220 jet engines for the F-16 meeting PWA-36035. It is a multipurpose anti-seizing compound containing molybdenum disulfide. The compound is intended to prevent seizing of a component, due to heat, dirt buildup, or corrosion after extended use. Before 1992, this product was formulated with an ODS and listed under NSN 8030-00-111-6266. Since then, the product has been reformulated and is now available without any ODSs in its formulation under the NSN 8030-01-222-1995.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

FEL-PRO, Inc.
Commerce City, CO
(800) 992-9799

Mr.Charlie Schroeder
Technical Service Representative

Moly Dry Film is available in aerosol or bulk form:

Item	Part Number
16 fl. oz. aerosol can	51026
1.5 lb can	51028
10 lb can	51029

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE DEGREASING/CLEANING

Revision: 1/96
Process Code: Navy: ID-02-09; Air Force: AD07; Army: CLD
Substitute for: Vapor degreaser containing methyl chloroform, NSN 6810-00-551-1487, per Technical Order 34B3-4-11
Applicable EPCRA Targeted Constituents: Methyl chloroform (1,1,1-trichloroethane)

Overview: ODS-containing solvents have long been used by maintenance organizations as degreasers for metal components. Alternatives have become available that are ODS-free.

Alternative solvents and cleaning methods are now on the market to replace ODS-containing cleaners/degreasers. Generally, there are two categories of alternatives to choose from: chemical and mechanical. Chemical alternatives are typically another solvent without ODSs, while the mechanical alternatives clean with detergent and water using a hot, high pressure spray or other form of mechanical agitation.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ozone depleting substances going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Chemical:

P-T Technologies, (800) 441-7874, Manufacturer of PF Degreaser
Inland Technology, (800) 552-3100, Manufacturer of Skysol
Hurri Kleen Corporation Manufacturer of Hurri-Safe Special
Formula Degreaser
Hurri-Safe Hot Immersion Degreaser

Mechanical:

Better Engineering Manufacturing, Inc.
8361 Town Center Court
Baltimore, MD 21236-4964
(800) 229-3380
Manufacturers of detergent washers for degreasing and cleaning

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

MOTOR VEHICLE AIR CONDITIONING REFRIGERANT CONVERSIONS FROM CFC 12 TO HFC-134A

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Dichlorodifluoromethane, CFC-12 (also known as Refrigerant R-12)
Applicable EPCRA Targeted Constituents: CFC-12, dichlorodifluoromethane

Overview: CFC-12 has been the refrigerant of choice for motor vehicle air conditioning systems until it was discovered to be an ozone-depleting substance. New motor vehicle air conditioning systems are now using the refrigerant HFC-134a. The imminent CFC production ban will force any CFC-12 based systems without access to reclaimed CFC-12 to convert fully to HFC-134a or to use a drop in HCFC.

CFC-12 is the refrigerant currently used by the majority of motor vehicle air conditioning systems now in operation. Atmospheric CFCs have been determined to be the primary cause of stratospheric ozone layer depletion over the last quarter century as these products have made their way into the atmosphere. The widespread use of CFCs, not only in motor vehicle air conditioning systems, but in many other applications as well, has resulted in a significant increase in the concentration of atmospheric chlorine, which reacts with ozone, reducing its stratospheric concentration, and thus destroying the ultraviolet radiation shielding ability of the ozone layer.

Conversion of a large number of motor vehicle air conditioning systems now using CFC-12 is likely, given the large number of existing CFC-12 based units in service and the production ban on CFCs beginning January 1, 1996.

It is certain that an increasing number of conversions will be done as CFC-12 based air-conditioning systems require servicing. There may be two options, depending on the vehicle and its system and location. The HFC-134a conversion is ODS-free, but also relatively expensive and results in reduced cooling capacity. Tests are now underway using an HCFC or an HCFC blend designed to mimic the refrigerant characteristics of CFC-12. Thus, using HCFCs as the refrigerant should result in better cooling performance at a lower cost. HCFCs should be available for the converted systems until they reach the end of their useful life cycle (~2010). Finally, any system converted to either alternative should have its CFC-12 removed and reused for servicing a vehicle with not being converted.

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Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduces the amount of ODSs going into the environment.

Disadvantages: N/A

Economic

Analysis: Conversions of motor vehicle air conditioning systems now using CFC-12 to HFC-134a are expected to be relatively expensive and perhaps not totally satisfactory. For example, a conversion will require replacement of the dryer, hoses, seals, lubricant, and refrigerant at a cost for a typical automobile system estimated at \$500. However, because of the differing physical properties of the refrigerants, systems designed for CFC-12 and converted to HFC-134a will suffer an approximate 30% reduction in efficiency, and hence cooling ability.

HCFC conversions are expected to be simpler and cheaper. Component changes should be minimal, and refrigerant cost will likely be \$8 to \$10 a pound with a typical system using 2 to 4 pounds. Cooling performance is expected to be comparable to the system with CFC-12.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Scott Custer
Automotive Refrigeration Engineer
WR-ALC/LVR-1
DSN 468-2927 or (912) 926-2927

Vendors: N/A

MOTOR VEHICLE AIR-CONDITIONING REFRIGERANT ALTERNATIVES

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Dichlorodifluoromethane, CFC-12
Applicable EPCRA Targeted Constituents: Dichlorodifluoromethane (CF₂Cl₂)

Overview: Chlorofluorocarbon-12 (CFC-12) has been the refrigerant of choice for motor vehicle air-conditioning systems, until it was discovered to be an ozone-depleting substance. New motor vehicle air conditioning systems are using the refrigerant Hydrofluorocarbon-134a (HFC-134a). The imminent CFC production ban will force any CFC-12 based systems without access to reclaimed CFC-12 to convert fully to either HFC-134a or R-401C, or use a drop-in hydrochlorofluorocarbon (HCFC) blend. The HCFCs do have ozone-depleting potential, and both HCFCs and HFCs are greenhouse gases having relatively high global warming potentials (GWPs). Therefore, the EPA strongly recommends the containment and reclamation of these substitutes (closed-loop recovery systems provide a means to achieve the conservation of these refrigerants). This is an indication that future regulation of these compounds will only increase. One example is the “no venting” regulation of the Clean Air Act Amendments, 58 FR 92, Section 608(c)(2), page 28,664. This regulation requires users to recover HFCs and other alternative (to CFCs) refrigerants when servicing equipment, effective 15 November 1995.

CFC-12 is the refrigerant used by the majority of motor vehicle air conditioning systems currently in operation, particularly those manufactured prior to 1993. Atmospheric CFCs have been determined to be the primary cause of stratospheric ozone layer depletion over the last quarter century as these products have made their way into the atmosphere. The widespread use of CFCs not only in motor vehicle air-conditioning systems but in many other applications as well, has resulted in a significant increase in the concentration of atmospheric chlorine. Atmospheric chlorine reacts with ozone and reduces its stratospheric concentration, thus destroying the ultraviolet radiation shielding ability provided by the ozone layer.

Conversion of a large number of motor vehicle air-conditioning systems currently using CFC-12 is likely, given the large number of existing CFC-12-based units in service and the production ban on CFCs beginning 1 January 1996.

It is certain that an increasing number of conversions will be done as CFC-12-based air-conditioning systems require servicing. There may be

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two options, depending on the vehicle, its system, and the geographic location. The use of HFC-134a or R-401C (an HFC/HCFC blend of 52 percent HCFC-124, 15 percent HFC-152a, and 33 percent HCFC-22) to retrofit a motor vehicle's CFC-12-based air-conditioning system would require change out of numerous components, including the old lubricant. Retrofits with both HFC-134a and R-401C are approved by the EPA's Significant New Alternatives Policy (SNAP) program. This type of conversion provides an ODS-free (in the case of HFC-134a) or very low ODS (using R-401C) refrigeration system. The conversion is relatively expensive and may result in reduced or inadequate cooling capacity, especially at "hot idle" conditions.

Several HCFC blends have been developed to mimic the refrigerant characteristics of CFC-12 for use as drop-in replacements. Using drop-in replacements should result in equivalent cooling performance at a lower cost. HCFC blends are expected to be available for the converted systems until they reach the end of their useful life cycle, provided their production phaseout is not accelerated. The drop-in replacements are also SNAP approved.

Any motor vehicle air-conditioning system converted to an alternative, by law, must be evacuated and have its CFC-12 removed, recovered, and reused for servicing a vehicle not being converted.

Materials

Compatibility:

Any HFC or any blends using solely HFCs are not compatible with mineral oil lubricants found in CFC-12 refrigerant systems. For conversions, manufacturers typically recommend triple-flushing the lubricant from the system before charging with HFC-134a. Flushing can usually be accomplished after removing and recovering the existing refrigerant by simply draining the existing mineral oil, either from an oil drain plug or by removing the compressor and draining from the suction line. In most automotive systems, 90 to 95 percent of the lubricant can be removed from the system in this manner. Larger systems may require multiple drainage points, particularly if there are low spots around the evaporator. In all conversions, measure the volume of lubricant removed and compare to the compressor/system specifications to assure that greater than 95 percent of the lubricant has been removed. If greater than 95 percent of the mineral oil lubricant has not been removed, flushing will be required (if the system shows poor heat transfer, the mineral oil residual is typically still too high). Equipment using HFC-134a and R-401C requires synthetic oils (although R-401C tolerates a higher proportion of mineral oil, since it contains two HCFCs, so triple flushing is probably not necessary for R-401C conversions), such as polyalkylene glycol or polyol ester lubricating oils.

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Safety and Health: The SNAP-approved refrigerants for motor vehicle applications have been developed to minimize safety and health concerns. They are non-flammable under all expected working conditions and have low toxicity. Personal protective equipment is not mandatory, but when working with refrigerants, use of safety glasses or chemical splash goggles is always recommended. For more information on the safety and health aspects of these refrigerants, consult your local Industrial Health specialist, your local health and safety personnel, and the product MSDS prior to any refrigerant conversion.

Benefits: Conversion and retrofits, along with recovery of the existing CFC refrigerant charge, reduces the amount of ozone-depleting substances (ODSs) going into the environment.

Disadvantages: The use of HCFCs as drop-in replacements are their moderate ozone-depletion potential and the fact that they will probably have to have dedicated servicing equipment to comply with EPA regulations (in contrast, the latter requirement is essentially fulfilled for HFC-134a conversions because dedicated systems are, for the most part, already in place for new motor vehicle air-conditioning systems, which now use HFC-134a).

**Economic
Analysis:**

Conversions of motor vehicle air conditioning systems now using CFC-12 to HFC-134a are expected to be relatively expensive. A complete conversion will require replacement of the dryer, hoses, seals, refrigerant, and lubricant, and also flushing of the old lubricant. The cost of a complete HFC conversion for a typical automobile CFC-12 system is estimated between \$500 and \$1,000. In addition, because of the differing physical properties of the refrigerants, systems designed for CFC-12 and converted to HFC-134a may suffer some reduction in efficiency (up to 30 percent less efficient according to some tests), and hence cooling ability.

Drop-in replacements of the HCFC blends are expected to be simpler and cheaper, since no flushing or changing of lubricating oils is required. Furthermore, component changes should be minimal, although new connections and tagging are required by law. Refrigerant cost will likely be \$8 to \$10 a pound, with a typical system using 2 to 4 pounds. However, complete refrigerant replacement is required; “topping off” a CFC-12 system with an HCFC blend is not allowed. Cooling performance is expected to be comparable to the original systems operating with CFC-12.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Point of Contact: Mr. Scott Custer, Automotive Refrigeration Engineer
WR-ALC/LVR-1
DSN 468-2927, (912) 926-2927

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Allied-Signal Inc.
Fluorocarbons
P.O. Box 1053
Morristown, NJ 07962-1053
(800) 631-8138, FAX (201) 455-6395
Manufacturer of HFC-134a

DuPont Fluorochemical Products Information
Ms. Allison Minton, (800) 582-5606, or Mr. Bob Luksic, (800) 242-4618
Technical Information Specialists
Manufacturer of HFC-134a

Elf Atochem N.A., Inc.,
Research and Applications Laboratory
900 First Ave., P.O. Box 1536
King of Prussia, PA 19406
(800) 435-3286
Manufacturer of HFC-134a

Source(s):

PA Technical Inquiries: 2065, 2984, and 3136.

Rolotti, G. D., and S. Leonard, "Experience in Retrofitting CFC-12 Auto Air-Conditioning Systems with HFC-134a: An Update After a Year of Testing," Proceedings of International CFC and Halon Alternatives Conference '94, p. 765-774, Oct 94.

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ODS-FREE STERILIZATION

Revision: 1/96
Process Code: Navy: MD-01-01, MD-02-02; Air Force: MD01; Army: Not available
Substitute for: Ethylene Oxide/CFC-12
Applicable EPCRA Targeted Constituents: Ethylene Oxide, CFC-12
(dichlorodifluoromethane)

Overview: Sterilizing agents can contain CFCs, which, because they are relatively inert, are added for safety and ease of use. CFCs are often used as part of the formulation for sterilizing agents. Because the sterilizing agents are oxidizers, such as ethylene oxide, and are usually very combustible, the CFCs/HCFCs serve as both fire suppressant and propellant. A typical sterilizing mixture of ethylene oxide and CFC-12 is produced in a formulation of 12% ethylene oxide and 88% CFC-12. The best application of this type of sterilizing agent is for heat sensitive equipment on which steam autoclaving (sterilization with heat) can not be done.

Despite the fact that ethylene oxide is a suspected carcinogen, some 100% ethylene oxide (CFC and HCFC free) sterilizers are in development. Also, some ethylene oxide-free replacements have been produced; for example, hydrogen peroxide and ozone based sterilizers, but they are not yet in widespread use.

Ethylene oxide, although not an ODS, is a suspected carcinogen. Use of ethylene oxide should be minimized. In fact, relatively low levels of use (25-50 lb/yr) will trigger technical reviews of the process and may require implementation of Maximum Achievable Control Technology.

Some manufacturers have substituted an HCFC for the CFC, which reduces the sterilizers ozone depleting potential, but does not eliminate it. Two tradenames of these products are Penngas 2 and Oxyfume 2000.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment.

Disadvantages: N/A

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**Economic
Analysis:**

Retrofitting or repairing an existing EO/CFC based sterilizer that is less than 5 years old to an EO/HCFC mixture based sterilizer is cheaper than purchasing new equipment based on one of the new technologies. It would be best if possible to delay purchases of any new sterilizers until the new technologies have been thoroughly evaluated.

**Approval
Authority:**

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Captain Rick Owen
Equipment Specialist
DSN 343-7487

Mr. Terry Black
AFMC/ENX
DSN 787-0349, (513) 257-0349

Vendors:

The following list is not meant to be complete, as there are other manufacturers of this product.

Amsco Scientific
(800) 444-9009
Mr. Pete Buczynski
Service Engineering Technical Support

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ETHYLENE OXIDE STERILIZER ALARM SYSTEMS

Revision: 1/96
Process Code: Navy: MD-01-01, MD-02-02; Air Force: MD01; Army: Not available
Substitute for: Kem Medical Model 9000
Applicable EPCRA Targeted Constituents: Ethylene Oxide, CFC-12
(dichlorodifluoromethane)

Overview: Sterilization equipment using ethylene oxide (EO) can sometimes develop leaks. Detection systems are available to warn of EO presence; however, the detectors are also sensitive to CFCs and HCFCs, and thus can give false alarms.

CFCs and HCFCs are often used as part of the formulation for sterilizing agents. Because the sterilizing agents are oxidizers, such as EO, and are usually very combustible, the CFCs/HCFCs serve as both fire suppressant and propellant. EO is a suspected carcinogen, and CFCs and HCFCs are ODSs, so leak detection is a critical part of sterilization equipment maintenance. Current detection systems for EO are also sensitive to CFCs and HCFCs, but since most products used are mixtures and not 100% EO, any leak detected, even if it is not high in EO, is cause for concern, and is probably an indication of a component problem.

Despite the fact that EO is a suspected carcinogen, some 100% EO (CFC and HCFC free) sterilizers are in development. Also, some EO-free replacements have been produced (for example, hydrogen peroxide and ozone-based sterilizers), but they are not yet in widespread use.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Detect leakage of EO and ODSs.

Disadvantages: N/A

Economic

Analysis: Retrofitting or repairing an existing EO/CFC based sterilizer that is less than 5 years old to an EO/HCFC mixture-based sterilizer is cheaper than purchasing new equipment based on one of the new technologies.

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It would be best if possible to delay purchases of any new sterilizers until the new technologies have been thoroughly evaluated.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Mr. John Monville
Armed Forces Medical Logistics Office
Medical Equipment Management Team (AFMLO/FOM)
DSN 343-7487

Mr. Terry Black
AFMC/ENX
DSN 787-0349, (513) 257-0349

Vendors:

The following list is not meant to be complete, as there are other manufacturers of this product.

Amsco Scientific
(800) 444-9009
Mr. Pete Buczynski, Service
Engineering Technical Support
Amsco Model 5700

Cryotech
Puriten Bennett
Mr. Bowey
(904) 374-6603

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ODS-FREE SKIN REFRIGERANT

Revision: 1/96
Process Code: Navy: MD-02-99; Air Force: MD01; Army: Not available
Substitute for: CFC-114, NSN 6506-00-576-8915
Applicable EPCRA Targeted Constituents: CFC-114 (dichlorotetrafluoroethane)

Overview: The ODS CFC-114 is used as a refrigerant for conducting cold-sensitivity studies at dental clinics. A suitable substitute, an HFC-134a (a non-ODS) based product called Green Endo-Ice, is an available alternative.

Dental applications of CFC-114 as a skin refrigerant can be substituted with an HFC-134a based product called Green Endo-Ice. While not an ODS, HFC-134a is a green house gas and has a global warming potential.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of ODSs going into the environment

Disadvantages: N/A

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Lt. Col. Kane, DDS
Dental Investigation
Armstrong Laboratory, AL/AOCD,
DSN 240-3502, (210) 536-3502

Mr. Bob Luksic
Du Pont Fluorochemicals Customer Service
(800) 242-4618

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Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Green Endo-Ice is available from Henry Schein, Incorporated
(516) 843-5500

Manufactured by Hygenic Corporation, (216) 633-8460

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ODS-FREE SUBSTITUTE FOR INSULATING FOAM

Revision: 1/96
Process Code: Navy: SR-04-99; Air Force: SV01; Army: Not available
Substitute for: CB 120 Filler Foam
Applicable EPCRA Targeted Constituents: ODSs

Overview: CFCs and HCFCs are common blowing agents used in expansion of polymer foams, such as expanded polystyrene (STYROFOAM®). Most companies, however, have switched from using CFCs to using HCFCs as blowing agents or other alternative methods.

CFCs and HCFCs are used in expansion of polymer foams. The trend is away from CFCs and toward HCFCs and other alternatives. One new alternative to gas induced expansion is “electroset” technology. Electrosetting materials are made up of ordinary resins mixed with an electrically polarizable aggregate that makes the resin semiconductive while in its liquid state. The fluid resin is then heated electrically until, at a certain temperature, one constituent of the resin changes phase from liquid to gas, thus creating bubbles. The rest of the resin then solidifies, resulting in an expanded foam. By altering the applied electrical energy, qualities such as foam density and compressibility can be controlled. Using alternating current in the process produces a homogeneous foam. Direct current causes a thermal gradient in the resin resulting in foam with properties that vary within the foam matrix. Molded items can also be produced.

A new fire-resistant insulation foam has also been developed by a Swiss company called Polypag. Their foam is applied with a can, and the propellant is a blend of HFC-152A and dimethyl ether.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amounts of CFCs and other ODSs going into the environment

Disadvantages: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Economic

Analysis: Costs for “electroset” technology are claimed to be comparable to CFC technologies.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Macklanburg-Duncan, (405) 528-4411, produces Macklanburg-Duncan Minimal Expanding Foam, which contains an HCFC.

Insta-Foam Sealant, (815) 741-6800, produces Insta-Seal, which also contains an HCFC.

RHH Foam Systems, Inc., (800) 728-6067, produces polyurethane foam, which does not contain any Class I ODS.

3M Corporation, (800) 480-1704, produces Scotch Seal Chemical Grout 5600, which does not contain any chlorinated solvents.

U.S. Navy, FAX (410) 293-2561, for information on “Electroset” technology.

Polypag, FAX (49) 71-756-142, for information on a new fire-resistant space-filling insulation foam that comes in a can with a propellant blend of HFC-152a and demethyl ether.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

FIRE STOP SETTING COMPOUNDS

Revision: 1/96
Process Code: Navy: ID-19-99; Air Force: SV01; Army: Not available
Substitute for: ODSs and propane expanded insulating foams
Applicable EPCRA Targeted Constituents: ODSs

Overview: Expanded insulating foams have become popular with the evolution of building codes in the last several years. Codes now require impervious protection between certain walls and structures to improve fire resistance. These foams can be applied where and when needed. However, ODS and propane-free substitutes are preferable.

Expanded insulating foams are an important part of new building construction, given strengthened building codes. These foams are used to seal holes between walls especially where pipes or conduits penetrate the walls. Since the expanded foams are made from isocyanate materials, no isocyanate-free substitutes exist. Some foams may, however, contain more innocuous propellants than propane and ODSs, but these are not readily available.

Fire stop compounds are acceptable alternatives to expanded insulating foams and should meet the latest building codes. The only application in which a foam would normally be required is where an object passing through a wall or floor will shrink in a fire; for example, polyvinyl chloride piping. However, the expanded foam can be avoided in this case also by wrapping an intumescent collar around the pipe and applying a fire stopping joint compound around the annular opening.

Materials

Compatibility: N/A

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduce the amount of isocyanates, ODS and alkyl propellants going into the environment.

Disadvantages: N/A

Economic

Analysis: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Mike Gardener
Technical Director
Association of the Wall and Ceiling Industry International
Falls Church, VA
(703) 534-8300

Vendors: The following list is not meant to be complete, as there are other manufacturers of this product.

Mr. Mark Chapman
National Gypsum Corporation
(800) 628-4662
Manufacturer of fire stop joint compound "FS0-90"

Mr. Lee Holder
U.S. Gypsum Company
(770) 393-0770
Manufacturer of fire stop joint compound "Fire Code Compound"

Mr. George Shortreed
Domtar Gypsum, Inc.
(800) 366-8274
Manufacturer of fire stop joint compound "Fire Halt"

DRY FILTER PAINT BOOTH CONVERSION

Revision: 1/96
Process Code: Navy: ID-05-99; Air Force: PA01; Army: PNT
Substitute for: Water Curtain Spray Booths
Applicable EPCRA Targeted Constituents: Lead, Chromium, and Zinc Compounds

Overview: Water curtain spray booths are primarily used to control particulate emissions from painting operations. A typical water curtain system consists of a large collection sump, water pumps, and one or more baffles. Water is pumped up from the collection sump over the baffles to produce one or more water curtains, depending on the number of baffles. Air is scrubbed as it passes through the water curtain and then vented into the atmosphere. The water forming the curtain falls back into the collection sump and is recirculated until it cannot be used. Paint sludge is collected on the bottom of the sump and is disposed of as hazardous waste. Wastewater is normally sent to an industrial waste treatment plant (IWTP).

Crossdraft and downdraft water curtain spray booths can be retrofitted into dry filter paint booths. There are many types of dry filter systems, but all operate on the same principle. Particulate-laden air flowing towards the filter media is forced to rapidly change directions. The particulate, having more inertia than the surrounding air, impacts the filter media and is removed from the air flow. The scrubbed air is then vented into the atmosphere.

General system issues to be considered in the conversion of a paint spray booth include characteristics and applicability of dry filter systems, required fan size, dry filter surface area, paint booth duty cycles, and paint usage rates. There are many types of dry filter particulate emissions control systems (PECS) and filters available on the market.

There are four principal types of filters currently used: fiberglass cartridges, multilayer honeycombed paper rolls or pads, accordion-pleated paper sheets, and cloth rolls or pads. Each principal type of filter has different characteristics for particulate capacity, removal efficiency, cost, and replacement time. Filter performance is characterized by three basic parameters: particulate capacity, resistance to air flow, and particulate removal efficiency. Filter replacement is required when the pressure differential across the filter face reaches the maximum specified by the manufacturer. Filter manufacturers sell manometers that measure the pressure differential.

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When using lead or zinc chromate paints, the dry filter will eliminate approximately 50 to 90 percent of the hazardous waste that would be generated with a water wall paint booth. Generally, the only hazardous waste generated from the process is the dry filter contaminated with paint. When using water-based paints, used filters from a dry filter paint booth are not considered hazardous waste, whereas wet sludge from a water curtain spray booth would be considered hazardous waste because of heavy metal contamination.

Materials

Compatibility:

Powder paint is typically not used in dry filter paint booths because this type of paint is usually recycled, which is difficult to do in a dry filter paint booth.

Safety and Health:

The concerns with the dry filter systems are the variety of paints that are used. When using lead and zinc chromate paints, inhalation of lead or zinc can irritate the respiratory tract and can be poisonous. Some lead compounds are carcinogenic. Solvent-based paints can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Lower initial capital cost compared to wet booth equipment
- Can decrease operation cost compared to water wash booths
- Eliminate chemical costs
- Reduce electrical costs
- Increase flexibility in design installation and performance
- Eliminate water and possible sewer costs
- No removal or daily skimming of sludge from the booth
- No water-wash sludge for hazardous waste disposal
- Reduce plant noise, odor, and worker stress by eliminating the water falls or vacuum suction
- Reduce maintenance cost by eliminating booth and duct rust from contact with water
- Decrease down time results from failures in the water pumping system
- Eliminates down time due to clogged nozzles
- Eliminate water tank overflow onto the booth floor
- Eliminates the need to heat water

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- Dry filter paint booths can have a better particulate removal efficiency
- Less clean-up is needed

Disadvantage: The principal disadvantage of dry filter systems is that, if not properly selected based on the painting operation and paint usage rate, the downtime during filter replacement could be high.

Economic Analysis: Converting a water curtain spray booth to a dry filter paint booth can be easily accomplished and can be done in-house. The cost of conversion usually ranges from \$200 to \$2,000, depending on the size and condition of the old water curtain spray booth. Purchasing a new dry filter paint booth can cost between \$2,000 and \$20,000. The conversion from a water curtain spray booth to a dry filter paint booth can save several thousand dollars in operating and maintenance costs per year.

- Assumptions (from Columbus Industries, Inc.):
 - Water wash paint booth is 7' high 12' wide; dry filter booth has twenty-eight modules, each 20" x 20"
 - 8-hour shift
 - Electricity at \$ 0.055/kwh; water wash uses 15 hp motor and dry filter uses 3 hp motor
 - Chemical usage at 20 lbs/shift and \$0.80/lb
 - Filters usage at 10/shift and \$0.62/filter
 - Labor at \$10/hr; water wash requires 12 min/shift and dry filter requires 10 min/shift.

	<u>Water Wash</u>	<u>Dry Filter</u>
• Capital Cost	\$9,400	\$2,975
• Typical Cost per shift:		
Electricity	\$4.92	\$0.98
Chemicals	\$16.00	-
Filters	-	\$6.20
Labor	\$2.00	\$1.67
Total/shift	\$22.92	\$8.85

- Cost Savings per shift = \$14.
- Annual Saving: 260 days x \$14.07 = \$3,658.2007
- Payback Period: About 9 months

Approval Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Points of Contact: Charles Tittle
NAVSEA 00TB
Naval Sea Systems Command
2531 Jefferson Davis Hwy.
Arlington, VA 22242-5160
Phone: (703) 602-3594
DSN: 332-3594
Fax: (703) 602-7213

Bob Fredrickson
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Code 423
1100 23rd Avenue
Port Hueneme, CA 93043-4370
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DSN: 551-4897
Fax: (805) 982-4832

Vendors: The following is a list of Dry Filter Booth manufacturers. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Columbus Industries, Inc.
P.O. Box 257
2938 State Route 752
Ashville, OH 43103-057?
(614) 983-2552

The DeVilbiss Company
1724 Indianwood Circle, Suite F,
Maumee, OH 43537-4050
(800) 338-4448

Research Products Corp.
P.O. Box 1467
Madison, WI 53701-1467
(608) 257-8801

Chemco Manufacturing Company, Inc.
3175 MacArthur Blvd.
Northbrook, Illinois
(800) 323-0431

ELECTROSTATIC PAINT SPRAY SYSTEM

Revision: 1/96
Process Code: Navy: ID-05-03; Air Force: PA01; Army: PNT
Substitute for: High Velocity Spray Paint Systems
Applicable EPCRA Targeted Constituents Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds

Overview: In conventional paint spray systems, paint atomization occurs via high velocity air jets forcing paint through small air holes in the paint gun face caps. Air pressures used range from 40 to 80 psi, with air volumes of 8 to 30 sqfm. The atomized paint particles travel at high velocities and tend to bounce off the object being painted, rather than adhering to the surface. In addition, the expanding high-pressure air (as high as 70 psi) passes through the small face cap openings, causing turbulent flow of the paint stream following air currents within the paint booth. The amount of paint that bypasses the workpiece (overspray) is relatively high for air pressure atomized spray painting. Transfer efficiencies of 15 to 30 percent are associated with conventional painting systems.

In electrostatic finishing, negatively-charged, atomized paint particles and a grounded workpiece create an electrostatic field that pulls the paint particles to the workpiece. An ionizing electrode, typically located at the paint gun atomizer tip, causes paint particles to pick up additional electrons and become negatively charged. As the coating is deposited on the workpiece, the charge dissipates through the ground and returns to the power supply, completing the circuit. The electrostatic field influences the path of the paint particles. Because the charged particles are attracted to the grounded workpiece, overspray is reduced. Paint particles that pass a workpiece can be attracted to and deposited on the back of the piece. This phenomena is known as “wrap.”

A potential drawback to electrostatic finishing, particularly for coating complicated surfaces, is the Faraday cage effect: a tendency of charged coating particles to deposit around entrances of cavities. High particle momentum can help overcome Faraday cage effects, since particles with greater momentum (larger particles or particles traveling at higher speeds) are influenced less by the electrostatic forces. None the less, high particle momentum also lowers efficiency. In addition, in high humidity atmospheres electric charges can leak off into the air, decreasing the charge on the particles and lowering efficiency. Transfer efficiencies for electrostatic finishing range from 45 to 85 percent.

Electrostatic paint equipment is available in three basic types: air atomized, airless, and rotating discs and bells, depending on how the

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paint is atomized. High-speed discs atomize the coating more finely than air atomization and direct more paint to the target. This technology is particularly efficient for the application of difficult to disperse, high-solids paints. However, the Faraday cage effect is generally greater with rotary atomizers than with air or airless types. Rotary atomizers, therefore, may not provide adequate coverage for complicated surfaces.

Because electrostatic finishing systems operate at high voltages (30 to 150 kV), operator safety is a major concern. All items in the work area must be grounded, including the operators, the paint booth, the application equipment (unless applying conductive coatings), and conveyors. Ungrounded items should be removed from the work area. Removing paint buildup from the paint booth helps assure that workpieces are grounded. Workers should never wear rubber- or corked-soled shoes, which can turn them into ungrounded capacitors. (Special shoe-grounding devices are available.) Adequate skin contact is required when using hand-held guns. Painters should grasp the gun with bare hands or use gloves with finger tips and palms cut out.

Materials

Compatibility:

Any material that can be atomized can accept an electrostatic charge, regardless of the coating conductivity. The workpiece must be groundable. Metal and some wooden pieces can be painted electrostatically, but plastic, rubber, ceramic, or glass can not.

Safety and Health:

Proper design, operation, and maintenance of the equipment is required for its safe use. The spray booth must be well ventilated. Proper personal protective equipment should be worn, if required.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

The significant reduction in overspray, paint bounce, and blow back can significantly reduce the amount of paint materials required to coat a part. The quantity of paint used can be reduced by 50 to 70 percent. Less overspray also results in a reduction in paint booth maintenance (filter changeouts, etc.), since less paint is deposited on paint booth surfaces. In addition, if a water-wall paint booth is used, less paint sludge will need to be removed from the scrubber and disposed as hazardous waste.

Disadvantages:

- High capital cost and more maintenance are required.
- The electric charges tend to repel on complicated surfaces.

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Economic Analysis: Cost will vary, depending upon specific applications: painting/coating type, paint volume, workpiece specifications, and technique. Generally, electrostatic air systems cost approximately \$4,000, and electrostatic airless systems cost approximately \$6,500. Installation and training are extra costs.

- Assumptions:
 - Gallons of paint used per year for using electrostatic spray: 5,000 gallons
 - Paint Procurement Cost: \$10/gallon
 - Transfer Efficiency of Electrostatic Spray: 70 percent

	<u>Electrostatic spray</u>	<u>High Velocity Spray</u>
• Capital Cost:	\$5,300	\$300-\$800
• Paint Cost:	\$50,000	\$200,000
• Annual Savings:	\$150,000	
• Payback Period:	2 weeks	

Approval Authority:

Navy: Approval is controlled locally should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Point of Contact:

Scott Mauro
Naval Facilities Engineering Service Center, Code 423
1100 23rd Avenue
Port Hueneme, CA 93043-4370
Phone: (805) 982-4889, DSN: 551-4889
FAX: (805) 982-4832

Vendors:

The following is a list of electrostatic spray painting system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Accuspray, Inc.
23350 Merchantile Rd.
Cleveland, OH 44122
Phone: (800) 618-6860 or (216) 595-6860
Fax: (216) 595-6868

Binks Manufacturing Co.
9201 W. Belmont Ave.
Franklin Park, IL 60131
Phone: (708) 671-3000

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Customer Service Fax: (708) 671-3067

The DeVilbiss Co.
1724 Indian Wood Circle
Maumee, OH 43537
Phone: (419) 891-8191
Fax: (800) 338-0131

Smith Eastern Corp. (AirVerter)
5020 Sunnyside Ave.
Beltsville, MD 20705
Phone: (301) 937-4548
Fax: (301) 937-7295

Graco Inc.
P.O. Box 1441
Minneapolis, MN 55440-1441
Phone: (800) 367-4023
Fax: (612) 623-6777

Source: Robinson, Frank and Dennis Stephens, "Understanding Electrostatic Finishing," *Industrial Finishing*, 9/90, p 34-37.
"Reducing Waste in Railcar Coating Operations," *Graco Equipment and Emissions Update*, June 1994, pp. 8-9.
Vendors.

HIGH TRANSFER EFFICIENCY PAINT SPRAY SYSTEMS

Revision: 1/96
Process Code: Navy: ID-06-04, ID-05-01/-02; Air Force: PA01; Army: PNT
Substitute for: High Velocity Spray Paint Systems
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds

Overview: In conventional paint spray systems, paint atomization occurs via high-velocity air jets, forcing paint through small air holes in the paint gun face caps. Air pressures used range from 40 to 80 psi, with air volumes of 8 to 30 sqfm. The atomized paint particles travel at high velocities and tend to bounce off the object being painted rather than adhering to the surface. In addition, the expanding high pressure air (as high as 70 psi) passing through the small face cap openings causes turbulent flow of the paint stream following air currents within the paint booth. The amount of paint that bypasses the workpiece (overspray) is relatively high for air pressure atomized spray painting. Transfer efficiencies of 15 to 30 percent are associated with conventional painting systems.

There are four basic types of high transfer efficiency paint guns: high volume/low pressure (HVLP), airless (also called pressure atomized), pressure atomized air-assisted, and electrostatic. Electrostatic spray paint systems are discussed in a separate Pollution Prevention Opportunity Data Sheet, "Electrostatic Finishing;" the others are described below.

High Volume Low Pressure (HVLP) paint systems atomize paint via a high volume of air delivered at a low pressure (less than 10 psi). In some HVLP systems, the air supply is turbine generated; in others, shop air (100 psi) is converted to less than 10 psi. Because the atomized paint particles are delivered at low speeds to the object being painted, less paint is lost as overspray, bounce, and blow back. Typically the transfer efficiency with HVLP is 50 to 65 percent.

Airless spray painting systems atomize paint by forcing it through a small tip orifice at high fluid pressures (1,500 to 3,000 psi). Typical transfer efficiencies with airless spray painting are 20 to 40 percent. Large areas can be painted quickly by pressure atomized paint systems. This technology is, however, inappropriate for fine finishing work, because a large quantity of paint is delivered with particles that are less finely divided.

Pressure-atomized, air-assisted systems combine the features of the air atomized (conventional) and airless systems. An airless fluid spray tip is

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used to atomize the coating into a fan pattern at high pressures (400 to 800 psi). A second, low-pressure air stream (10 to 30 psi) is injected after the nozzle to improve atomization and the spray pattern. This system is reported to provide the fine control of air-atomized spray guns and the improved transfer efficiencies of airless systems. Typical transfer efficiencies for pressure-atomized air-assisted systems are 25 to 40 percent.

Materials

Compatibility:

High transfer efficiency spray painting systems can be used in a wide variety of painting applications. Each technology has advantages and disadvantages, depending on the viscosity of the paint used, the part painted, the type of finishes desired, and production rate required. Higher production rates can be achieved with airless paint guns. The finer atomization of HVLP and pressure atomized air-assisted systems produce smoother surface finishes. There are many different paint gun models, with a variety of tip sizes to accommodate most coatings, including solvent-based paints, water based coatings, fine finish metallic, high-solids polyurethane, contact adhesives, varnish, top coats, lacquer, enamel primer, latex, primer, epoxy, and vinyl fluids. The efficiency of these systems is reduced if painting is done in exposed areas.

Safety and Health: Proper design, separation, and maintenance of the equipment is required for its safe use. The spray booth must be well ventilated. Proper personal protective equipment should be worn, if required.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

The significant reduction in overspray, paint bounce, and blow back can significantly reduce the amount of paint materials required to coat a part. The quantity of paint used can be reduced by 50 to 70 percent. Less overspray also results in a reduction in paint booth maintenance (filter changeouts, etc.), since less paint is deposited on paint booth surfaces. In addition, if a water-wall paint booth is used, less paint sludge will need to be removed from the scrubber and disposed as hazardous waste

Disadvantages:

To achieve high quality finishes at normal production rates, the temperature, pressure, and volume of air used by the system must be properly controlled. Some HVLP paint guns allow the air pressure to be adjusted. If operated at pressures above the manufacturer-specified

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limits, the paint gun's transfer efficiency could be lowered; the gun could be made into a conventional high-pressure gun.

Economic Analysis: Costs will vary depending upon specific applications: painting/coating type, paint volume, workpiece specifications, and technique. Generally, HVLP paint spray system equipment costs approximately \$1,000 for a gun, hose, and paint pot. Airless or air-assisted airless paint spray systems range from \$2,000 to \$3,500. Installation costs will also vary, depending upon location.

- Assumptions:
 - Gallons of paint used per year for HVLP gun: 10,000 gallons
 - Paint Cost: \$10/gallon
 - Transfer Efficiency of HVLP gun: 50 percent

	<u>HVLP Gun</u>	<u>High Velocity Spray</u>
• Capital Cost	\$1,000	\$300-\$80
• Paint Cost	\$100,000	\$200,000

- Annual Savings: \$100,000
- Payback Period: one week

**Approval
Authority:**

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Point of Contact:

Scott Mauro
Naval Facilities Engineering Service Center, Code 423
1100 23rd Avenue
Port Hueneme, CA 93043-4370
Phone: (805) 982-4889, DSN: 551-4889
FAX: (805) 982-4832

Vendors:

The following is a list of HVLP spray painting system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Accuspray, Inc.
23350 Merchantile Rd.
Cleveland, OH 44122
Phone: (800) 618-6860 or (216) 595-6860, Fax: (216) 595-6868

Binks Manufacturing Co.
9201 W. Belmont Ave.

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Franklin Park, IL 60131
Phone: (708) 671-3000, Customer Service Fax: (708) 671-3067

The DeVilbiss Co.
1724 Indian Wood Circle
Maumee, OH 43537
Phone: (416) 470-2169, Fax: (800) 338-0131

Smith Eastern Corp. (AirVerter)
5020 Sunnyside Ave.
Beltsville, MD 20705
Phone: (301) 937-4548, Fax: (301) 937-7295

Graco Inc.
P.O. Box 1441
Minneapolis, MN 55440-1441
Phone: (800) 367-4023, Fax: (612) 623-6777

PLURAL COMPONENT PROPORTIONING SYSTEM FOR EPOXY PAINTS

Revision: 1/96
Process Code: Navy: ID-05-99; Air Force: PA01; Army: PNT
Substitute For: Manual Paint Mixing
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds

Overview: Under most current operating procedures, epoxy paint mixtures are prepared by premixing a base and catalyst, and combining them in appropriate proportions in a separate container. After mixing and waiting the specified time, application of the paint to the object may proceed. Epoxy paint ingredients have a limited pot life once mixed which cannot be exceeded without affecting the characteristics of the paint. If the pot life is exceeded, the mixture must be disposed, and the application equipment must be cleaned with a solvent. The cleaning solvent, as well as mixed and unused paints, must be disposed as hazardous waste. Common solvents used for cleaning are methyl ethyl ketone (MEK), xylene, toluene, and mineral spirits.

Plural component proportioning systems are self-contained machine proportioning and mixing systems. Application devices are separate components which are used in conjunction with the plural component proportioning system. The proportioning and application system layout typically includes the following components: 1) proportioning pump module, 2) mix manifold, 3) mixer, 4) application device, 5) material supply module, and 6) purge or flush module. These systems optimize painting operations by maximizing efficiency and minimizing waste generated. The base and catalyst components of the epoxy paint mixture are mixed by machine within the proportioning system. The position of the mixer with respect to the applicator is determined by the pot life.

In particular, the proportioning system design is highly dependent upon pot life, material viscosity, material compatibility, and application methods.

Materials

Compatibility: Material specification data for the epoxy paint materials need to be evaluated with respect to the proportioning and application system components prior to specification of the actual system to ensure material compatibility. The materials used for the pumps and packings need to be evaluated on a case-by-case basis. Stainless steel and Teflon® components do not pose compatibility problems with most materials used in epoxy paint operations.

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Safety and Health: Health concerns are dependent on the variety of paint that is used. Inhalation of lead- and zinc chromate-based paints can lead to irritation of the respiratory system. Some lead compounds are carcinogenic. Solvent-based paints can irritate the lungs and mucous membranes. prolonged exposure can affect respiration and the central nervous system. proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The Plural Component Proportioning System for epoxy paints provides total control of materials from container(s) to application. Machines are more accurate and can provide more consistent material quality than hand mixing. Machines can keep pace with higher production requirements. Machines mix on demand (e.g., as the gun is triggered), which results in no significant left overwaste. Material cleanup requires less labor and maintenance, and generates less waste because the mixed material can be purged with solvent from the manifold, mixer, hose, and applicator before it cures. The Plural Component Proportioning System is a closed system and, as a result, there are fewer spills, less contamination or waste to clean up, and less contact between personnel and potentially hazardous materials. In addition, the proportioning system makes bulk purchase of material practical.

Disadvantage: Plural component proportioning and application systems need to be designed for specific applications.

Economic Analysis: Capital costs for plural component proportioning systems can range from \$50,000 to \$70,000 for systems that mix multiple materials to \$6,000 to \$7,000 for basic units that mix two materials. Applicator systems are additional and their capital costs can range from \$500 to \$5,000. Each application needs to be evaluated on a case-by-case basis with respect to material and labor costs and savings.

The following is an example of the replacement of a hand-mixing paint operation with a relatively simple Plural Component Proportioning System.

- Assumptions:
 - Total capital cost for installed equipment at \$15,000/system
 - 4,000 gallons of paint per year at \$85/gallon
 - 2,250 gallons of solvent per year at \$7/gallon
 - 250 labor hours/year for equipment cleaning at \$16/hour
 - 5,500 pounds of solid paint waste generated per year

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- Paint solid waste disposal at \$1/pound
- Solvent waste disposal at \$3/pound
- Plural component proportioning system reduces paint usage by 15%
- Plural component proportioning system reduces solvent usage and waste by 50%
- Plural component proportioning system reduces labor usage by 50%
- Plural component proportioning system reduces paint waste by 50%

	<u>Plural Component Proportioning System</u>	<u>Manual Mixing</u>
• Capital Cost:	\$15,000	-
• Operational Cost/yr:		
Labor	\$2,000	\$4,000
Paint Cost	\$289,000	\$340,000
Solvent Cost	\$7,875	\$15,750
Paint Waste Disposal	\$2,750	\$5,500
Solvent Waste Disposal	\$3,375	\$6,750
• Annual Savings: \$67,000		
• Payback Period: 4 months		

Approval

Authority:

Navy: Approval is controlled locally should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Point of Contact:

Scott Mauro
 Naval Facilities Engineering Service Center, Code 423
 1100 23rd Avenue
 Port Hueneme, CA 93043-4370
 Phone: (805) 982-4889, DSN: 551-4889
 FAX: (805) 982-4832

Vendors:

The following is a list of plural component proportioning system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

DeVilbiss Ransburg Industrial Liquid Systems
 320 Phillips Avenue
 Toledo, OH 43612
 (800) 233-3366

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Graco Inc.
P.O. Box 1441
Minneapolis, MN 55440-1441
(800) 367-4023

Binks Manufacturing Company
9201 Belmont Avenue
Franklin Park, IL 60131-2887
(708) 671-3000

POWDER COATING PAINTING SYSTEM

Revision: 1/96
Process Code: Navy: ID-05-03, ID-05-04; Air Force: PA01; Army: PNT
Substitute For: Conventional Solvent-based, Waterborne, or High Solids Painting
Applicable EPCRA Targeted Constituents: Acetone, n-Butanol, Lead, Methyl Ethyl Ketone, Toluene, and Xylene

Overview: In conventional paint spray systems, paint atomization occurs via high-velocity air jets, forcing paint through small air holes in the paint gun face caps. Air pressures used range from 40 to 80 psi, with air volumes of 8 to 30 sqfm. The atomized paint particles travel at high velocities and tend to bounce off the object being painted, rather than adhering to the surface. In addition, the expanding high-pressure air (as high as 70 psi) passes through the small face cap openings, causing turbulent flow of the paint stream following air currents within the paint booth. The amount of paint that bypasses the workpiece (overspray) is relatively high for air pressure atomized spray painting. Transfer efficiencies of 15 to 30 percent are associated with conventional painting systems.

Thin film powder coating, also referred to as a “dry painting” process, eliminates volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and solvents, and produces superior surface finish. There are four basic powder coating application processes: electrostatic spraying, fluidized bed, electrostatic fluidized bed, and flame spray. Electrostatic spraying is the most commonly used powder application method. For all application methods, surface preparation (i.e., cleaning and perhaps application of a conversion coating) is required to develop good coating adhesion to the workpiece surface. Characteristics of the four different powder coating application techniques are summarized in Table 1 and described below.

In electrostatic spraying, an electrical charge is applied to the dry powder particles while the component to be painted is electrically grounded. The charged powder and grounded workpiece create an electrostatic field that pulls the paint particles to the workpiece. The coating deposited on the workpiece retains its charge, which holds the powder to the workpiece. The coated workpiece is placed in a curing oven, where the paint particles are melted onto the surface and the charge is dissipated.

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Table 1. Characteristics of Powder Coating Techniques

Characteristic of Workpiece	Electrostatic Spray	Fluidized Bed and Electrostatic Fluidized Bed	Flame Spray
Size	Larger	Smaller	Not limited
Material	Metallic, must be conductive	Any, not necessarily conductive	Any, not necessarily conductive
Temperature Resistance	Relatively high	High	Not relevant
Aesthetic Value	High	Low, not suitable for decorative purposes	Low, not suitable for decorative purposes
Coating Thickness	Thinner films	Thick high-build films with excellent uniformity	Thick high-build films; uniformity dependent on the operator
Type of Coatings	Thermoplasts and thermosets	Thermoplastic and thermosets	Thermoplasts only
Color Change	Difficult	Relatively difficult	Easy
Capital Investments	Moderate to high	Low	Very low
Labor	Low since highly automated	Moderate depending on the automatization	Relatively high
Energy Consumption	Only post-heating	Preheating and often postheating	Low, no preheating and postheating
Coating Waste	Very little	Very little	Dependent on the workpiece geometry

From Miser, Tosko A. 1991. *Powder Coatings: Chemistry and Technology*, Table 6.4, p. 350.

In a fluidized bed, powder particles are kept in suspension by an air stream. A preheated workpiece is placed in the fluidized bed where the powder particles coming in contact with the workpiece melt and adhere to its surface. Coating thickness is dependent on the temperature and heat capacity of the workpiece and its residence time in the bed. Post heating is generally not required when applying thermoplastic powder

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coatings. However, post heating is required to completely cure thermoset powder coatings.

Electrostatic fluidized beds are similar in design to conventional fluidized beds, but the air stream is electrically charged as it enters the bed. The ionized air charges the powder particles as they move upward in the bed, forming a cloud of charged particles. The grounded workpiece is covered by the charged particles as it enters the chamber. No preheating of the workpiece is required. Curing of the coating is, however, necessary. This technology is most suitable for coating small objects with simple geometry.

The flame-spray technique was recently developed for application of thermoplastic powder coatings. The thermoplastic powder is fluidized by compressed air and fed into a flame gun where it is injected through a flame of propane, and the powder melts. The molten coating particles are deposited on the workpiece, forming a film on solidification. Since no direct heating of the workpiece is required, this technique is suitable for applying coatings to most substrates. Metal, wood, rubber, and masonry can be successfully coated by this technique. This technology is also suitable for coating large or permanently-fixed objects.

The choice of powders is dependent on the end-use application and desired properties. Powders are typically individually formulated to meet specific finishing needs. Nevertheless, powder coatings fall into two basic categories: thermoplastic and thermosetting. The choice is application dependent. However, in general, thermoplastic powders are more suitable for thicker coatings, providing increased durability, while thermosetting powders are often used when comparatively thin coatings are desired, such as decorative coatings. The principal resins used in thermoplastic powders are vinyl, nylon, and fluoropolymer. Thermosetting powders use primarily epoxy, polyester, and acrylic resins.

The concentration of powder in air must be controlled to maintain a safe working environment. Despite the absence of flammable solvents, any finely divided organic material, such as dust or powder, can form an explosive mixture in air. This is normally controlled by maintaining proper air velocity across face openings in the spray booth. In the dust collector, where the powder concentration cannot be maintained below the lower explosive limit, either a suppression system or a pressure relief device must be considered.

Materials

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Compatibility: Only workpieces that can be oven heated can be coated by the electorostatic, the fluidized bed, and the electrostatic fluidized bed application methods. These technologies are, therefore, most suitable for relatively small, metal objects. The flame-spray method allows powder coatings to be applied to other substrates such as wood, rubber, and plastic, and to large or stationary structures.

Safety and Health: Powder and air mixtures, in the correct concentrations, can be a fire hazard when an ignition source is introduced. Inhalation of the powders should be avoided, as this can cause irritation to the lungs and mucous membranes. proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Powder coating eliminates the need for expensive and often toxic solvents, as well as the control equipment, employee exposure, and the disposal requirements and liabilities associated with liquid coating (wet solvent) use. Because the powder is dry when sprayed, any overspray can be readily retrieved and recycled, regardless of the complexity of the system, resulting in shorter cleanup times. In all cases, the dry powder is separated from the air stream by various vacuum and filtering methods and returned to a feed hopper for reuse. Powder efficiency (powder particles reaching the intended surface) approaches 100 percent. Other advantages over conventional spray painting include greater durability; improved corrosion resistance; and elimination of drips, runs, and bubbles.

Disadvantages: Fluidized Bed, Electrostatic Fluidized Bed and Flame Spray are not widely used due to the following disadvantages:

- Low aesthetic value
- Thick high-build films
- High labor and dangerous operation due to the flame if using Flame Spray.

Economic Analysis: The following economic data and basis provided by the Powder Coating Institute, Powder Coating Today, 1987, p 10.

- Assumption:
- The square feet area is painted per year: 1,000,000 sqft

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	Powder System	Conventional Solvent Based System	Waterborne Coating System	High Solids Coating System
Capital Costs	\$120,000	\$150,000	\$110,000	\$110,000
Material Costs	\$27,300	\$34,900	\$35,600	\$24,400
Operating Costs (Utilities, Clean up, Disposal...)	\$38,000	\$56,600	\$56,400	\$44,100
Annual Savings, if using the Powder System:		\$26,200	\$26,700	\$3,200
Payback Period, if using the Powder System:		5 years	5 years	38 years

Approval Authority:

Navy: Contact NAVAIR Code 530 (Ref. R 182002Z) for further approval for use on aircraft and aircraft components. Phone is (703) 692-6025; DSN 222-6025. This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Points of Contact:

Powder Coating Institute
1800 Diagonal Road, Suite 600
Alexandria, VA 22314
(703) 684-1770

Scott Mauro
Naval Facilities Engineering Service Center, Code 423
1100 23rd Avenue
Port Hueneme, CA 93043-4370
Phone: (805) 982-4889, DSN: 551-4889
FAX: (805) 982-4832

Vendors:

The following is a list of powder coating system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Coating Manufacturers:

Cardinal Industrial Finishes
Powder Coating Division
901 Stimson Avenue
City of Industry, CA 91745
Phone: (818) 336-3345, Fax: (818) 336-0410

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

EVTECH

9103 Forsyth Park Drive
Charlotte, NC 28273
Phone: (704) 588-2112, Fax: (704) 588-2280

Farboil Company

8200 Fischer Road
Baltimore, MD 21222
Phone: (410) 477-8200, Fax: (410) 477-8995

Plastic Flamecoat® Systems, Inc.

3400 West Seventh Street
Big Spring, TX 79720
Phone: (800) 753-5263, Fax: (915) 267-1318

Pratt & Lambert Inc.

Powder Coatings Division
40 Sonwil Drive
Cheektowaga, NY 14225
Phone: (716) 683-6831, or Customer Service (800) 777-6831
Fax: (716) 683-6204

Equipment Manufacturers:

Nordson Corp.

555 Jackson Street
Amherst, OH 44001
Phone: (216) 988-9411, Fax: (216) 985-1417

Sames Electrostatic, Inc.

555 Lordship Blvd.
Stratford, CT 06497
(203) 375-1644

Gema

3939 W. 56th Street
Indianapolis, IN 46208
Phone: (317) 298-5001, Fax: (317) 298-5059

Source: Powder Coating Institute, 1987, *Powder Coating Today*, p.10.

Miser, Tosko A., 1991. *Powder Coatings: Chemistry and Technology*, Chapter 6, Powder Coatings Application Techniques.

"Reducing Waste in Railcar Coating Operations," *Graco Equipment and Emissions Update*, June 1994, pp. 8-9.

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UNICOAT PAINT TECHNOLOGY

Revision: 1/96
Process Code: Navy: ID-05-99; Air Force: PA01; Army: PNT
Waste Stream: Epoxy Primer and Polyurethane Topcoat
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds

Overview: The traditional painting system for aircraft consists of an epoxy primer for adhesion and corrosion inhibition, and a polyurethane topcoat for aesthetics, durability, and additional protection against degradation. This two-coat primer and topcoat paint system contains high levels of volatile organic compounds (VOCs) and carcinogenic chromates.

Unicoat, developed by Naval Air Warfare Center (NAWC) Warminster, is a self-priming topcoat for aircraft and other industrial applications that applies directly to metal without a primer. Unicoat, which is formulated lead- and chrome-free, replaces the two-coat system with a blend of organic and inorganic zinc compounds that are nontoxic. Unicoat, like traditional paints, is polyurethane; however, Unicoat is different because corrosion inhibitors and adhesion promoters have been added. Unicoat has been successfully used on both Navy and Air Force aircraft. It has provided equivalent or superior performance to the toxic paints that have been used in the past.

Materials

Compatibility: Like traditional paint and primer application, the surface to be painted needs to be completely clean. To avoid adverse reactions, freshly painted wet surfaces must not be allowed to come into contact with alcohols, amines, water, or acids.

Safety and Health: Unicoat contains high levels of volatile organic compounds and heavy metals. Inhalation of these compounds is the primary concern. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Contains no toxic chromate pigments
- Reduces VOCs and hazardous waste by 50 - 70%
- Paint and primer cost savings
- Lightened paint weight on equipment and aircraft
- Labor savings
- Stripping savings

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Disadvantage: • Unitcoat can be more expensive than regular-type topcoat paint.

Economic Analysis:

- Assumptions:
 - Unicoat: \$130-\$150 per 2-gallon kit.
 - Epoxy Primer: \$67-\$80/gallon
 - Topcoat: \$145-\$208/gallon
 - 1 mil coat: 842 sqft/gallon
 - Aircraft skin area (F-X Fighter Aircraft): 3,100 sqft
 - 3 aircraft are painted per month.
 - Assume paints are used up and no waste is generated.

- | | <u>Unicoat</u> | <u>Primer & Topcoat</u> |
|----------------------------|----------------|-----------------------------|
| • Material Cost/Aircraft | \$300 | \$1,152 |
| • Annual Savings: \$30,672 | | |

Approval Authority:

Navy: Contact NAVAIR Code 530 (Ref. R 182002Z) for further approval authority for use on aircraft and aircraft components. Phone is (703) 692-6025; DSN: 222-6025. This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Points of Contact: Anthony Eng
Phone: (301) 342-8067

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Naval Facilities Engineering Service Center, Code 423
1100 23rd Avenue
Port Hueneme, CA 93043-4370
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FAX: (805) 982-4832

Vendors: The following is a list of Unicoat vendors. This is not meant to be a complete list, as there may be other manufacturers of this type of product.

Deft Inc.
17451 Von Karman
Irvine, CA 92714
Phone: (800) 544-3338, Fax: (714) 474-7269
Attn: Mr. Leon Ewalt

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WATERBORNE PAINT

Revision 1/96
Process Code: Navy: ID-05-00; Air Force: PA01; Army: PNT
Substitute for: Solvent-Based Paints
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Chromium, Cyanides, Lead, and Zinc Compounds

Overview: Waterborne paints have been evaluated as alternatives to solvent-based paints. Conventional solvent-based paints are high in volatile organic compound (VOC) emissions.

Waterborne (or latex) paints are compositions of synthetic resins and pigments kept dispersed in water by surfactants. They also contain small amounts of coalescing solvents. Waterborne paints dry by evaporation of the water. The coalescing solvents allow the particles of resin to fuse together (coalesce) as the water evaporates to form a continuous coating. Waterborne paints must be protected from freezing and applied at a minimum temperature of 50 degrees F/10 degrees C.

Fairchild Air Force Base (AFB) currently uses latex paint (DTM Acrylic Coating by Sherwin Williams Co.) for KC-135 aircraft interiors since health and safety requirements for paint applications are significantly reduced or eliminated when waterborne paints are used in place of solvent-based paints. Only the floors and removable parts are painted with other materials, epoxy paint (floors), and polyurethane (removable parts). Diluted latex paint waste is treated in the Fairchild AFB wastewater treatment plant, and solid latex paint waste is disposed at the AFB's waste-to-energy plant.

Materials

Compatibility: Waterborne paints rust plain steel and sometimes attack aluminum. Application equipment must be constructed of a material such as 316 stainless steel.

Waterborne coating material conducts high voltage electricity much more readily than solvent-based material. As a result, the electrostatics in a waterborne system will only work if all wetted equipment is isolated from potential grounds. Three methods can be used to avoid grounding out the electrostatics in a waterborne system: (1) isolate the entire paint system from the electrical grounds; (2) isolate a small part of the wetted system with a voltage blocking device; and (3) indirectly change the paint particles away from any of the wetted equipment. Each method has its advantages and disadvantages and should be evaluated

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for the specific application. The use of a voltage block at each atomizer is often the most cost-effective method.

Safety and Health: Health and safety issues are reduced significantly by using waterborne paints. However, they do contain coalescing solvents, which can be slight irritants by inhalation. Proper personal protective equipment is recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Waterborne paints are generally easy to apply and clean up. VOC emissions and health and safety requirements for workers are significantly reduced or eliminated when waterborne paints are used as replacements for solvent-based paints. Gloss and color retention may be better with certain waterborne paints than solvent-based paints. Disposal requirements for waterborne paint waste may vary based on local requirements and/or waste quantities. Dried waterborne paint waste may be disposable in landfills as non-hazardous waste.

Disadvantages: Waterborne Paint is not:

- superior resistant to chemicals.
- temperature resistant.
- for emerging services.
- abrasive resistant.

Economic Analysis: Solvent-based paint systems can usually be converted to waterborne paint systems with a limited capital investment. The cost of waterborne paints will vary depending on the quantities used. In general, the price of waterborne paints is comparable to the price of solvent-based paints.

Latex paint: \$10-\$28/gallon

Solvent-based paint: \$18-\$100/gallon

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Technical Sargent Ken Parks
201 N. Bates
Charleston Air Force Base, SC 29404
DSN: 673-4656, Phone: (803) 566-4656

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Staff Sargent Benjamin Lee
92MS/LGMSME
201 West Arnold, Suite 101
Fairchild Air Force Base, WA 99011
DSN: 657-3610, Phone: (509) 247-3610

Vendors: Sherwin Williams
7230 1/2 Woodrow Street
Irmo, SC 29063
Rick Hiller
Phone: (803) 749-0392
Local distributor can also be contacted.

Sikkens
5555 Spalding Dr.
Norcross, GA 30092
Phone: (800) 227-0238 or (404) 662-8464

Source: R. Konieczynski, "Converting to Waterbornes for Less Cost," *Metal Finishing*, January 1995, Vol. 93, No. 1, pp. 20-23.
P. Bankert, "Waterborne Paint Circulation," *Industrial Finishing*, July 1990, Vol. 66, No. 7, pp. 42-43.
"GM Adopts Waterborne Basecoats," *Industrial Finishing*, July 1990, p. 32.
R. Joseph, "Environmental Coating Problems," *Metal Finishing*, May 1994, pp. 44-45.

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AUTOMATIC PAINT GUN WASHER

Revision: 1/96
Process Code: Navy: ID-05-00; Air Force: PA01; Army: PNT
Substitute for: Manual Cleaning of Paint Guns
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds

Overview: The manual cleaning of paint guns can be labor intensive and can generate significant quantities of solvent wastes. Using automatic paint gun washers results in the generation of less paint solvent waste when compared to manual equipment cleaning. Automatic paint gun washers are similar to conventional home dishwashing machines, except the thinners and solvents in the automatic washers are not heated in the process. The paint gun to be cleaned is attached to a nozzle within the automatic paint gun washer, and the machine is sealed. Most automatic paint gun washers can wash two to three paint guns at a time. The exterior of the paint gun is cleaned with atomized paint thinner using a dishwasher action. The interior of the paint gun is cleaned by circulating solvent through the nozzle attachment. Automatic paint gun washers collect used solvent in a reservoir. Impurities in the used solvent are filtered out in the reservoir. The filtered solvent is then ready for reuse instead of being disposed of as hazardous waste. The solvent impurities form a sludge, which is collected and disposed. The typical solvent capacity of the spray gun washer is 3 gallons; it must be changed out every 3 to 8 weeks, depending on usage.

Materials

Compatibility: Chlorinated solvents cannot be used in most automatic paint gun washers.

Safety and Health: Health concerns are dependent on the variety of paint that is used. Inhalation of lead- and zinc chromate-based paints can lead to irritation of the respiratory system. Some lead compounds are carcinogenic. Solvent-based paints can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- 75 to 90 percent cost savings of solvent used to manually wash gun, cup, and mixing vessels.
- Less hazardous waste is generated.

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- Localized handling site for solvent used for paint gun washing.
- Because solvent storage is localized, procurement of standardized solvent(s) are possible for this maintenance action.
- Accurate waste solvent classification for this maintenance action is simplified.
- Fully automatic.
- Pneumatically operated (non-electric).

Disadvantage: Users of automatic paint gun washers have noticed that if they delay washing the paint guns, the cleaning efficiency is reduced, and additional hand cleaning of the equipment is required.

Economic Analysis:

- Assumptions:
 - 18 spray guns were cleaned per week
 - 7 gallons of thinner was required to clean the guns automatically per week
 - 360 gallons of solvent were needed to clean an equal number manually
 - Hazardous waste disposal charge: \$38 per gallon
 - Solvent procurement cost: \$4 per gallon
 - Labor rate: \$45 per hour
 - Minimum time saved if using automatic paint gun washer: 10 min./gun

	<u>Automatic Wash</u>	<u>Manual Wash</u>
• Capital Cost:	\$600	-
• Operational Cost/yr:		
- Labor	\$360	\$7,000
- Electricity	Negligible	-
- Chemicals	\$1,500	\$75,000
- Waste Disposal	\$14,000	\$711,000

- Annual Savings: \$777,000
- Payback Period: immediately

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Barbara Roehm
 Pearl Harbor Naval Shipyard
 Phone: (808) 471-0799

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Vendors:

The following is a list of automatic paint gun washer manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Technical Innovations, Inc.
2105 Austin Ave.
Troy, MI 48083
(810) 528-0232, FAX: (810) 528-9330

Graco Inc.
P.O. Box 1441
Minneapolis, MN 55440
(612) 623-6709, FAX: (612) 623-6777

PAINT STRIPPING USING SODIUM BICARBONATE MEDIUM

Revision: 1/96
Process Code: Navy: ID-01-01/-99; Air Force: ST01; Army: DPT
Substitute for: Solvent Stripping
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds, Phenols, Chloroacetic Acids, Methylene Chloride

Overview: Sodium bicarbonate stripping is used as an alternative to traditional chemical paint stripping. Sodium bicarbonate stripping process can be used with or without water. Sodium bicarbonate stripping process is most frequently used water primarily as the dust suppressant. In this form, compressed air delivers sodium bicarbonate media from a pressure pot to a nozzle, where the media mixes with a stream of water. The soda/water mixture impacts the coated surface and removes old coatings from the substrate. The water used dissipates the heat generated by the abrasive process, reduces the amount of dust in the air, and aids the paint removal by hydraulic action.

Sodium bicarbonate is a soft blast media with a heavier specific gravity and less hardness than most plastic abrasives. Workers do not need to prewash or mask the surface. The dust is not an explosive hazard, nor is sodium bicarbonate toxic in this form. However, the airborne particulate generated from the stripping operation can contain toxic elements from the paint being removed.

The effectiveness of bicarbonate of soda blasting depends on optimizing a number of operating parameters, including nozzle pressure, standoff distance, angle of impingement, medium flow rate, water pressure, and traverse speed. In general, sodium bicarbonate blasting systems remove paint slower than most methods currently used.

Use of sodium bicarbonate in its dry form can create a cloud of dust which will require monitoring and may require containment to meet air standards. Sodium bicarbonate stripping process should be performed in areas where wastewater and/or exhaust particulates can be contained and/or exhaust ventilation system controls are present to remove hazardous airborne metals.

Because of the noise and dust produced (with or without water), a sodium bicarbonate stripping system should only be operated in an isolated area outdoors or indoors in an abrasive blast room. Operators must wear double hearing protection equipment; an air-hood blast helmet with an air-supplied respirator and optional half mask for

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nuisance dust, or a full-faced air purification respirator with HEPA filters; and protective clothing (e.g., rain suits, rubber gloves, and safety-toed rubber boots). (Note: The protective equipment required will be dependent upon the substrate coating.) If Sodium bicarbonate stripping system is operated outdoors, air monitoring of dust (e.g., for metals) will be necessary to ensure that air standards are met.

The waste generated from use of a sodium bicarbonate stripping system in the wet form is a wet slurry consisting of sodium bicarbonate media, water, paint chips, and miscellaneous residues such as dirt and grease. In its dry form, waste generated includes nuisance dust, paint chips, and miscellaneous residues such as dust and grease. Filtered wastewater containing dissolved sodium bicarbonate may be treated at an industrial waste treatment plant. The solid waste may be suitable for a sanitary landfill. Verification of wastewater and solid treatment/disposal is required for each process. Wastewater and bicarbonate residue disposal requirements will depend on the toxicity of the coatings and pigments to be removed. The sodium bicarbonate media cannot be recycled. The paint chip and miscellaneous residue wastes may be considered a hazardous waste.

Currently, sodium bicarbonate stripping is not approved by NAVAIR as an alternative for depainting aircraft. The NAVAIR's primary concern is that at temperatures of 140 to 160 degrees F, sodium bicarbonate may convert to sodium carbonate, which is corrosive. BOSS is being considered for use in degreasing parts where parts can subsequently be rinsed and residual sodium bicarbonate/sodium carbonate removed.

The type of equipment used in this stripping process may have significantly different results (e.g., Accustrip System® vs. Aqua Miser®). Some of the disadvantages of the original process have been eliminated through the use of much lower amounts of sodium bicarbonate with medium pressure water. This application is discussed in greater detail in the Pollution Prevention Opportunity Data Sheet, "High and Medium Pressure Water Processes."

Materials

Compatibility:

In general, material compatibility is not a concern, but it must be specifically evaluated with respect to the item being cleaned. Uninhibited sodium bicarbonate and water residue can corrode substrates; however, current testing indicates that the corrosion potential of inhibited formulations is similar to that of organic solvent strippers. Results from an Air Force test program (Tasking Directive 1- 90) indicated that there was excessive erosion of aluminum cladding materials when sodium bicarbonate and water slurry was used.

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Safety and Health: Health concerns are dependent on the variety of paint that is used. Inhalation of lead- and zinc chromate-based paints can lead to irritation of the respiratory system. Some lead compounds are carcinogenic. Solvent-based paints can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

- Benefits:**
- Significant reduction in amount of hazardous waste generated compared to chemical stripping.
 - Selectively removes individual coating-layers.
 - Prewashing and masking is not needed in most applications.
 - No size limitations for parts being stripped.
 - Wastewater stream is compatible with conventional wastewater plants available to many installations.
 - Blast media is usually less expensive than PMB, wheat starch, and CO₂ pellets.

- Disadvantages:** The specific application must be reviewed on a case-by-case basis and the following limitations considered:
- Removes one layer at a time.
 - Does not remove corrosion.
 - Requires subsequent washing of the item; thus, electrical components cannot be exposed to this stripping process.
 - The substrates to be removed will impact personal protection and waste collection/disposal considerations.

Economic Analysis: Annual operational costs for depainting 228 aircraft wheels with sodium bicarbonate stripping (ACCUSTRIP) versus chemical paint stripping were evaluated at the Lyndon B. Johnson Space Center, Houston, Texas, as shown below.

Accustrip System:	\$20,000
Compressor, trailer mounted:	\$20,000
Materials and installation:	\$125,000
Other significant costs (engineering, contingency, startup):	\$60,000

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	<u>ACCUSTRIP</u>	<u>Chemical Paint Stripping</u>
Labor hours	\$2,180	\$16,150
Waste disposal	\$2,300	\$41,200
Raw Materials	\$2,650	\$1,600

- Annual costs savings: \$51,820.
- Payback Period: 5 years

The Marine Corps tested sodium bicarbonate media in three types of commercial off-the-shelf equipment. The cost of these systems ranged from \$15,000 (Accustrip 16W) to \$40,000 (Aqua Miser E25 and Jet Stripper DP-1). The AquaMiser and Jet Stripper use high/medium-pressure water to remove paint with sodium bicarbonate injected to aid removal effectiveness. The Accustrip can be used dry or water can be added at the nozzle when dust control is required. Accustrip uses high pressure air to propel sodium bicarbonate against the surface, and the sharp edges of the media cut paint away from the base metal.

Approval Authority:

Navy: Approval has not been made by NAVAIR for application on aircraft and aircraft components without pretreatment of aircraft substrate to eliminate all blast media. NAVAIR, (703) 692-6025. This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Points of Contact:

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Albany, Georgia
DSN 317-1126, Phone: (912) 439-5344

Mike Haas
San Antonio Air Logistics Center
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Vendors:

The following is a list of sodium bicarbonate paint removal system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Accustrip System®
Schmidt Manufacturing, Inc.
P.O. Box 37
Fresno, TX 77545
Phone: (800) 231-2085 or (713) 431-1717
Fax: (713) 431-1717

Aqua Miser®
Carolina Equipment and Supply
E. Larry Fulmer
7251 Cross Country Rd.
N. Charleston, SC 29418
Phone: (800) 394-4987 Ext. 20, Fax: (803) 760-3500

JETSTRIPPER
WhiteMetal, Incorporated
6300 Midvale
Houston, TX 77087
Phone: (800) 728-8861

SOBI System
Friess Equipment
2222 Akron-Peninsula Rd.
Akron, OH 44313
Phone: (800) 899-7624, Fax: (216) 923-5833

ARMEX Blast Media
Church and Dwight Specialty Cleaning
469 N. Harrison St.
Princeton, NJ 08540
Phone: (800) 221-0453; FAX: (609) 497-7176

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CARBON DIOXIDE BLASTING OPERATIONS

Revision: 1/96
Process Code: Navy: ID-01-99; Air Force: ST01; Army: DPT
Substitute for: Solvent cleaning and stripping
Applicable EPCRA Targeted Constituents: Acetone, n-Butyl Alcohol, Methyl Ethyl Ketone, Toluene, Xylene, Lead, Chromium, Zinc, Phenols, Chloroacetic Acids, and Methylene Chloride

Overview: Blasting operations are alternative processes to solvent and other chemical stripping and cleaning operations. No toxic or hazardous chemicals are introduced; however, most common blasting media become contaminated by mixing with the material being removed from the blasted surface. Solid carbon dioxide (CO₂) blasting avoids the formation of contaminated media since the CO₂ vaporizes shortly after impact, limiting waste disposal to the residue itself.

Blasting operations can almost always be substituted for solvents in the removal of surface materials, such as paint, dirt, corrosion, carbonaceous residues, etc. In fact, some blasting experts believe that for every paint removal application, a blasting medium/process exists which is superior to any solvent system. This belief is, in a large measure, substantiated by the wide variety of blasting media and processes developed by the industry. Justifiably, blasting has long had one overriding advantage over solvent stripping; namely, time savings. Blasting processes in general are estimated to reduce the time required for paint stripping by over 90%. The other obvious advantage of blasting over solvent stripping is the introduction of inert media which either 1) dissipates, in the case of carbon dioxide; 2) can be recycled; or 3) is disposed without incineration. In contrast, solvents are typically toxic, hazardous, or ozone depleting.

There are two basic types of CO₂ blasting: pellet blasting for heavy cleaning, and snow blasting for precision cleaning.

Pellet Blasting:

Blasting media are normally classified by the particle shape of the medium. Materials with irregular shapes are called angular media and tend to abrade surfaces upon impact, removing the coating or corrosion, as well as some of the substrate. Blasting operations using these media are called "abrasive" blasting. Materials with uniform shapes like steel shot and glass beads are called spherical media. Spherical media effect cleaning and stripping by peening or dimpling a surface upon impact. The impact tends to flake off material; hence, a blasting operation using a spherical medium is termed "impact" blasting.

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CO₂ pellets, being a uniform shape blasting medium, fall somewhere between the two main categories of pellet blasting. Although the effectiveness of CO₂ pellet blasting is similar to abrasive blasting, it does not affect the substrate; thus, it is technically not an abrasive operation. It can be used for cleaning, degreasing, some de-painting applications, surface preparation, and de-flashing (flashing is the excess material formed on the edges of molded parts).

The process begins with liquid CO₂ stored under pressure (~850 psig). The liquid CO₂ is fed to a pelletizer, which converts the liquid into solid CO₂ snow (dry ice flakes) and then compresses the dry ice flakes into pellets, typically at about -110 degrees F. The pellets are metered into a compressed air stream and applied to a surface by manual or automated cleaning equipment with specially designed blasting nozzles. The CO₂ pellets are projected onto the target surface at high speed. As the dry ice pellets strike the surface, they induce an extreme difference in temperature (thermal shock) between the coating or contaminant and the underlying substrate, weakening the chemical and physical bonds between the surface materials and the substrate. Immediately after impact, the pellets begin to sublime (vaporize directly from the solid phase to a gas), releasing CO₂ gas at a very high velocity along the surface to be cleaned. The high velocity is due to the extreme density difference between the gas and solid phases. This kinetic energy dislodges the contaminants (coating systems, contaminants, flash, etc.), resulting in a clean surface. Variables which allow process optimization include the following: pellet density, mass flow, pellet velocity, and propellant stream temperature.

Waste cleanup and disposal are minimized because only the coating or contaminant residue remains after blasting. No liquid wastes must be disposed, nor toxic air emissions controlled (the CO₂ shears surface materials such as paint into particles too large to remain airborne). Moving and handling operations are minimal compared most solvent cleaning operations.

CO₂ pellet blasting is effective in removing some paints, sealants, carbon and corrosion deposits, grease, oil, and adhesives, as well as solder and flux from printed circuit board assemblies. Furthermore, since CO₂ pellet blasting is not an abrading operation, it is good for components with tight tolerances. It also provides excellent surface preparation prior to application of coatings or adhesive and is suitable for most metals and some composite materials. However, thin materials may be adversely affected. Blasting efficiency is approximately equal to that of other blasting operations and can approach 1 ft²/minute after

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optimization. CO₂ blasting can be done at various velocities: subsonic, sonic, and even supersonic. Therefore, equipment noise levels are high (between 95 and 130 dB). This operation always requires hearing protection.

Snow Blasting:

In contrast to CO₂ pellet blasting, CO₂ snow blasting is a low impact process. Its applications are primarily in the precision cleaning domain. A typical precision cleaning operation must clean small contaminant particles that attach to surfaces and/or surface layers of adsorbed moisture or soil due to electrostatic attraction. These particles are so small that they have a large fraction of their surface area attached to the surface layers. To break the adhesive forces between the small contaminant particles and the component surface with traditional solvent flushing or gas blowing (e.g., compressed nitrogen) methods cleaning fluid velocity has to increase; otherwise, another method of cleaning has to be used. Media blasting is a good choice for solving this problem, since the media striking the contaminant particles can transfer their kinetic energy to the contaminant particles, thus breaking the adhesive forces and dislodging the particles from the substrate surface. CO₂ snow is most effective in accomplishing this act. It is often used as a final cleaning process for sub-micron particulate and light soils removal.

Like carbon dioxide pellets, CO₂ snow is also generated from liquid CO₂, but not as a separate process; rather, directly in the discharge nozzle of the blasting device. The liquid CO₂ is partially vaporized as it passes through the nozzle, while the rest of the stream solidifies as pressure is reduced. The “snow,” fine solid particles, is propelled by the fraction of CO₂ that vaporizes. No compressed air or other inert gas is needed to propel the snow. Therefore, CO₂ snow blasting eliminates the pelletizing and entraining steps, significantly reducing both the equipment and its operating costs, compared to CO₂ pellet blasting operations.

Most media cannot be used in precision cleaning because they are too aggressive or they contaminate the component with media residue. CO₂ snow, however, is ideal for this application, since it is relatively gentle in application, leaves no media residue, and is highly purified, introducing no new contaminants. Small flakes of dry ice transfer their kinetic energy to sub-micron particulate contaminants, then sublime, lifting the particulate matter from the substrate surface as the adhesive bonds are broken.

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Thin layers of organic contaminants can be removed from components by another mechanism. Because CO₂ can dissolve thin or light layers of organic soils such as fingerprints, oils, or fluxes, contaminants not removed by the mechanism of kinetic energy transfer can instead be dissolved and carried away by the flow of gas and snow.

CO₂ snow blasting is often done in a clean room or cabinet purged with nitrogen to provide a dry atmosphere, minimizing moisture buildup on the component.

Materials

Compatibility:

Carbon dioxide as a completely oxidized compound is a non-reactive gas, and thus compatible with most metals and non-metals.

Dry ice processes are cold and can cause thermal fracture of a component. In addition, prolonged use in one spot on a component will cause condensation and ice buildup. However, this is rarely problematic, because CO₂ blasting is a fast-acting, non-stationary process. Particulate and organic contamination is either quickly removed or will not be removed by continued blasting at a single point. Therefore, the component temperature does not change much, since contact time is short. Nevertheless, should component temperature drop below the dew point of the surrounding atmosphere, moisture will accumulate on the component. This problem can be mitigated by heating the component in some manner so that its temperature remains above the surrounding atmosphere's dew point after blasting. If components cannot take heat, then blasting can be done in an enclosed space purged with a dry gas to lower or eliminate the dew point problem.

Movement of solid particles at high velocity, such as those used in blasting operations, can generate a static charge. Static buildup with CO₂ blasting is not normally a problem, even for electronic equipment, because carbon dioxide is non-conductive and the charge generally dissipates gradually rather than instantaneously. Nonetheless, carbon dioxide blasting should not be done in flammable or explosive atmospheres.

Safety and Health:

Carbon dioxide does not support combustion, is non-toxic, but it is an asphyxiant. CO₂ will displace air since its density is greater than that of air, causing it to accumulate at the lowest level of enclosed spaces. When blasting with CO₂ pellets, additional ventilation should be provided for enclosed spaces.

Personal protective equipment is required when blasting.

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High pressure gases should be handled with great care. Always chain or secure high pressure cylinders to a stationary support such as a column after moving, but before using.

Consult your local Industrial Health specialist, your local health and safety personnel, and the MSDS for carbon dioxide prior to implementing either of these processes.

Benefits:

Use of CO₂ blasting can reduce the amount of toxic and dangerous chemicals going into the environment compared to solvent/chemical stripping and de-painting operations. Blasting operations are also fast compared to other cleaning/stripping processes, allowing quick turnaround of process equipment. One of the most important advantages of CO₂ cleaning is the fact that the blasting medium vaporizes, leaving only contaminant behind for disposal, thereby greatly reducing disposal volumes.

Although carbon dioxide is a global warming gas, CO₂ used for pellet or snow blasting is normally recovered from other industrial processes such as fermentation or natural gas processing. Therefore, net carbon dioxide emissions into the atmosphere do not increase.

Disadvantages:

Some blasting media leave behind a residue that can contaminate the component or corrode the blasted surface. This is not the case for CO₂ blasting, since it quickly vaporizes, leaving no residue on the part. Another disadvantage of blasting is that it is not always a one-pass operation; an effective blasting operation usually requires multiple passes to achieve the desired effect. A fixed position blasting operation may damage the object's surface. Despite the few disadvantages, CO₂ blasting has become an effective alternative to solvents or other blasting media as a highly desirable cleaning process.

Economic Analysis: CO₂ Pellet Blasting: units come in several different configurations.

- 1) The blasting unit alone can be:
 - Purchased- \$25K to \$50, or
 - Rented- \$1,500 to \$2,500 per month.
- 2) Pellets can be:
 - Made by a stand-alone pelletizer that can be purchased - \$50K to \$130K (cost to make pellets from delivered liquid carbon dioxide is about \$0.10-0.15/lb.), or
 - Purchased directly from a manufacturer for between \$0.10/lb. and \$0.50/lb. delivered, depending on the purity and the distance from the manufacturer (pelletizer purchase is reported to be economical only if blasting is done more than 40 hours/week).

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- 3) Units that combine pelletizing and blasting are also available, but generally are not economical unless the blasting operation is 24 hours/day, 7 days/week
- 4) Pellet blasting jobs can be done on a contract basis for \$200 to \$300 per hour including labor, pellets, and equipment, but not including travel time or travel expenses.

CO₂ Snow Blasting: Units are much lower in cost and operation compared to pellet blasting, and again there are several different configurations to choose from:

- 1) All manual units are about \$2,000.
- 2) Semi-automated units (can also be used in assembly applications) are \$3,000 to \$5,000.
- 3) For highest quality precision cleaning with substantial volume requirement, CO₂ purifiers are also available. Carbon dioxide purity can be an issue, since contaminants can be added to components from dirty CO₂. Units can purify commercial grade liquid CO₂ (at \$0.10-\$0.30/lb.), saving anywhere from \$2 to \$10/lb. of CO₂ for high purity purchased carbon dioxide. Purifiers start at about \$5,000.

Some of the following data are obtained from U.S. Air Force for paint stripping of FX Fighter Aircraft using CO₂ blasting.

- Assumptions:

- Aircraft skin area: 3,098.88 sqft
- Paint removal and cleaning area: 2,410.24 sqft
- Paint removal and cleaning time: 211 hrs
- Paint removal rate average: 11.4058 sqft/hr
- Dry paint waste residue: 26.46 lbs
- Chemical waste residue: 0.0 lb
- Water waste residue: 0.0 lb
- Normal wet chemical waste residue: 1,372.80 gallons
- Normal contaminated water waste residue: 308,700 gallons
- Total CO₂ usage (including training): 101,430 lbs
- Labor rate: \$60/hr
- CO₂ cost: \$.50/lb
- Man-Hours for chemical stripping: 1,500 hrs
- Paint and solvent sludge disposal cost: \$2/gallon
- Paint disposal cost: \$2/lb
- Water treatment/disposal cost: \$8.24/1,000 gal
- Chemical procurement cost: \$11/gallon
- One aircraft is de-painted per month.

	<u>CO₂ Stripping</u>	<u>Chemical Stripping</u>
• Capital Cost	\$50,000	-
• Operation Cost/Aircraft:		

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Materials	\$50,000	\$15,100
Labor	\$12,660	\$90,000
Waste Disposal	\$53	\$5,290

- Annual Savings: \$563,544
- Payback Period: 1.2 months

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Mr. Alan Dailey
Mechanical Engineer
SM-ALC/TIELE

McClelland AFB, California
DSN 633-6151, Fax 633-2869
(916) 643-6151, Fax (916) 643-2869

For information on design, procurement, and use of a mobile CO₂ pellet blasting system primarily for cleaning and degreasing operations.

Mr. Mike Patry
Production Engineer
OC-ALC/LPPEE
Tinker AFB, OK

DSN 336-5185, Fax 336-2501
(405) 736-5185, Fax (405) 736-2501

For information on procurement and use of carbon dioxide pellet blasting systems for cleaning and some de-painting operations.

The Joint Depot Maintenance Analysis Group, Technology Assessment Division, is in the process of preparing a final report on CO₂ Blasting. This report is expected to be available in June 1995; phone (513) 296-8296.

Vendors:

Alpheus Cleaning Technologies
9119 Milliken Ave.
Rancho Cucamonga, CA 91730
(909) 944-0055

Fax (909) 980-5696

Mr. Howard Bartley, Sales Engineer

Manufacturer of carbon dioxide pelletizers and blasting equipment.

Cold Jet Inc.

455 Wards Corner Road, Suite 100

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Loveland, OH 45140
(800) 337-9423, (513) 831-3211
Fax (513) 831-1209
Manufacturer of carbon dioxide pelletizing and blasting equipment.
Mr. Michael A. Henderson

Va-Tran Systems, Inc.
677 Anita St., Suite A
Chula Vista, CA 91911-4661
(619) 423-4555
Fax (619) 423-4604
Manufacturer of the SNO-GUN™ carbon dioxide precision cleaning system.
Mr. Jim Sloan
Model SG-1 is an all manual operated unit ready to hook up to a liquid CO₂ cylinder. Model SG-PN is a semi-automatic unit with a 24V DC actuated solenoid valve to control bursts of CO₂ snow. Custom units can also be built to order. For high purity precision cleaning needs, Va-Tran Systems sells a bench-top CO₂ purification system using 110V AC powered mechanical refrigeration unit (refrigerant is HCFC-22) and fractional distillation to purify technical grade CO₂ to 99.9999% purity, model SGP-50C. Company also builds custom designed purifiers for larger needs.

Source(s): EPA SAGE 2.0 "Solvent Alternative Guide."
Cold Jet® product literature and video.
Va-Tran Systems, Inc. product literature.
Hill, E. A., "Carbon Dioxide Snow Examination and Experimentation," *Precision Cleaning*, p. 36-39, February 1994.
Sloan, J., "Dry Ice Snow Surface Cleaning of Electronics, Optics and Metal Parts," *MICROCONTAMINATION 93 Conference Proceedings*, p. 671-676, 1993.

FLUIDIZED BED PAINT STRIPPER

Revision: 1/96
Process Code: Navy: ID-03-99; Air Force: ST01; Army: DPT
Substitute for: Chemical Paint Stripping and Degreasing
Applicable EPCRA Targeted Constituents: Cadmium, Chromium, Lead, Zinc

Overview: The fluidized bed paint removal process has been evaluated as an alternative method to the chemical paint stripping and degreasing of metal parts. The fluidized bed paint stripper (FBPS) can be used for forged steel, but not aluminum or aluminum alloys. It is a potential replacement to caustic stripping of non-aluminum and non-heat-sensitive materials. FBPS is not a potential replacement for solvent stripping/degreasing of aluminum alloy materials. Field demonstrations of the FBPS were performed by USATHAMA at two Army Depots, Letterkenny and Red River. The findings and conclusions of these demonstration projects noted specific limitations of the fluidized bed paint removal process.

The FBPS process removes paint or other organic coatings by heating the part to an elevated temperature above 650 degrees F to cause pyrolysis and decomposition of the organic portion of the paint. A granular material, aluminum oxide (alumina) in most cases, is used as a heat transfer medium. Air passing through the bed keeps the media fluidized. Parts to be cleaned are lowered into the fluidized bed, which quickly heats the part and its surface coatings (paint, grease, oil etc.) to a temperature at which organic components of surface contamination and finishes pyrolyze into carbon oxides and other products of combustion. The thermal decomposition of paint produces gases and leaves some carbon-inorganic char on the part. Much of the char may be removed in the fluidized bed, but most parts require further cleaning before they can be repainted. The emissions from the process are combusted in an afterburner.

The FBPS typically consists of the following four components: 1) fluidized-bed furnace or retort, 2) fluidized-bed cooling system; 3) off-gas afterburner, and 4) low energy shot-blast unit. The fluidized-bed furnace or hot bed is where pyrolysis of the coatings takes place. The fluidized-bed cooling system or cold bed is used to cool the parts after the organics have been pyrolyzed. Carbon monoxide and unburned hydrocarbons are generated during pyrolysis. These volatile organic constituents (VOCs) are combustible and are burned in the afterburner. The shot-blast unit is used to remove the inorganic coatings and char to prepare the parts for repainting.

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Materials

Compatibility: The FBPS process is not suitable for use with aluminum and aluminum alloy parts because these materials lose essentially all of their hardness or temper when exposed to the 700 to 800 degree F temperatures of the FBPS process.

Safety and Health: Inhalation of lead and zinc chromate paints can lead to irritation of the respiratory tract. Some lead compounds are carcinogenic. Solvent-based paints can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment is, therefore, recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Fluidized bed paint stripping leaves practically no waste residue, thus eliminating significant waste sludge disposal costs as well as avoiding the future liability associated with the hazardous components of the paint sludge.
- Fluidized bed paint stripping system uses an inert medium to clean parts of any shape, size or geometry and coated with any type of paint. The rapid changes in coating technology do not affect the performance of the system.
- Fluidized bed paint stripping provides cleaning to the bare metal.

Disadvantages: The two demonstrations of FBPS performed by USATHAMA noted the following limitations:

- FBPS is not a suitable replacement for chlorinated solvent stripping systems that are used to remove paint from aluminum and aluminum alloy parts. The aluminum and aluminum alloy parts lost essentially all of their hardness or temper when exposed to the 700 to 800 degrees F temperatures of the FBPS process for the 1 to 2 hour residence time required to pyrolyze paint.
- FBPS can be used to remove paint from non-aluminum and non-heat sensitive parts, but the cost is an order of magnitude greater to operate than one alternative, the caustic stripping process.
- As the FBPS process removes paints, coatings, or platings containing toxic metals (e.g., lead, chromium, cadmium), the fluidized bed media would be regulated as a RCRA characteristic hazardous waste because of toxicity.

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- The FBPS process is not suitable for parts with crevices, channels, or cavities that would retain FBPS media and be difficult to clean afterward (e.g., engine blocks).
- The FBPS process has little or no effect on corrosion removal.
- The FBPS generates four waste streams: (1) air exhaust from the afterburner and scrubber systems, (2) water discharge from the scrubber system, (3) dust collected in the cyclone separator on the ventilation system between the fluidized bed and the afterburner, and (4) fluidized bed media. The environmental emissions were monitored and evaluated over the demonstrated test periods. These monitoring results serve only as indicators of waste stream characteristics for the FBPS process. Quantities of particulates and metals in the air exhaust (stack gases) were determined during these demonstrations. The concentrations of particulates were below state (Texas and Pennsylvania) and federal standards/guidelines. Data from both demonstrations indicated that the combustion of hydrocarbons was complete (no detectable hydrocarbons were found). Results from the Letterkenny demonstration indicated that carbon dioxide was formed from the afterburner combustion. The liquid effluent from both of the demonstration projects was acceptable for treatment at the industrial wastewater treatment plant. The fluidized-bed media and cyclone separator dust were contaminated with metals that could make it a RCRA-characteristic hazardous waste.
- The amount of waste generated by the FBPS system would be highly dependent upon the use of capturing and recycling systems for media dragout and dusts. For one of the USATHAMA demonstrations (Letterkenny Army Depot), the quantity of wastes generated by the FBPS process exceeded those wastes generated by the caustic stripping system. For the second USATHAMA demonstration (Red River Army Depot), the volume of waste generated by the FBPS system was less than that generated by the caustic stripping system, because media dragout and dusts were captured and recycled.
- The FBPS workers and any workers in the buildings containing the system may be subject to Occupational Safety and Health Act requirements for employees exposed to lead under 29 CFR 1910.1025. This is based on the likelihood that the FBPS would be used to remove paints, coatings, or platings containing lead.

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Economic Analysis: The following cost benefit analysis is reported in Technical Report No.TR-FBS-86-01 dated January 16, 1986 by Procedyne Corporation.

- Assumptions:
 - 400 lbs cured paint per load for skids
 - 300 lbs uncured paint per load for grates
 - one load per hour
 - 10 percent of the paint is converted to dry ash (non-hazardous waste): 160,000 lb/yr
 - Disposal cost of sludge: \$2/lb
 - Operator (one per shift): \$15/hr (figure supplied by General Motors, Arlington, Texas)
 - Amount of sludge generated from skids: 4.8×10^6 lb/yr
 - Amount of sludge generated from grates: 1.2×10^6 lb/yr
 - Operating cost is based on using high pressure water for skids and chemical cleaning for grates.
 - The yearly cost is based on the operation of 2 shift/day, 5 days/week, 50 weeks/yr.

	<u>FBPS</u>	<u>Water Blast plus</u>
<u>Chemical Cleaning</u>		
• Capital Cost:	\$800,000	\$400,000
• Operating Cost:		
- Utilities:	\$257,200	\$ 93,600
- Labor (1 man/shift):	\$ 62,400	\$ 62,400
- Shot & Fluid Bed Media	\$ 6,500	-
- Water (200 GPM)	-	\$ 38,400
- Chemical & Supplies	-	\$100,000
- Maintenance Labor & Parts	\$ 7,500	\$250,000
- Disposal Cost	\$ 800	\$12,000,000

- Annual Savings: \$12,210,000
- Payback Period: immediately

Approval Authority:

Navy: Approval is controlled locally should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Ed Hanna
 SDSRR-ME
 Red River Army Depot
 Texarkana, Texas
 DSN: 829-3380, Commercial: (903) 334-3380, Fax: (903) 334-3650

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Dennis Reed
Attn SDSLE-MME
Letterkenny Army Depot
Chambersburg, PA 17201
Commercial: (717) 261-9427

Vendors: The following is a list of fluidized bed paint stripping system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Karen Bickford
Procedyne Corporation
11 Industrial Drive
New Brunswick, NJ 08901
(908) 249-8347

Luc Cyssens
Segers Dinamec
351 Thorton Road
Lithia Springs, GA 30057
(404) 739-4205

Source: USATHAMA Reports: (1) *Final Report: Engineering Test Report Paint Waste Reduction Fluidized Bed Process Demonstration at Letterkenny Army Depot*, Chambersburg, Pennsylvania (July 1991). Contract No. DAAA15-88-D-0001, Task Order 0007, and (2) *Final Report: Evaluation of a Fluidized - Bed Paint Stripper Red River Army Depot*, Texarkana, Texas (April 1992). Contract No. DAAA 1S-88-D-001, Task Order 0005. Point of Contact (E. Hanna).

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HIGH AND MEDIUM PRESSURE WATER PAINT STRIPPING PROCESSES

Revision 1/96
Process Code: Navy: ID-01-01; Air Force: ST01; Army: DPT
Substitute for: Chemical Paint Stripping Wastes
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Methylene Chloride, Chromium, Zinc Compounds, Phenols, Chloroacetic Acids, and Cyanides

Overview: High and medium pressure water systems blast surfaces with low-volume water streams at pressures ranging from 10,000 to 15,000 psi (medium pressure operations) to 25,000 to 55,000 psi (high pressure operations). The medium pressure systems may be augmented. For example, sodium bicarbonate may be added to the water stream, or environmentally compliant chemicals may be applied to painted surfaces prior to water blasting. High pressure systems typically use pure water streams. With both medium and high pressure water systems, specialized nozzles can be used to achieve effects ranging from a relatively gentle, layer-by-layer removal of organic paints to removal of metal flamespray and other tough, tightly adherent coatings. Water recycling systems can be used with both medium and high pressure water processes.

Materials

Compatibility: No material compatibility problems have been documented for use of high and medium pressure water processes to depaint metallic surfaces. The use of specific chemicals to augment medium pressure water processes must be evaluated on a case-by-case basis.

Safety and Health: Proper design, operation, and maintenance of the equipment is required for its safe use.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Significant reduction in amount of hazardous waste generated, compared to chemical stripping.
- Selectively removes individual coating-layers.
- Prewashing and masking is not needed in most applications.
- No size limitations for parts being stripped.
- Wastewater stream is compatible with conventional industrial wastewater plants available to many installations.

Disadvantages:

- Consumes more time and labor.

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Economic Analysis: The capital cost for high and medium pressure water processes will vary considerably, depending upon the process and its application. Capital costs for medium pressure systems are \$40,000 to \$70,000 and capital costs for high pressure systems range from \$850,000 to \$1,500,000.

The following cost elements and estimates identified in this comparison are for the stripping of one aircraft T-45 at NAS Kingsville facility by using high pressure water system.

- Assumptions:
 - 3 aircraft are de-painted per month.
 - External paint area: 937.8 sqft
 - Labor rate: \$60/hr

	<u>High Pressure Water Process</u>	<u>Chemical Process</u>
• Capital Cost:		
- System Hardware	\$1,400,000	-
- Tele-Robotic Manipulator (\$900,000)		
• For one aircraft:		
- Strip Rate (ft ² /min)	2.00	0.22
- Flow Time (hrs)	11.3	93.8
- Strip Hours	7.8	70.3
- Material Cost	\$985	\$2,212
- Energy Cost	\$454	-
- Man-Hours	27.6	375.1
- Labor Cost	\$1,657	\$22,507
- Waste Disposal Cost	\$30	\$6,369
- System Maintenance Cost	\$311	-

- Annual Savings: \$995,400
- Payback Period: 1.5 years (without Tele-Robotic Manipulator)

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

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 SN-M-ALC/TIELA
 4920 46th Street
 McClellan Air Force Base, CA 95652-1346
 DSN: 633-5476, Phone: (916) 643-5476, Fax: (916) 643-2869
 (Medium Pressure Blasting)

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Randel Bowen
3001 Staff Drive, Suite 2Y43
Tinker Air Force Base, OK 73145
Phone: (405) 736-5980
(Medium and High Pressure Blasting)

Vendors: The following is a list of high and medium pressure water system vendors. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Aqua Miser®
Carolina Equipment and Supply
E. Larry Fulmer
7251 Cross Country Rd.
N. Charleston, SC 29418
Phone (800) 394-4987, Ext. 20 or (803) 760-3000, Fax: (803) 760-3500
(Medium pressure water systems)

Water Jet Systems, Inc.
Mike Brown
6000 Technology Drive
Huntsville, AL 35085-1955
Phone: (205) 721-2770

PLASTIC MEDIA BLASTING (PMB) PAINT STRIPPING

Revision: 1/96
Process Code: Navy: ID-01-99; Air Force: ST01; Army: DPT
Substitute for: Chemical Paint Stripping/Sand Blasting
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds, Phenols, Chloroacetic Acids, and Methylene Chloride

Overview: Plastic Media Blasting (PMB) is a dry abrasive blasting process designed to replace chemical paint stripping operations and conventional sand blasting. Chemical paint stripping is primarily used on aircraft by applying chemical gels to the painted surfaces or by dipping the component into a tank of unquelled stripper. The paint and solvent mixture are scraped and washed off with water. The process generates large quantities of paint/solvent sludges which may contain chromium, other toxic metals, and toxic organic substances (e.g., phenols, chloroacetic acids, and methylene chloride) from the stripping solvents.

Conventional industrial sand blasting uses silica sand suspended in a high pressure air stream to remove paint from surfaces. Fugitive dust composed of both paint and sand particles is created and requires management during the abrasive process. The used silica sand is not typically recycled; the waste stream mixture of sand and paint chips is disposed as hazardous waste depending on the paint constituents.

PMB is performed in a ventilated enclosure such as a small cabinet (glove box), a walk-in booth, a large room, or airplane hanger. PMB is similar to conventional sand blasting except that soft, angular plastic particles are used as the blasting medium. The PMB process propels the plastic media at a much lower pressure (less than 40 psi) than conventional blasting. PMB is well suited for stripping paints, since the low pressure and relatively soft plastic medium have minimal effect on the surfaces under the paint.

After blasting, the media is passed through a reclamation system that consists of a cyclone centrifuge, a dual adjustable air wash, multiple vibrating classifier screen decks, and a magnetic separator. In addition, some manufacturers provide dense particle separators as a reclamation system. The denser particles, such as paint chips, are separated from the reusable blast media, and the reusable material is returned to the blast pot. Typically, media can be recycled ten to twelve times before it becomes too small to effectively remove paint. Waste material consists of blasting media, floor particles, and paint chips. Plastic waste may be

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classified as RCRA hazardous waste because of the presence of metal contaminants. Disposal options include solidification and landfill disposal of the plastic dust and paint chips, incineration of the waste, or use of the waste as a fuel additive in authorized cement kilns. An alternative solution to handling a potential hazardous waste is to locate a vendor that would “lease” the blast media to the base and then recycle the media to recapture the metals.

Plastic media are manufactured in a variety of types, sizes, and harnesses. A military specification (MIL-P-85891) has been developed for plastic media. The specification provides general information on the types and characteristics of plastic media.

Operators must wear continuous flow airline respirators in accordance with OSHA with OSHA 29 CFR 1910.94 when blasting operations are in progress.

PMB is being used at Puget Sound, Charleston, and Portsmouth Naval Shipyards; Naval Aviation Depots (NADEPs) Norfolk and Cherry Point; and Naval Surface Warfare Center (NSWC) Indian Head, as well as other Navy activities and throughout the Air Force. Plastic media glove boxes and enclosed blasting booths have been installed at aircraft maintenance activities to remove paint from support equipment and components. A blast media lease and recycle program is in place at NADEP Cherry Point. A more detailed list of organizations within the DoD depot maintenance community that have implemented PMP operations is provided in Appendix III of *Joint Paint Removal Study; Final Report Plastic Media Blast*, Joint Depot Maintenance Analysis Group, Technology Assessment Division, June 1994.

Materials

Compatibility:

Storage and handling of plastic media and blast waste associated with this process pose no compatibility problems. Prior to using plastic media for depainting operations, personnel should check any applicable military specifications and operations manuals for the systems. Plastic media cannot be used with a system designed for other types of media. Some military specifications do not allow PMB for depainting certain types of materials (i.e., fiberglass, certain composites, honeycomb sandwich structures, and some applications with thin-skinned aircraft components). In certain cases, PMB can inhibit crack detection on some of the softer alloys used for aircraft components (i.e., magnesium).

Safety and Health:

As with any blasting operations, airborne dust is a major safety and health concern. Proper precautions should be taken to ensure inhalation of dust/particulate matter is avoided. Additional protective measures

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should be taken when stripping lead chromate- or zinc chromate-based paints, as these compounds may be hazardous. Inhalation of lead and zinc compounds can irritate the respiratory tract, and some compounds are known to be carcinogenic. Inhalation of paint solvents can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: There is approximately a 50 percent reduction in hazardous chemical paint stripper waste. In addition, PMB benefits the environment because the media can be recycled for use a number of times. Technologies are being developed which recycle the media on site and further reduce the amount of hazardous waste generated.

Disadvantages: Since the media used in this abrasive blasting process is generally not compatible with existing equipment that is designed for blasting with sand or chemical paint stripping, a capital equipment investment is required. Incompatibilities between media are due to the differing cone angles in the blast pots. Wastewater disposal costs (typical in chemical paint stripping operations) are virtually eliminated with PMB; however, the solids generated from this process have to be disposed. Actual solids disposal costs can vary greatly depending on the quantity, proximity, and disposal facility, and also any state and local fees. Disposal costs also depend upon the material removed from the aircraft; materials determined to be hazardous will have significantly greater disposal costs than nonhazardous materials. This problem can be solved by locating a vendor that leases the media. The vendor supplies the media to the user and collects the spent media and blast waste. Therefore, the user does not spend time and resources disposing of the potentially hazardous waste.

Economic Analysis: The following information on investment costs and costs/payback for PMB systems at Hill AFB, Utah, was provided in *Joint Paint Removal Study; Final Report; Plastic Media Blast*, Joint Depot Maintenance Analysis Group, Technology Assessment Division, June 1994.

In 1987, Hill AFB gathered data during the stripping of F-4 aircraft using chemical stripping and PMB.

- Labor rate: \$45.00/hr.
- Work Load = 150 aircraft/yr

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- Chemical Procurement Cost: \$11.40/gallon
- Water Treatment/Disposal: \$8.24/1000 gallons
- Plastic Media Procurement Cost: \$1.76/lb
- Paint and Solvent Waste Disposal: \$200/ton
- Spent Media and Blast Waste Disposal: \$260/ton
- Water: \$0.43/1000 gallons

	<u>PMB</u>	<u>Chemical Stripping</u>
• Capital Cost	\$1,400,000	-
• Operational Cost:		
- Labor	\$8,235	\$16,380
- Chemical	-	\$5,335
- Plastic Media	\$2,640	-
- Water Treatment/Disposal	-	\$1,648
- Electricity	\$173	\$333
- HVAC	\$47	\$1,347
- Hazardous Waste Disposal	\$221	\$102
- Water	-	\$86
- Non-PMB Cost	\$667	-
(Parts can not be done by using PMB)		
- Maintenance Cost	\$1,333	\$667

- Annual Savings: \$1,887,300
- Payback Period: 9 months

Approval Authority:

Navy: PMB is not authorized for use on aluminum and magnesium components that require a fluorescent penetrant inspection. NAVAIR has authorized PMB use on metal substrates under specific process control parameters at depot activities. NAVAIR has not authorized PMB for repainting composites, other non-metal substrates, or honeycomb sandwich structures. This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Points of Contact:

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 2531 Jefferson Davis Highway
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Don Hendrix
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Naval Aviation Depot
Naval Air Station Jacksonville
Jacksonville, FL 32212-0016
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Calvin Brown
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Naval Aviation Depot
1126 Pocohantas Street
Norfolk, VA 23511-5899
Phone: (804) 444-8898, DSN: 445-8898

Dave Frederick
Ogden Air Logistics Center
OO-ALC/TIELM
5851 F Ave
Hill AFB, UT 84056-5713
Phone: (801) 775-2992

James Whitfield
Naval Aviation Depot
Code 34520
Marine Corps Air Station
Cherry Point, NC 28533-5030
Phone: (919) 466-7342

Darren Lutovsky
Puget Sound Naval Shipyard
Code 248.315
Bremerton, WA 98314-5000
Phone: (206) 476-6053

Vendors:

The following is a list of PMB manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

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BSMI
P.O. Box 322
Seahurst, WA 98062
Phone: (206) 433-6947

Pauli & Griffin
907 Cotting Lane
Vacaville, CA 95688
Phone: (800) 666-1115

Schlick-America Inc.
P.O. Box 374
Randallstown, MD 21133
Phone: (410) 655-0770

Leasing Services:

Composition Materials
1375 Kings Highway East
Fairfield, CT 06430
Phone: (800) 262-7763

L.S. Solutions, Incorporated
P.O. Box 309
Deer Park, TX 77536
(713) 478-6522

PPI Industries
2860 Cordelia Road, Suite 120
Fairfield, CA 94585
(707) 421-8818

Composite Leasing Corporation
P.O. Box 102
Minocqua, WI 54548
Mr. Bill Stromdahl
Phone: (715) 358-2625, Fax: (715) 358-3100

Sources: Pro-Act Technical Inquiry 4396

Vendors

Joint Paint Removal Study; Final Report; Plastic Media Blast, Joint Depot Maintenance Analysis Group, Technology Assessment Division, Dayton, Ohio; June 1994; (513) 296-8296.

DEGREASING AND PAINT STRIPPING USING SPONGE BLASTING

Revision: 1/96
Process Code: Navy: ID-01-03; Air Force: ST01; Army: DPT
Substitute for: Sand Blasting and Chemical Paint Stripping
Applicable EPCRA Targeted Constituents: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds, Methylene Chloride, Phenols, and Chloracetic Acids

Overview: Sponge blasting systems are an abrasive blasting process using grit-impregnated foam. The sponge blasting system incorporates various grades of water-based urethane-foam cleaning media that are ground into fine particles used to clean and prepare surfaces. There are two basic types of foam cleaning media produced by Sponge-Jet™ Incorporated. The non-aggressive media grades are used to clean delicate substrates. The aggressive media grades are used to remove surface contaminants, paints, protective coatings, and rust. In addition, the aggressive grades can be used to roughen concrete and metallic surfaces, if desired.

The foam cleaning media is absorptive and can be used either dry or wetted with various cleaning agents and surfactants to capture, absorb, and remove a variety of surface contaminants such as oils, greases, lead compounds, chemicals, and radionuclides. The capability of using the foam cleaning media wetted also provides for dust control without excess damping of the surface being cleaned. The equipment consists of three transportable modules, which include the feed unit, the classifier unit, and the wash unit.

The feed unit is pneumatically powered for propelling the foam cleaning media. The unit is portable and produced in several sizes (depending on capacity required). A hopper, mounted at the top of the unit, holds the foam media. The media is fed into a metering chamber that mixes the foam cleaning media with compressed air. By varying the feed unit air pressure and type of cleaning media used, sponge blasting can effectively removing soot from wallpaper to the removal of high-performance protective coatings on steel and concrete surfaces.

The classifier unit is used to mechanically remove comparatively large debris and powdery residues from the foam media after each use. The used media is collected and placed into the electrically-powered sifter. The vibrating sifter classifies the used media with a stack of progressively finer screens. Coarse contaminants, such as paint flakes, rust particles, etc., are collected on the coarsest screens. The reusable foam media are collected on the corresponding screen size. The dust

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and finer particles fall through the sifter and are collected for disposal. After classifying, the reclaimed foam media can be immediately reused in the feed unit.

The foam media must be washed after three to five cycles. The laundering of the foam media takes place in the wash unit, which is a centrifuge, portable, closed-cycle device. The contaminated wash water is collected, filtered, and reused within the wash unit. The concentrated bottom residue is collected and disposed.

Materials

Compatibility: Sponge blasting systems are compatible in any situation where other types of blasting media have been used.

Safety and Health: As with any blasting operations, airborne dust is a major safety and health concern. Proper precautions should be taken to ensure inhalation of dust/particulate matter is avoided. Additional protective measures should be taken when stripping lead chromate- or zinc chromate-based paints, as these compounds may be hazardous. Inhalation of lead and zinc compounds can irritate the respiratory tract, and some compounds are known to be carcinogenic. Inhalation of solvents can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Safer for operators and public than other blasting media and chemical strippers
- Environmentally safe
- Easily transportable
- Waste minimization using recyclable sponge media (can recycle Sponge media on the average of ten to fifteen times)
- Absorbs and removes contaminants
- Reduces dust generation
- Less ricochet of Sponge media, therefore, less containment is needed.

Disadvantage: Foam media costs more expensive than sand.

Economic Analysis:

- Assumptions:
 - 5,000 square feet of paint to be removed per year

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- Paint removal speed of The sponge blasting system: 2 sqft/min
- Labor rate: \$45/hr
- Foam Media Cost: \$65/50 lbs
- Feed Unit Cost: \$15,500
- Classifier Unit Cost: \$8,550
- Washer Unit Cost: \$23,700
- Chemical Cost: \$11.40/gal
- Water Treatment/Disposal: \$8.24/1000 gal
- Paint and Solvent Sludge Disposal Cost: \$200/ton
- Dry Paint Waste Residue (after recycling foam media): 60 lbs
- Paint Disposal Cost: \$2/lb

	<u>Sponge Jet</u>	<u>Chemical Stripping</u>
• Capital Cost	\$47,750	-
• Operational Costs		
Labor	\$1,890	\$32,760
Chemical	-	\$10,670
Foam Media	\$5,850	-
Water Treatment/Disposal	-	\$3,296
Hazardous Waste Disposal	\$120	\$200
• Annual Savings:	\$39,066	
• Payback Period:	15 months	

Approval Authority:

Navy: Unless locally controlled, no major claimant has endorsed this technology for use on aircraft components without subsequent retreatment to ensure substrate is completely free of blast media. NAVAIR, Phone: (703) 692-6025. This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Point of Contact:

Scott Mauro
 Naval Facilities Engineering Service Center, Code 423
 1100 23rd Avenue
 Port Hueneme, CA 93043-4370
 Phone: (805) 982-4889, DSN: 551-4889
 FAX: (805) 982-4832

Vendors:

The following is the Sponge-Jet™ manufacturer. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Sponge-Jet™
 P.O. Box 243
 Eliot, ME 03903
 Phone: (207) 439-0211, Fax: (207) 439-0309

PAINT STRIPPING USING WHEAT STARCH BLASTING

Revision: 1/96
Process Code: Navy: ID-01-06; Air Force: ST01; Army: DPT
Substitute for: Chemical Paint Stripping
Applicable EPCRA Targeted Constituent: Toluene, Xylene, Methyl Ethyl Ketone, Acetone, n-Butyl Alcohol, Lead, Chromium, Zinc Compounds, Phenols, Chloroacetic Acids, and Methylene Chloride

Overview: Wheat starch blasting is a user-friendly operation wherein wheat starch can be used in systems designed for plastic media blasting (PMB), as well as systems specifically designed for wheat starch blasting. The wheat starch abrasive media is a crystallized form of wheat starch that is non-toxic, biodegradable, and made from renewable resources. The media is similar in appearance to plastic media; however, it is softer than plastic media.

The wheat starch blasting process propels the media at less than a 35 psi nozzle pressure for most applications. The low pressure and relatively soft media have minimal effect on the surfaces under the paint. For this reason, wheat starch is well suited for stripping paints without risking damage to the substrate. Examples include removing paint from aluminum alloys and composites like graphite, fiberglass, and aramid (Kevlar™) with little or no damage to the surface. Ongoing tests on aluminum alloys, composites, and steel components are being performed at Beech Aircraft Corp. and Boeing.

Commercial and military testing have shown that the wheat starch blasting process can remove a variety of coatings. Coating types range from resilient rain-erosion resistant coatings found on radomes and radar absorbing materials to the tough polyurethane and epoxy paint systems. The wheat starch system has been shown to be effective on removing bonding adhesive flash (leaving the metal to metal bond primer intact), vinyl coatings, and sealants. It has been found effective in removal the paint from the cadmium parts, leaving the cadmium plating on the component.

There are several important components required in all wheat starch systems. First, a moisture control system where dry air at 35 to 40 degrees F dew point is fed, via a refrigerated air dryer, into the product hopper to control the storage conditions of the medium. This is especially important when the system is shut down for extended periods. Second, to remove contaminants from the wheat starch media, the spent wheat starch residue is dissolved in water, then it is either filtered or separated in a dense particle separator/centrifuge. The wheat

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starch is recycled in the system and may be used for 15 to 20 cycles. Low levels of dense particle contamination in the media will result in a rough surface finish on delicate substrates.

Currently, CAE Electronics (CAE) holds the patent for the wheat starch blasting product and process; however, in the future, CAE expects to license other vendors to supply this product and process. CAE has recently been developing control devices for this process to ensure the optimal media mix and application at their testing facility in Montreal, Quebec, Canada.

The disposal of wheat starch stripping waste includes landfilling, combustion (incineration), and biological treatment. Biological treatment is becoming more attractive, as landfilling and combustion are becoming prohibitively more costly for the hazardous waste disposal. DOT Technologies has developed a biological treatment process that will effectively treat contaminated starch stripping waste. The system is a four-step process: 1) starch liquefaction using an alpha-amylase enzyme; 2) removal of paint solids via filtration; 3) metal extraction via ion exchange; and 4) aerobic starch digestion. The process is a batch digester process that converts the starch waste to carbon dioxide and water. The filtered paint organic compounds are reduced and metals can be recovered.

Materials

Compatibility:

Wheat starch blasting can be used on metal and composite surfaces. Direct contact of wheat starch with water must be avoided. Wheat starch blasting requires explosion protection. If conditions are right, a static electrical charge developed by a high velocity wheat starch particle in air could effectively ignite the material, like dust in a grain elevator can explode when exposed to a static charge. Preventive measures must be taken.

Safety and Health:

As with any blasting operations, airborne dust is a major safety and health concern. Proper precautions should be taken to ensure inhalation of dust/particulate matter is avoided. Additional protective measures should be taken when stripping lead, chromate, zinc chromate, or solvent-based paints, as these components may be hazardous. Inhalation of lead and zinc compound can irritate the respiratory system and some compounds are known to be carcinogenic. Inhalation of paint solvents can irritate the lungs and mucous membranes. Prolonged exposure can affect respiration and the central nervous system. Proper personal protective equipment should be used.

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Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

Wheat starch is a plentiful natural resource that is biodegradable. The waste generated from this process can be treated in a bioreactor. The waste volume requiring subsequent disposal is estimated to be only 5 percent of the original volume. Note that the material requiring subsequent disposal may be a RCRA characteristic hazardous waste.

The wheat starch blasting process can be used for removing coatings from both metallic and composite materials. This process is very controllable; it can be used to selectively remove from one to all coating layers. Wheat starch blasting does not cause fatigue to the surface.

Disadvantages:

- High capital cost investment.
- Operators need training.

Economic Analysis: Capital costs for wheat starch blasting systems will vary, depending upon the application. A PMB system can be modified for a cost of approximately \$10,000 for a small application. An automated, closed, dust-free system for a large application (e.g., aircraft) can cost up to \$1.5 million.

The operating costs for wheat starch blasting have been estimated to be 50 percent less than chemical paint stripping (i.e., methylene chloride).

The cost of biological treatment is estimated to be \$0.50 per pound for 150,000 pounds or more and \$0.75 per pound for 50,000 pounds. Labor costs for handling are the major factor in this estimate. Landfill costs are dependent on location. An estimate for landfill disposal of dry hazardous waste ranges from \$1.75 per pound to \$3.25 per pound. Incineration cost for dry waste is estimated at \$1.50 per pound.

- Assumptions:
 - The square feet area of paints to be removed/year: 93,800 sqft
 - Labor rate: \$60/hr
 - Stripping Rate of an Automated System: 5 sqft/min/nozzle
 - Media Consume Rate: 1 lb/sqft
 - Wheat Starch Media Cost: \$1.70/lb
 - Waste Disposal Cost: \$2/lb

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	<u>Wheat Starch Blasting</u>	<u>Chemical Stripping</u>
• Capital Cost	\$1,500,000	-
• Operational Cost/yr		
Material	\$170,000	\$230,000
Labor	\$1,300,000	\$2,250,000
Waste Disposal	\$200,000	\$1,260,000
• Annual Savings: \$2,070,000		
• Payback Period: 9 months		

Approval Authority:

Navy: Unless locally controlled, no major claimant has endorsed this technology for use on aircraft and aircraft components without subsequent retreatment to ensure substrate is completely free of blast media. NAVAIR, phone: (703) 604-3090 ext. 4151. This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Points of Contact:

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 Corpus Christi, TX 78419-6160
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 1100 23rd Avenue
 Port Hueneme, CA 93043-4370
 Phone: (805) 982-4889, DSN: 551-4889
 FAX: (805) 982-4832

Vendors:

The following is a list of wheat starch media manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

EnviroStrip®
 CAE Electronics
 980 Whit Oaks Pass
 Alpharetta, GA 30202
 Phone: (404) 664-1500
 FAX: (404) 664-5004
 (Note: CAE Electronics holds the patent for the product and process.)

USED OIL SEGREGATION AND STORAGE

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Proper segregation and storage of used POLs is necessary to ensure that recycling is promoted. Required segregation is normally dictated by the waste oil transporter so that waste oils are consistent with the intended use. Proper storage is the same, regardless of the degree of segregation. Generally, the goal of proper storage is to eliminate water and dirt contamination of the waste POL prior to off-site shipment.

Based upon a review of Title 40 Code of Federal Regulations (CFR) Part 279, "Used Oil Management Standards," Subpart A, "Definitions," used oil is defined as any oil refined from crude oil or any synthetic oil that has been used and, as a result of its use, is contaminated by physical or chemical impurities. Subpart B, "Applicability," states mixtures of used oil and any hazardous waste requires regulation as a hazardous waste under 40 CFR, Parts 260 through 266, 268, 270, and 124, rather than as used oil under 40 CFR 279.

All used oil should be tested using the following methods to determine if it is hazardous waste in accordance with 40 CFR, Parts 261 and 279. Measured values should be compared to those presented in 40 CFR 261.

- Environmental Protection Agency (EPA) Method 1311, "Toxicity Characteristic Leaching Procedure (TCLP)" (40 CFR 261.24);
- EPA Method 1010 Pensky Martens Closed Cup (PMCC) Method, or EPA Method 1020;
- Setaflash Closed Cup (SCC) Method - "Flash Point" (40 CFR 261.21);
- EPA Method 1110, "Corrosivity (pH)" (40 CFR 261.22);
- EPA Method 9040 or 9041, "Reactivity" (40 CFR 261.23); and
- EPA Method 8010, "Halogenated Volatile Organics."

Process knowledge can also be applied to any used oil to eliminate any or all of the above tests. For example, if it is known that no acids or bases were added, or may have been accidentally deposited into the used oil, the corrosivity test may be eliminated. Also, the reactivity test is usually not performed on most used oils.

Used oil becomes hazardous when any one of the four characteristics are met, or when the used oil contains 1,000 ppm or greater total halogens, subject to rebuttal (40 CFR 279).

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Assuming the oil meets the criteria of used oil rather than a hazardous waste, it is regulated under 40 CFR 279. Forty CFR 279.1, "Definitions," defines the following terms:

Used Oil Collection Center: "...means any site or facility that is registered/licensed/permitted/recognized by a state/county/municipal government to manage used oil and accepts/aggregates and stores used oil collected from used oil generators regulated under subpart C of this part who bring used oil to the collection center in shipments of no more than 55 gallons under the provisions of subpart 279.24. Used oil collection centers may also accept used oil from household do-it-yourselfers."

Used Oil Aggregation Point: "...means any site or facility that accepts, aggregates, and/or stores used oil collected only from other used oil generation sites owned or operated by the owner or operator of the aggregation point, from which used oil is transported to the aggregation point in shipments of no more than 55 gallons. Used oil aggregation points may also accept used oil from household do-it-yourselfers."

Forty CFR 279, Subpart D - "Standards for Used Oil Collection Centers and Aggregation Points" requires both the used oil collection center and the aggregation point to comply with the requirements of 40 CFR 279, Subpart C, "Standards for Used Oil Generators." The essential difference between a used oil aggregation point and a collection center is the aggregation point can accept oil only from used oil generation sites owned or operated by the owner or operator of the aggregation point and there is no requirement for state, county, or municipal registry, licensing, permitting, or recognition. In both cases, shipment, acceptance, and transport of used oil is limited to 55 gallons or less. There is no limitation on the amount of used oil that may be accumulated at the collection center or the aggregation point.

Forty CFR 279, Subpart C, "Standards for Used Oil Generators," requires used oil to be stored in tanks, containers, or units subject to regulation under 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." Subpart C, "Standards for Used Oil Generators," states containers and above ground tanks used to store used oil at generator facilities must be labeled or marked clearly with the words "Used Oil."

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In addition to federal requirements, state regulations should be carefully reviewed to ensure all applicable requirements are met.

The most effective method of minimizing contamination is to segregate the used oil from possible contaminants such as non-petroleum oils, solvents, and antifreeze. This can be done by providing separate, labeled containers for the collection of waste solvents, synthetic oils, glycol, and other materials. Physical separation of the processes using materials which contaminate oil can be helpful in solving the problem.

Materials

Compatibility:

Material compatibility concerns exist with non-petroleum-based POLs, solvents, fuels (some), and non-POLs such as antifreeze. For example the following materials are not normally mixed with used oils:

- Non-petroleum based hydraulic fluids
- Solvents
- Parts cleaners
- Gasoline (MO gas)
- Antifreeze
- Methanol
- Water

Waste diesel fuel and jet fuels JP-4 and JP-8 may be acceptable for mixing depending upon the ultimate use of the used oil. For example, if used oil is destined for energy recovery, waste diesel fuel and jet fuels JP-4 and JP-8 may be acceptable for mixing.

With regard to used refrigerant oil, according to 40 CFR Part 266, Subpart E, "Used Oil Burned for Energy Recovery" (enclosed), used oil containing greater than 1,000 ppm total halogens is considered a RCRA hazardous waste under the assumption the oil was mixed with chlorinated hazardous waste. However, if a person can document the used oil was not mixed with chlorinated hazardous wastes (e.g., document the oil is, in fact, used refrigerant oil), the oil does not need to be managed as a hazardous waste, as long as the total halogens do not exceed 4,000 ppm and the used oil is recycled. In order to keep accurate records of the source of the oil, the used refrigerant oil should be kept separate from other types of used oils. Most used refrigerant oils do exhibit greater than 1,000 ppm chlorides. However, if the analytical results of the used refrigerant oil indicate it contains less than 1,000 ppm chlorides, the used refrigerant oil can be mixed with other types of used oils destined for energy recovery. If the amount of chlorides in the oil is variable, the oil must be analyzed each time it is removed from a refrigeration unit before mixing it with other types of oil. Keeping the

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

used refrigerant oil separate from other types of used oil will ensure compliance with the regulations.

Safety and Health: There are minimal safety and health concerns regarding waste oils. Care should be taken when hot oils. Consult your local health and safety personnel for specific precautions.

Benefits: Proper used oil segregation and storage helps:

- Ensure the marketability of used oil
- Generators avoid the high cost of disposing of oil as hazardous waste

Disadvantages: N/A

Economic Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Ken Gladstone, Sea OOT5
Naval Sea Systems Command
2531 Jefferson Davis Hwy.
Arlington, VA 22242-5160
(703) 602-3594, DSN 332-3594, Fax (703) 602-7213

Vendors: N/A

Sources: 58 Federal Register (FR) 26425, "Final Rule; Technical Amendments and Corrections," *Environmental Protection Agency (EPA) Standards for Managing Used Oil*, US EPA, 3 May 1993, including the clarification of issues discussed in the preamble.
Title 40 *Code of Federal Regulations* Part 279, "EPA Standards for Managing Used Oil," US EPA, 10 September 1992, amended at 58 FR 26425, 3 May 1993 and 58 FR 33342, 17 June 1993.
Guide to Used Oil Regulations, Thompson Publishing Group, 1992.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ON-SITE RECYCLING OF USED OIL

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute for: Off-Site Disposal/Off-Site Recycling
Applicable EPCRA Targeted Constituents: N/A

Overview: It is possible to recycle used lubricating oils generated from fluid changeouts of internal combustion engines in tactical service (MIL-L-2104) and in administrative service (MIL-L-46152), steam turbine and gear oil (MIL-L-17331), marine diesel service (MIL-L-9000), petroleum-based 90W and 140W gear lube oil (MIL-L-2105), and vacuum and compressor oils.

On-site recycling options for used lubricating oil are limited to diesel fuel supplementation and burning as a boiler fuel supplement. Based upon a study performed at Red River Army Depot in 1993, oil could not be successfully reconditioned on site for reuse due to heavy metal contamination. In addition, re-additizing of treated oils by on-site processors is generally not recommended.

Diesel Fuel Supplementation

The criteria that must be used in electing on-site recycling options involves the volume of used lubricating oil generated annually. Diesel fuel on-site use includes the volume of diesel fuel use (40,000 gal/yr is required to burn 2,000 gallons of used diesel lubricating oil at a 5 percent mixture ratio), volume of diesel lubricating oil generated, diesel engine warranty, and activity policy.

Facilities that consume large volumes of diesel fuel (40,000 gal/yr or more) can reclaim diesel-engine lubricating oil using a combination of filtration/coalescers and utilize the reclaimed product as a diesel fuel supplement (NIPER BO6803-1 DEC, 1987). This recycling option is attractive, because it eliminates the disposal of 2,000 gallons or more of used lubricating oil annually, and also reduces the purchase of diesel fuel by 2,000 gallons annually. When used in conjunction with a fast lube oil change system (FLOCS), a cost-effective on-site recycling option for used lubricating oil becomes possible. Among the three major diesel engine manufacturers, neither Cummins nor Caterpillar have restrictions prohibiting the use of used lubricating oil as a diesel fuel supplement, although Detroit Diesel does not recommend the practice. If the warranties of the diesel engines to be employed to consume the used lube oil or activity policy prohibits such use, this option should not be selected.

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Boiler Fuel

Used lubricating oils, including internal combustion engine, steam turbine and gear oil, petroleum-based gear lube oil, and mechanical pump oils, can be dewatered and filtered for use as a supplement to No. 6 burner fuel or used to fuel dedicated waste oil burners. To burn these used oils in a boiler, you may require a permit from the state which defines the source of the fuel. The boiler must be of a special design to burn used oil and must meet federal containment limits. Technically, the Navy can burn used lubricating oil, but in practice it is not done.

There is an increased boiler maintenance cost resulting from burning higher used lube oil as a supplement to No. 6 fuel oil. Any volume of used oil that is burned as a burner fuel supplement can be cost-effective, although if the blend of No. 6 oil with used lube oil exceeds 50 percent, the maintenance costs become a significant factor in Net Uniform Annual Savings.

Black Gold manufactures dedicated waste oil burners that are designed to burn high carbon content waste crankcase oils, lubricating oils, automatic transmission fluids, and No. 2 heating oils. Black Gold offers turnkey systems that include everything but the flue.

Materials

Compatibility:

The six types of lubricating oil listed (L-2104, L-17331, L-46152, L-9000, and L-2105) can and should be combined for efficiency and economy of collection. Do not mix or blend low-flash hydrocarbons with used lubricating oil. It is permissible to collect hydraulic oils (H-5605 and H-17672B) with lubricating oils if neither are recyclable for original use and not contaminated with halogens.

These oils should be accumulated by the generator in clean, well-labeled, and color-coded drums. When the drum is full, the generator should complete a standard 1348-1 manifest form and request Public Works or other appropriate activity to transfer the drum to the central storage facility.

Storage of used lubricating and gear oils is necessary during the period required to accumulate a sufficient volume for recycling or disposal. Storage should be achieved in clean 55-gallon labeled drums, bowsers, buffaloes, above-ground tanks, or railroad tank cars. If drums are used, these should be covered so that water does not collect on top of the drum with possible contamination of the contents. Storage containers

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should be placed in an area that is bermed or diked to contain spills from reaching groundwater.

Safety and Health: Care should be taken when handling lubricating oils. Proper personal protective equipment is recommended. Consult your local health and safety personnel for specific precautions.

Benefits: Potential benefits of on site recycling of used oil are as follows:

- Reduced waste oil disposal
- Reduced diesel fuel and fuel oil purchases

Disadvantages: • Due to heavy metal contamination, onsite reconditioning of oil for reuse (for its original intended purpose) has not been successful

Economic Analysis: Diesel Fuel Supplement

Racor Industries, Inc., Modesto, California, provides a unit designed specifically for processing used lube oil for use as a diesel fuel supplement. If permanently installed, it is generally used in conjunction with a fuel reservoir or tank. It automatically blends used crankcase oil with diesel fuel. It also filters, recycles, and transfers diesel fuel. It has its own waste oil holding tank and oil injection system.

The bare equipment costs to recycling used lubricating oil as a diesel fuel supplement are \$8,500 to \$10,000, and the total capital investment ranges from \$57,000 to \$80,000. These costs assume that tankage for the diesel fuel exists. The total capital investment includes installation materials and labor, training, and start-up materials costs. Payback period of these initial investment costs can be achieved in less than the estimated 10-year life of the equipment.

A brief summary of the economics of the option to recycle used lube oil as a diesel fuel supplement follows:

Annual volume of used lube oil, gal	2,000
Annual volume of diesel fuel required to meet the 1:20 dilution factor, gal	40,000
Estimated value of diesel fuel per gallon	\$1.00
Bare equipment costs	\$8,500
Total capital investment costs	\$57,000
Savings Investment Ratio (SIR)	1.543
Net Uniform Annual Savings (NUAS)	\$5,022
Investment payback period, years	5.3

Waste Oil Burners

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Material and installation costs for a 200,000 BTU/Hr. (1.4 gallons per hour of waste fuel) waste oil burner is estimated to be \$9,500. The waste oil burner will require a 2,000-gallon, above-ground tank to store the waste oil, at an estimated cost of \$8,000. Total installed cost allowing for training and SPCC preparation (update) is estimated to be \$18,700. Assuming a status quo disposal cost of \$0.75 per gallon for oil, the payback period is approximately 3.5 years. A brief summary of the economics is presented below.

Volume of used lube oil to be consumed (6,050 gallons in 6 months at 24 hours/day)	1.4 gallons/hour
Waste oil furnace and vent installed	\$9,500
2,000 gallon storage tank installed	\$8,000
Training and SPCC preparation	\$1,200
Energy value of waste oil (per year) (7,600 Therms/year)	\$3,200
Waste oil disposal cost (status quo)	\$0.75/gallon
Increased labor for waste oil handling	\$975/year
Payback period	3.5 years

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Diesel Fuel Supplement

Luis Reyes
Code 421
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Waste Oil Burners

Naval Facilities Engineering Service Center
Peter Fanning
(805) 982-3564

Vendors:

Diesel Fuel Supplement

The following is a list of lube oil recycling system manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

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Aeroquip Corp.
300 S E Jackson Ave.
Jackson, MS 49203
(517) 787-8121
Model 3A FLOCS (or any newer models if available)
Stock Number 4930-01-163-6696

Racor Industries Inc.
P.O. Box 3208
Modesto, CA 95353
(209) 521-7860, (800) 344-3286
Models: 800D (series) and 850

Waste Oil Burners

The following is a list of manufacturers of on-site heat recovery systems. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Black Gold Corp.
Suite 344
240 Great Circle Road
Nashville, TN 37228
(615) 251-0680, (800) 351-0643

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

OFF-SITE RECYCLING OF PETROLEUM BASED HYDRAULIC FLUID

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute for: Single Use Of Hydraulic Fluids
Applicable EPCRA Targeted Constituents: NA

Overview: Offsite recycling of hydraulic fluid is performed by numerous companies using a variety of technologies. Although a technically viable option for pollution prevention, offsite recycling tends to be significantly more expensive than disposal. To secure a successful off-site recycling program, off-site recycling costs must be less than the sum of disposal costs plus the cost of new hydraulic fluid, as illustrated in the economic analysis in this datasheet.

Materials

Compatibility: Mixtures of certain hydraulic fluids may not be acceptable for recycling. Consult the recycler for specific requirements.

Safety and Health: Personnel handling hot hydraulic fluid should take necessary precautions. Use of the proper personal protective equipment is recommended. Consult your local health and safety personnel for specific precautions.

Economic Analysis: Typical *disposal costs: \$4.34 to \$5.38
Typical new hydraulic fluid: \$2.62 to \$4.00
Total: \$6.96 to \$9.38

Typical off-site recycling costs: \$8.50 to \$15.30

*Disposal completed through the Defense Reutilization and Marketing Office (DRMO)

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Charles Franklin (OS-305)
Office of Solid Waste- EPA
401 M Street SW
Washington, DC 20460
(202) 260-4646

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Luis Reyes
Code 421
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Industrial Materials Exchange (IMEX)
Mr. Bill Lawrence
506 2nd Ave, Rm. 201
Seattle, WA 98104
(206) 296-4899, Fax: (206) 296-3997

Pacific Materials Exchange
Mr. Bob Smee
1522 North Washington, Suite 202
Spokane, WA 99205
(509) 466-1532, Fax: (309) 325-2086

Vendors:

The following is a list of hydraulic fluid recyclers. This is not meant to be a complete list, as there are other providers of this service.

Murphy Oil Corp.
200 Jefferson Ave.
El Dorado, AR 71730

Recycling Resources, Inc.
1340 W. Lincoln St.
Phoenix, AZ 85007-3420
(602) 258-6155
Service: Processor

Williams Energy Co.
P.O. Box 2060
Anchorage, AK 99510

Chevron Research Company
576 Standard Ave.
Richmond, CA 94802

Environmental Disposal Services, Inc.
P.O. Box 1071
Coalinga, CA 93210

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

OFF-SITE REFINING OF WASTE OIL

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute for: Off-Site Heat Recovery, On-Site Heat Recovery
Applicable EPCRA Targeted Constituents: N/A

Overview: Refining of waste petroleum lubricants allows the materials to be reused at a similar level of services as they were originally intended (i.e., reuse as a motor oil). As such, this is a higher level of recycling than recycling to recover the energy value of the waste petroleum. Currently, the EPA has identified four facilities that refine used oil solely.

Under this option, the waste oil generator contracts with an oil refiner or intermediate broker for disposal of waste oil. The broker/refiner will not normally accept less than full tanker truck loads of waste POL; therefore, on-site storage and accumulation will be necessary until sufficient quantities are generated. One advantage to this option is that all POLs can normally be combined into a single tank, including engine oils, petroleum-based hydraulic fluids, gear lubricants, and petroleum-based transmission oil.

Materials

Compatibility: Waste fuel may not be acceptable for mixing.

Safety and Health: Care must be taken when handling waste oils due to high temperatures. Proper personal protective equipment is recommended. Consult your local health and safety personnel, prior to implementing this pollution prevention opportunity.

Benefits: • Refining of used oil is a higher use than any other option for used oil

Disadvantages: • Onsite storage and accumulation is necessary until sufficient quantities are generated

Economic Analysis: Safety Kleen reports that they will accept truck load quantities of waste oil for \$0.11 to \$0.15 per gallon at the generator's site.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Point of Contact: Luis Reyes
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Vendors: Safety Kleen Corp.
777-T Big Timber Rd.
Elgin, IL 60123
(800) 669-5740

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

OFF-SITE HEAT RECOVERY OF WASTE POL

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute for: On-Site Disposal, On-Site Recycling
Applicable EPCRA Targeted Constituents: N/A

Overview: Off-site heat recovery is the most common ultimate disposal method of used oil in the United States. Processors of used oil typically collect automotive and industrial oil, perform limited processing on it to remove water and sediment, and offer the used oil for sale, primarily to fuel blenders and industrial fuel burners. Some fuel processors may use the blended fuel on site in their own boilers and industrial furnaces.

Off-site heat recovery is facilitated by waste oil processors who collect, process, and burn or offer for sale the processed product as specification fuel. Processing is a physical/chemical process that may include: 1) blending with virgin petroleum, 2) blending to meet fuel specification, 3) filtration to remove sediment and/or water, 4) simple distillation to remove water, and 5) physical/chemical separation. The specification fuel is then burned or sold to industrial facilities to be burned for energy recovery.

Materials

Compatibility: Materials that are not suited for this type of disposal should not be mixed with the waste oil.

Safety and Health: Care must be taken when handling the waste oils due to high temperatures. Proper personal protective equipment is recommended. Consult your local health and safety personnel prior to implementing this pollution prevention opportunity.

Benefits:

- Hazardous waste disposal is avoided
- An abundance of used oil transporters and processors exist

Disadvantages: N/A

Economic Analysis: Economics are usually favorable for off-site heat recovery of waste oil. Specific economics should be performed on a case-by-case basis, since handling charges differ from one oil transporter/processor to another.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Luis Reyes
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Vendors: There are numerous used oil transporters and processors listed in the phone directory under "Oils-Waste." Prior to releasing oil to the transporter, the generator should verify that the transporter has an EPA identification number.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SUBSTITUTING SYNTHETIC OIL FOR CONVENTIONAL OIL

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Conventional Oils
Applicable EPCRA Targeted Constituents: N/A

Overview: When used in place of conventional motor oil, synthetic oil lasts longer, requiring fewer changeouts. As a result, waste oil generation and consumption of virgin oil is reduced.

Materials

Compatibility: N/A

Safety and Health: There are minimal safety and health concerns with synthetic oils. Care must be taken when handling hot oil. Proper personal protective equipment is recommended. Consult your local health and safety personnel for specific precautions.

Benefits:

- Synthetic oil lasts two to five times longer than conventional oil
- Waste oil generation can be reduced two to five times if synthetic oil is used

Disadvantages:

- Synthetic oil costs more than conventional oil (the higher cost is typically offset by reduced waste generation however)

Economic Analysis: An economic analysis assuming synthetic oil lasts three times as long as conventional oil is presented below for a 12-quart capacity vehicle.

- Assumptions:

Labor Cost	\$20/hour
Labor	1 hour per oil change
Oil Disposal	\$0.75/gallon
Oil Cost - Synthetic	\$17.50/gallon
Oil Cost - Conventional	\$4.50/gallon

- Analysis:

Oil Consumption - Conventional (three changes per year)	36 quarts
Oil Consumption - Synthetic (one change per year)	24 quarts
Oil Savings	12 quarts
Oil Cost - Conventional (per year)	\$40.50
Oil Cost - Synthetic (per year)	\$52.50
Oil Disposal - Conventional (per year)	\$6.75
Oil Disposal - Synthetic (per year)	\$2.25
Oil Disposal Savings (per year)	\$4.50

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Labor - Conventional (per year)	\$60
Labor - Synthetic (per year)	\$20
Labor Savings (per year)	\$40

Total Savings per Year:

Oil	24 quarts
Dollars	\$32.50

Note: There is no payback period because there is no capital cost. Also note that costs for oil analysis are the same whether conventional or synthetic oil is used.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Luis Reyes
Code 421
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Vendors:

Most oil suppliers have a synthetic brand of motor oil. Some are listed below.

Amoco Oil Company
Commerce Plaza, 5th Floor
2021 Spring Road
Oak Brook, IL 60521
(800) 876-3221

Castrol, Inc.
16715 Von Karman
Suite 230-T
Irving, CA 92714
(800) 458-5823

Mobil Oil Company
3225 Gallows Rd.
Fairfax, VA 22037
(800) 662-4525

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

PERMANENT FILTER FOR VEHICLE MOTOR OIL

Revision: 1/96
Process Code: Navy: SR-02-99; Air Force: PM05; Army: N/A
Substitute for: Oil Changes
Applicable EPCRA Targeted Constituents: N/A

Overview: Permanent filters are full-flow filtration units that contain a reusable, stainless steel wire cloth filter installed inside a serviceable housing. The filter removes solids just as a normal canister filter would. The advantage to using a permanent filter is that the permanent filter can be cleaned and reused many times, eliminating the need for disposal of canister filters.

With a permanent filter, the standard canister filter is replaced with an adapter which spins onto the filter header. The adapter directs oil into hoses, which take the oil to the permanent filter housing, where the oil is passed through a stainless steel screen-type filter element. Filter elements can remove particles down to various sizes with 5 to 10, 15, 28, 40, and 60 microns being typical. The 28 or 40 micron filter element is the typical size used for vehicle engines and is comparable to a conventional canister filter. After filtration, the oil is returned to the adapter and recirculated through the engine.

The RACOR Tattletale Filter is equipped with a by-pass when the wire cloth filter element restricts flow due to clogging. At this point, a signal light tells the operator that there is a need for service. To service the filter, the filter housing is disassembled, and the wire cloth screen is soft brushed in solvent or cleaned in a parts washer. The clean filter is then put back into service. A visual evaluation of dirt accumulated on the filter may be helpful in diagnosing engine wear problems.

Materials

Compatibility: N/A

Safety and Health: There are minimal safety and health concerns regarding vehicle motor oil. Care must be taken while handling oils when high in temperature. Proper personal protective equipment is recommended. Consult your local health and safety personnel before implementing this pollution prevention opportunity.

Benefits:

- There are no canister filters to be removed, drained, crushed, or disposed
- An indicator light reveals when filter is ready for servicing

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Disadvantages: • Labor involved in disassembling and cleaning permanent filters

Economic Analysis: Typical cost of the equipment for an automobile/light truck are as follows (RACOR).

<u>Model Number</u>	<u>Description</u>	<u>Price</u>
LFS5528TT	Filter unit with sensor	\$142
N/A	Adapter (varies)	\$40-\$150
Equipment Cost		\$182-\$300

Typical cost for a larger capacity filter suitable for large diesel engines are as follows (RACOR).

<u>Model Number</u>	<u>Description</u>	<u>Price</u>
LFS9028TT	Filter unit with sensor	\$396
N/A	Adapter (varies)	\$40-\$150
Equipment Cost		\$450-\$550

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Luis Reyes
Code 421
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Vendors:

The following is the vendor whose data appears in this datasheet. This information is not meant to be all encompassing as there are many other manufacturers of permanent filters. Consult the Thomas Register under “automotive filters” for suppliers of filters in your area.

RACOR
Parker Hannifin Corporation
RACOR Division
P.O. Box 3208
3400 Finch Road
Modesto, CA 95353
(800) 344-3286

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

BYPASS FILTER FOR VEHICLE MOTOR OIL

Revision: 1/96
Process Code: Navy: SR-02-99; Air Force: PM05; Army: N/A
Substitute for: Oil Changes
Applicable EPCRA Targeted Constituents: N/A

Overview: Bypass filters are designed to remove smaller particulate than would be removed by the engine's normal filter, so that oil changes are not necessary. Oil added during filter changing, and to replace burned oil, is normally sufficient to replenish the oil's additive package (the component of the oil that is responsible for maintainig pH and preventing deterioration of the oil).

Bypass filters are installed in the engine compartment of a vehicle or, nearby a stationary engine. The bypass filter is fed a slip stream of oil that is bypassed around the engine. There are several different types of bypass filters. Those manufactured by Gulf Coast and Enviro Filtration rely upon filter elements that remove particles down to the 1 to 10 micron range. The Gulf Coast unit is distinctive in that it uses a commonly available roll of toilet paper (or paper towels for larger units) as the filter element. The TF Purifier unit filters down to 0.5 to 1 micron, and then refines the oil by passing it through a heated element refiner that is vented back into the engine air intake. The heated element volatilizes any unburned fuel, water, or glycols that contaminate the oil and cause the oil's additive package to breakdown. With these systems, the engine's canister filter is changed regularly, and the micron filter is changed according to the manufacturer's recommendations. Oil that is used to replenish the oil removed from the system during the filter change, and oil that is added to replace burned oil, is sufficient to keep the additives package intact without ever having to change the vehicle's oil.

Materials

Compatibility: N/A

Safety and Health: There are minimal safety and health concerns regarding vehicle motor oil. Care must be taken when handling oils that are high in temperature. Proper personal protective equipment is recommended.

Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

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- Benefits:**
- Reduce operating expenses by:
 - Eliminating oil changes
 - Reducing new oil purchases
 - Reducing waste oil handling and disposal
 - Provide environmental benefits by:
 - Reducing the use of oil
 - Reducing the generation of waste oil

Economic Analysis: TF Purifier

An up to 12 quart capacity bypass filter has a payback period of approximately 14 years for systems operated with conventional oil. If synthetic oil is being processed, the payback period is reduced to approximately 3 years. For an up to 24 quart bypass filter, the payback periods are 5 years and 1.5 years for conventional and synthetic oils, respectively.

Enviro Filtration

An up to 12 quart capacity bypass filter has a payback period of approximately 2.2 years for systems operated with conventional oil. If synthetic oil is being processed, the payback period is reduced to approximately 0.8 years. For an up to 24 quart bypass filter, the payback periods are 1.3 years and 0.4 years for conventional and synthetic oils, respectively.

	TF Purifier Bypass Filter		Enviro Filtration Bypass Filter		Status Quo	
	12 Quart	24 Quart	12 Quart	24 Quart	12 Quart	24 Quart
Capital Cost (Installed)	\$510	\$560	\$140	\$160	N/A	N/A
Number of Oil Changes Per Year	0	0	0	0	4	4
Operating Labor	1 hr/yr	1 hr/yr	1 hr/yr	1 hr/yr	3 hrs/yr	5 hrs/yr
Supplies	\$55/yr	\$66/yr	\$10/yr	\$30/yr	\$0	\$0
Payback Period, Years:						
Conventional						
Synthetic	3	1.5	0.8	0.4	N/A	N/A
Assumptions:						
Motor Oil Cost						
Conventional \$4/gallon						
Synthetic \$17/gallon						
Oil Disposal Cost \$0.75/gallon						

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Eglin Air Force Base
Management and Equipment Evaluation Program (MEEP)
201 Biscayne Road, Suite 2
Fort Walton Beach, FL 32542-5303
Jacob Detweiler
(904) 882-4210

Vendors: This is not meant to be a complete list, as there may be other suppliers of this type of equipment.

Enviro Filtration
4719 Roosevelt Street
Gary, IN 46408
(219) 884-7963
Mr. Kendal Smith, Marketing Manager

Gulf Coast Filters
P.O. Box 2787
Gulfport, MS 39505
(601) 832-1663
Jerry Simms

TF Purifier
3020 High Ridge Road, Suite 100
Boynton Beach, FL 33426
(407) 547-9499
(800) 488-0577
Mr. Ken Hackman, National Sales Manager

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

OIL FILTER CRUSHING

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Classification of used oil and fuel filters as non-hazardous solid waste for disposal purposes or for metal recycling can often be accomplished by crushing or otherwise voiding the filters of oil. On May 20, 1992, the Environmental Protection Agency (EPA) promulgated a used oil filter regulation that excludes certain types of oil filters from the definition of hazardous waste, allowing generators to manage used oil filters as nonhazardous solid waste. The regulation, published in the Code of Federal Regulations, 40 CFR 261.4(b)(13), excludes oil filters from hazardous waste regulations provided three criteria are met: 1) the filters must not be terne plated; 2) must not be mixed with other hazardous waste; and 3) must be gravity hot-drained. These criteria are further explained below.

Non-Terne Plated

Terne is an alloy of tin and lead formerly used to cover the interior of oil filters. The lead content may cause terne-plated filters to exhibit a hazardous characteristic.

Mixture Rule

According to 40 CFR 261.3(a)(2)(ii-iv), mixtures of solid wastes and hazardous wastes are regulated as hazardous wastes. Used oil filters mixed with hazardous waste are classified as hazardous waste.

Gravity Hot-Draining

40 CFR 261.4(b)13 specifies used oil filters must be gravity hot-drained using one of the following methods:

- puncturing the anti-drain back valve or dome end;
- crushing;
- dismantling; or
- using any other method which will remove oil.

The EPA defines hot-draining in 57 Federal Register 21523 (the preamble to the used oil filter regulation) as draining the oil filter near engine operating temperature and above room temperature (i.e., 60 degrees F). The EPA also recommends a minimum hot-drain time of 12 hours. The preamble also states, "if an oil filter is picked up by hand or lifted by machinery and used oil immediately drips or runs from the filter, the filter should not be considered to be drained." States with

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authorized hazardous waste programs may choose to adopt the EPA regulations, or may adopt more stringent hazardous waste rules. For this reason, facilities considering recycling or disposal of used oil filters must coordinate with their state agencies.

Recycling of Filters

EPA encourages recycling of used oil filters. Waste managers must contact recycling facilities to ensure drainage techniques and handling methods are compatible with the recycling facility's requirements. For example, filters being recycled at smelters or steel plants should be crushed. However, if components such as the gasket or filter papers are to be recycled separately or must be removed, puncturing or dismantling would be a more appropriate drainage method.

At Naval Station San Diego, oil filters are collected for recycling. The filters are crushed using a commercial filter crusher. All free-flowing oil is removed and collected during the crushing process. The used filters are gathered until a minimum of 5,000 pounds are accumulated. The collected filters are shipped to a local private mill, where they are used as feed stock in the company's steel mill operations. The company does not pay for the crushed filters and does not charge for their disposal. Transportation costs to ship the crushed filters to the mill site are paid by the generator. The crushed filter's final product is rebar for use in reinforced concrete structures.

At the Puget Sound Naval Shipyard, an oil filter crushing operation has also been established. This operation has been very successful in minimizing the hazardous waste disposal costs associated with oil filters.

Materials

Compatibility: Oil filters should be kept segregated from hazardous wastes so as not to be considered hazardous waste under the "Mixture Rule".

Safety and Health: Care must be taken when handling oil filters. Skin absorption is a concern when handling metals. Proper personal protection is recommended. Consult your local health and safety personnel prior to implementation of this pollution prevention opportunity.

Benefits: Oil filter crushing and emptying helps:

- Eliminate the cost and liability associated with hazardous waste disposal
- Minimize the volume of waste disposed (even if the oil filters are still considered hazardous waste this is beneficial)
- Create useful steel products through recycling

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Disadvantages: N/A

Economic Analysis: The price range for oil filter crushers is from \$1,500 to \$5,000, depending on the crusher size needed and particular specifications. Depending on the endpoint of the crushed filters (recycled or disposed as solid waste) the economics are also variable. However, in either situation, a cost savings would be realized (after the payback period) due to avoidance of hazardous waste disposal fees.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Filter Manufacturers Council
MEMA Environmental Institute, Inc.
P.O. Box 13966
10 Laboratory Drive
Research Triangle Park, NC 27709-3966
(919) 549-4800; Filter Hotline: (800) 99-FILTER

Sr. Chief Montgomery, Recycling Manager
San Diego Naval Station, CA
Code OD4.1.2
DSN 526-9799, (619) 556-9799

Charles Tittle, Sea OOTB
Naval Sea Systems Command
2531 Jefferson Davis Hwy.
Arlington, VA 22242
(703) 602-3594, DSN 332-3594

Luis Reyes
Code 422
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Vendors: Airboy Sales Company, Inc.
P.O. Box 2649
Santa Rosa, CA 95405
(800) 221-8333

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Autop of North America
2608 Grissom Drive
Nashville, TN 37204
Mr. Jim Rau
(615) 255-7434

C. Frost Company
Washington Automotive Equipment
13649 NE 126th Pl. #202W
Kirkland, WA 98034
(206) 820-1900

Enviro Care Kruncher Corp.
685 Rupert Street
Waterloo, Ontario N2V 1N7
(519) 725-9285, (800) 598-7915

Hercules Equipment Corp.
8230 Goldie
Walled Lake, MI 48390
(313) 363-8882, (800) 444-4351

Oberg USA, Inc.
12428 Hwy 99 South, Bay 80
Everett, WA 98204
(206) 353-2595

ProCycle Metals
433 E. Las Colinas Blvd., Ste. 1180
Irving, TX 75039
(800) 775-2202

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

LUBRICANT ANALYSIS PROGRAMS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Premature Oil Changes
Applicable EPCRA Targeted Constituents: N/A

Overview: Lubricant Analysis Programs are testing programs that enable mechanics to determine whether a lubricant remains effective. Samples of lubricant are collected and either analyzed in the field (using test equipment) or sent away to an analytical laboratory for analysis. Representative sample collection is critical to ensure that the sample sent for analysis is indicative of the lubricant's overall condition. The four main types of lubricant testing procedures are explored in this datasheet.

Physical/Chemical Analysis

The parameters that are typically monitored are viscosity, total base number (a measure of the oil's ability to neutralize acids), and the concentration of some metal ions (e.g., calcium, magnesium, phosphorus, sodium, and zinc) which are part of many additives. Once the samples are analyzed, various factors must be considered in determining when oil requires changing. For instance, metal levels in engine oils can vary depending on factors such as:

- engine metallurgy
- dispersion characteristics of the oil's additive package (which help hold metals in suspension)
- filtration configuration
- oil/lubricant consumption and replacement (which dilutes values)
- types of engine lubricants and additives (many lubricants and additives may contain metals such as aluminum, chromium, copper, and lead as trace ingredients)
- engine usage (light or heavy loads, long or short hauls)
- ambient conditions (summer versus winter conditions, ambient air contaminants).

These and other factors must be considered when evaluating whether an oil is good for continued use. Rapid changes in contaminant metal concentrations or rapid fluctuation of other oil properties are much more important in determining whether an oil is failing than a strict adherence to published ranges or criteria.

Determining whether an additive package is depleted is difficult, because additive packages vary from one manufacturer to another, and

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most analytical tools available do not directly measure the concentration of the additive package.

Ferrographic Analysis

Ferrographic analysis of wear particles is a means of identifying specific conditions of parts wear. Ferrographic analysis is a different category of analysis, compared to the parameters just discussed. It is a predictive method for determining equipment condition long before signs of wear become noticeable. Ferrography detects large and small particles of ferrous, non-ferrous, and nonmetallic materials that are generated at the contact surfaces of two moving parts. These particles are analyzed, and aberrations from trends provide the first indication of a developing mechanical problem. If sufficient information about the equipment's metallurgy is available, it may be possible to identify which gear, bearing, etc., is wearing. The size, number composition, and type of particles tells an analyst the severity of the wear.

Dielectric Constant

A third form of analysis is a field test unit that measures the dielectric constant of a lubricating oil which is indicative of oxidation of the lubricant molecules. Dielectric constant is monitored as a function of time, and once the deterioration exceeds recommended limits, the oil should be changed. The test equipment will indicate one of three potential problems if present: 1) moderate dielectric increase indicative of contamination due to fuel soot, sludge, dirt, oxidation, or acid build-up (this condition is monitored over time until a predetermined point is reached at which time the oil should be changed); 2) severe dielectric increase indicative of water, antifreeze, or metal particles (immediate action is called for to avoid potentially serious engine damage); and 3) moderate dielectric decrease due to gasoline or diesel fuel dilution (this condition is also indicative of a potentially serious problem that needs immediate attention). Note that moderate dielectric decreases are sometimes difficult to detect.

Particle Counters

A fourth form of analysis is the particle counter, which measures the number and size of particles present in oils and hydraulic fluids. Use of an electronic particle counter offers a viable alternative to the patch test, which has traditionally been conducted with CFC-113 or methyl chloroform (both class 1, ozone depleting substances). This equipment requires no hazardous solvents, and test results are accurate and non-subjective. Use of this technology is approved for Navy activities in the NA 01-1A-17 Hydraulics Manual.

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Through a Navy-funded effort to eliminate ODSs, and in conjunction with the Navy's Reverse Engineering program (a hands-on effort to help field activities deal with rapidly changing environmental regulations), particle counters have been introduced to four prototype sites to completely eliminate the need for CFC-113 in patch tests to determine contamination levels of hydraulic fluids.

The goals of the hydraulic fluid contamination testing project were to eliminate the need for ODSs and to reduce the need for patch test. Subtasks of the project included reviewing the sampling frequency requirements, evaluating field replacements for the patch test, investigating alternate solvents, and prototyping (at the field level) the most promising candidates.

Electronic particle counting has long been approved as a means of determining contamination of hydraulic systems (NAVAIR 01-1A-17 Aviation Hydraulics Manual), but has been a depot-maintenance-level practice, due in part to the cost and complexity of the particle counter equipment.

Bench-top and portable particle counting equipment were evaluated with the goal of finding an inexpensive portable unit suitable for deployment.

After investigation, it was determined that none of the portable units were developed enough for prototype at field activities. Although rather costly, the HIAC Model 8011, 8003, or 8003 with ASAP sampler benchtop particle counter appeared to be the best alternative. After a successful 2-week initial prototype aboard the USS *Theodore Roosevelt*, four of the units (8011) were procured for prototype at four sites (NAS Miramar, NAS Cecil Field, NAS Oceana, and USS *Theodore Roosevelt*), at a total cost of \$71,000.

After several months in the prototype stages, the results have been extremely positive. The sample turnaround time has proven to be well within requirements to maintain fleet readiness. The relationship between patch test results and particle counter results had been acceptable. The mechanics using the particle counter equipment are satisfied with its operation and prefer its use to the patch test. The USS *Theodore Roosevelt* has completed the transition to use of the particle counter during their 1993 6-month cruise.

Materials

Compatibility: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Safety and Health: Waste engine oil must be handled with care. The main concern is skin absorption. Proper personal protective equipment is, therefore, recommended. Consult your local health and safety personnel prior to implementing any of these technologies.

Benefits: Lubricant testing programs help:

- Reduce the frequency of oil changes
- Decrease consumption and purchase of virgin oil
- Reduce the generation of waste oil
- Reveal valuable diagnostic information

Disadvantages: • A higher level of knowledge is required by shop mechanics either in performing the diagnostic tests or in taking representative samples for shipment to the lab

Economic Analysis: Dielectric Constant
Northern Technologies International Corporation

<u>Model</u>	<u>Description</u>	<u>Retail Price</u>
NI-3A	Lubri-Sensor Oil Quality Analyzer	\$359
NI-2B	Lubri-Sensor Oil Quality Analyzer	\$525
NI-2C	Lubri-Sensor Oil Quality Analyzer	\$595
NI-LS	Hydroil Sensor	\$619

Particle Counters
H1AC/ROYCO

<u>Model</u>	<u>Description</u>	<u>Retail Price</u>
8011	Batch Sampling System includes: 8000A Counter ABS-2 Sampler HRLD-400 Sensor	\$20,000
	VERSACOUNT Portable Monitor	\$9,900
8012	Batch Sampling System includes: 8000A Counter SDS Syringe Sampler HRLD-400HC Sensor	\$22,250

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Particle Counters

Greg Piner/Mary Beth Fennell
Naval Aviation Depot-Cherry Point Code 342/345
PSC Box 8021
Cherry Point, NC 25833-0021
(919) 466-7396

Ethel Arrington
Naval Aviation Depot
Code 97830
1126 Pocahontas St.
Norfolk, VA 23511-2195
(804) 455-8818

Luis Reyes
Naval Facilities Engineering Service Center, ESC 422
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN: 551-6514, Fax (805) 982-4832

Vendors:

Test Equipment

The following vendors have been identified as supplying test equipment for lubricants. This is not meant to be a complete list, as there may be other providers of this type of equipment.

Northern Technologies International Corp.
(Lubri-Sensor / Hydroil Sensor)
6680 N. Highway 49
Lino Lakes, MN 55014
(612) 784-1250
Linda Petro, Marketing

Predict Technologies
9555 Rockside Road
Suite 350
Cleveland, OH 44125
(800) 543-8786

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Russel Loede
Senior Machine Condition Analyst

Analytical Testing Services

The following test services have been identified as providing analytical testing of lubricants. This is not meant to be a complete list, as there may be other providers of this service.

Predict Technologies
9555 Rockside Road
Suite 350
Cleveland, OH 44125
1-800-543-8786
Russel Loede
Senior Machine Condition Analyst

Haliburton NUS
5909-C Hampton Oaks Parkway
Tampa, FL 33610
1-800-476-6463

Particle Counters

The following are particle counter equipment manufacturers. This is not meant to be a complete list, as there may be other manufacturers of this type of equipment.

Pacific Scientific Co.
HIAC/ROYCO
2431 Linden Lane
Silver Spring, MD 20910
(301) 495-7129

HIAC/ROYCO
762 Palomar Ave.
Sunnyvale, CA 94086
(408) 730-4585
FAX: (408) 730-9749

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SUBSTITUTE LUBRICANTS (NON-LEAD, NON-OZONE-DEPLETING SUBSTANCES)

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Lead Based or Ozone Depleting Substances
Applicable EPCRA Targeted Constituents: Lead, Ozone-Depleting Substances

Overview: Substitute lubricants that contain no or reduced amounts of lead, ozone-depleting compounds, or other hazardous or toxic substances are preferable over conventional formulations, because they reduce the consumption and disposal of these harmful substances.

Hazardous and toxic compounds should be avoided in products where possible, or a formulation that uses reduced amounts of these compounds should be employed. Product content is checked using the material safety data sheet (MSDS). In Section II of the MSDS, chemical components and their percentage (or range of percentage) of the product is presented. By comparing MSDSs for multiple products with the same MIL SPEC and NSN, a more environmentally friendly product may be selected. As a starting point, the list of hazardous and toxic compounds that should be avoided include the ozone-depleting compounds (ODCs) and the "EPA 17" list. Both of these lists are presented below.

Ozone-Depleting Compounds

Trichlorofluoromethane (CFC-11)
Dichlorodifluoromethane (CFC-12)
Trichlorotrifluoroethane (CFC-113)
Dichlorotetrafluoroethane (CFC-114)
Chloropentafluoroethane (CFC-115)
Bromochlorodifluoromethane (Halon 1211)
Bromotrifluoromethane (Halon 1301)
Dibromotetrafluoroethane (Halon 2402)
Chlorotrifluoromethane (CFC-13)
Pentachlorofluoroethane (CFC-111)
Tetrachlorodifluoroethane (CFC-112)
Heptachlorofluoropropane (CFC-211)
Hexachlorodifluoropropane (CFC-212)
Pentachlorotrifluoropropane (CFC-213)
Tetrachlorotetrafluoropropane (CFC-214)
Trichloropentafluoropropane (CFC-215)
Dichlorohexafluoropropane (CFC-216)
Chloroheptafluoropropane (CFC-217)
Carbon Tetrachloride
Trichloroethane

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Dichlorofluoromethane (HCFC-21)
Chlorodifluoromethane (HCFC-22)
Tetrachlorofluoroethane (HCFC-121)
Trichlorodifluoroethane (HCFC-122)
Dichlorotrifluoroethane (HCFC-123)
Chlorotetrafluoroethane (HCFC-124)
Trichlorofluoroethane (HCFC-131)
Dichlorodifluoroethane (HCFC-132)
Chlorotrifluoroethane (HCFC-133)
Dichlorofluoroethane (HCFC-141)
Chlorodifluoroethane (HCFC-142)

EPA 17 List

Benzene
Cadmium and compounds
Carbon Tetrachloride
Chloroform
Chromium and compounds
Cyanides
Dichloromethane
Lead and compounds
Mercury and compounds
Methyl Ethyl Ketone
Methyl Isobutyl Ketone
Nickel and compounds
Tetrachloroethylene
Toluene
Trichloroethane
Trichloroethylene
Xylene(s)

Note: The number in parentheses is the halocarbon number formula.

Potentially applicable substitute lubricants are presented below. MIL SPEC approval where known is presented.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

MIL SPEC	Product	NSN	Comment
N/A	Break Free CLP (Non-Chlorinated in US since April 1993) Break- Free, Inc.	9150-01-054- 6453 (Liquid) 6850-00-105- 3089 (Aerosol)	Substitute for general purpose lubricants and corrosion prevention
N/A	Cloveland Maint: No. 81246 Silicone Lubricant	9150-00-823- 7860	ODC-Free Substitute
N/A	Borden Inc. Lubricating Compound 1349 Silicone Lube	9150-00-823- 7860	ODC-Free Substitute
L-23398D Amend 1, Type I and II	Molykote 3402C (Low Lead) Dow	9150-00-142- 9361	
L-46010D Type III	#099 Solid Film Lubricant Sandstrom Products Co.		Low VOC, Lead- Free Dry Film
L-46010D Type III	Everlube 9002 Solidfilm Lubricant E/M Corporation		Low VOC, Lead- Free Dry Film
L-46147A	No Lead-Free Substitute Available		
L-46147B Type III	Available Soon; Contact: Ms. Ellen Purdy Belvoir, DSN 654-3722		
L-63460	Break Free CLP Non-Chlorinated (Liquid)	9150-01-054- 6453	Non-Chlorinated
C-81302	Break Free CLP Non-Chlorinated (Aerosol)	6850-00-105- 3084	Non-Chlorinated

Materials

Compatibility: N/A

Safety and Health: The concerns vary with the type of lubricants being used. Proper personal protective equipment should be used, if needed. Consult your local health and safety personnel, and the appropriate MSDS prior to making a substitution.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Benefits: The benefits of using environmentally preferable products are as follows:

- Reduced consumption of hazardous substances,
- Reduced worker exposure to hazardous substances, and
- Wastes generated by product use may not be classified as hazardous wastes

Disadvantages:

- Substitute lubricants may cost more
- More of a substitute lubricant may be required to do the same job as the original lubricant

Economic Analysis: Economics depends upon the substitute lubricant chosen. An economic analysis should compare the cost of the environmentally friendly product to the previously used product. The analysis should account for different product consumption rates (i.e., used to take 1 ounce of spray, now it requires 2 ounces), and for different labor amounts required to use the product.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Luis Reyes
Code 422
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Vendors: Vendors should be consulted regarding their product lines to see if they are developing environmentally preferable products. Most companies are developing alternative products and are working with the DOD to obtain MIL SPEC and QPL approval. Vendor names are readily obtained from the MSDS.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

EXTENSION OF METAL WORKING FLUID SERVICE LIFE

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Single Use Of Metal Working Fluids
Applicable EPCRA Targeted Constituents: N/A

Overview: Generation of waste metal working fluids can be minimized by extending the useful life of the fluids. Metal working fluid life is a function of various factors including: type of metal working operation, type/quality of fluid used, housekeeping practices, contamination, bacterial contamination, and water quality.

Modular systems are available for on-site, batch recycle of metal working fluids. These systems clean the fluids by removing solids, bacteria, and tramp oil contaminants. These systems may incorporate filtration, centrifugation, pasteurization, oil skimming, and/or coalescence processing steps. Water or fluid concentrate may be added to the reclaimed fluid to adjust the fluid concentration to the desired level. The fluids are then returned to the machine sump(s).

Cincinnati Milacron markets modular systems for collection, treatment, and recycling of metal working fluids, one of which is in use at the Naval Shipyard in Portsmouth, New Hampshire. The capital costs for a fluid collection device and recycle module would start at around \$40,000.

An alternative to purchase, operation, and maintenance of recycling equipment by the shop is the use of mobile recycling services, such as Fluid Recycling Services. These services utilize similar processing steps to those described above to treat metal working fluids on-site on a periodic basis. There is typically a minimum charge per visit plus a rate per gallon of fluid treated.

For shops that generate less than 25 tons/yr. of waste cutting oil, or less than 45 tons/yr. of waste soluble oil machine coolant, a mobile fluid recycling service would probably be the preferred arrangement. For shops that generate larger amounts of waste metal working fluids, purchase of in-house recycling equipment should be considered. For either option, the economics of recycling metal working fluids are improved by minimizing the number of different metal working fluids used in one shop.

Materials
Compatibility: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Safety and Health: There are mild skin and eye irritation effects associated with these compounds. Personal protective equipment should be used.

Consult your local health and safety personnel for specific precautions regarding these pollution prevention opportunities.

Benefits:

- 40% expected reduction in HW generated
- Reduced purchase of new metal working fluids

Disadvantages: N/A

Economic Analysis: Mobile Fluid Recycling Service

- Assumptions:
 - Disposal costs for waste cutting oil of \$2.50/gal
 - Cost of fresh cutting fluid of \$3/gal
 - Typical activity usage rate of 3,000 gal/yr
 - Capital costs based on two 500-gallon tanks installed
 - \$950 minimum charge per visit for less than 1,000 gallons (O & M)
 - Six visits per year
- Total Installed Capital Cost: \$3,000
- O&M Costs: \$5,700/yr
- HW Treatment/Disposal Savings \$3,000/yr
- Savings on fresh cutting fluid \$3,600/yr
- Total Savings \$6,600/yr
- Payback Period 3.3 years

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Portsmouth Naval Shipyard
Code 300H
Portsmouth, NH 03804-5000
DSN 684-1610, (207) 438-1610

Vendors: The following are cutting fluid recycler equipment suppliers. This is not meant to be a complete list, as there may be other suppliers of this type of equipment.

Cincinnati Milacron
P.O. Box 9013
Cincinnati, OH 45209
(513) 841-8100

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Finish Engineering Co.
921 Greengarden Road
Erie, PA 16501-1591
(814) 455-4478

Fluid Recycling Services, Inc.
2720 Croddy Way
Santa Ana, CA 92704
(714) 754-7220

Hyde Products, Inc.
28045 Ranney Parkway
Cleveland, OH 44145
(216) 871-4885

Environmental Mgmt Technologies
26881 Vista Terrace
Lake Forest, CA 92630
(714) 583-0512

Sanborn Environmental Systems
25 Commercial Dr.
Wrentham, MA 02093
(800) 343-3381, (508) 384-3181

Ferguson Industries
Dynamic Process Industries Div.
1900 W. Northwest Hwy.
Dallas, Texas 75220
(214) 556-0010

E & K Sales, Inc.
14730 E. Firestone Blvd., Unit 307
La Mirada, CA 90638
(714) 670-0988

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SEMI-SYNTHETIC AND SYNTHETIC COOLANT SUBSTITUTION

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Conventional Cutting Fluids
Applicable EPCRA Targeted Constituents: Spent Halogenated and Non-Halogenated Solvents, Methylene Chloride, 1,1,1 Trichloroethylene, Trichlorofluoromethane, Xylene, And Acetone, Depending On Application And Contaminants.

Overview: Semi-synthetic and synthetic coolants typically have longer useful lives, and thus require fewer changeouts, than conventional oil-based cutting fluids. Semi-synthetic and synthetic coolants are also more resistant to problems such as rapid bacterial growth, which is often the reason coolants are disposed of prematurely. At a typical shop, the personnel change cooling fluid when it emits a rancid odor. The odor is caused by anaerobic bacterial growth and does not indicate that the cutting fluid has lost its cooling and lubricating properties. However, the presence of microorganisms over a period of time can cause coolants to degrade. The resulting adverse condition of the coolant include foul odors, clogged transfer lines, changes in pH, and splitting emulsions. These conditions can affect the quality of the final product.

The coolant is typically removed from the cutting machine's sumps when the odor of the bacterial growth overpowers shop personnel. On average, the coolant is removed from the cutting machines every 3 weeks. The time between fluid change is usually 2 to 3 weeks in the summer months, while it is extended to 3 to 4 weeks during the winter. This is due to the variance of temperature and moisture, both of which affect the rate of bacterial growth.

Several DOD facilities have switched to a semi-synthetic coolant with considerable success. Personnel at Portsmouth Naval Shipyard in New Hampshire, code 120, have tested semi-synthetic coolants, among others Castrol TLS-995. This effort was conducted as part of a NAVSEA machine shop modernization program to determine cutting fluid pollution prevention alternatives among eight naval shipyards. The results showed that the semi-synthetic coolant had been in use for over 6 months without changeout or experiencing the bacterial growth problems encountered at other facilities which use oil-based coolants. By switching to a semi-synthetic coolant that would last 6 months, an activity can reduce the amount of coolant waste by almost 90%, as evidenced at NADEP Norfolk.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Materials

Compatibility: N/A

Safety and Health: There are mild dermal and eye irritation effects associated with these compounds. Personal protective equipment should be used.

Consult your local health and safety personnel, and the appropriate MSDSs prior to using these materials.

Benefits: Using a semi-synthetic or synthetic coolant can:

- Reduce coolant waste by as much as 90%
- Lower disposal costs
- Reduce coolant replacement costs

Disadvantages: • Semi-synthetic and synthetic coolants cost more than oil-based coolants

Economic Analysis: The extra expenditure in purchasing semi-synthetic and synthetic coolants is offset by the savings incurred from the petroleum-based coolant waste disposal costs and coolant replacement costs.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Charles Tittle, Sea OOTB
Naval Sea Systems Command
2531 Jefferson Davis Hwy.
Arlington, VA 22242-5160
DSN 332-3594, (703) 602-3594

Thomas Blackmer
Portsmouth Naval Shipyard, Code 120
Portsmouth, New Hampshire

Luis Reyes
Code 421
Naval Facilities Engineering Service Center
1100 23rd Ave.
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Vendors: The following is a list of synthetic metal cutting fluid coolant manufacturers. This is not meant to be a complete list, as there may be other manufacturers of these products.

Environmental Management Technologies
27766 Deya
Mission Viejo, CA 92692
(714) 583-0512

Castrol Industrial East Inc.
775 Louis Dr.
Warminster, PA 18974
(215) 443-5220

Cincinnati Milacron
Cincinnati, OH 45209
(513) 841-8100

Spartan Chemical Co., Inc.
110 N. Westwood Ave.
Toledo, OH 43607
(800) 537-8990

Orelube Corp.
201 East Bethpage Rd
Plainview, NY 11803
(516) 645-9124

Hyde Products, Inc.
29045 Ranney Parkway
Cleveland, OH 44145
(216) 871-4885

Finnish Engineering Co.
921 Greengarden Road
Erie, PA 16501-1591
(814) 455-4478

Sanborn Environmental Systems
25 Commercial Drive
Wrentham, MA 02093
(800) 343-3381, (508) 384-3181

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ANTIFREEZE RECYCLING (ON-SITE AND OFF-SITE)

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: N/A
Substitute for: Single Use of Antifreeze/Ethylene Glycol
Applicable EPCRA Targeted Constituents: Ethylene Glycol And Heavy Metal Contaminants That Include Arsenic, Barium, Lead, Chromium, And Copper Compounds

Overview: Recycling of spent antifreeze solutions is a viable alternative to disposing of these products, which may be considered hazardous in some states due to the toxicity of the ethylene glycol component, the toxicity of the products of degradation/oxidation of ethylene glycol, and/or the heavy metals content.

Several reclamation systems are available for on-site recycling of waste antifreeze. The systems are designed to provide maintenance managers with a cost-effective solution to potentially serious environmental and maintenance problems. Currently, there are two DOD-approved recycling systems (in addition to many other manufacturers of equipment, and also recyclers) for waste anti-freeze originally procured under MIL-A-46153. One system uses ion exchange, and the other uses vacuum distillation as the primary separation/purification processes. These systems filter solids (precipitants) from the spent antifreeze, as well as remove the metal ion contaminants from the solution. The coolant solution is restored to its initial state and is essentially as good as a new antifreeze/deionized water coolant mixture. The two DOD-approved recycling systems work with either ethylene or propylene glycol (not yet approved for use in military vehicles), but each must be processed separately. These systems are relatively user-friendly, compact (~4' x 4'), portable (on wheels or can be mounted on a trailer or truck), and simple to maintain.

Of the two DOD-approved systems, the distillation unit produces the most waste residue. Residue production is on the order of 3 gallons of residue (likely hazardous waste due to lead contamination greater than 5 ppm, but only Toxicity Characteristics Leaching Procedure [TCLP] analyses can verify with certainty that the waste has this hazardous characteristic) per 75 gallons of spent antifreeze. However, the manufacturer claims that a batch of accumulated concentrated residue can itself be processed as a batch to further reduce the total volume of waste produced. The ion exchange unit does not produce any hazardous waste (HW) per se, because the metal ions concentrate in the ion exchange beds. It does, however, require filter replacement, and since solids accumulate inside the spent filters, they are considered hazardous

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

waste, unless TCLP testing proves otherwise. Once the ion beds are spent they must be shipped back to the manufacturer for regeneration. The spent beds are not generally treated as HW.

Off-site recycling of antifreeze is also possible through companies that specialize in this area. Some of these companies charge for recycling and restoration of the antifreeze back to standard specifications so that it may be returned to the original user as good as new. Other companies charge a handling fee, and recycle and restore the antifreeze to sell to other users.

Materials

Compatibility:

Ethylene and propylene glycols are formulated so that they are compatible with most engine cooling systems. Additives are included in the formulations to minimize metal corrosion and to inhibit formation of acidic compounds due to the high-heat operating conditions. Some old formulations may not be suitable for use in systems containing aluminum. Contact the original equipment manufacturer and the antifreeze manufacturer for specific material concerns.

Glycol recycling equipment is manufactured to withstand the most severe chemical conditions of used anti-freeze. However, special concerns or cases may require consultation with the manufacturer. Follow manufacturer directions carefully when combining additives to bring recycled glycol back to Mil-Spec conformance.

Safety and Health:

Handling heavy metal contaminants can be dangerous to human health. They are experimental carcinogens and teratogens and skin adsorption is a major health concern. Ethylene glycol can be irritating to the skin, eyes and mucous membranes. It can also be toxic if inhaled. Proper personal protection equipment is therefore recommended. Consult your local health and safety personnel, and the appropriate MSDS for specific precautions.

Benefits:

Recycling antifreeze helps:

- Reduce coolant storage, transportation, and purchasing requirements
- Minimize production and storage of HW
- Protect the environment by reducing the amount of HW produced by at least 95 percent
- Save generators thousands of dollars in HW disposal costs annually
- Reduce hazardous material cleanup costs associated with spills, leaks, or soil and groundwater contamination from stored HW

Disadvantages:

N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Economic Analysis: Recycling economics will vary, depending on whether on-site or off-site recycling is chosen, and the amount of spent antifreeze generated.

On-Site Recycling Economics:

In general, a one to three year payback can be expected for an average installation. Preliminary operating cost data with the two DOD-approved units seems to indicate that for comparable situations the ion exchange unit has a higher overall operating cost. More explicit cost data are available for testing of another (unapproved) unit. The cost data are as follows:

- Assumptions

- 55-gallon-per-batch unit
- \$8/gallon fresh antifreeze
- \$200/55-gallon drum for disposal of waste antifreeze
- Estimated labor requirement of 2 work hours/55-gallon batch @ \$40 per labor hour burdened labor cost
- \$700/yr operating and maintenance costs for a system installed at the Naval Air Warfare Center, Aircraft Division, Lakehurst
- Typical Application: 550 gallons/year per activity (10 batches)

• Total Installed Capital Cost:	\$12,000
• Annual O & M Costs:	\$1,500
• Total Costs First Year:	\$13,500
• Annual HW Disposal Savings:	\$2,000
• Annual Avoided Antifreeze Costs:	\$4,400
• Total Annual Savings:	\$6,400
• Payback Period:	~2 years

Off-Site Recycling Economics (Product to be returned for reuse):

- Assumption:

- \$200/55-gallon drum for disposal of waste antifreeze
- Recycling Cost Per Gallon: \$2.50
- Glycol Addition Per Gallon: \$3.44
- Total Cost Per Gallon For Antifreeze Processing: \$5.94
- Average Cost For Processing *55-Gallon Drum \$170.00
- HW Disposal Savings Per Gallon \$30.00

*Dollar savings is incurred for processing on a 55-gallon drum basis as opposed to on a per-gallon basis.

Off-Site Recycling Economics (Product to be sold by recycler):

- Assumption:

- \$200/55-gallon drum for disposal of waste antifreeze
- Handling Cost Per Gallon \$0.85
- Average Cost For Handling 55-Gallon Drum \$46.75

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

- HW Disposal Savings Per Gallon \$153.25

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Mr. Dwayne Davis, Chemist
TARDEC, Fuels and Lubricants Division
Fort Belvoir
DSN 654-3720, (703) 704-3720

For information on the process and economic evaluations of the two DOD approved systems and development of a military specification for a propylene glycol based antifreeze.

Charles Tittle, SEA OOTB
Naval Sea Systems Command
2531 Jefferson Davis Hwy.
Arlington, VA 22242-5160
DSN 332-3594, (703) 602-3594

Mr. Luis Reyes
Code 422
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-6514, DSN 551-6514, Fax (805) 982-4832

Hazardous Technical Information Services
Defense General Supply Center
8000 Jefferson Davis Highway
Richmond, VA 23297-5609
(800) 848-4847 or DSN 695-5168
Fax (804) 279-4194 or DSN 695-4194

Vendors:

The following is a list of vendors of on-site recycling units and off-site recycling services. This is not meant to be a complete list, as there may be other vendors of equipment and services for antifreeze recycling.

On-Site Recycling Hardware:

DOD Approved Systems available from DGSC (800) 352-2852:
BG Products, Inc., manufacturer of an ion exchange processing system called "Cool'r Clean'r System" capable of processing up to 180 gallons/hour. Filter replacement is required every 200 to 500 gallons, and two supplemental additives (BG) are also necessary. 110V or 220V

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

power is required. The following NSNs include all the start-up supplies necessary to use the “Cool’r Clean’r System” (not available in kit form and must be ordered individually):

- NSN: 6850-01-380-9047 (with 1 set of filtration tanks) ~\$8,500
- NSN: 6850-01-380-9034 (with 2 sets of filtration tanks) ~\$10,000
- NSN: 6850-01-382-0628 Cleaning compound ~\$240
- NSN: 6810-01-381-9299 Charcoal filter ~\$100
- NSN: 6810-01-381-7201 Charcoal filter ~\$90
- NSN: 6850-01-383-0366 Corrosion inhibitor ~\$70
- NSN: 6850-01-383-0343 Corrosion inhibitor ~\$100
- NSN: 6810-01-381-9241 Activated charcoal ~\$28.50

Finish-Thompson
921 Greengarden Road
Erie, PA 16501-1591
(800) 934-9384, Fax (814) 455-8518
Mr. Louis A. Nichilo, Inside Sales Manager

Manufacturer of vacuum distillation units known as BE Series Recycling Systems, BE-15C (a 15-gallon/batch processing system) and BE-55C (a 55-gallon/batch processing system), with processing rates of 1 and 3.2 gallons per hour, respectively. Power requirements for the BE systems are 240V only; 20 amp for the BE-15C, and 40 amp for the BE-55C. Heaters are band or immersion style. Systems can be equipped with a diverter valve that automatically switches from atmospheric to vacuum operation; atmospheric pressure to remove the water, and vacuum to distill the glycol. After most of the water is removed, the boiling temperature rises rapidly. The unit can then switch to vacuum operation in order to drop the boiling point and prevent scorching of the glycol solution. The flexibility provided by the atmospheric/vacuum operating capability should also speed processing, compared to units that operate only at a fixed pressure. No filter replacement is necessary, but distillation residue remains after processing and must be considered hazardous waste. The processing units are available by ordering the following:

- NSN: 6850-01-387-5654 (BE-15C) ~\$4,800
- NSN: 6850-01-387-2551 (BE-55C) ~\$11,300

A supplemental additive called “Remilfth-55” is also necessary when using the units. The BE Series start-up supplies come in kit form containing a pump primer, coolant treatment, and an output receiver. Order kits as a unit by using the following NSNs:

- NSN: 6850-01-387-1136 (BE-15C start-up kit) ~\$500
- NSN: 6850-01-387-1099 (BE-55C start-up kit) ~\$300

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These two systems are certified to meet the specifications of antifreeze originally procured under MIL-A-46153. Using other recycling systems, services, or products may not adequately recycle MIL-A-46153 antifreeze or may produce a product that is incompatible. Furthermore, do not use Antifreeze Extender Additive, MIL-A-53009, with recycled antifreeze, as it may be chemically incompatible and cause damage to the cooling systems. Replace recycled antifreeze after determining that the corrosion additives are depleted by using the antifreeze test kit, NSN: 6630-01-5034. For items under warranty, follow the manufacturer's recommendations until the warranty has expired.

Other Vendors Of On-Site Recycling Systems:

FPPF Chemical Company, Inc.

117 W. Tupper St.

Buffalo, NY 14201

(800) 735-3773

Kleer-FLO Co.

15151 Technology Dr.

Eden Prairie, MN 55344

(800) 328-7942

KASCO, Inc.

4481 Beech Road

Temple Hills, MD 20748

(301) 423-5888

Off-Site Recycling Services:

Antifreeze Environmental Service Corp.

16031 E Arrow Hwy., Unit H

Irwindale, CA 91706

(818) 334-1835

American Fluid Technology

10654 Balboa

Grenada Hills, CA 91344

(818) 832-1188

Propylene Glycol Products:

Vehicle Radiator Coolant (no Mil-Spec approved yet for propylene glycol use):

NSN: 6850-01-383-3918 (DR-55 gallon), \$270.05/drum

NSN: 6850-01-383-4068 (GL), \$17.94/gallon

NSN: 6850-01-383-4244 (BX, 6 1-gallon bottles), \$30.66/box

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SUBSTITUTION AND RECYCLING OF AIRCRAFT DEICING PRODUCTS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Disposal Of Aircraft Deicing Fluids As Hazardous Waste
Applicable EPCRA Targeted Constituents: Ethylene glycol

Overview: Deicing fluids usually become diluted during application onto an aircraft as a result of precipitation or when ice on the aircraft's fuselage melts after the deicing fluid is applied. In this impure and diluted form, the deicing fluids cannot be reused and disposal can be costly since most of these fluids contain ethylene glycol, which is regulated as hazardous waste in some states. Recycling of ethylene glycol deicers or substituting these deicers with more environmentally friendly products are feasible pollution prevention opportunities.

Substitution of environmentally-preferred propylene-glycol-based deicing solutions for ethylene-glycol-based solutions may help mitigate environmental problems. Ethylene glycol, long the standard component of antifreeze and deicing products, is a highly soluble chemical that greatly increases the BOD of receiving waters, and it is also quite toxic to mammals at relatively low concentrations. Propylene glycol actually exerts a higher BOD, but it is non-toxic; in fact it is a common additive to cosmetics, medical products, and pet foods. Use of propylene-glycol-based products represents the current best choice for aircraft deicing unless, of course, the mission can be delayed during inclement weather or heating systems (for example, infrared heaters) can be carefully deployed. The military specification covering aircraft deicing fluids is MIL-A-8243, which specifies two products: Military type I deicers that are propylene glycol based, and Military type II deicers that are ethylene glycol based (three parts ethylene glycol and one part propylene glycol). The Military type I fluid is currently the deicer of choice, and should always be specified unless some very specific need requires the ethylene-glycol-based, type II solution. (The Military types I and II are not the same, and should not be confused with the commercial S.A.E. type I and II fluids, which are formulated per Aerospace Material Specifications, AMS 1424 and AMS 1428, respectively.)

There are other options for replacing ethylene glycol (and propylene glycol) in certain applications. The deicing products potassium, magnesium, sodium, or calcium magnesium acetates and urea pellets are better suited for airfield pavement application than the glycols, both of which are being phased out for direct pavement deicing. Isopropyl alcohol is also approved for airfield deicing, but is operationally limited, due to its high volatility which results in fumes that can be carried inside

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aircraft. The preferred replacement products for airfield surfaces are the acetates because they are non-toxic and almost entirely biodegradable. Potassium acetate is formulated in a 50% solution and applied as a liquid. Sodium acetate is a granulated product that is applied to pavement in the same fashion as urea pellets. Urea products are still used, but they are not the products of choice because of the ammonia nitrogen's toxicity to aquatic life. To eliminate the toxicity, somewhat complicated nitrification/ denitrification treatment is required for wastewater containing ammonia-nitrogen-rich compounds like urea. In addition, urea products are not as versatile as acetate products, especially for low temperature situations, due to the relatively high temperature to which urea depresses the melting point of ice, at best about 15°F. Functionally, urea pellets are usually not applied when temperatures are much below 25°F.

Some facilities contract with recyclers to recover and process glycol for reuse. There are two common recovery methods. The diluted glycol fluids are either concentrated using evaporation or membrane separation to enable their reuse as antifreeze agents, or they are concentrated and then purified using fractional distillation. The concentrated glycol solutions can be used where quality considerations are not important; for example, to spray onto coal so that it will not freeze in a railcar when ready to unload. The purified glycol can be used for blending with virgin feedstock to make new antifreeze and other new glycol-based products.

Because of the high BOD exerted by the glycols, they are not readily sewered either to surface water or to a wastewater treatment plant. Thus, if the spent deicing fluids can not be recycled easily or economically, they should at least be contained and collected to allow treatment and disposal. Some treatment options are available to handle spent deicing fluids; for example, biological degradation using a semi-continuous anaerobic process to convert glycols and low concentrations of any other organic contaminants, such as fuel, oil, or grease, into carbon dioxide and methane.

Materials

Compatibility:

Propylene-glycol-based anti-freeze formulations should not be mixed with any other chemicals, anti-freeze formulations, or similar products made by different vendors without first carefully verifying compatibility. These products should also be stored in dedicated, labeled containers. Commercial S.A.E. type I (deicing attributes only, not shear sensitive) glycol deicing fluids are generally compatible with common materials of construction. Therefore, stainless steel, mild steel, lined steel, or reinforced plastic are acceptable. Piping and any ancillary

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equipment should also use only the same compatible materials. One incompatible material, galvanized steel, should never be used in any glycol service.

Commercial S.A.E. type II (shear sensitive fluid with anti-icing attributes) glycol fluids are also relatively compatible with common materials of construction, but have a slightly narrower range of material compatibility. Stainless steel or reinforced plastic are the preferred materials of construction for shipping or storage containers for commercial type II fluids by at least one vendor. However, mild steel can be used for commercial type II fluids, provided the container has a chemically resistant liner like polyurethane or phenolic epoxy resins. Piping and any ancillary equipment should also use only compatible materials, such as stainless steel or plastic.

Potassium acetate formulations should meet all the standards established under AMS 1432 for corrosion and materials compatibility. Its product formulation does contain some corrosion inhibitors which, when exposed to low alloy metal or steel surfaces, forms a barrier on the metal surface to prevent accelerated corrosion. To prevent depletion of the inhibitors, shipment and storage is recommended in plastic (polyethylene) or stainless steel containers. Shipment or storage in low alloy or steel containers can result in fluid degradation.

Granulated sodium acetate products should meet all the standards established under AMS 1431A. Granulated sodium acetate is typically supplied in polyethylene lined containers, but is also compatible with mild steel, as well as stainless steels, plastics, glass, and polyester-reinforced fiberglass.

Safety and Health: Ethylene glycol is toxic to mammals if ingested and attracts animals because of its fragrant odor and sweet taste. Propylene glycol is non-toxic to mammals. Nevertheless, personal protective equipment such as chemical splash goggles, impervious gloves, and splash aprons should be considered for most handling operations. Consult your local health and safety personnel and the appropriate MSDS for specific precautions.

Benefits: Substitution or recycling helps:

- Reduce the amount of hazardous waste generated
- Save thousands of dollars in hazardous waste disposal costs annually
- Eliminate hazardous material cleanup costs associated with spills, leaks or soil and groundwater contamination

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Economic Analysis: Economics must be analyzed on a case-by-case basis after considering the unique variables of each site. In general, the more dilute the solution and the larger the volume generated, the more feasible on-site recycling becomes. Other considerations include distance from the recycle facility, frequency of generation, storage availability, amount of coincident precipitation, cost of labor, and cost of real estate and site preparation.

Note: Comparisons with and evaluation of anti-freeze recycling equipment for aircraft deicing fluid recycling should not be made. Deicing fluids are always more dilute than anti-freeze solutions and contain different types of contaminants. Deicing fluids come in contact with external surfaces of aircraft and are likely to contain various soils, but no glycol oxidation products. Antifreeze can contain heavy metals, glycol oxidation products (primarily organic acids), and precipitated salts from prolonged use.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Dr. John Boodey
Warminster Naval Air Station/Warfare Division
DSN 441-1423 or (215) 441-1423
For information on the MIL-A-8243.

Mr. George Legarreta
Office of Airport Safety and Standards
Federal Aviation Administration
(202) 267-8766
For information on commercial and federal efforts to control aircraft deicing fluid discharges.

Mr. Jesse Marzette
Pollution Prevention Manager
Headquarters Air Force Reserve
HQ AFRES/CEVP
DSN 497-1067 or (912) 327-1067
For information on aircraft deicing fluid recovery systems.

Chief Master Sergeant Wayne McGlothlin
Air Force Civil Engineering Support Agency (AFCESA)
DSN 523-6466, (904) 283-6466
For information on airfield deicing.

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Ms. Susan Stell
Headquarters Air Force Reserve
HQ AFRES, Robins AFB
DSN 497-1078 or (912) 327-1078
Mr. Gus Zachariades, Staff Chemist
Product Engineering Division
San Antonio Air Logistics Center (SA-ALC/SFTT)
DSN 945-7613, (210) 925-7613
For information on aircraft deicing fluid formulations.

Vendors: The following is not meant to be a complete list as there may be other manufacturers of similar products or suppliers of similar services.

Biological Treatment Systems for Spent Glycols:

AAA Environmental Services Corporation
1800 Second Street, Suite 808-13
Sarasota, FL 34236

(813) 953-5300, Fax (813) 953-5353

Manufacturers an anaerobic biofilter system for treating aircraft deicing fluids and small fuel spills prior to discharge to either a publicly-owned treatment works or directly to a receiving waterway under a NPDES permit.

Mr. Thomas G. Cannon and Mr. Al J. Keyser

Deicing Fluid (Glycol) Recycling:

ECOLO Corp Inc.
1515 Jefferson Highway, Suite 817
Arlington, VA 22202

(202) 429-0247, Fax (202) 429-8787

Reprocesses spent aircraft deicing fluids (glycols) into purified glycol by evaporation and fractional distillation, and has a current contract with the Greater Pittsburgh International Airport.

Mr. Lee Howar

Glycol Specialists,
c/o Silco Distributing Co.
Denver, Colorado

(303) 292-2000, Fax (303) 292-0429

Designs, sells, and operates systems that can concentrate (by membrane technology) and purify (by chemical pretreatment and distillation) spent aircraft deicing fluids. Recovered glycols are sold to the commercial market. Has current contract to recover glycols at the new Denver International Airport. Large quantities are usually processed on site (airfield), but can process small generators' fluids off site. Systems are custom built and can be either owner-operated or contractor-operated.

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Mr. Rick Silverberg, Mr. Jim Hamilton, or Mr. Lee Durrwachter

Propylene Glycol Products:

Aircraft Chemical Deicing (type I) MIL-A-8243D

NSN: 6850-01-281-0338 (DR-55 gallon)

NSN: 6850-01-451-8153 (Pint can)

NSN: 6850-01-281-0340 (DR-55 gallon)

NSN: 6850-01-281-0339 (Pint can)

ARCO Chemical Company

3801 West Chester Pike

Newton Square, PA 19073-2387

(800) 321-7000, (610) 359-5540

Ms. Diane A. Kooker, Customer Support Representative

ARCO Chemical manufactures ARCOPLUS® (Commercial type I) and KILFROST ABC-3® (Commercial type II) propylene-glycol-based deicing fluids.

Acetate Product Vendors For Airfield Deicing:

Ashland Chemical Company

IC&S Division

5200 Blazer Parkway

Dublin, Ohio 43017

(614) 889-3863, Fax (614) 889-3465

Distributor of potassium acetate formulation Cryotech E36™ brand Liquid Runway Deicer, calcium magnesium acetate formulation Cryotech CMA™, and sodium acetate formulation Cryotech Clearway 2s.

Mr. Bob Strawn, Marketing Director
or Mr. Tony Myhra, Product Manager

Old World Industries, Inc.

4065 Commercial Avenue

Northbrook, IL 60062-1851

(708) 559-2085

Distributor of potassium acetate brand Safeway KA deicing liquid.

Potassium acetate is available by ordering NSN: 6850-01-341-9855 (55 gallon drum).;

Source(s): PA Technical Inquiries 2182, 3183, 3383, and 3827.
HTIS Bulletin, Vol. 5, No. 1, Jan/Feb 95.
Ashland Chemical Technical Bulletin 2105.
ARCO Chemical Technical Bulletins ARCOPLUS 10/93 and Kilfrost ABC-3 10/93.
Strawn, R. J., "Cryotech E36™ Liquid Runway Deicer," *Conference Proceedings of the Air Force 1993 Worldwide Pollution Prevention Conference & Exhibition, San Antonio, Texas*, p. 325-336, June 93.

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CORRUGATED CARDBOARD

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Corrugated cardboard is made from strong, good quality wood fiber and includes un-waxed cardboard boxes and brown paper bags. Paperboard cartons such as cereal boxes and other non-corrugated boxes cannot be recycled as cardboard. Waxed cardboard used for packaging fresh vegetables is contaminated and cannot be recycled. It can be composted, however. Cardboard generation on base is widespread and contributes significantly to the waste stream. It is universally marketable, profitable, and easily processed. It is reportedly the largest single source of waste paper for recycling, comprising 46 percent of all waste paper recycled in the U.S. (American Forest and Paper Association, 1994).

The simplest and most cost effective method for reducing the amount of cardboard in waste is by producing less of it (source reduction). Many suppliers over-package goods because they believe that is what the customer wants. If an item can be delivered with less cardboard or other packaging, negotiate with the supplier to redesign it.

If source reduction is not an option, recycle the cardboard. The first step in setting up a recycling program is to identify local markets and contact paper dealers to determine dealer and end-user requirements. Some dealers require that it be baled, others will take it loose. The regular waste hauler may also be willing to separately collect the corrugated cardboard, depending on the volume generated and the availability of local markets. This may be not desirable however, since cardboard recycling generates significant revenue.

There are four ways to methods of processing corrugated containers for storage and marketing: loosely bundling, flat packing, baling, and piling in roll-off containers. Small quantity generators generally flatten boxes and tie them, loosely bundled. Flat packing is similar except that flattened boxes are stacked on a pallet about shoulder high and then banded. Balers are commonly used by small, medium and high generators of cardboard for compacting into stackable rectangles. The bales are much easier to handle and move than bundled cardboard and can be picked up with a forklift. Baling sometimes increases the market value of the cardboard. For larger generators, a roll-off compactor or stationary dumpster may be used for collecting loose, flattened

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cardboard. These containers will typically hold 30 cubic yards. A dealer may be willing to provide a roll-off container on base if it can be filled quickly; about once per week on a consistent basis.

If cardboard recycling is not possible, it can be composted. The cardboard should be shredded so that it will mix with other materials and decompose quickly.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits:

- Recycling corrugated cardboard can potentially reduce the volume of waste disposed by an average of 12.7% (EPA, 1994)
- Cost savings are incurred from reduced landfill disposal fees
- Money is generated from the sale of the cardboard

Disadvantages: N/A

Economic Analysis: Capital costs for a cardboard recycling system will depend on the selected handling systems. Recycling trailers (16 ft by 7 ft by 8 ft) for collecting loose, flat corrugated cardboard will cost approximately \$4,000 to \$5,000 each. Capital costs for balers range from \$37,000 to \$150,000, depending on the model type and capacity required. Operating costs for a cardboard recycling program include labor costs for a coordinator/monitor, collection costs (if applicable), materials handling costs (if applicable), and transportation costs to deliver the material if pick-up service is not arranged with the contractor. These operating costs are usually offset by savings incurred from reduced landfill disposal fees and revenue from the sale of the cardboard. Market prices for cardboard are currently \$15 to \$30/ton, based on recent surveys in selected regions, with prices on the west coast generally higher (\$80 to \$110/ton).

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Rachel Lichtman, Communications Manager
Fibre Box Association and Corrugated Packaging Council
2850 Golf Road
Rolling Meadows, IL 60008
(708) 364-9600, (800) 879-9777 (24-h toll-free number)

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American Forest and Paper Association
1111 19th Street, N.W.
Washington, DC 20036
(800) 878-8878, FAX: (202) 463-2785

PaperMatcher Recycling Directory
(publication of the American Forest and Paper Association)

Montgomery County
Department of Environmental Protection
101 Monroe Street
Rockville, MD 20850
(301) 217-2380, Recycling Hotline: (301) 217-2870

Local and state solid waste management government authorities.

Vendors: See Equipment - Balers and Recycling Trailers.

Source: Montgomery County Department of Environmental Protection, *Your Guide to Recycling: Used Corrugated Cardboard*.
EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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ALUMINUM CANS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Aluminum cans have rapidly been replacing steel cans in the beverage can market and provide a “cash crop” for many recycling centers due to the high prices paid for aluminum. Recycled aluminum saves 95% of the energy required to make new aluminum from raw materials, and therefore maintains a high market value. In addition, many states put a deposit value on aluminum beverage cans. Aluminum cans are currently recycled by many military installations due to their value, marketability, and public awareness of the recyclability of aluminum. Although recycling aluminum cans will not significantly reduce the waste stream, their high value and ease of collection can provide a good return that will sustain a recycling program that collects lower value items.

Recycled aluminum beverage cans are generally marketed to aluminum can manufacturers where the material is processed into can sheet for the production of new beverage containers. Aluminum mills are another market where recycled aluminum can be used in the manufacture of other products made from aluminum. Scrap metal dealers and traders can also be very competitive for aluminum cans, offering higher than market prices on occasion. Steel mills or foundries use aluminum cans to help remove chemical contaminants from steel, and secondary smelters consume a small percentage of the aluminum beverage can market.

Mechanical extraction of aluminum from commingled recyclables or mixed solid waste is being developed but is not yet feasible on a commercial scale. Source-separated aluminum cans are preferred by recycling centers. Aluminum cans can be source separated by base residents and personnel participating in curbside or voluntary drop-off collection programs or manually separated at a materials recovery facility. In addition, the base could purchase or lease one or more outdoor aluminum can recycling machines (e.g., Golden Goat) to encourage recycling among base residents and personnel by paying the consumer for the used cans. Many recycling centers also accept aluminum foil, food trays, and castings.

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Cans can be crushed or baled to reduce storage and transport space requirements. The amount of processing required depends on the needs of the buyer.

Materials

Compatibility: N/A

Safety and Health: Proper personal protective equipment such as long sleeves and gloves should be worn when handling scrap metal.

Benefits:

- Recycling aluminum cans can reduce the volume of waste disposed in the landfill by somewhat less than 1% (EPA 1994)
- Energy conserving
- Conserves natural resources needed to produce new steel or aluminum
- Reduced landfill disposal fees
- High market value for relatively simple collection and processing
- Simple or no processing equipment needed

Disadvantages: N/A

Economic Analysis: Metal can recycling can easily be incorporated into residential and commercial/industrial recycling programs with minimal additional capital costs. The same collection containers used for curbside collection of residential recyclables can be used for metal can collection. Dedicated collection containers could be purchased for offices or other commercial/industrial areas to increase metal can recovery from the commercial/industrial waste stream. Operating costs for recycling steel and aluminum cans include labor costs for a coordinator/monitor, collection costs (if applicable), materials handling costs (e.g., separation of metal by type), and transportation costs to deliver the material if pick up service is not arranged with the contractor. These operating costs are typically offset by savings incurred from reduced landfill disposal fees and revenue from the sale of the aluminum and steel.

Capital costs for purchase of a Golden Goat would be approximately \$20,000 per unit. Operating costs would include electricity, maintenance activities (e.g., cleaning of the unit, trash removal, coin loading), consumer revenue, and transportation costs to deliver the cans to market.

Market prices for aluminum range from \$350 to \$800/ton from local recycling centers, with prices on the west coast considerably higher (greater than \$1,000/ton). Higher market prices are generally obtained for good quality (uncontaminated) metal cans.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Can Manufacturers Institute
1625 Massachusetts Avenue, N.W.
Washington, DC 20036
(202) 232-4677, FAX: (202) 232-5756

Vendors: Aries Aluminum Corporation (Golden Goat vendor)
7686 Fishel Drive N.
P.O. Box 128
Amlin, Ohio 43002
(800) 572-0877

Source: EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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STEEL CANS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Steel cans containing food and drinks are a major component of ferrous metals in the solid waste stream. The steel category includes bi-metal cans (steel cans with an aluminum top), and tin cans (steel cans coated with tin). Although steel cans contribute only a small amount to the waste stream, they have a fair market value and recycling saves energy and resources.

The marketability of steel cans depends on the form and purity of the recovered scrap. The three major potential markets (steel industry, foundries, and de-tinning companies) have specifications for purchasing post-consumer steel cans that vary markedly. There are a number of methods for processing steel cans; therefore, it is essential to arrange a market prior to processing the cans to ensure that the preparation process will be acceptable. There is equipment available to compress the cans, removing the contents and contaminants. This clean, compressed steel is more marketable and has a higher value. The steel industry is the largest end-user of recycled steel cans. Recycling is an integral part of the steel making process; all steel cans produced domestically contain about 25 percent recycled steel.

Magnetic separation makes steel cans easy to reclaim from commingled recyclable material. Alternatively, steel cans can be source separated by base residents and personnel participating in curbside or voluntary drop-off collection programs. Processing requirements for steel cans vary, but generally cans should be rinsed. Labels do not need to be removed, and lids can also be recycled (including steel lids from glass and plastic bottles). In addition to steel food and beverage containers, empty steel paint and aerosol cans are also accepted by the steel industry for recycling. Paint cans do not need to be rinsed, but the thin layer of skin paint remaining in the empty can must be dry. Aerosol cans must be completely empty, with the plastic lid removed (spray nozzles do not need to be removed for recycling). Can scrap may be baled, bundled, or shipped loose to the recycling facility. There may be specific requirements for bale size and density or bundle weight and density.

Materials
Compatibility: N/A

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Safety and Health: Proper personal protective equipment such as long sleeves and gloves should be worn when handling scrap metal.

Benefits:

- Recycling “tin” cans can reduce the volume of waste disposed in the landfill up to a national average of 1.3 % (EPA 1994)
- Energy conserving
- Conserves natural resources needed to produce new steel
- Reduced landfill disposal fees
- Simple or no processing equipment needed

Disadvantages:

- May not be marketable in some regions
- Small quantities may not be economical to recycle

Economic Analysis: Metal can recycling can easily be incorporated into residential and commercial/industrial recycling programs with minimal additional capital costs. The same collection containers used for curbside collection of residential recyclables can be used for steel can collection. Dedicated collection containers could be purchased for offices or other commercial/industrial areas to increase metal can recovery from the commercial/industrial waste stream. Operating costs for recycling steel cans would include labor costs for a coordinator/monitor, collection costs (if applicable), materials handling costs (e.g., separation of metal by type), and transportation costs to deliver the material if pick up service is not arranged with the contractor. These operating costs are typically offset by savings incurred from reduced landfill disposal fees and revenue from the sale of the aluminum and steel.

Market prices for steel are currently \$0 to \$50/ton from local recycling centers based on recent surveys in selected regions. Higher market prices are generally obtained for good quality (uncontaminated) metal cans.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Steel Recycling Institute - Headquarters
Greg Crawford, V.P. of Recycling Operations
680 Andersen Drive
Pittsburgh, PA 15220-2700
(800) 876-7274

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Steel Recycling Institute - Northeastern Region
Paula Thompson, Recycling Manager
1740 Massachusetts Avenue
Boxborough, MA 01719
(508) 266-1847

Steel Recycling Institute - Central Eastern Region
Gary Gallo, Recycling Manager
680 Andersen Drive
Pittsburgh, PA 15220-2700
(412) 922-3049

Steel Recycling Institute - Mid Atlantic Region
Chuck Nettleship, Recycling Manager
5102 #2 West Village Green Drive, Suite 107
Midlothian, VA 23112
(804) 744-7408

Steel Recycling Institute - Southeastern Region
Suzette Miller, Recycling Manager
4400 Bayou Boulevard, Suite 16D
Pensacola, FL 32503
(904) 479-7208

Steel Recycling Institute - Southwestern Region
101 East Ninth Street, Suite 1104
Austin, TX 78701
(512) 472-3276

Steel Recycling Institute - Central Northern Region
Dave Keeling, Recycling Manager
8405 West Forest Home Avenue
Greenfield, WI 53228
(414) 529-8448

Can Manufacturers Institute
1625 Massachusetts Avenue, N.W.
Washington, DC 20036
(202) 232-4677, Fax: (202) 232-5756

Vendors: N/A

EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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GLASS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Glass food and beverage containers can be reused or recycled, and window, mirror, and other glass can be crushed for other uses. Glass comprises a significant portion of the waste stream, has a reasonable market value (with an added redemption value in some states), and people are generally aware that it is recyclable. A simple glass recycling program requires no processing equipment.

Glass should be reused if possible to reduce losses associated with recycling. Reusable bottles are found only in the wine and beer industry. Some beer companies bottle their product in reusable, heavier bottles, and sell them to bars and drinking establishments. Since the bottles never leave the site, they are easily returned to the manufacturer. Wine bottles are also made from a thicker glass and some wineries will accept them for refilling.

Recyclable glass is clear, brown, and green. The highest demand is for clear glass, followed by brown or amber glass. Green glass is generally undesirable, as there is typically an overabundant supply on the market. Broken mixed color glass has a low value, and may not be marketable at all. Beverage containers have a deposit value in many states, and the bottles are often worth more whole than crushed since it is possible to identify the deposit bottles. Long distances to markets may necessitate crushing the glass to lower transport costs. It can be broken into pieces called "cullet" with a glass crusher. Any food or beverage container made from glass is recyclable, even if it has no deposit value.

The primary market for recycled glass is in the manufacture of container glass. Competition for good quality recycled glass bottles and jars (i.e., free of contaminants) that are separated by color is particularly acute. Recycled glass is sold to end users as cullet. The cullet is generally sold to glass beneficiation facilities where it is cleaned and processed to meet the quality standards of glass container manufacturers. Contamination of recyclable glass is a serious impediment to glass container recycling. Contaminants that are present in the glass stream include non-recyclable glass, ceramics, metal caps, lids, and bottle neck rings, stones, and dirt. Standard separation equipment is available at beneficiary facilities to remove contaminants; however, there is no established technology for removing ceramics, and the current technology for removing non-

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ferrous metal (eddy current detectors) result in about 5% to 8% glass loss. The glass container industry maintains a high demand for reasonably priced cullet of good quality. Some states require minimum percentages of cullet in new glass containers and the glass manufacturing industry has announced an overall goal of 50% cullet use.

Other uses for cullet include the manufacture of building materials such as glass tile and composite wall panel, concrete applications, construction aggregate, industrial mineral uses, insulation applications, paving applications in road construction, and re-melt applications to make colored windows and stained glass.

Window glass, Pyrex, drinking glasses and other non-recyclable glass can be pulverized and turned into a fine sand that can be used in construction and other applications. These glass materials are of a different composition than bottle glass and are considered contaminants to the container glass industry.

Materials

Compatibility: N/A

Safety and Health: Precautions must be taken when handling glass. Safety gear such as heavy gloves, long sleeves, boots, and eye protection should be worn to protect handlers from broken and flying glass shards.

Consult the base safety office on procedures for handling glass.

Benefits:

- Recycling glass can reduce the volume of waste disposed in the landfill up to a national average of 5.7% (EPA, 1994)
- Cost savings are achieved from reduced landfill disposal fees
- Revenue is generated from sale of recyclable glass
- Pulverized glass can reduce the purchase of aggregate for construction
- Re-usable bar bottles can be less expensive than disposables

Disadvantages:

- Extreme care must be taken to avoid glass contamination
- Glass commodities market fluctuates frequently

Economic Analysis: Glass recycling can easily be incorporated into residential and commercial/industrial recycling programs with minimal additional capital costs. The same collection containers used for curbside collection of residential recyclables can be used for glass collection. Dedicated collection containers could be purchased for offices or other commercial/industrial areas to increase glass recovery from the

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commercial/industrial waste stream (see “Equipment--Recycling Containers”). Operating costs for recycling glass would include labor costs for a coordinator/monitor, collection costs (if applicable), materials handling costs (e.g., separation of glass by color), and transportation costs to deliver the material if pick up service is not arranged with the contractor. These operating costs are usually offset by savings incurred from reduced landfill disposal fees and revenue from the sale of the glass. Market prices for glass are currently \$0 to \$15/ton from local recycling centers, based on recent surveys in selected regions, with prices on the west coast considerably higher (\$10 to \$50/ton). A higher market price could be obtained if good quality glass is consistently delivered or the glass is delivered directly to a glass processing facility.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Local and state solid waste management government authorities.

Glass Packaging Institute, Western States
921 11th Street, Suite 1101
Sacramento, CA 95814
(916) 444-0491

Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon,
Utah, Washington

Kevin Hardie
Glass Packaging Institute, Midwestern Office
770 East 73rd Street
Indianapolis, IN 46268
(317) 283-1603
Illinois, Indiana, Kentucky, Ohio, Tennessee, Wisconsin

Glass Packaging Institute, Headquarters
1627 K Street, N.W., Suite 800
Washington, DC 20006
(202) 887-4850, Fax: (202) 785-5377
Connecticut, Iowa, Maine, Massachusetts, Michigan, Minnesota,
Nebraska, New Hampshire, North Dakota, Rhode Island, South Dakota,
Vermont, Wyoming

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Gail Ederer
Glass Packaging Institute, Southwest States
4825 South Peoria, Suite 4
Tulsa, OK 74105
(405) 447-9955, FAX: (918) 742-8342
Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico,
Oklahoma, Texas

Doug Gibboney
Glass Packaging Institute, Northeastern States
P.O. Box 1088
Carlisle, PA 17013
(717) 243-1738, FAX: (717) 243-1658
Delaware, District of Columbia, Pennsylvania, Maryland, Virginia,
West Virginia

Vendors: N/A

Sources: Diaz, L. F., et. al., 1993, *Composting and Recycling Municipal Solid Waste*, Lewis Publishers.
Glass Packaging Institute - Mid Atlantic States.
Reindl, John, June 17, 1993, *Reuse/Recycling of Glass Cullet for Non-container Uses*.
Resource Recycling, August 1994, *Removing Contaminants from Crushed Glass Containers*.
Resource Recycling, 1994, *Recycling Market Profile: Glass Containers*
EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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METAL AND PLASTIC DRUMS

Revision: 1/96
Process Code: Navy: SR-11-99; Air Force: HW01; Army: N/A
Substitute for: Disposal of contaminated drums
Applicable EPCRA Targeted Constituent: Lead, Chromium

Overview: Various hazardous materials and other chemicals used by the Navy are delivered in large plastic and metal drums. Empty drums are exempt from hazardous waste regulation in 40 CFR Section 261.7. For hazardous wastes that are not “acute” as listed in 40 CFR 261.31, 261.32, or 261.33, empty is defined as containing less than three percent of the original contents (by weight) or less than a one inch residue on the bottom. Drums that contained acute hazardous waste are empty after they have been triple rinsed with a solvent capable of removing the product. Rinse water should be tested for hazardous substances to determine the method of treatment required.

Empty drums in good condition can be re-used as collection containers for hazardous wastes, usually for the same type of product they originally contained. For example, used motor oil or oil soaked rags can be stored in a used oil drum. Damaged or excess metal drums can be washed and recycled as ferrous scrap metal.

Materials

Compatibility: Empty drums should be stored and handled as if the drums were still full (i.e., store incompatibles separately). Wash waters will contain the residues from the drums; therefore, segregation of incompatibles and proper treatment is essential.

Safety and Health: Consult your local industrial health specialist, the base safety office, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Re-using drums saves the cost of purchasing new ones
- Recycling of drums prevents them from entering the waste stream
- Recycling drums generates income

Disadvantages: Wastewater from drum rinsing may require special treatment depending on test results of the rinse water

Economic Analysis: N/A

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mike Viggiano, ESC 423
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-4895 DSN: 551-4895 FAX: (805) 982-4832

Julie Kerscher
Public Works Center
San Diego, CA 92136-5294
DSN 526-7999, (619) 556-7999 FAX: (619) 556-8000

Vendors: Enviro-Techniques Products Incorporated
120 Thadeus Street
South Portland, ME 04106
(207) 767-5510

Velcron
122 S. Avenue
P.O. Box 2230
Freeport, TX 77541
(409) 233-5461

Advanced Environmental Solutions
7118 South 220th Street
Kent, WA 98032
(206) 872-9011

FLUORESCENT LIGHT TUBES AND HIGH INTENSITY DISCHARGE LAMPS

Revision: 1/96
Process Code: Navy: SR-04-99; Air Force: PM06; Army: ELM
Substitute for: Disposal of used fluorescent light tubes and HID lamps
Applicable EPCRA Targeted Constituent: Mercury, Lead, Cadmium

Overview: Fluorescent lights, though more expensive initially, are cost-effective replacements for incandescent lights, not only because they last nine times longer, but also because fluorescent lights use just 25% of the energy of incandescent bulbs for equal light intensity. Fluorescent lights are a major source of lighting and are widely used by government agencies, as well as industrial, commercial, and residential customers. Their use is also expected to increase as a result of the EPA Green Lights Program, which is promoting the reduction of lighting-related energy consumption.

Despite these excellent attributes, fluorescent lights, and also high intensity discharge (HID) lamps, have one important drawback: relatively high environmental costs associated with their use; specifically, the disposal costs. Mercury and trace amounts of lead and other metals inside the tubes can cause used fluorescent light tubes and HID lamps to be considered hazardous waste, since both mercury and lead are regulated under the Resource Conservation and Recovery Act (RCRA). Even small quantities of these metals may be potentially harmful to human health and the environment, especially when mass quantities of used tubes are landfilled. Used fluorescent light tube disposal in municipal landfills is, in fact, considered the second largest source of mercury pollution entering the environment. These pollutants can often migrate into groundwater supplies or even become airborne (due to mercury's relatively high volatility), at which time they pose an even greater environmental threat. Thus, proper disposal and, especially, recycling of these tubes would help reduce and prevent heavy metal pollution.

Proper handling and disposal of used fluorescent light tubes and HID lamps is becoming an increasingly expensive and problematic chore for big users of these lights. The metal content of used lights usually exceeds the threshold levels qualifying them as hazardous waste. The mercury content of a typical fluorescent lamp is on the average of 25 to 30 mg/lamp. This is expected to fall as manufacturers improve their lamp design. Unfortunately, manufacturers' information on the heavy metal content of their fluorescent lights products has too great an uncertainty to rely upon its accuracy for determination, so RCRA requires testing of representative samples. The lab analysis to determine

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whether or not materials are hazardous, based on their heavy metal content, is known as the Toxicity Characteristics Leaching Procedure (TCLP). Testing of some representative samples can be done, but it is usually prohibitively expensive. The cost of a typical TCLP analysis is between \$125 and \$200. It is almost always cheaper to consider all used fluorescent lights as hazardous waste than to test even representative samples.

Landfill disposal of used fluorescent lights and HID lamps is not necessarily the best option, nor does it represent a real environmental solution, since heavy metals do not degrade or become inert with time. Recycling may be the better option. There are a number of companies across the country that specialize in recycling fluorescent light tubes and HID lamps. They recycle all of the components of the used lights into reusable/salable raw materials (except for any polychlorinated biphenyl [PCB] containing ballasts, which are incinerated). These companies will pick up or accept shipments of used lights, whichever is more cost-effective for the generator. Most states have specific storage and shipment requirements; for example, a common requirement is that a shipment of used lights must be treated as if it were a hazardous waste going to a waste disposal facility. In that case, a hazardous waste manifest is needed to ship to the recycling facilities. Some states, however, do not require a manifest. Check with your state regulators or the recycling companies before shipping used fluorescent lights or HID lamps. They are very often aware of most of the states' latest environmental requirements for storage and shipment of used lights.

The recycling procedure is a proven technology capable of reliably recovering greater than 99% of the mercury in the spent lights. This is done by using a crush and sieve method, a process in which the spent tubes are first crushed and then sieved to separate the large particles from the mercury-containing phosphor powder. The phosphor powder is collected and processed under intense heat and pressure. The mercury is volatilized and then distilled to the required purity. The glass particles are segregated and recycled into fiberglass. Aluminum components are also segregated and recycled separately.

EPA has proposed two regulatory alternatives to full regulation of used fluorescent lights and HID lamps as hazardous wastes. The eventual decision may change the manner in which used lights are stored and shipped, but it will probably not change the fact that recycling is usually the best end result for used fluorescent lights and HID lamps.

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Materials

Compatibility: Storage and handling of used lights pose no compatibility problems; nevertheless, storage and shipment of the glass tubes is best done keeping the glass tubes intact. This prevents any mercury or mercury-containing materials from leaking and entering the environment, which could result in contamination of storage areas, packaging, soil, etc.

Safety and Health: Fluorescent light tubes must be handled with care because of the mercury, lead, and cadmium. Mercury and lead are experimental carcinogens, and cadmium dust can be poisonous by inhalation. Proper personal protective equipment is highly recommended.

Consult your local industrial health specialist, your base safety office, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Saves landfill space
- Reduces raw materials production needs
- Keeps the potentially toxic materials out of landfills
- Savings in electricity by replacement with a more energy-efficient lamp
- Electrical costs and pollution from power plants are reduced

Disadvantages: Not Available

Economic Analysis: Actual disposal costs of used lights vary greatly, depending on the quantity, proximity, and disposal facility, and also on any state and local fees. The cost to recycle a used light is usually calculated per linear foot, or per bulb for HID lamps. Shipping of the used lights may or may not be provided, depending on the company. Nonetheless, overall costs to recycle are usually comparable to direct disposal costs. Typical costs for fluorescent light tubes are \$0.10/ft to recycle and \$0.25 to \$0.50 per 4-foot tube for direct disposal in a hazardous waste landfill. HID lamp recycling costs range from \$1.25/lamp to \$4.50/lamp, with an average cost of \$2.50/lamp. None of the above prices include storage, packaging, and shipping.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Points of Contact: EPA's RCRA Hotline (800) 424-9346

Mark Hathway, ESC 422
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
DSN 551-5576, FAX 551-4832
(805) 982-5576, FAX (805) 982-4832

Master Sergeant Michael Wantland
Analytical Services Division
Armstrong Laboratory (AL/OEA)
DSN 240-6105, (210) 536-6105

Johna Woods
Naval Surface Warfare Center
Public Works Department
Environmental Division, Code 0952D
Indian Head, MD 20640
DSN 354-4180, (301) 743-4180

Vendors:

Lighting Resources, Inc.
805 E. Francis St.
Ontario, CA 91761
(909) 923-7252, FAX (909) 923-7510
37 F Foster Drive
Willimantic, CT 06226
(800) 866-6818, FAX (203) 423-5572
1522 East Victory Street, #4
Phoenix, AZ 85040
(800) 572-9253, (602) 276-4278, FAX (602) 276-5432
498 Park 800 Drive
Greenwood, IN 46143
(317) 888-3889

Mercury Recovery Services
2021 South Myrtle St.
Monrovia, CA 91016
(818) 301-1372

Mercury Refining Company
790 Watervliet-Shaker Rd.
Latham, NY 12110
(518) 459-0820

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Recyclights
401 West 86th Street
Minneapolis, MN 55420-2707
(612) 948-0626, FAX (612) 948-0627, (800) 831-2852,
Ms. Patti Cimler, National Account Manager; also
4972 Woodville Highway
Tallahassee, FL 32311

Bethlehem Apparatus Company, Inc.
890 Front St., P.O. Box Y
Hellerton, PA 18055
(610) 838-7034

Mercury Technologies International
9520 Jefferson Boulevard, Suite E
Culver City, CA 90232
(310) 836-4684 FAX 836-3342

Source: PRO-ACT Technical Inquiries: 2232, 2352, 2450, 2532, 2621, 2643, 2773, 2878, 3564, and 3426, and Jan-Feb 95 issue of HTIS Bulletin, Vol. 5 No. 1.

Current State Regulations Regarding Disposal of Mercury-Containing Lamps:

- CA If a generator produces more than twenty-five spent lamps per day, the spent lamps are considered hazardous waste; however, manifesting is not required. Spent lamps can be shipped with a bill of lading.
- FL After 7-1-94, lamps may not be burned in any municipal waste incinerator. Generators of greater than ten lamps per month must arrange disposal in permitted lined landfill (unless prohibited by Dept. Rule after 7-1-94).
- IL Lamps exhibiting the toxicity characteristics are subject to hazardous waste management. EPA has enforcement authority in Illinois.
- IN Subject to RCRA through TCLP testing and may be regulated as hazardous waste under 329 IAC 3.1.
- KS Determined on a case-by-case basis.
- LA Considered hazardous waste.
- MA Can be shipped to a recycler without a manifest.
- ME Lamps failing TCLP are handled as hazardous waste, including hazardous waste licensed transporter requirements.
- MI Mercury-containing lamps must be stored according to Michigan Pollution Control Agency guidelines and shipped to an existing recycling facility in accordance with MPCA requirements.
- PA Landfilling allowed only when certification shows that the waste has passed TCLP.
- RI Treat as hazardous waste. Log system is used for transporters and generators.
- SC Some landfills ban disposal.
- TX Must be disposed or recycled at permitted hazardous waste facility.
- WI Hazardous waste lamps and bulbs (including bulbs with high lead concentrations) may not be placed in a solid waste landfill. Lamps and bulbs that are recycled are subject to reduced hazardous waste management requirements.

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DIAPERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Disposable diapers can be a significant source of waste in residential trash. They contribute untreated human waste to the landfill or waste disposal system, increasing the potential for groundwater contamination and the spread of disease-carrying organisms. An alternative to using disposable diapers is to purchase cloth diapers and launder them at home or contract with a diaper service to take away soiled diapers and deliver clean ones.

The most cost effective way to reduce the quantity of disposable diapers in the waste stream is to educate base residents on the benefits of using cloth diapers. Cloth diapers are made of natural fibers and may be safer for a baby's skin than disposable diapers. They can be as convenient to use as disposable diapers when a diaper service is employed. These services usually deliver and pick up diapers twice a week. The diaper does not need to be pre-soaked or treated in any way. The soiled diaper is taken off the baby, put into the hamper, and picked up by the service. If a cloth diaper service is not locally available, the base could consider financing a contracted operation and charging base residents for the service.

Materials

Compatibility: N/A

Safety and Health: Good hygiene practices such as frequent hand washing and careful handling should be practiced when removing soiled diapers.

Benefits:

- Source reduction potential of 1.3 % of disposed waste (EPA, 1994)
- Reduction of untreated human waste in landfills
- Reduction of resource consumption from disposable diapers
- Cost savings due to reduced landfill disposal fees
- Cost savings from reusable diapers

Disadvantages:

- Less convenient
- Handling, storing, and laundering diapers is a disagreeable task

Economic Analysis: The following assumptions were made for these calculations:
- Each use of a cloth diaper is equivalent to one disposable diaper.
- A baby uses 60 diapers each week, which is 3,120 diapers per year.

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- The 1990 report, Disposable vs. Reusable Diapers by Arthur D. Little reports that 45 soiled, disposable diapers weigh, on average, 22.44 lbs as they enter the landfill. The weight of a soiled disposable is therefore 0.499 lbs. The weight of soiled disposable diapers produced (60 diaper per week) is 1,559 lbs/yr per baby.
- In the 1990 report Diapers: Environmental Impacts and Lifecycle Analysis, Carl Lehrburger conservatively estimated that each cloth diaper is used 78 times before disposal. The repeated home use of one cloth diaper therefore replaces 78 disposables.
- A package of 12 cloth diapers costs \$15.29, they are used 78 times, so that 3.33 packages are required per year, and they are recycled as rags when no longer usable.
- A package of 32 disposable diapers costs \$7.39, and 97.5 packs are used per year.
- Cost for laundering diapers at home is \$1.75 per load, and two loads per week will wash 60 diapers.
- The cost of using a diaper service is \$ 13.70 per week, or \$712.40 per year.
- Waste disposal costs are \$40 per ton, diaper disposal cost is therefore \$31.18 per baby, per year.

Cost Comparison of Diaper Alternatives for a One Year Period

	Disposables	Diaper Service	Home Laundry
Diaper Cost	720.50	0.00	50.96
Laundering	0.00	712.40	182.00
Disposal Cost	31.18	0.00	0.00
Total Cost	751.68	712.40	232.96

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

National Association of Diaper Services
2017 Walnut Street
Philadelphia, PA 19103
(215) 569-3650
FAX: (215) 569-1410

Recycling and Resource Conservation Section
Vermont Agency of Natural Resources
103 S. Main Street
Waterbury, VT 05676
Recycling Hotline: (800) 932-7100

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New York State Consumer Protection Board
99 Washington Avenue
Albany, NY 12210
(518) 474-5015

Local and state solid waste management government authorities.

Vendors: Local diaper service companies.
Drug or department stores that sell cloth diapers.

Source: EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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CLOTHING AND HOUSEHOLD ITEMS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Durable goods such as clothing, shoes and accessories, toys, cookware, appliances, and furniture often end up in the trash from on-base housing. Household items can easily be diverted from the waste stream if housing residents are aware of the location and donation policies of local or base secondhand stores. Clothing and household items in fair to good condition can be reused if they are donated to thrift shops, churches, or shelters. Damaged clothing can be reused as rags by individual households or processed by a textile recycler. Larger thrift shops often sell clothing that is in poor condition to a recycler that shreds them and produces carpet padding, furniture stuffing and other products.

Some military installations have thrift shops on base where residents can donate durable goods or leave them on consignment for a period of time. If the base does not have a second hand store, larger thrift stores may be willing to bring a truck to a convenient location on base for specified time periods. Base residents or personnel would be able to bring clean textiles and other durable goods to be received by the thrift store attendant. The base recycling coordinator could be responsible for monitoring the effect of the program and distributing information on what types of household goods can be donated, and in what condition they must be received.

Since textile recyclers do not commonly accept material from the public, the simplest solution is to donate the clothing or fabric to a charitable organization and let them divert it to the recycler. Currently, approximately 1.25 million tons of post-consumer textile waste is recycled annually. Post-consumer textile waste consists of any type of garment or household article made of some manufactured textile. Approximately half of this material is recycled as secondhand clothing, which is typically given or sold to third-world nations. The remaining textile waste is either used as wiping and polishing cloths, or converted into fiber and reused.

Materials
Compatibility: N/A

Safety and Health: N/A

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- Benefits:**
- Diversion of clothing and footwear can potentially reduce disposed waste by 2.1% (EPA, 1994)
 - Cost savings are achieved from reduced disposal fees
 - Donations to charitable organizations provide affordable household products and clothing for low income people, generate revenue for charity, and provide an industry for the employment of handicapped adults

Disadvantages: N/A

Economic Analysis: There are no capital investments for establishing a durable goods collection program on base, if done in conjunction with the Salvation Army or other charitable organization that will provide a truck and attendant free of charge. Alternatively, a recycling container could be purchased by the base and centrally located for voluntary collection of textiles and leather. The donated goods could be periodically transported to a thrift store. Costs for this option include the capital cost for the purchase of a recycling container and transportation and labor costs for trips to the thrift shop.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Council for Textile Recycling
7910 Woodmont Avenue
Suite 1212
Bethesda, MD 20814
(301) 718-0671
FAX: (301) 656-1079

Local charitable organizations, shelters, and churches.

Local and state solid waste management government authorities.

Vendors: N/A

Source: EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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FOOD WASTE

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Food waste consists of vegetable trimmings, raw and cooked food, meat and dairy products, spoiled food, leftovers, plate scrapings, and some animal feeds. It is a major contributor to the weight of disposed waste due to its high water content. Military bases produce large concentrations of food waste at eating facilities which makes the waste easy to capture and divert. A significant reduction in landfilled waste could be achieved by initiating or expanding programs to re-use or compost food waste.

It is possible to re-use food waste by diverting it to a hog or livestock farmer. This is a source reduction activity. There has been extensive research on feeding beef and dairy cattle with food by-products and wastes. Food waste and paper waste from food service operations can be processed through waste pulpers. The waste pulpers grind up organic matter with water (the process is similar to a household garbage disposal) and then extract most of the moisture to produce a dry, organic waste product. This can be transported to the livestock farmer. The waste pulper processes food waste and paper waste into a pulp that is easily mixed with traditional feedstuffs such as urea and corn.

Food waste can also be fed to hogs, but if it contains meat, it may require processing. Licensed animal food processors will contract to pick up food waste. They then cook it, and use it for animal food for a price that is sometimes about half the cost of landfilling the waste. If unlicensed farmers accept the food waste, the military installation may be liable for potential damages. Consult with your state's Department of Agriculture about legal requirements, permitting, or the location of animal farmers who can accept food waste.

An estimated 75% of food waste is usable for composting operations. Food containing meat and dairy products is not suitable for composting because it attracts scavengers and creates odor problems. Most composting operations can be designed or adapted to incorporate food waste into the compost. The addition of food often helps yard waste decay faster. Housing residents can practice backyard composting and large scale composting systems can be set up for the food services. Although any composting method can be used for food waste, in-vessel composting is particularly appropriate since it eliminates problems with

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odor and scavengers. Food waste can be separated and put into large collection containers ranging from 90 gallons to four cubic yards that have a lockable lid. Residential food waste could be collected in smaller, 10 to 30 gallon, containers. Collection frequency should be at least twice a week to avoid spoiling and odors. Once materials are collected and delivered to the compost site, the materials should be processed immediately and incorporated into the compost mix so that storage of the food waste is not required at the site.

Material

Compatibility: N/A

Safety and Health: N/A

Benefits:

- Reusing or composting food waste can result in a potential 6.7% reduction of disposed waste (EPA, 1994)
- Composted food waste can be used as a soil amendment on base, possibly reducing the need for purchased supplies
- Cost savings are achieved from reduced landfill disposal fees

Disadvantages:

- Food waste introduces problems of odor and scavengers in outdoor composting operations
- Source separation of food requires extra work and special containers in the kitchen
- Food waste contaminated with trash is not suitable for use as animal food
- Storing food waste between pickups can be messy, smelly, and requires frequent cleaning of containers
- Food waste composting may require permits

Economic Analysis: Capital costs for incorporating food waste into an existing composting operation would include the purchase of separate collection containers for the compostable material.

Capital costs for using food waste to produce animal feed may include the cost of one or more Hobart waste pulpers as well as bulk collection containers for the processed material. Capital costs for a Hobart waste pulper range from \$27,000 (Model EL-5, 12-24) to \$34,000 (Model EL-7, 15-30). Operating costs would include transporting the material to the livestock farmer.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Local and state solid waste management government authorities.
State Department of Agriculture

Vendors: Hobart (Food processing equipment)
401 West Market Street
Troy, WI 45374
(513) 332-3000

Sources: Resource Recycling, January 1995, Cleaning the Plate: Composting Commercial and Institutional Food Waste.
BioCycle, December 1993, University Recycles Dining Center Residuals.
BioCycle, November 1994, Food Processor Hits 80 Percent Recycling Rate.
BioCycle, August 1993, A Compost Program for Institutional Food Waste.
EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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CONSTRUCTION AND DEMOLITION WASTE

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Construction and demolition (C&D) waste consists of concrete, asphalt, wood, fixtures, rebar, metals, drywall, roofing, and other materials. Many building materials and the majority of asphalt and concrete in the waste stream can be recycled. This can result in a significant reduction of disposed waste due to the large quantities of this material generated on base. C&D waste generation and disposal is usually handled by contractors at many military installations, but alternate diversion methods can be specified in the contract. Recycling building materials such as rebar, asphalt, and concrete, and selling salvaged lumber, building materials, and fixtures is more economical than disposal and can result in a lower bid price if a tipping fee is charged.

Current practices of recycling asphalt and concrete include recycling the material with a local recycling center or recycling the material on base. Local recyclers of asphalt and concrete may include construction material companies, sand and gravel producers, and asphalt plants. Information on local recyclers with stationary asphalt and concrete recycling equipment should be available from the local government solid waste authority. Alternatively, the material can be recycled on base. Asphalt and concrete rubble can be recycled on base without further processing for use as general rubble fill in low lying areas or quarries. However, a more beneficial use of the material is to crush the asphalt and concrete using a portable crusher. Local contractors may be available to crush stockpiled material on an as-needed basis. Alternatively, the base could purchase a portable crusher. The crushed product can be used as a substitute for crushed stone products in road construction (pavement and road base) and as a fill material (footing and foundation backfill and general fill). The use of crushed concrete for landfill roadways or landfill cover should also be investigated as a potential market. Large slabs of concrete can be used as rip rap to prevent shoreline and stream erosion, or used in various projects such as artificial reef development and underground cavern stabilization.

Recycling asphalt pavements on site can be beneficial, as these materials are immediately reused and do not enter the waste stream. The two types of on-site recycling include surface recycling and road base recycling. Surface recycling involves breaking up the top layer of a pavement structure to a depth of about one inch by milling or crushing

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the material, and then re-compacting the loose material. Performance specifications for the pavement surface should be considered prior to using the recycled asphalt. A new surface is placed on top of the recycled asphalt, and the pavement is compacted again. Road base recycling involves recycling both the asphalt surface and base material to produce a new road base. There is a machine on the market that uses a downward rotation of a cutter drum to raise asphalt and base material by cutting a path 10 feet wide and as much as 24 inches deep. The base aggregate and asphalt top coat are blended and crushed by the machine to produce a well-graded base course, and then deposited back on the roadway, all in one pass. A new surface is then placed on top of the recycled road base. In some applications, the base is never hauled away from the project site. Specifications for pavement base course are not as stringent, and can generally contain 100% recycled material.

Alternatively, recycled asphalt can be transported to an asphalt batch plant and processed. The quality of the recycled pavement should be documented to help determine the percentage of reclaimed asphalt pavement (RAP) that can be combined with virgin asphalt to produce new asphalt pavement. The percentage of RAP that can be used in the intermediate or surface asphalt concrete course depends primarily on the performance specifications of the road being constructed. Governing specifications should be consulted to determine the percentages of recycled material or RAP allowed in asphalt pavements.

Materials

Compatibility: N/A

Safety and Health: Care should be taken when handling asphalt, as it may contain carcinogenic components. It is a moderate irritant. Proper personal protection equipment is, therefore, recommended.

Consult your base safety office and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Recycling asphalt and concrete on base provides a source of crushed stone product for base applications and reduces the cost of new material
- A substantial increase in recycling rate can be achieved
- Income is generated from the sale of scrap rebar, lumber, and fixtures
- Cost savings in landfill tipping fees
- Cost savings in transportation when material is re-used on base
- Conserves resources

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Disadvantages: N/A

Economic Analysis: The cost for a contractor to crush asphalt and concrete on site will vary depending on the volume of material collected, the size requirements of the finished product, and the distance to the facility. Average costs for crushing are approximately \$5/ton. Alternatively, costs for hauling and disposing of the material with a local recycling center can range from \$5 to \$13/ton. Cost savings may be obtained by minimizing crushed stone product purchases and reducing landfill disposal fees.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Asphalt Recycling and Reclaiming Association
3 Church Circle, Suite 250
Annapolis, MD 21401
(410) 267-0023

Solid Waste Association of North America
P.O. Box 7219
Silver Spring, MD 20907
(301) 585-2898
FAX: (301) 589-7068

METRO
Solid Waste Department
600 N.E. Grand Ave.
Portland, OR 97232-2736
(503) 797-1650
FAX: (503) 797-1795

Local and state solid waste management government authorities.

Vendors: See Equipment - Asphalt and Concrete Crushers

Sources: Resource Recovery, 1994. *Current Practices and Applications in Construction and Demolition Debris Recycling*. Authored by Edward L. von Stein and George M. Savage. Resource Recovery, April 1994, Volume XIII, Number 4, pp. 85-94.
Cosper, S. D., W. H. Hallenbeck, and G. R. Brenniman, 1993. *Construction and Demolition Waste: Generation, Regulation, Practices, Processing, and Policies*. Public Service Report OSWM-12, January 1993, Office of Solid Waste Management, University of Illinois at Chicago.

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COLLECTION CONTAINERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Compartmentalized recycling containers are used to separate common recyclables such as plastics, glass, paper, cans, and compostables from both residential and commercial waste streams. The containers may be placed at exterior or interior locations around the residential or work areas, allowing the residents or personnel to place each type of material in its own bin. This eliminates or reduces the need to sort the materials at the recycling center and results in lower processing costs.

Containers are made in a wide range of sizes and types, suitable for a large variety of applications. Examples of these containers are listed below:

- Personal desk-top office paper recycling containers
- Centralized recycling containers
- Bins for residential recyclables
- Modified trash cans, compartmentalized to permit the separation of household kitchen wastes (e.g., cans, plastics, and compostables)

Source separation of recyclables by the waste generators requires consistent education and program support to prevent them from becoming contaminated with other materials. All recycling bins should be clearly labeled with the types of material that are acceptable listed on each one, as well as who to call (name and phone number) for further information. Color coded bins for each material type will help users quickly identify the proper container. A trash can should be placed next to all recycling stations to reduce contamination. Regularly publicizing the location and availability of the containers will bring in new users and keep the old ones current.

In an office situation, recycling containers should be placed so that using them is as convenient as putting the material in the trash. For material such as office paper that is generated sheet by sheet, desktop or individual containers are recommended. For less commonly generated items, such as aluminum cans, a centralized set of bins should suffice. A single bin that is compartmentalized for different materials may be difficult to empty unless special handling equipment is purchased. Bins that contain a single material type are more suitable for hand collection.

Materials Compatibility: N/A

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Safety and Health: N/A

Benefits:

- Reduction of landfilled waste through recycling and composting
- Lower processing costs for recyclables
- Separating recyclables and/or compostables at the source of generation eliminates the need for a materials recovery facility

Disadvantages:

- Mixing of material types often occurs to some degree and the material may not be pure enough to go directly to market without further sorting
- Some participants who do not understand which materials belong in the categories, or find it too difficult to separate may stop recycling

Economic Analysis: Capital cost for bins is \$4 to \$125 each depending on size and degree of compartmentalization.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Donald Hopson
510 CES/CEV
8120 Edgerton Drive, Suite 40
US Air Force Academy
Colorado Springs, CO 80840-2400
(719) 472-4483

Scott Ammon
509 CES/CEV
Whiteman AFB, Missouri
(816) 687-7777, DSN 975-7777

Mr. Clarence Best
Fort Eustis, Virginia
(804) 878-2692

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Vendors: The following vendors manufacture recycling containers. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

SSI Schaefer
10021 Westlake Dr.
PO Box 7009
Charlotte, NC 28241
(704) 588-2150

Toter Incorporated
P.O. Box 5338
841 Meachum Rd
Statesville, NC 28677
(800) 772-0071

Recycling Products, Inc.
P.O. Box 1929
Andover, MA 01810
(800) 875-1735

Rehrig Pacific Company
1738 West 20th Street
Erie, PA 16502
(800) 458-0403

Windsor Barrel Works
PO Box 47
Kempton, PA 19529
(800) 527-7848

TrashMasters, Inc.
3001 Kaverton Road
Forestville, MD 20747
(301) 568-1400, FAX (301) 568-0077

Cardinal Packaging
Recycling Division
834 North 7th Street
Minneapolis, MN 55411-4394
(800) 822-2342

Source: Personal communication with vendors listed.

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RECYCLING TRAILERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Compartmentalized trailers are used to separate plastics, glass, paper, cans, and compostables at the source--that is, from residential and commercial trash. The trailers may be placed at exterior locations around the residential areas or office buildings, allowing the residents or personnel to place each type of material in its own bin. This eliminates or reduces the need to sort the materials at the recycling center and results in lower processing costs. The trailers are usually located in centralized, easily accessible locations.

Trailers are made in a wide range of sizes and types, suitable for a large variety of applications. Trailers may be up to 20 yards long, with between two and ten compartments for segregated wastes disposal. Some may be stationary, and others may be mobile with the use of a truck. The recyclables can be emptied from the compartments, or the whole trailer can be towed away when full.

Source separation of recyclables by the waste generators requires consistent education and program support to prevent them from becoming contaminated with other materials. All recycling compartments should be clearly labeled with the types of material that are acceptable listed on each one, as well who to call (name and phone number) for additional information. A trash container should be placed next to all recycling stations to reduce contamination. Regularly publicizing the availability and location of the containers will bring in new users and keep the old ones current.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits:

- Reduction of landfilled waste through recycling and composting
- Lower processing costs for materials
- Separating recyclables and/or compostables at the generation source eliminates the need for a materials recovery facility
- Trailers are mobile and can be towed away when full or moved to another location

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- Disadvantages:**
- Mixing of material types often occurs to some degree and the material may not be pure enough to go directly to market without further sorting
 - Some participants who do not understand which materials belong in the categories, or find it too difficult to source separate may stop recycling

Economic Analysis: Capital cost are \$4,000 to \$13,000 per trailer, depending on size, features, and degree of compartmentalization.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Donald Hopson
510 CES/CEV
8120 Edgerton Drive, Suite 40
U.S. Air Force Academy
Colorado Springs, CO 80840-2400
(719) 472-4483

Scott Ammon
509 CES/CEV
Whiteman AFB, MO
(816) 687-7777, DSN 975-7777

Tim Brecheen
4 CES/CEV
1095 Mitchell Ave
Seymour Johnson AFB
Wayne Co., NC 27531
(919) 736-6501, DSN 488-6501

Vendors: The following vendors manufacture recycling trailers. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

Fibrex, Inc.
3724 Cook Boulevard
Chesapeake, VA 23323
(800) 346-4458, FAX (804) 487-5876

Protainer, Inc.

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P.O. Box 427
4941 Highway 27 East
Alexandria, MN 56308
(800) 248-7761, FAX (612) 763-7667

Marathon Equipment Co.
P.O. Box 1798
Vernon, AL 35592-1798
(800) 633-8974

National Manufacturing Co.
675 12th Avenue, SE
Valley City, ND 58072
(701) 845-1017

Source: Personal communication with vendors (Protainer, Fibrex, and Marathon).

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BALERS

Revision 1/96
Process Code: Navy: ID-15-00, ID-25-00; Air Force: SV05; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Balers are machines that compact and bind recyclable materials. The baler can process paper, cardboard, corrugated boxes, tin cans, aluminum cans, plastics, or large metal components into dense stackable bales of a uniform material. The bales reduce space required for storage and transportation, and can be moved with a forklift. There is a wide range of sizes for balers, and recycling facilities from small military bases to high volume municipal waste recovery facilities use them to prepare recyclable materials for market. Some recyclables must be baled or they will not be accepted by the buyer.

A baler uses a hydraulic ram to compact material into a box shape. Compressed bales are then tied with wire. Balers may be fed material manually, by using gravity feed, a mechanical conveyor, or air feed systems. If the operation calls for the use of the same baler to bale more than one material type, the baler must be specifically designed to handle different materials at different ranges of capacity. Tying bales with wire can be manual or automatic. The number, size, and tension of the baling wires must be adequate for the particular materials baled. Throughput capacity for a typical baler is 20 tons per day.

Materials

Compatibility: N/A

Safety and Health: Safety issues deal with the operation of power equipment. Operators should be trained to use the baler and exercise caution to keep limbs, clothing and hair from being caught up in the hydraulic rams or feed hoppers. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment, possibly including gloves, eye protection, and hearing protection, should be used. Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Enhanced marketability of commodity
- Increased market value of commodity
- Reduced transportation costs
- Reduced storage space

Disadvantages: N/A

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Economic Analysis: Typical application: closed-end horizontal, manual tying baler with a capacity of less than 20 tons/day: capital cost are \$37,000 to \$50,000; operating cost would include labor (dollars per ton or hour), electrical costs (dollars per KWH), and minimal upkeep (dollars per year).

Alternate application: open-end horizontal, automatic tying baler with a capacity of more than 20 tons/day: capital cost are \$75,000 to \$150,000; operating cost would include labor (dollars per ton or hour), electrical costs (dollars per KWH), and minimal upkeep (dollars per year).

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Wallace Eakes, ESC 423
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, California 93043-4370
(805) 982-4882, DSN 551-4882

Vendors:

The following vendors manufacture balers. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

Balemaster
980 Crown Court
Crown Point, IN 46307
(219) 663-4525

Enterprise Baler Co.
P.O. Box 15546
Santa Anna, CA 92705
(714) 835-0551

Harns Waste Management Group (Mosley Machinery)
P.O. Box 1552
Waco, TX 76703-1552
(817) 799-2491

Lindemann Recycling Equipment, Inc.
10620 Southern Loop Boulevard
Pineville, NC 28241-0928
(704) 587-9646

Source: *Handbook, Material Recovery Facilities for Municipal Solid Waste*, USEPA, EPA/625/6-91/031.

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AEROSOL CAN PUNCTURING AND CRUSHING

Revision: 1/96
Process Code: Navy: ID-25-99; Air Force: HW01; Army: OTG
Substitute for: N/A
Applicable EPCRA Targeted Constituents: CFC Propellants

Overview: The category “aerosol cans” encompasses all metal containers that use a propellant to spray out the contents. This includes cans for spray paint, lubricating oil, cleaning products, oven cleaner, hair spray, and other products. They can be recycled as scrap metal if the contents are completely removed. Aerosol cans comprise only a small percentage of the waste stream, but if not empty, they are classified as a hazardous waste because the residual contents are under pressure. Aerosol can puncture devices are available that breach and empty the cans to make them classifiable as “empty,” for EPA requirements. The processed cans are then no longer considered to be hazardous waste and can be sold as scrap metal. However, any can-puncturing process must be licensed by state or federal EPA. Aerosol can puncturing, crushing, and recovery systems should comply with 40 CFR Sec. 261.7. Because puncturing cans may involve local air quality regulations, consultation with city and county governments is advised.

Puncturing is not required by law, nor is it considered treatment. However, some regulatory agencies may consider an unpunctured aerosol can to exhibit the characteristic of reactivity, as heat or external pressure can cause detonation if the can is partially or completely filled. The law only requires the container to be “empty.” “Empty” is defined as “removing all wastes that can be removed using practices commonly employed to remove materials from that type of container; and no more than one inch of residue remains on the bottom of the container; or no more than three percent by weight of the total container capacity remains within the container (if the container is less than 110 gallons in size).” Furthermore, a container that has held a compressed gas is considered empty when the pressure in the container approaches atmospheric. Containers meeting these “empty” criteria are not hazardous waste and can be disposed of as non-hazardous waste.

Aerosol can puncturing devices safely puncture the cans, capturing their contents for easy recycling or disposal. Spray nozzles are removed as well. A simple, low-capacity can operator puncturing unit does not require power and is manually operated. The user presses on a handle which causes a puncture pin to pierce the aerosol can, which is secured inside a cylinder. The can contents are then collected in a drum.

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More sophisticated units have a pre-loader that moves aerosol cans into a 12-inch sealed cylinder. This cylinder is then ruptured and may be crushed into a ½-inch thick wafer by a piston, depending on the unit purchased. The propellant and concentrate then pass through a check valve in the piston and are collected in a pressure tank. A scavenger system accepts the small amount of propellant remaining around the crushed cans to reduce pressure to atmospheric before the cylinder is opened. The cans may then be discharged onto a well-ventilated, drying conveyor where they remain for 10 to 15 minutes, before being collected in a container.

Sophisticated aerosol can puncturing devices can process over 99% of the cans for either safe disposal or recycling. Capacities range from 120 to 2,000 cans per hour. Available features on the more sophisticated units include explosion-proofing, and electric, hot oil, and steam heaters to vaporize residual propellant.

In some states, like California, volatile organic carbon (VOC) venting is regulated. Since frequently the propellants used are VOCs, the puncturing operation could result in release of these compounds to the environment. One example of a frequently used propellant is butane. To address this problem, some devices provide an activated carbon adsorption canister to capture any VOCs released from the punctured can. However, the carbon has to be replaced and disposed of periodically and is not intended to adsorb CFCs.

Materials

Compatibility:

The residual contents of all aerosol cans being crushed must be compatible. It is important to check material compatibility when disposing of many cans at once, especially when disposing of a group of cans that contain different products. The containers (55 gallon steel drum or other container) into which the residues are discharged should be designated and labeled for specific materials, e.g., paints, lubricants, etc. Check with product manufacturers for compatibility within the same class of material, e.g., are two different types of paints compatible with each other in a disposal drum? Mixing aerosol can contents of different types of products is discouraged. The practice of designating drums for specific classes of materials also simplifies waste management and disposal.

Safety and Health:

Proper design, operation, and maintenance of the equipment is required for its safe use. There are minimal health concerns regarding this process, but care must be taken when handling the pre-loading of these cans for a manual process. Precautions must be taken and proper personal protective equipment is recommended.

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Consult your local industrial health specialist, base safety office, and the appropriate MSDS prior to implementing any of these technologies.

- Benefits:**
- Renders a potentially hazardous waste non-hazardous
 - Diversion of aerosol cans results in a reduction in disposed waste
 - Revenue is generated from the sale of the cans as scrap metal

Disadvantages: May conflict with local air quality regulations

Economic Analysis: Typical Navy or Air Force Application: at 200 paint cans/hour
Capital cost: \$775; Operating cost: operator's annual salary
Alternate Navy Application: at greater than 500 paint cans/hour
Capital cost: \$30,000; Operating cost: operator's salary, minimal electricity and air.

Disposal Cost:

Unpunctured aerosol cans are disposed as hazardous solid waste, with disposal costs ranging as high as \$1,500 per 55 gallon drum. One 55 gallon drum typically holds 100 unpunctured aerosol cans or the residual liquid from over 4,000 spent aerosol cans. Therefore, the cost savings from using aerosol can puncturing devices can be significant. For example, if 4,000 aerosol cans per year were used, then 40 drums of unpunctured cans would be disposed as hazardous waste; or, if the cans were punctured and drained, one drum of liquid would be disposed as hazardous waste. By puncturing and recycling the steel cans and disposing of only the spent liquids as hazardous waste, a 98% (39-40 drums) savings in disposal costs could be realized.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Kenneth Plaisted
Director of Environmental Affairs
Portsmouth Naval Shipyard
Portsmouth, NH
(207) 438-3830, FAX (207) 438-1535

NAVSEA
Charles Tittle, SEA 00TB
Naval Sea Systems Command
2531 Jefferson Davis Highway

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Arlington, VA 22242-5160
(703) 602-3594, DSN 332-3594, FAX (703) 602-7213

Vendors: Sources of can puncturing systems:

Abar EnviroSystems
21000 Aurora Road
Cleveland, OH 44146-1010
(216) 587-0001, FAX (216) 587-0000
Mr. Louis G. Hajma, President
Manufacturer of three models of drum-mounted can piercing and processing equipment ranging in price from about \$1,000 to \$2,500. Units capable of processing up to 40,000 cans per month. Accessories, such as an activated charcoal attachment, are also available to adsorb and contain residual volatile organic compounds (VOCs) released after piercing the used cans. This is important, since many VOCs are photochemically reactive, forming ground-level ozone, a serious pollution problem in most major metropolitan areas. Manufacturer estimates 80 percent efficiency for VOC removal and particulate reduction to 15 micron particles.

Beacon Engineering Co.
P.O. Box 129
Jasper, GA 30143
(706) 692-6411, FAX (706) 692-3227
Manufacturer of can crusher models EVAC JR (200 to 300 cans/hour) and EVAC II (1,200 to 2,000 cans/hour).

Herkules Corporation
8230 Goldie
Wald Lake, MI 48390
(800) 444-4351 or (810) 960-7100
Manufacturer of the AFC-2 Puncturing and Crushing Unit.

Katec, Inc.
P.O. Box 3399
Virginia Beach, VA 23454
(800) 843-6808
Manufacturer of the AEROSOLV Aerosol Can Puncturing system.

Justrite Manufacturing Company
2454 Dempster Street
Des Plaines, IL 60016
(800) 798-9250, FAX (800) 488-5877

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Sources of can crushing systems:

C. S. Bell
170 W. Davis St.
P.O. Box 291
Tiffin, OH 44883
(419) 448-0791

Drew-It Corporation
P.O. Box 10111
Greenville, SC 29603
(864) 292-6376

International Compactor Inc.
P.O. Box 5918
Hilton Head Island, SC 29938
(800) 423-4003

Can recycler:

Macon Iron and Metal
(912) 743-6773
Mr. Evan Koplín

Source: PA Technical Inquiries: 2200, 2210A, 2301, 2760, and 3922.
Vendors.

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GLASS PULVERIZERS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Glass pulverizers are used to convert any waste glass (e.g., from bottles to windshields) into usable aggregate products. The consistency of these products may range from coarse sand to fine gravel. Pulverized glass can be used in many ways, such as an aggregate substitute for gravel and sand, as well as for glassphalt (e.g., glass/asphalt mixes), turf and soil amendment, decorative landscaping, water filtration media, and sandblasting. Glass containers usually have a higher market value when sold to recyclers. However, a glass pulverizer is useful when large amounts of non-recyclable glass are generated, or recycling is not an option. In March 1995, a glass pulverizer was purchased for use at Lajes Field, Azores, Portugal, to crush glass bottles generated on base. The crushed product is expected to be used as a substitute for sand on the base.

Typical glass pulverizer systems consist of a glass pulverizer, trommel screen/separator, and metering surge hopper. The capacity of the glass pulverizer ranges from less than one to 20 tons per hour. The trommel screen capacity ranges from three to 20 tons per hour, and the metering surge hopper capacity ranges from two to four cubic yards. In addition, mobile systems are available. The system pulverizes glass and separates caps, metal, or plastic from the glass raw material.

Materials

Compatibility: N/A

Safety and Health: Safety issues for using pulverizers deal with the operation of power equipment and respiration protection. The dust from crushing glass necessitates respiratory protection. Proper personal protective equipment including gloves, eye protection, respiratory protection, and hearing protection should be used. Operators should be specifically trained to use the crusher. Machinery should not be used if workers are intoxicated or on medication.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment. Consult your safety office or local industrial health specialist, and the appropriate MSDS prior to implementing any of these technologies.

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Benefits:

- Removes non-recyclable glass from the waste stream
- Provides aggregate for paving or construction
- Equipment is usually light, portable, and easily moved to another location

Disadvantages: Glass pulverizing units usually require relatively high levels of maintenance owing to the abrasive nature of the processed glass.

Economic Analysis:

Application: at one to five tons/hour (includes glass pulverizer, trommel screen, and metering surge hopper); capital cost are \$36,000; operating cost would include labor (dollars per ton or hour), electrical costs (dollars/KWH), and maintenance (dollars per year).

Application: at five to 10 tons/hour (includes glass pulverizer, trommel screen, and metering surge hopper); capital cost are \$51,300; operating cost would include labor (dollars per ton or hour), electrical costs (dollars/KWH), and maintenance (dollars per year).

Application: at 15 to 20 tons/hour (includes glass pulverizer, trommel screen, and metering surge hopper); capital cost are \$68,000; operating cost would include labor (dollars per ton or hour), electrical costs (dollars/KWH), and maintenance (dollars per year).

Alternate application (capital cost for glass pulverizer only): at one to five tons/hour = \$16,400; at five to ten tons/hour = \$26,825; at 15 to 20 tons/hour = \$38,000.

Approval Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Captain Michael Roache
65th CES/CEV
Lajes Field, Azores, Portugal
DSN 535-1110 or (351) 95-540100 ext. 23791

Vendors:

The following vendors manufacture glass pulverizers. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

Andela Tool & Machine, Inc.
Richfield Springs, NY 13439
(315) 858-0055, FAX (315) 858-2669

Source:

Vendor Communication: Andela Tool & Machine, Inc. (March 1995).

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METAL DRUM CRUSHERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Drum crushing machines can compact drums, pails, and paint cans into dense disks prior to recycling, reducing storage space and transportation requirements. Volume reduction for the drum crushers ranges from 6:1 to 14:1. A 14:1 volume reduction equates to crushing a standard 55-gallon drum to less than 2 1/2 inches thick. The mid-size crusher will reduce most pails and paint cans by 90 percent. The crushed containers can be recycled as scrap metal. These machines are used at installations that generate significant quantities of metal drums.

Drum crushing machines typically include a 3 to 10 horsepower motor, and one or two (30 to 40 inch) stroke cylinders. The single drum crusher requires one stroke cylinder, while the double drum crusher requires two. Drum crushers have a compacting force ranging from 35,000 lbs to 105,000 lbs, with a cycle time of 30 to 60 seconds. Space requirements for drum crushers range from approximately 10 square feet for the single crushers to 20 square feet for the double unit.

Mid-range crushers have also been developed to handle pails and paint cans. These units are pneumatically operated; therefore, a source of clean, dry air must be provided. An Occupational Safety and Health Administration lock-out-tag-out safety valve, and an air regulator with lubricator and filter are included as standard equipment.

Materials

Compatibility: N/A

Safety and Health: Safety issues for using drum crushers deal with the operation of power equipment. Operators should be specifically trained to use the crusher and exercise caution to keep limbs, clothing and hair from being caught up in the works. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment possibly including gloves, eye protection, and hearing protection should be used.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

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- Benefits:**
- Increases marketability of metal containers
 - Decreases storage and transport requirements

Disadvantages: N/A

Economic Analysis: Budget-level capital costs for drum crushers range from approximately \$7,000 to \$43,000. An average budget-level estimate for a single drum crusher is approximately \$15,000, and an average budget level estimate for a double drum crusher is approximately \$35,000. Operating costs would include labor, power to operate a 3 to 10 HP motor, preventive maintenance (changing oil once a year), and maintenance.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Fred Brown
Newport News Shipbuilding
Newport News, Virginia
(804) 380-7518

Mike Kelly
Crown, Cork & Seal
Batesville, Mississippi
(601) 563-7664

Joe Fallon, Div. of Public Works
U.S. Army
Fort Monmouth, New Jersey
(908) 532-6223

Bob Lannon
Commins Engine Co., Inc.
Lakewood, New York
(716) 456-2233

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Vendors: This is not meant to be a complete list, as there are other manufacturers and vendors of drum crushers.

American International Company
Vincent J. Cerniglia, President
P.O. Box 515
Wayne, PA 19087
(610) 964-9191

Waste Recycler Manufacturing Company
Arthur J. Hughes, Jr., Vice-President
P.O. Box 410364
Charlotte, NC 28241
(704) 588-4506

Source: Vendor Communication: American International Company (May 1995), Waste Recycler Manufacturing Company (May 1995).

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

CONCRETE/ASPHALT CRUSHERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Portable concrete/asphalt crushers are typically used at construction sites or landfills to crush chunks of concrete or asphalt into small pieces. This crushed material may then be recycled for use in other construction applications.

Crushed concrete and asphalt can be re-used in new construction as road and railroad base material, fill, or pavement constituents. In some applications, recycled concrete may be used in place of aggregate for drainage layers and sub-bases. Other potential uses include ballast, sub-ballast, and trickling filter media for wastewater treatment plants. Finely crushed concrete can be utilized as a neutralizing agent in a variety of applications.

In practice, crushing is usually performed in two steps; a primary crusher reduces the larger incoming debris, and a secondary crusher brings the material nearer the desired particle size. Magnetic ferrous metal recovery can take place after both stages.

The three main types of equipment are jaw, impact, and rolling crushers. Jaw crushers are best suited to quickly reducing large or odd-shaped debris from construction/demolition (C/D) projects to a manageable size. Impact crushers are more effective than jaw crushers at freeing rebar encased in the rubble. A rolling crusher is composed of two heavy cylindrical rollers and is used for secondary crushing.

Construction work at an installation is usually performed for a specific project and may not require year-round usage of a crusher. In addition, it is possible to stockpile the material for extended periods of time, provided land is available for stockpiling. Therefore, it may be appropriate to lease a unit as required. There are also companies that will bring portable crushers on site, crush the material, and leave it for use at the base. The fees will vary based on the contractor and the distance to the site.

Materials
Compatibility: N/A

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Safety and Health: Asphalt is a moderate irritant and may contain carcinogenic components. The dust from crushing concrete necessitates respiratory protection. Proper personal protective equipment including gloves, eye protection, respiratory protection, and hearing protection should be used. Safety issues for using crushers deal with the operation of power equipment and respiration protection. Operators should be specifically trained to use the crusher. Machinery should not be used if workers are intoxicated or on medication.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment. Consult your safety office or local industrial health specialist, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- Reduction of significant component of landfilled waste
- Crushed concrete/asphalt may used in other construction applications and reduce purchase of aggregate materials
- Crushed material can be used on site and eliminate transport and hauling of waste and new material

Disadvantages: Stockpiled material may become a trash pile

Economic Analysis: The following example illustrates the possible saving from purchasing and using a concrete and asphalt crusher. Actual results will vary depending on local disposal rates and the amount of this material generated on base. All costs and savings for this example are for a time period of one year.

- Assumptions
 - 1,000 tons/yr. demolition asphalt and concrete generated
 - \$13/ton to haul and dispose
 - Portable crusher is 36" diameter by 36" wide
 - Processes 10-15 tons/hr of 12" to 14" concrete chunks
 - All of the 1,000 tons/yr can be crushed and reused on site so there is an avoided purchase of 1,000 tons/yr of new material
 - New fill material costs \$15/ton
 - Operating Cost (including labor and maintenance) \$3/ton

Operating Cost Comparison

	Recycling	Landfilling
Disposal Cost	\$0	\$13,000
Operating Cost	\$3,000	\$0
New Material Savings	-\$15,000	\$0
Yearly Costs	-\$12,000	\$13,000

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- Capital Cost: \$55,000
- Annual Savings: \$25,000
- Payback Period: 2 years

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Wallace Eakes, ESC 423
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-4882, DSN 551-4882

Vendors: The following vendors manufacture portable concrete/asphalt crushers. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

American Pulverizer
5540 West Park Avenue
Saint Louis, MO 63110-1897
(314) 781-6100

Hazemag USA, Inc.
P.O. Box 1064
Uniontown, PA 15401
(412) 439-3512

Excell Recycling & Manufacturing
P.O. Box 31118
Amarillo, TX 79120
(800) 858-4002

Jacobson Companies
2477 Nevada Avenue N.
Minneapolis, MN 55427
(612) 544-8781

Sources: Personal Communication with vendors (Hazemag, American Pulverizer, and Excell) (March 1995).
Casper, S. D., W. H. Hallenbeck, and G. R. Brenniman, 1993. *Construction and Demolition Waste - Generation, Regulation, Practices, Processing, and Policies*. Public Service Report published by the Office of Solid Waste Management, Chicago, Illinois.

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BACKYARD AND SMALL SCALE COMPOSTING

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Backyard and small facility composting is a simple and inexpensive way to recycle yard and garden trimmings, some food waste, wood ash, manure, and paper waste onsite to eliminate the whole process of pickup and central processing. This technology is appropriate for residences and facilities such as universities, hospitals, and military bases that want to compost their own waste on site and turn it into a soil amendment.

The two primary methods of backyard composting are aerobic composting and anaerobic composting. Aerobic composting requires once a week turning and watering, while anaerobic methods require only final aeration before being used for gardening. Organic material is formed into open piles or contained in composting bins that can be built or purchased in a variety of design types and materials. A more intensive system for institutions might include a paved area for heavy equipment maneuvering and multiple bins to allow for continuous composting.

A balanced compost mixture should contain approximately two parts carbon-rich materials such as leaves, wood waste, sawdust, and straw and three parts nitrogen-rich materials such as grass clippings and food waste. Food waste will tend to attract scavengers, but burying it a foot below the surface of the pile will eliminate this problem. Meat, oil, or animal products should not be added to backyard compost since they will produce an unpleasant odor and attract animals. For quicker and more homogenous compost, materials should be shredded, chopped or chipped. A home or landscaping quality chipper can be bought or rented for occasional use. These machines will allow the inclusion of woody branches which are otherwise non-compostable and shred all material into a fine mulch that can be used directly in landscaping, or that will decompose in weeks or months into a fine soil amendment.

For backyard aerobic composting, a single pile should not exceed two cubic yards or it will be difficult to turn. If a front end loader is available for institutional composting, the piles can be larger. The piles should be watered and turned at least once a week for the first few weeks and will produce compost in about 1 to 2 months. A well aerated, well mixed compost pile will smell clean and woody. Compost can be

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used when it is a rich dark brown color, individual particles are not distinguishable, and it is no longer producing heat.

Materials

Compatibility: N/A

Safety and Health: As long as no meat or animal products are included, compost does not pose health risks and can be touched with bare hands. Sensitive people should consider using a mask when turning compost to prevent inhaling bacteria or particles.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Compost reduces the amount of waste to be disposed. Complete recovery of yard waste will reduce the amount of waste generated by an average of 15.9% while the addition of food waste will divert another 6.7% (EPA, 1994)
- Backyard or single facility composting incurs no costs for processing
- No pickup mechanisms or transport required
- It is easy and requires low technology
- It produces a nutrient-rich soil amendment for home gardening and landscaping

Disadvantages: NA

Economic Analysis: Capital costs for wholesale/retail or mail order purchase of backyard composting bins can vary from \$30 to \$300. Homemade compost bins can be easily built from a variety of materials such as pallets, cinder blocks (for aerobic composting), and garbage cans with tight lids (anaerobic composting). Building costs will vary.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: SMSgt. Michael Reyes
401 L. Avenue
Altus AFB, OK 73523
DSN 866-6221 (405) 481-6221

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BioCycle Magazine
419 State Avenue
Emmaus, PA 18049
(610) 967-4135

The Composting Council
114 South Pitt Street
Alexandria, VA 22314
(703) 739-2401
FAX: (703) 739-2407

Harmonious Technologies
John Roulac
P.O. Box 1865
Ojai, CA 93024-1865
(805) 646-8030
FAX: (805) 646-7404

Santa Barbara County Composting Specialist
County of Santa Barbara
Public Works Department
Solid Waste Management Division
1213 State Street, Suite 1
Santa Barbara, CA 93101
(805) 681-4066

Local and state solid waste management government authorities.

Vendors:

The following list of vendors is not intended to be complete, as there are other vendors and manufacturers of backyard composting bins.

Barclay Recycling, Inc.
Tony Novembre
75 Ingram Drive
Toronto, Ontario M6M 2M2
(416) 240-8227
FAX: (416) 240-0114

C.E. Shepherd Co., Inc.
P.O. Box 9445
Houston, TX 77261-9445
(713) 928-3763
FAX: (713) 928-2324

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Gardner Equipment Co., Inc.
Daryl Benson
P.O. Box 106
Juneau, WI 53039-0106
(800) 393-0333
FAX: (414) 386-5611
Norseman Plastics Limited
Herb Noseworthy/Sharon Palansky
2296 Kenmore Avenue
Buffalo, NY 14207
(800) 267-4391

Smith & Hawken
Jim Downing
117 E. Strawberry Drive
Mill Valley, CA 94941
(415) 383-4415
FAX: (415) 383-8971

Source: County of Santa Barbara Backyard Composting and Yard Waste Reduction Guide.
EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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WINDROW COMPOSTING

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Windrow composting is a process that biodegrades organic material and destroys pathogens, producing a stabilized compost product for use as mulch, soil conditioner, and topsoil additive. The organic material is left to decompose outdoors, aided only by watering and mechanical turning for aeration. This method is simple, non-intensive, has a very low capital cost, and is commonly used by farmers, municipalities, and waste processing corporations. It is the slowest large scale method used to produce compost. Windrow composting can be used to process yard waste, food, paper, and sewage sludge.

The process of composting begins with collecting, receiving, processing, and storing feed stock materials, followed by mixing and pile construction. The compostable materials must be screened or hand picked for non-biodegradable contaminants and then chipped, ground, or shredded into uniform particles that will decompose quickly. The high-carbon, dry wood and paper waste should be mixed in equal proportion with high-nitrogen, high moisture grass clippings and food waste to provide balanced nutrition for the organisms of decomposition. Feedstock materials are mixed using a pugmill, front-end loader, or paddle-blade mixer to evenly distribute the carbon and nitrogen, and then formed into piles to decompose.

Oxygen and temperature are key environmental parameters that must be maintained within a specific range to provide optimum conditions for the microorganisms. The temperature must be high enough to kill pathogens and weed seeds but not kill the microorganisms as well. The process of decomposition produces heat, and the organic material itself provides insulation. Oxygen is required for aerobic decomposition and a well aerated, properly mixed compost pile should not produce unpleasant odors.

Compost is formed into long piles called windrows that are typically 1.5 to 3 meters high, 3 to 6 meters wide, and up to 100 meters or more in length. Windrows can be placed directly on the soil or paved area. The land requirement for a windrow composting facility is dependent on the volume of material processed. Generally, all of the materials handling and pile building can be accomplished with a front-end loader. The

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windrows can be aerated mechanically by turning with a front end loader for smaller operations or using a windrow turner.

Following the composting period, the windrows are broken down and reconstructed into curing piles for additional aging and drying of the material. Curing compost stabilizes it to prevent odors or other nuisances from developing while the material is stored. After curing, the compost can be screened to improve the quality of the final compost product, depending on the requirements of the compost buyer or consumer.

Material

Compatibility: N/A

Safety and Health: Safety concerns for composting deal with the operation of power equipment and health issue of working with decomposing organic matter. Operators should be specifically trained to use the equipment and should not operate machinery if intoxicated or on medication. Proper personal protective equipment including gloves, eye, hearing, and respiratory protection should be used if needed.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Compost reduces the amount of waste to be disposed. Complete recovery of yard waste will reduce the amount of waste generated by an average of 15.9% while the addition of food waste will divert another 6.7% (EPA, 1994)
- Easy to implement and operate
- Handles a large volume of material
- Low capital costs
- Less equipment and maintenance needed than other composting methods
- Uses few resources

Disadvantages:

- Requires a lot of land for composting
- Attracts scavengers
- Often produces odors
- Requires a large buffer zones due to odor and vectors
- May require a permit depending on size
- May require processing of rainwater runoff
- Compost gets too wet and can become anaerobic in rainy conditions

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Economic Analysis: The estimated capital cost for a facility processing approximately 5,000 tons/yr of wood and yard waste is approximately \$600,000 to \$800,000, not including land costs. Operating costs may run \$40 to \$50/ton (including labor, benefits, maintenance, fuel, administration, etc.). The cost of constructing and operating a windrow composting facility will vary from one location to another. The operating costs are highly dependent on the volume of material processed. For example, a yard waste facility processing an average of 25,000 tons/yr may have an annual average operating cost of \$25/ton of material processed. The use of additional feed materials, such as paper and mixed municipal solid waste, will require additional capital investment and labor for processing the materials.

Cost savings can be incurred from using the compost for base landscaping and/or selling the compost product, as well as decreased landfill disposal costs. These cost savings will vary from one location to another. Annual cost savings have been estimated at \$30,000 to \$60,000 (for facilities producing around 5,000 tons/yr of compost) due to avoiding disposal fees and fertilizer and topsoil purchases.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Donald Hopson
US Air Force Academy
Colorado Springs, CO
(719) 472-4483

Tim Brecheen
4 CES/CEV
1095 Mitchell Avenue
Seymour Johnson AFB, NC 27531-2355
(919) 736-6501, DSN 488-6501

Local and state solid waste management government authorities.

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Vendors: Engineering firms specializing in solid waste management and composting technologies:

Don Landry
Valley Compost & Topsoil
P.O. Box 1013
Buellton, CA 83427
(805) 965-6617

Wolfgang Ebert
Buhler, Inc.
P.O. Box 9497
Minneapolis, MN 55440
(612) 540-9226, FAX: (612) 540-9246

Sources: Martin E. Simson, and C. M. Connelly. September 1994. "Composting and Costs: The Bigger, The Better," *Waste Age*.
Parsons Engineering Science, Inc. November 1994. *Vandenberg AFB Recycling and Composting Feasibility/Economic Analysis for Municipal Solid Waste*
EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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AERATED STATIC PILE COMPOSTING

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Aerated static pile composting is a process that biodegrades organic material and destroys pathogens, producing a stabilized compost product that can be used as mulch, soil conditioner, or a soil amendment. This method requires more infrastructure than other composting systems and is typically built by municipalities and waste processing corporations. Compost is placed inside the facility in a large pile and air is forced through it via pipes in the floor. Aerated static pile composting degrades material faster than the windrow method but more slowly than an in-vessel system. These facilities can be used to compost yard waste, food, paper, municipal solid waste, and sewage sludge.

The process for composting begins with collecting, receiving, processing, and storing feedstock materials, followed by mixing and pile construction. The compostable materials must be screened or hand picked for non-biodegradable contaminants and then chipped, ground, or shredded into uniform particles that will decompose quickly. The high-carbon, dry wood and paper waste should be mixed in equal proportion with high-nitrogen, high moisture grass clippings and food waste to provide balanced nutrition for the organisms of decomposition. Feedstock materials are mixed using a pugmill, front-end loader, or paddle-blade mixer to evenly distribute the carbon and nitrogen, and then formed into piles to decompose.

Oxygen and temperature are key environmental parameters that must be maintained within a specific range to provide optimum conditions for the microorganisms. The temperature must be high enough to kill pathogens and weed seeds but not kill the microorganisms as well. The process of decomposition produces heat and the organic material itself provides insulation. Oxygen is required for aerobic decomposition and a well aerated, properly mixed compost pile should not produce unpleasant odors.

Aerated static piles are similar to windrows, but are generally higher, wider, and considerably shorter in length. Pile sizes are typically 3 to 4 meters high, 6 to 8 meters wide, and 30 to 40 meters in length. This type of composting relies on precise control of environmental conditions to process material quickly. Composting is done inside the facility and only a small amount of land is needed to compost a lot of

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waste. Building enclosures protect the piles from weather conditions and can contain odors. Odor control can be achieved with negative aeration, as all of the contaminated process air is drawn through the pile and is contained, allowing easy collection to a central source for treatment. Alternative methods use positive aeration in enclosed operations which collect and treat building air. The land requirement for an aerated static pile facility should include a substantial buffer around the facility due to noise, odors and possible scavenger problems.

Aerated static pile composting uses a series of perforated pipes under each compost pile to force oxygen through the compost. Each pipe in the aeration system is connected to blowers that either draw or blow air through the pipes. The pipes are typically covered with a layer of wood chips that facilitate the distribution of air, providing uniform aeration. The compost mix is placed on top of the wood chip layer forming the piles. The piles are then covered with a layer of material, typically recycled cured compost, for insulation. Unlike windrow composting, the piles are not turned. Pile temperature is controlled by increasing aeration to vent excess heat.

Following the composting period (typically 30 days for biosolids), the piles are broken down and reconstructed into curing piles for additional aging and drying of the material. Curing compost stabilizes it to prevent odors or other nuisances from developing while the material is stored. After curing, the compost can be screened to improve the quality of the final compost product, depending on the requirements of the compost buyer or consumer.

**Material
Compatibility:**

N/A

Benefits:

- Compost reduces the amount of waste to be disposed. Complete recovery of yard waste will reduce the amount of waste generated by an average of 15.9% while the addition of food waste will divert another 6.7% (EPA, 1994)
- The aerated static pile method requires less land than outdoor methods.
- It produces compost quickly.
- It is possible to contain odors.
- Indoor operation reduces access to scavengers.
- Controlled conditions can produce a high quality, marketable compost.

Disadvantages:

- Higher capital cost, and requires more resources to operate than outdoor methods

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- Requires maintenance to keep perforated pipes from clogging. Clogged pipes reduce the efficiency of the systems.

Economic Analysis: A budget-level estimated capital cost for an enclosed facility processing approximately 5,000 tons/yr of wood and yard waste is approximately \$3,000,000 to \$5,000,000. The capital cost, not including land, for an open facility will be decreased by building costs (approximately \$75/sq. ft.). Estimated annual operating costs may run \$50 to \$70/ton (including labor, benefits, amendment grinding, maintenance, fuel, etc.). Compared to in-vessel systems, labor requirements are high, due to the large amount of materials handling, which is usually not automated. The cost of constructing and operating an aerated static pile composting facility will vary from one location to another. Capital costs are dependent on the degree of site preparation and odor controls required, as well as the volume of material processed. The operating costs are highly dependent on the volume of material processed and the type of feed materials. The use of additional feed materials such as paper and mixed MSW will require additional capital investment and labor for processing the materials.

Cost savings can be incurred from using the compost for base landscaping and/or selling the compost product as well as decreased landfill disposal costs. These cost savings will vary from one location to another. Annual cost savings have been estimated at \$30,000 to \$60,000 (for facilities producing around 5,000 tons/yr of compost) due to avoiding disposal fees and fertilizer and topsoil purchases.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Bruce F. Zimmerman
Public Works Director
Mackinac Island Department of Public Works
Market Street
Box 515
Mackinac Island, MI
(906) 847-6130

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Joel Thompson, Operations Manager
Montgomery County Regional Composting Facility
2201 Industrial Parkway
Silver Spring, MD 20904
(301) 206-7575

Local and state solid waste management government authorities.

Vendors: The following is a list of engineering firms specializing in solid waste management and composting technologies. This list is not meant to be complete, as there may be other providers of these services.

Steve Knight
Daneco, Inc.
119 N. Fourth Street, Suite 508
Minneapolis, MN 55401
(612) 376-7920
FAX: (612) 376-7612

Wolfgang Ebert
Buhler, Inc.
P.O. Box 9497
Minneapolis, MN 55440
(612) 540-9226
FAX: (612) 540-9246

Sources: Martin E. Simson and C.M. Connelly. September 1994. "Composting and Costs: The Bigger, The Better:" *Waste Age*.
Parsons Engineering Science, Inc. August 1994. *Feasibility Study for a Full-Scale Composting Facility*.
EPA, *Characterization of Municipal Solid Waste in the United States: `1994 Update*.

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IN-VESSEL COMPOSTING

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Composting is a process that biodegrades organic material and destroys pathogens, producing a stabilized compost product for use as mulch, soil conditioner, and topsoil additive. In-vessel systems can compost yard waste, food, sewage sludge, mixed wastes, and paper to produce a marketable, high quality product. The materials degrade aerobically or anaerobically in a tank under optimum conditions. Some aerobic in-vessel systems can produce compost within 72 hours. This system is high technology compared to other composting methods and requires precise temperature and oxygen control. It is used in applications where land space is limited, and works very well for food waste (including animal products) and sewage that is often to messy or smelly for open composting. Anaerobic systems are used to compost mixed waste and other organics and produce bio-gas that can be burned for energy. These systems are used by municipalities and large facilities.

Although carbon to nitrogen ratios and moisture content must be considered, the composition of feed materials is more flexible for selected in-vessel systems compared to windrow or aerated static pile systems. This flexibility allows for different mixes to be composted, based on availability of feed materials. The compostable materials must be screened or hand picked for non-biodegradable contaminants and then chipped, ground, or shredded into uniform particles that will decompose quickly. Feedstock materials are mixed using a pugmill, front-end loader, or paddle-blade mixer to evenly distribute the carbon and nitrogen.

Oxygen and temperature are key environmental parameters that must be maintained within a specific range to provide optimum conditions for the microorganisms. The temperature must be high enough to kill pathogens and weed seeds but not kill the microorganisms as well. The method of air supply to the compost mix depends on the particular in-vessel system selected. Generally, air is supplied by blowers and flows up through the compost. Air can be supplied via piping networks or through damper arrangements beneath the compost. Blowers can operate automatically based on measured temperature set points or set at regular intervals. Pile temperature is controlled by cycling the aeration system on and off.

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There are two main types of in-vessel systems: plug-flow and dynamic. In plug-flow systems, material flows or is pushed through a system that operates on a first-in, first-out basis. In dynamic systems, the composting material is mechanically mixed during the process, typically moving through the vessel as it is mixed. Vertical composting reactors are generally over 4 meters high and can be enclosed with a silo or other large structure. These reactors are generally plug-flow systems, with the compost mix introduced into the reactor at the top and gravity fed to an unloading mechanism such as a discharge screw at the bottom. Process control is difficult due to the height of the reactors. These systems also require a more uniform and porous feedstock than horizontal agitated bed systems due to the lack of internal mixing, and are rarely used for heterogeneous materials like mixed waste. Horizontal reactors are also enclosed and come in a wide range of configurations and sizes, including static or agitated, and pressure or vacuum-induced aeration. Agitated systems use a mechanized turning device to move material through the system in a continuous mode, while static systems require a loading and unloading mechanism. Process control is more manageable in a horizontal reactor due to ease of accessibility, mixing capabilities, and shallower depth of compost. Another type of reactor, called a rotating drum reactor or digester, homogenizes and shreds the feedstock for a minimal time period (several hours to several days) to initiate microbial degradation. The compostable material is then removed from the reactor and further processed.

The land requirement for an in-vessel composting facility is similar to that required for aerated static pile composting for horizontal reactors, and considerably less for vertical reactors. Operator labor is minimized with in-vessel systems and is primarily limited to materials handling (using a front-end loader) and monitoring the composting process parameters. Conveyors, feed screws, and mixer/agitators are used to mechanically move the material through the composting process.

The composting period in an in-vessel system is generally shorter than that required for windrow and aerated static pile systems (14 to 21 days). However, the material is commonly moved into windrows or static piles for further decomposition and curing (i.e., additional aging and drying of the material). Curing compost stabilizes mature compost to prevent odors or other nuisances from developing while the material is stored. After curing, the compost can be screened to improve the quality of the final compost product, depending on the requirements of the compost buyer or consumer. Good odor control is achieved as most of these systems can effectively contain the contaminated process air, allowing easy collection to a central source for treatment. Enclosed

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operations allow for collection and treatment of building air, further reducing the potential for odors to travel off site.

Materials

Compatibility: Many in-vessel systems have never been operated with yard waste as a bulking agent. A description of the desired feedstock should be discussed with the vendor to determine compatibility with the facilities goals for waste reduction.

Safety and Health: Care should be taken when handling compost material. The odors from the compost can be an irritant. Respiratory protection may be required.

Consult your local base safety office prior to implementing any of these technologies.

Benefits:

- Compost reduces the amount of waste to be disposed. Complete recovery of yard waste will reduce the amount of waste generated by an average of 15.9% while the addition of food waste will divert another 6.7% (EPA, 1994)
- Fast method of composting
- Requires fewer human operators than other composting methods
- Materials handling systems are more mechanical and efficient in design than aerated static pile and windrow composting systems
- Some in-vessel composting technologies have considerable operational flexibility in feedstock composition
- Good odor control is achieved through collecting and treating the process air and building air

Disadvantages:

- Higher capital cost, and requires more resources to operate than outdoor methods
- Requires maintenance to keep equipment working

Economic Analysis: There is considerable variation in costs between the various in-vessel composting systems. A budget-level estimated capital cost for a 4-bay horizontal agitated bed in-vessel International Process Systems (IPS) facility, processing approximately 5,000 tons/yr of wood and yard waste, food waste, and miscellaneous compostables, is approximately \$2,400,000 to \$2,800,000. Estimated annual operating costs could range from \$40 to \$60/ton (including labor, benefits, amendment grinding, maintenance, fuel, etc.). The cost of constructing and operating an in-vessel composting facility will vary from one location to another based on feed stock, odor control requirements, and site constraints. The capital and operating costs are highly dependent on the volume of material processed.

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An alternative technology for processing mixed MSW and wastewater biosolids, as opposed to selected waste stream components, is the Bedminster/Eweson system. This three compartment rotary vessel uses a tube-shaped digester to accelerate microbial action in the waste material. The estimated capital cost for this type of system is approximately \$70,000 to \$100,000 per design day ton of solid waste. For a 35 tpd capacity, the anticipated capital cost would be \$2,500,000 to \$3,500,000. The operating costs would be approximately \$45 to \$65/ton.

Cost savings can be gained from using the compost for base landscaping and/or selling the compost product, as well as decreased landfill disposal costs. These cost savings will vary from one location to another. Annual cost savings have been estimated at \$30,000 to \$60,000 (for facilities producing around 5,000 tons/yr of compost) due to avoiding disposal fees and fertilizer and topsoil purchases.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Phil Hayes, Facility Manager
Pinetop-Lakeside Sanitary District
Route 3, Box P-LSD
Lakeside, AZ 85929
(520) 368-5370

Local and state solid waste management government authorities.

Vendors:

This is not meant to be a complete list, as there are other manufacturer and vendors of in-vessel composting systems.

Wheelabrator Clean Water Systems, Inc.
Jay Harper
Director, Technical Services
Liberty Lane
Hampton, NH 03842
(508) 347-7344

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Bedminster Bioconversion Corporation
Billy J. Toups
Regional Marketing Director
12 Executive Campus
535 Route 38
Suite 580
Cherry Hill, NJ 08002
(318) 989-0116

Jim Schliefle, Sales Manager
CBI Walker
1501 North Division Street
Plainfield, IL 60544-8929
(815) 439-6543

Robert Harris
Taulman, Inc.
415 E. Paces Ferry Road, N.E.
Atlanta, GA 30305
(404) 262-3131

Compost Systems Company/Fairfield Service Company
240 Boone Avenue
P.O. Box 354
Marion, OH 43302
(614) 387-3335

Tom Laken
Waste Solutions, Inc.
500 Southland Drive
Suite 124
Birmingham, AL 35226
(205) 823-5231

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VERMICOMPOSTING

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Landfilling
Applicable EPCRA Targeted Constituents: N/A

Overview: Vermicomposting is a process that uses red worms to consume organic waste, producing an odor-free compost product for use as mulch, soil conditioner, and topsoil additive. Naturally occurring organisms, such as bacteria and millipedes, also assist in the aerobic degradation of the organic material. Vermicomposting is especially useful for processing food waste since the worms consume the material quickly and there are fewer problems with odor. Worms cannot be added to “hot “ composting piles since the temperatures of ordinary compost piles would kill the worms. For this reason, vermicomposting is more appropriate for food, paper, and yard waste only since pathogen reduction through high temperatures is not a significant concern. Worms can be added to pre-composted material that is at a lower temperature.

This composting process is popular for small scale use by individuals or groups of individuals as an alternative to traditional backyard composting because it is fast and produces a high quality compost. Large scale vermicomposting operations for handling commercial food and yard waste are becoming more popular. This method is significantly different from other types of composting since the material is consumed by worms rather than degraded by microorganisms. In some states, vermicomposting is considered an animal raising, rather than a composting activity, and is exempt from the composting permitting process.

Organic material should be chopped or shredded for faster degradation. Unprocessed materials can be used in vermicomposting, but the time required for complete degradation of the organic waste is generally 6 months or longer. Vermicomposting does not require a balanced carbon-to-nitrogen ratio like traditional aerobic composting methods (e.g., windrow and aerated static pile).

Composting bins for residential use can be built or purchased through mail order gardening supply catalogs. The bin must have sufficient aeration, drainage, and a secure lid to exclude scavengers and insects. Bin size depends on the average amount of food waste generated during a week. A 36 by 48 by 36 inch outdoor bin developed by the Oregon

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Soil Corporation will process 6 to 12 pounds of food scraps per day. Worms can consume half of their body weight each day.

Preparing a vermicomposting composting bin requires moistened bedding, a few handfuls of soil, and red worms. More care must be taken than with other types of composting to provide for the unique needs of the worms. , The bedding material can be made from newspaper strips, wood shavings or similar materials. It retains moisture, reduces odors, and serves as food for the worms. It is also used to escape the heat from the decomposing food waste. The worms are spread onto the bedding and allowed to move below the surface. Organic waste is introduced into a carefully dug hole in the bedding mixture and covered with a one inch layer of bedding to exclude flies. As the worms digest the bedding and organic waste, dark brown castings will be produced. After 4 to 6 months, the vermicompost should be pushed to one side of the bin and fresh bedding placed in the other side. For an additional month, the food waste should be put into the fresh bedding and the worms will migrate to the food source. The mature compost is then harvested.

On a larger scale, one vermicomposting operation utilizes a raised, 120-foot bed or trough that is 2.5 feet deep and 8 feet wide, with a mesh floor, to process approximately 5 to 6 tons of food waste and over 2 tons of yard waste per day. The operation is enclosed within a greenhouse type structure. An adapted manure spreader makes a daily pass over the trough, spreading roughly 3 inches of prepared organic materials per day. As the worms eat their way through the fresh material, their castings sink down and are mechanically scraped off the bottom of the screen and collected. It takes approximately 21 days to make earthworm castings using this method.

Another large-scale proprietary vermicomposting system called the “Vermiconversion System” utilizes thermophilic composting (for pathogen destruction and weed seed neutralization) for 3 to 15 days, and then places the composting material in vermiprocessing beds or windrows for an additional 30 days. Two to 4 inches of new material are applied to the rows every other day, not exceeding a total row height of 3 feet. The beds or windrows can be built on a sloped plastic liner for water reclamation, and utilize aeration piping and a micro emitter sprinkler to maintain proper oxygen and moisture levels.

Materials

Compatibility: N/A

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Safety and Health: If the compost contains food waste and animal products, it should be handled with gloves and care should be taken to wash hands and clothing after processing it. It might be necessary to wear a mask when turning and working with compost to prevent inhaling bacteria or particles.

Benefits:

- Compost reduces the amount of waste to be disposed. Complete recovery of yard waste will reduce the amount of waste generated by an average of 15.9% while the addition of food waste will divert another 6.7% (EPA, 1994)
- Vermicomposting produces a nutrient-rich humus with a smaller particle size, lower odor, and greater nutritional value than other types of compost. It is more marketable as well.
- Vermicomposting sometimes has a less stringent permitting process
- It produces compost quickly

Disadvantages: Requires more management and maintenance than other composting systems to meet the needs of the worms

Economic Analysis: Capital costs for materials or mail order purchase of individual vermicomposting bins can vary from \$30 to over \$300. Red worms can be purchased from bait shops, garden centers, or through mail order businesses for approximately \$10 per pound. The estimated capital cost for a large-scale facility processing approximately 10 tons/day (2,500 to 3,000 tons/yr) of food and yard waste is approximately \$30,000 to \$40,000 for a basic reactor system, not including equipment land costs. The cost of materials processing equipment will vary depending on the type of equipment selected. Annual operating costs may run \$40 to \$60/ton (including labor, benefits, maintenance, fuel, administration, etc.). The cost of constructing and operating a vermicomposting facility will vary from one location to another. The operating costs are highly dependent on the volume of material processed and the type of system selected. Alternatively, a 200 ton/day facility using the Vermiconversion System (thermophilic composting followed by vermicomposting) was recently implemented for capital cost of approximately \$2,000,000. Each naval activity will need to evaluate the economic feasibility of establishing a vermicomposting operation compared to alternative solid waste management technologies.

For large-scale vermicomposting, cost savings can be incurred from using the compost for base landscaping and/or selling the compost product as well as decreased landfill disposal costs. These cost savings will vary from one location to another. Annual cost savings have been estimated at \$30,000 to \$60,000 (for facilities producing around 5,000

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tons/yr of compost) due to avoiding disposal fees and fertilizer and topsoil purchases.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

John Longfellow
Klickitat County Public Services
205 South Columbus Avenue
Goldendale, Washington
(509) 773-4448, FAX: (509) 773-5713

Local and state solid waste management government authorities.

Vendors:

Sky and Chris Hunt
Recycleit Corporation
3861 Appalachian Way
Redding, CA 96001
(800) 769-1044

Joseph Roberts
Resource Conversion Corp.
7825 Fay Avenue, Suite 380
La Jolla, CA 92037
(619) 551-4800

Sources: *Biocycle*, October 1994 and February 1995.
EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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TUB GRINDERS

Revision 1/96
Process Code: Navy: SR-05-00; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: A tub grinder is used to reduce wood or other organic matter into small particles. The upper section is a large, revolving tub and the stationary, lower section contains a hammer mill. Typically, the tub grinder is fed by a front-end loader or stationary grapple, while a conveyor carries away the continuous stream of shredded material. Tub grinders are not limited in opening size like smaller chippers and shredders, and can process large and odd shaped wood including stumps, pallets, and waste lumber. The larger-sized output material from the tub grinder can be used as a biomass fuel or as a bulking agent to balance high nitrogen loads in composting operations. The smaller-sized material is composted.

Normal tub widths range from 6 to 14 feet in diameter. Most Navy buyers prefer an 8 foot tub width. Engine horsepower can range from 100 hp to 800 hp. A 575 hp tub grinder is capable of providing a throughput of up to 120 tons per hour. Grinder weight varies from 5,000 pounds to 60,000 pounds. The entire tub grinder assembly is usually moveable from one site to another.

Materials

Compatibility: N/A

Safety and Health: Safety issues for using tub grinders deal with the operation of power equipment. Operators should be specifically trained to use the grinder. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment including gloves, eye protection, and hearing protection should be used if needed.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Produces usable products such as landscape mulch, fuel, and compost agents
- Grinds material to a fine, even texture that will compost quickly
- Can process large trees and finished lumber
- If all yard waste is ground and diverted, there is a possible average 15.9% reduction in waste (EPA 1993)
- If all wood is ground and diverted, there is an additional 6.6% possible reduction in waste (EPA, 1993)

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Disadvantages: N/A

Economic Analysis: Typical application: 8 foot tub grinder, 110 hp diesel; capital cost - \$40,000; operating cost - \$17/hour (includes labor, fuel, and maintenance).

Alternate application: 10 foot tub grinder, 300 hp diesel; capital cost - \$83,000; operating cost - \$24/hour (includes labor, fuel, and maintenance).

Alternate application: 12 foot tub grinder, 500 hp diesel; capital cost - \$170,000; operating cost - \$32/hour (includes labor, fuel, and maintenance).

Chipper applications: at 25 to 50 cubic yards per hour; capital cost: \$10,000 to \$40,000 (with replacement blades at approximately \$70 to \$200).

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Wallace Eakes. ESC 423
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-4882, DSN 551-4882

Tim Brecheen
4 CES/CEV
1095 Mitchell Avenue
Seymour Johnson AFB, NC 27531-2355
DSN 488-6501, (919) 736-6501

Julie Schambaugh
Environmental Control Specialist
MCB Camp Lejeune, North Carolina
DSN 484-5878, (910) 451-5878

Vendors:

The following vendors manufacture tub grinders. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

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DuraTech Industries International
P.O. Box 1940
Jamestown, ND 58402-1940
(701) 252-4601

Diamond Z Manufacturing
1102 Franklin Boulevard
Nampa, ID 83687
(208) 467-6229

Morbark Sales Corp.
P.O. Box 1000
Winn, MI 48896
(800) 233-6065

Olathe Manufacturing, Inc.
201 Leawood Drive
Industrial Airport, KS 66031
(913) 782-4396

Vermeer, Inc.
P.O. Box 200
Pella, IA 50219
(800) 829-0051

Source: Vendor Communication: DuraTech Industries International (March 1995).
Vendor Communication: Mobark Sales Corp. (March 1995).

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PAPER SHREDDERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Shredders can be used to cut paper into approximately ½-inch strips to make it more suitable for composting or reuse as animal bedding or packing material. Newspaper, office paper and mixed paper are more marketable when sold whole to recyclers since shredding reduces the fiber length, but this process can be applied to paper that cannot be recycled. This includes food contaminated, waxed, or other non-recyclable paper as well as paper from remote locations where recycling is not an option. Paper shredded for security purposes can also be diverted for these alternate uses. This finely shredded paper is sometimes not recyclable due to the reduction in fiber length.

Materials

Compatibility: N/A

Safety and Health: Safety issues for shredders deal mostly with the operation of power equipment. Operators should be specifically trained to use the shredder and exercise caution to keep limbs, clothing and hair from being caught up in the feed mechanism. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment including gloves, eye protection, and hearing protection should be used if needed.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits: Permits composting and reuse of otherwise non-recyclable paper
Potential reduction of disposed waste by 31.7% by diverting all paper products from the waste stream (EPA, 1994)

Disadvantages: N/A

Economic Analysis: Typical Navy Application: at 1,500 tons/year generating ½-inch strips; capital cost - \$35,000; operating cost - \$200/year (does not include labor or electrical costs).

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Donald Hopson
510 CES/CEV
8120 Edgerton Drive, Suite 40
US Air Force Academy
Colorado Springs, CO 80840-2400
(719) 472-4483

Vendors: The following vendors manufacture paper shredders. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

Allegheny Paper Shredders Corp.
P.O. Box 80
Old William Penn Highway East
Delmont, PA 15626
(800) 245-2497, FAX (412) 468-5919

Ameri-Shred Corp.
P.O. Box 46130
Monroeville, PA 15146
(800) 634-8981, FAX (412) 823-2451

Whitaker Brothers Business Machines, Inc.
12410 Washington Ave
Rockville, MD 20852
(800) 243-9226, FAX (301) 770-9217

PCR, Inc.
Rt. 1
Coon Valley, WI 54623
(608) 452-3651

Source: Personal communication with vendors (Ameri-Shred, Allegheny Paper Shredders, Whitaker Brothers, and PCR) (March 1995).

EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*.

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TROMMEL SCREENS

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: A trommel is a rotary cylindrical screen that is typically inclined at a downward angle. The screening surface consists of a perforated plate or a wire mesh which, combined with the tumbling action of the trommel, separates materials of different density. Trommel screens are used to separate commingled recyclables, municipal solid waste components, or to screen finished compost from windrow and aerated static pile systems.

Trommel screens are used by material recovery facilities to separate compostable paper from glass and other contaminants in previously shredded municipal solid waste. Smaller trommels have been used to separate labels and caps from crushed glass. Some trommels are designed to let paper pass through the screen while diverting heavier materials to re-crushing or a landfill. Other applications require multi-stage trommel screens which have meshes or plates of different aperture sizes. These screens may be used for the separation of commingled wastes with components of various sizes.

In composting applications, trommel screens are used to enhance the market value of finished compost by separating large particles and non-degraded bulking agents such as wood chips from the organic fines. The fines are used or sold as a soil amendment and the bulking agent can be re-used. Trommel screens are used when a high quality end product is desired.

The factors that influence the separation efficiency of trommel screens are:

- Characteristics and quantity of the incoming materials
- Size, proportions, and inclination of the cylinder screen
- Rotational speed
- Clogging of screen openings
- Size and number of screen openings

The types of trommel screens available range from electrically or hydraulically stationary units with or without conveyors and hoppers to electrically or hydraulically self-contained, portable/mobile units with conveyors, cleaning brushes, and variable speed trommel drums.

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Materials

Compatibility: N/A

Safety and Health: Safety issues for using trommel screens deal with the operation of power equipment. Operators should be specifically trained to use the trommel screen. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment including gloves, eye protection, and hearing protection should be used if needed.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Allows recovery of recyclable and compostable wastes from mixed waste stream
- Produces a high quality compost product for use in landscaping
- Produces a more marketable compost product that has higher value
- Allows reuse of compost bulking material

Disadvantages: N/A

Economic Analysis: Typical application: at 50 to 100 cubic yards/hour; capital cost - \$50,000 to \$180,000; operating cost - N/A.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Wallace Eakes, ESC 423
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-4882, DSN 551-4882

Vendors: The following vendors manufacture trommel screens. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

The McLanahan Corporation
P.O. Box 229
200 Wall Street
Hollidaysburg, PA 16648
(814) 695-9807, FAX (814) 695-6684

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Re-Tech
499 Houztown Road
Myerstown, PA 17067
(717) 866-2357

Triple/S Dynamics, Inc.
1031 South Haskell Avenue
Dallas, TX 75223
(214) 828-8600

Wildcat Manufacturing Co., Inc.
Box 523
Freeman, SD 57029
(800) 627-3954

Source: *Handbook, Material Recovery Facilities for Municipal Solid Waste*, USEPA, EPA/625/6-91/031.
Vendor Communication: Wildcat Mfg. Co. Inc. (March 1995).

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COMPOST MIXERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Compost mixers are used to mix raw materials such as food, yard waste, paper, and sewage sludge uniformly before composting. Mixing is an important step to distribute the carbon and nitrogen materials evenly and assure fast, clean smelling decomposition. For materials such as food waste and sewage sludge, mixers can be used to incorporate bulking agents such as wood chips that add carbon to the mix and break up wet clumps.

Mixers are large containers with mobile paddles to mix compostable materials. They are used for larger composting operations where mixing with a loader would be impractical, or ones which depend on precise mixtures of carbon and nitrogen according to compost recipes. The paddle mixer, pugmill mixer, and rotary drum mixer are the most common compost mixers. The units may be stationary or mobile, and may be powered electrically or by diesel engine. Some pieces of equipment designed for mixing other products such as animal feed can be used to mix compost.

Materials

Compatibility: N/A

Safety and Health: Safety issues for using compost mixers deal with the operation of power equipment. Operators should be specifically trained to use the mixer. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment including gloves, eye protection, and hearing protection should be used if needed.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Thorough mixing speeds up the composting process by making nutrients available to microorganisms
- Fast, efficient mixing of compost materials compared to mixing with a loader
- Can handle high volume of materials
- Breaks up clumps of material that can become anaerobic and smelly in the compost pile.

Disadvantages: N/A

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Economic Analysis: Typical Navy application (at 20 to 30 tph using a stationary unit with an electric motor): Capital cost - \$30,000 to \$40,000; operating cost - \$500/yr (does not include labor). Alternate application (at 40 tph using a mobile unit with a diesel 110 hp engine): Capital cost- \$60,000; operating cost - \$500/ton (does not include labor).

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of

Contact: Wallace Eakes, ESC 423
Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370
(805) 982-4882, DSN 551-4882

Vendors: The following vendors manufacture compost mixers. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

The F. B. Leopold Company, Inc.
227 South Division Street
Zelienople, PA 16063-1313
(412) 452-6300, Fax (412) 452-1377

The McLanahan Corporation
P.O. Box 229
200 Wall Street
Hollidaysburg, PA 16648
(814) 695-9807
Fax (814) 695-6684

Detcon
Farmingdale, NJ 07727
(908) 938-2211

Knight Industrial Division
PO Box 167
Brodhead, WI 53520
(608) 897-2131

Source: Personal communication with vendors (Leopold, McLanahan, Detcon, and Knight) (March 1995).

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FRONT-END LOADERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: A front-end loader is one of the most important pieces of equipment for a composting operation. It may be the only piece of equipment required for a small facility using a low-level technology approach. Typically, front-end loaders are used to move quantities of compostable materials. Loaders can be used to fill a tub grinder, load material into a compost mixer, mix shredded or ground feedstock, turn and aerate compost, combine decomposing windrows, and move finished compost off site. Unless the operation is a backyard composting project, a loader is a required piece of equipment for composting.

Front-end loaders may be fitted with attachments, such as claws for moving woody wastes, or simple compost turners for the mixing and aeration of windrows. In compost operations, a large capacity bucket, usually larger than 4 cubic yards (cy) and possibly up to 10 cy, is required.

Materials

Compatibility: N/A

Safety and Health: Safety issues for using front end loaders deal with the operation of power equipment. Operators should be specifically trained to use the loader. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment including gloves, eye protection, and hearing protection should be used if needed.

Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Efficient materials handling with oversized buckets.
- Functions as a compost turner with attachments
- Versatility for other uses
- Can handle all composting equipment needs for small to medium projects

Disadvantages:

- Slower for turning compost than a windrow turner

Economic Analysis: Typical Navy Application: Capital cost - \$80,000 to \$160,000; operating cost - \$4/hr.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Donald Hopson
510 CES/CEV
8120 Edgerton Drive, Suite 40
US Air Force Academy
Colorado Springs, CO 80840-2400
(719) 472-4483

Vendors: The following vendors manufacture front-end loaders. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

J. I. Case Corp.
700 State Street
Racine, WI 53404
(414) 636-6011, FAX (414)636-7809

Caterpillar, Inc.
100-T NE Adams Street
Peoria, IL 61629-0002
(309) 675-5394

John Deere
Dubuque Works
P.O. Box 538
Dubuque, IA 52001
(319) 589-5151

Source: Personal communication with vendors (Case, Caterpillar, and Deere) (March 1995).
Illinois Department of Energy and Natural Resources, 1989. *Management Strategies for Landscape Waste--Collection, Composting, Marketing* ILENR/RR-89/09.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

WINDROW TURNERS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Windrow turners are used to turn and aerate compost in windrows (long extended piles). Turners break up anaerobic pockets in the compost, introduce oxygen, and release heat from the pile. Windrow turners are especially suited for high-volume facilities.

Large windrow turners are typically self-propelled and straddle the windrow, using a cylindrical drum with attached flails to mix the compost. Smaller windrow turners consist of a unit that can be attached to a front-end loader or tractor that is driven between windrows. This side-mounted unit may have the advantage of being more economical for sites that do not require a full-time windrow turner, however, since they turn only half of the pile or windrow, more passes are needed for each pile and labor hours are increased.

Materials

Compatibility: N/A

Safety and Health: Safety issues for using windrow turners deal with the operation of power equipment and health issues of working with decomposing organic matter. Operators should be specifically trained to use the turner. Machinery should not be used if workers are intoxicated or on medication. Proper personal protective equipment including gloves, eye protection, respiratory protection, and hearing protection should be used if needed. Consult the base safety office on proper protective gear and training prior to using mechanized equipment.

Benefits:

- Turns more cubic yards per hour of compost than a front-end loader
- Produces compost with a superior texture relative to that produced by a front-end loader

Disadvantages:

- Turner design and size limits windrow dimensions to a maximum of 5 to 7 feet high and 14 to 18 feet wide at the base
- Windrow turners require level surfaces to operate efficiently
- Can be difficult to move from site to site

Economic Analysis: Typical application: at 2,000 cubic yards/hour (requires front-end loader); capital cost - \$45,000; operating cost - \$18/hour (does not include cost for labor or front-end loader).

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Alternate application: at 4,000 cubic yards/hour (self-propelled unit); capital cost - \$250,000; operating cost - \$35/hour (does not include labor).

**Approval
Authority:**

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

**Points of
Contact:**

Tim Brecheen
4 CES/CEV
1095 Mitchell Avenue
Seymour Johnson AFB, NC 27531-2355
DSN 488-6501 or (919) 736-6501

Vendors:

The following vendors manufacture compost turners. They do not represent a complete listing, as other similar manufacturers of this type of equipment may exist.

Brown Bear Corp.
Corning, IA 50841; (515) 322-4220

Double T Equipment Manufacturing Limited
Airdrie, Alberta
Canada T4B 2B8; (403) 948-5618

Scarab Manufacturing and Leasing, Inc.
White Deer, TX 79097; (806) 883-7621

Scat Engineering Division, ATI
Delhi, IA 52223; (800) 843-7228

Wildcat Manufacturing Co., Inc.
Freeman, SD 57029; (800) 627-3954

Source: Vendor Communication: Double T Equipment Manufacturing Limited (March 1995).
Vendor Communication: Scarab Manufacturing and Leasing, Inc. (March 1995).
Vendor Communication: Scat Engineering (March 1995).
Vendor Communication: Wildcat Manufacturing Company, Inc. (March 1995).
Illinois Department of Energy and Natural Resources, 1989. *Management Strategies for Landscape Waste - Collection, Composting, Marketing*. ILENR/RR-89/09.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Impact Concentrated Industrial Degreaser	Lectra Clean II
Application	Used as a wipe or spray, in high-pressure system to clean machinery, trucks, road equipment, engine blocks, roofing equipment masonry, building, & maintenance equipment.	Electrical cleaning and degreasing, motors, parts and other equipment.
Replaces	TCA, other chlorinated solvents, petroleum distillates, MEK, and Toluene	TCA, other chlorinated solvents
Method of Use	Wipe and spray	Spray and wipe
Chemical Ingredients	Citrus Terpenes, Coconut Diethanolamide, Nonionic surfactant, dye	Dipropylene, glycol monoethyl ether, petroleum distillate, DPM acetate
Paint Removal	Yes	No
Safety & Health	Irritation to eyes, skin and respiratory tract. Excessive inhalation can cause dizziness/nausea and loss of consciousness. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low dermal and ocular toxicity. Inhalation can cause irritation and central nervous system effects. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Cost	\$2037.42 55-gal \$321.99 5-gal \$131.71 12-1-qt	\$1,387.50 55-gal \$113.70 4-1-gal container \$132.00 5-gal can \$67.50 12/20 oz can/box
Water Soluble	Yes Emulsifier	No
Disposal	Sanitary system	
Recycling Options		
VOC	90%+	100%
Vapor Pressure	less than 10 mm Hg	5 mm Hg @ 25 °C
Flashpoint (°F)	130	142
Boiling Point (°F)	335	more than 375
Density (lbs/gal)	7.18	6.90
NSN	6850-01-380-4053 55-gal 6850-01-380-43695-gal 6850-01-384-0618 12-1-qt	6850-01-382-5252 55-gal 6850-01-382-5369 4-1-gal 6850-01-382-5390 5-gal 6850-01-382-5783 12/20 oz
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Allied Enterprises	CRC Industries Inc.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Hurri-Safe Special Formula Degreaser	OCS Systems/Hurri-Safe Exterior Surface Cleaner (HK188)
Application	Used in cold parts washing for metal cleaning & degreasing; ultrasonic degreasers used at ambient temperatures; wipe on/wipe-off process to remove contaminants from metals prior to painting.	Used in wipe-on/wipe-off cleaning of aircraft metal parts and surfaces prior to painting, bonding, priming, or using adhesives.
Replaces	TCA, Methyl Ethyl Ketone, Toluene, and various petroleum solvents	MEK, Toluene
Method of Use	wipe-on/wipe-off	wipe-on/wipe-off
Chemical Ingredients	2-butoxyethanol	2-butoxyethanol
Paint Removal	Yes	Yes
Safety & Health	Low dermal and ocular toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low dermal and ocular toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Cost	\$11.12 1-gal \$665.48 55-gal \$41.90 5-gal	\$588.55 55-gal
Water Soluble	Yes, completely	Yes, completely
Disposal	Sewer discharge	Sewer discharge
Recycling Options	Clarifier, OCS can provide a recycling unit	Clarifier, OCS can provide a recycling unit
VOC	0.05 %	0.05 %
Vapor Pressure	non-volatile	
Flashpoint (°F)	N/A	N/A
Boiling Point (°F)	212	212
Density (lbs/gal)	8.45	8.45
NSN	6850-01-369-2474 1-gal 6850-01-369-2475 55-gal 6850-01-369-9303 5-gal	6850-01-373-5865 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Bio T Max	Hurri-Safe Hot Immersion Degreaser
Application	Maximum strength degreaser/cleaner. Effective in dissolving and removing grease, dirt oil and similar tough substances. Ideal for use in dip tanks, pressure spray units, and other industrial equipment.	For use in immersion tanks, re-circulating in in-line wash systems, heated ultrasonic degreasers steam cleaners, and high pressure washers
Replaces	Chlorinated solvent, mineral spirits, naphtha based products.	TCA, MEK, CFC's, various petroleum solvents
Method of Use	Varied	Wipe-on/wipe-off
Chemical Ingredients	Natural terpene	2-butoxyethanol
Safety & Health	May cause dermatitis. Inhalation can result in central nervous system depression. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low toxicity. Skin exposure can cause dryness and irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$110.54 4-1-gal cans/box \$123.48 (5-gal can) \$1,228.92 (55-gal drum)	\$17.00 1-gal \$80.00 5-gal \$825.00 55-gal
Water Soluble	Dispersible	Yes, complete
Disposal	HW due to low flashpoint	Sanitary sewer
Recycling Options	Parts washer, filter	Clarifier, OCS can provide recycling unit
VOC	780 g/l	206 g/l
Vapor Pressure	Less than 2 mm Hg	14.2 mm Hg
Flashpoint (°F)	146	N/A
Boiling Point (°F)	334	212
Density (lbs/gal)	7.17	8.48
NSN	6850-01-381-3785 4/1-gal 6850-01-381-3930 5-gal 6850-01-381-3944 55-gal	6850-01-373-5866 5-gal 6850-01-373-5867 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Golden Technology Co.	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Teksol EP	AMEROID OWS
Application	For electronic & electrical cleaning, metal preparation, substitute for 1,1,1 trichloroethylene. For surface preparation for painting or welding, substitute for Toluene/xylene/MEK. For degreasing & resin removal, substitute for Trichloroethylene	Fast-breaking emulsifier for cleaning bilges and degreasing engines.
Replaces	TCA, Toluene/xylene/MEK Freon-113	N/A
Method of Use	Manual wipe, dip tank	Place mixture of seawater and OWS in bilges for 24 hours, allowing motion of vessel to agitate the mixture.
Chemical Ingredients	C10-C11 paraffinic hydrocarbons, d-limene	Dichlorotoluene-2, aliphatic and aromatic petroleum distillates.
Safety & Health	Low order oral and dermal toxicity. Repeated skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Prolonged skin exposure can cause defatting and dermatitis. Eyes can have redness, tearing, or blurred vision. Excessive inhalation can cause nasal and respiratory. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$148.50 6/1 gal \$132.06 5-gal can \$606.00 30 gal drum \$921.25 55-gal drum	\$11.35/gal (1992)
Water Soluble	No	Disperses in water, separates when emulsion breaks
Disposal	Contact federal, state, county, or local environmental regulatory agencies for guidance.	After emulsion breaks, water may be suitable for disposal as a non-hazardous waste or treatment. Oily residue should be incinerated.
Recycling Options	Distillation, Inland filtration system available	Oily contaminants can be filtered out, leaving water that may be suitable for reuse
VOC		98% volatile
Vapor Pressure	Less than 10 mm Hg	Less than 1 mm Hg
Flashpoint (°F)	112	140
Boiling Point (°F)	310	405
Density (lbs/gal)	6.40	7.5
NSN	6850-01-378-0581 1-gal 6850-01-378-0581 5-gal 6850-01-378-0700 30-gal 6850-01-378-0650 55-gal	6850-01-298-9823 6-gal 6850-01-298-9822 32-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Drew Ameroid Marine One Drew Plaza Boonton, NJ 07005 (201) 263-7600

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	HI-SOLV	OCS H2002U
Application	Degreaser	Removes grease, oil, dirt, carbon
Replaces		TCA, acetone, chlorinated solvents, perchloroethylene
Method of use	Immersion or brush	Ultrasonic cleaner
Chemical Ingredients	Azeotropic blend of odorless hydrocarbon solvents C ₁₂ C ₁₈	2-Butoxyethanol
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint removal	No	No
Cost		\$15/gal conc. (1992)
Water Soluble	No	Yes
Disposal	Spent solution may be suitable for processing in an industrial wastewater treatment system	Spent solution may be suitable for disposal as a non-hazardous waste after removal of contaminants by filtration or other treatment
Recycling Options	Solvent can be distilled and reused	None
Flashpoint (°F)	200	N/A
VOC		(in concentrate) 206 g/l
Vapor Pressure		14.2
Boiling Point (°F)	432	212
Density (lbs/gal)	7.0	8.4
NSN		
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Bio-Tek	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Bio-T	Bio-T Foam
Application	Effective for dissolving and removing grease, dirt, oil, and similar tough substances. Ideal for industrial use as a general purpose cleaner. Also removes adhesive and latex residues and inks.	Effective for dissolving and removing grease, dirt, oil, and similar tough substances. Ideal for industrial use as a general purpose cleaner. Also removes adhesive and latex residues and inks.
Method of use	Dip tank, parts washer, sprayer	Aerosol can
Chemical Ingredients	Natural terpene	Isopropyl alcohol, natural terpene, ammonium hydroxide
Safety & Health	May cause dermatitis. Inhalation can result in central nervous system depression. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	May cause dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$44.69 4-1-gal \$499.80 55-gal drum \$47.04 5-gal can	\$28.22 17-oz aerosol
Water Soluble	Dispersible	Dispersible
Disposal	Hazardous waste due to flashpoint	Hazardous waste due to flashpoint
Recycling options		
VOC	68 g/l	197 g/l
Flashpoint (°F)	no flash point	no flashpoint
Vapor Pressure	0.03 mm Hg	less than 2 mm Hg
Boiling Point (°F)	212	200
Density (lbs/gal)	7.77	8.07
NSN	6850-01-380-2062 4 1-gal 6850-01-380-4216 5-gal 6850-01-380-4298 55-gal	6850-01-381-1012 17-oz aerosol
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Golden Technology	Golden Technology

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citra-Safe and Citra Safe (deodorized)	Breakthrough Solvent
Application	Especially made for surface preparation, general cleaning, and cleaning prior to sealing.	For washing parts in paint cleanup, substitute for Stoddard solvent/mineral spirits; for degreasing, substitute for perchloroethylene.
Replaces	1,1,1 Trichloroethane (TCA), MEK, toluene, and blends of MEK and toluene, mineral spirits, thinners, and chlorinated solvents	Stoddard solvent/mineral spirits; perchloroethylene
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	D-limonene	C12-C13 Paraffinic Hydrocarbons
Safety & Health	Low oral and dermal toxicity. Prolonged skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Prolonged skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$808.00 30-gal \$155.00 5-gal \$650.00 12-15-oz. \$1,400.00 55-gal \$210.00 6-1-gal (deodorized version only) \$2,000.00 55-gal \$214.75 5-gal	\$1,115.00 55-gal \$120.00 5-gal \$250.00 15-gal
Water Soluble	No	No
Disposal		Non-hazardous waste of uncontaminated solvent.
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	132	150
Boiling Point (°F)	340	370
Density (lbs/gal)	6.98	6.40
NSN	6850-01-378-0564 30-gal 6850-01-378-05755-gal 6850-01-378-0616 12-15-oz 6850-01-378-0797 55 gal 6850-01-378-0886 6-1-gal (deodorized-version only) 6850-01-381-7081 55-gal 6850-01-381-71695-gal	6850-01-378-0666 55-gal 6850-01-378-06795-gal 6850-01-378-0698 15-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Electron Dielectric Solvent	Electron Aerosol Dielectric Solvent
Application	Electrical maintenance, motors, generators, general wipe down removes grease, fuel oil, carbon, and organic resins can be used on most plastic and rubber surfaces.	Electrical maintenance, motors, generators, general wipe down removes grease, fuel oil, carbon, and organic resins can be used on most plastic and rubber surfaces.
Replaces	TCA, CFC-113, and other chlorinated solvents	TCA, CFC-113, and other chlorinated solvents
Method of Use		
Chemical Ingredients		
Safety & Health	Long term skin contact causes drying and flaking. Vapors can cause eye irritation. Excessive inhalation can cause dizziness. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Long term skin contact causes drying and flaking. Vapors can cause eye irritation. Excessive inhalation can cause dizziness. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$924.00 55-gal drum	\$10.44 15-oz can
Water Soluble	Negligible	Negligible
Disposal	Under most circumstances, ELECTRON can be disposed as simple waste oil. Its high BTU value is excellent for fuel blending operations.	Under most circumstances ELECTRON can be disposed as simple waste oil. Its high BTU value is excellent for fuel blending operations.
Recycling Options	Can be recycled using vacuum distillation. Additionally, solvent which has been used in a large spray on application can be collected via containment and absorption and reused in parts until it is no longer effective.	Can be recycled using vacuum distillation. Additionally, solvent which has been in a large spray on application can be collected via containment and absorption and reused in parts until it is no longer effective.
VOC	782 g/l	782 g/l
Vapor Pressure	Less than 3 mm Hg	Less than 1 mm Hg
Flashpoint (°F)	147	147
Boiling Point (°F)	320	370-380
Density (lbs/gal)	6.53	6.53
NSN	6850-01-371-8049 22-oz 6850-01-375-5554 1-gal 6850-01-375-5553 6-gal 6850-01-375-5555 55-gal	6850-01-371-8049 12-22 oz 6850-01-375-5554 6 1-gal 6850-01-375-5553 6-gal 6850-01-375-5555 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Ecolink Inc. 1481 Rock Mountain Blvd. Stone Mountain, GA 30086 (800) 886-8240	Ecolink Inc. 1481 Rock Mountain Blvd. Stone Mountain, GA 30086 (800) 886-8240

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Parts prep (Some information is not available at this time)	ISO PREP
Application	Penetrates, loosens, removes deposits of carbon, smut, grease, multi-purpose lube oils and buffing compounds from ball bearings, aluminum, brass, stainless steel, carbon steel, and specialty alloys	Petroleum solvent, removes oil, grease, glues, wax, asphalt, and other deposits.
Replaces	TCA, CFC-113, other halogenated solvents	Chlorinated, fluoridated, or aromatic hydrocarbons
Method of Use		Manual wipe, dip tank
Chemical Ingredients	1-methylpyrrolidone	C12-C13 parafinic hydrocarbons
Safety & Health	At high concentrations causes nausea or narcotic effects. Repeated skin exposure causes redness and swelling. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low order acute oral and dermal toxicity. Prolonged skin exposure causes defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		No
Cost	\$1449.00 55-gal drum \$185.00 5-gal can	\$120.00 5-gal
Water Soluble	Yes	No
Disposal		
Recycling Options		Distillation, Inland filtration system available
VOC		100% volatile
Vapor Pressure	Less than 0.30 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	193	150
Boiling Point (°F)	396	370
Density (lbs/gal)		640
NSN	6850-01-383-0780 55-gal 6850-01-383-0833 5-gal	6850-01-378-0706 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	ISP	Inland Technology 2612 Pacific Highway St. Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Citrix Solvent	Partsmaster 140
Application	Carburetor cleaner and cold tank compound power stripping and cleaning agent for removing paints, coating, carbon, grease, fuel residues, and resin from ferrous and non-ferrous metals.	Parts washer use. Removes oil, grease, glues, inks, asphalt with controlled evaporation, designed to be used with the EDGE TEK Filter System
Replaces	Methylene chloride, cresylic acid, dichlorobenzene	Stoddard solvents/mineral spirits perchloroethylene
Method of Use		Parts washer
Chemical Ingredients	Mono-n-Butyl Ether	C12-C13 paraffinic hydrocarbons
Safety & Health	Inhalation causes irritation of respiratory tract. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low order acute oral and dermal toxicity. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		No
Cost	\$210.00(5-gal can) \$1900.00 (55-gal drum) \$250.00 6-1-gal containers/box	\$650.00(55-gal drum)
Water Soluble	Very slightly	No
Disposal		
Recycling Options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC	100% volatile	100% volatile
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	144	150
Boiling Point (°F)	340	370
Density (lbs/gal)	7.31	6.40
NSN	6850-01-378-0618 5-gal 6850-01-378-0624 55-gal 6850-01-378-0838 6/1 gal	6850-01-378-0610 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Citrex Soak	PF-145 HP Degreaser
Application	Cleaning compound, solvent	Virtually any industrial application via wiping, coarse spraying, or dipping, parts washing, ultrasonic cleaners, or flow rinsing systems, used as cleaning solvent for liquid penetrants.
Replaces	Various ozone depleters	TCA, other halogenated solvents
Method of Use	Manual wipe, dip tank	Wipe, coarse spraying, dipping
Chemical Ingredients	D-limonene, soprapylamine, dodecylbenzene, sulforate	N/A
Safety & Health	Low dermal and oral toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Inhalation of vapors at high concentrations can cause respiratory irritation and effect the central nervous system. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	N/A
Cost	\$178.00 5-gal can \$1,600.00 55-gal drum	\$89.11 6/1-gal containers/box \$65.24 5-gal can \$595.00 55-gal drum
Water Soluble	Water visible	N/A
Disposal		N/A
Recycling Options	Distillation, Inland filtration system available	N/A
VOC	90% volatile	N/A
Vapor Pressure	Less than 2 mm Hg	N/A
Flashpoint (°F)	134	N/A
Boiling Point (°F)	340	N/A
Density (lbs/gal)	7.15	N/A
NSN	6850-01-378-0649 5-gal 6850-01-378-0687 55-gal	6850-01-378-0944 6/1-gal 6850-01-377-9710 5-gal 6850-01-377-9360 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Warren Oil/Safety Brand

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	DG-7 Neutral pH Degreaser
Application	Designed to remove tough oil and grease problems. Removes grease from concrete floors, removes road film from trucks, degrease ship engines, removes oils and silicone residues from windows and frames.
Replaces	
Method of Use	Spray on
Chemical Ingredients	4-isopropyl-1-methocyclohexene
Safety & Health	Slight dermal toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No
Cost	\$225.00 5-gal container
Water Soluble	Yes
Disposal	Sanitary system
Recycling Options	None. Designed to emulsify.
VOC	
Vapor Pressure	Same as water
Flashpoint (°F)	N/A
Boiling Point (°F)	212
Density (lbs/gal)	8.31
NSN	6850-01-384-5205 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Dominion Restoration Inc. Richmond, VA (800) 833-4456

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	TURCO 5668	TURCO 6088A
Application	Removes epoxies, polyurethanes, chromated primers, PRC-1560M, and PRC-1560MC	Removes epoxy paints, polyurethanes, and epoxy primers or carbonaceous deposits.
Replaces	Chlorinated solvents	Chlorinated solvents
Method of Use	Immersion; tank heated to 160-180 degrees Fahrenheit. High pressure water rinse after immersion.	Immersion in tank heated to 70-140 degrees Fahrenheit. High pressure water rinse after immersion.
Chemical Ingredients	Potassium hydroxide, monoethanolamine, N-methyl pyrrolidone, hydrotreated naphthenic distillate, N-butyl-P-toluene sulfonamide.	Benzyl alcohol, 2-mercaptobenzo thiazole, hydroxyacetic acid, propylene glycol, sodium xylene sulfonate.
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	Yes
Cost	\$28.50/gal (1992)	\$21.33/gal (1992)
Water Soluble	No	No
Disposal	Spent solution will require disposal as a hazardous waste.	Spent solution will require disposal as a hazardous waste.
Recycling Options	None	None
VOC	765 g/l	505 g/l
Vapor Pressure	.3 mm Hg	Less than .1 mm Hg
Flashpoint (°F)	>200	>200
Boiling Point (°F)	250	220
Density (lbs/gal)	8.6	8.5
NSN	8010-01-019-7948 5 gal	
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Turco Products Inc. 7300 Bolsa Ave. Westminster, CA 92684-3600 (714) 890-3600	Turco Products Inc. 7300 Bolsa Ave. Westminster, CA 92684-3600 (714) 890-3600

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	DBE Solvent	Breakthrough
Application	Removes polyester resins. May be a suitable substitute for methylene chloride paint stripper, when mixed with m-pyrol and monoethanolamine	For washing parts in paint cleanup and degreasing.
Replaces	Methylene chloride	Perchloroethylene, Stoddard solvent/mineral spirits.
Method of use	Immersion, spray, or wipe	
Chemical Ingredients	Aliphatic dibasic acid esters-dimethyl adipate, dimethyl succinate, methanol and hydrogen-cyanide (<10 ppm)	
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	Yes
Cost	\$6.38/gal (1992)	
Water Soluble	No	
Disposal	Incineration	
Recycling options	Filter out contaminants to extend life of solution.	
VOC		770 gm/l
Vapor Pressure		< 2 mm Hg
Flashpoint (°F)	212	150
Boiling Point (°F)	385 - 437	370
Density (lbs/gal)	9.1	640
NSN		6850-01-378-0666 55-gal 6850-01-378-0679 5-gal 6850-01-378-0698 15-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	E.I. du Pont de Nemours and Co. Inc. 1007 Market Street Wilmington, DE 19980-0723 (800) 231-0998	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citra-Safe	EP-921
Application	Electronic & electrical cleaning. Also for metal preparation, surface preparation, printing/welding, washing parts, paint cleanup, degreasing, vapor degreasing, precision cleaning.	Functions as a low volatility surface preparation solvent on is used for resin and paint application equipment clean up.
Replaces	TCA, MEK/toluene/xylene, Stoddard solvent/mineral spirits, trichloroethylene	MEK, MEK/toluene, lacquer washes, TCA
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	D-limonene	Propylene carbonate d-limonene
Safety & Health	Low oral toxicity. Slight eye irritation. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Mild ocular. Respiratory and dermal irritation. Prolonged exposure can cause defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$808.00 30-gal drum \$155.00 5-gal can \$650.00 12/15 oz cans/box \$1,400.00 55 gal drum \$210.00 6-1-gal containers/box	\$167.75 5-gal can \$1,540.00 55-gal drum
Water Soluble	No	Very lightly
Disposal		
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC	840 gm/l	980 gm/l
Vapor Pressure	< 2 mm Hg	< 1 mm Hg
Flashpoint (°F)	132	146
Boiling Point (°F)	340	>340
Density (lbs/gal)	6.98	8.14
NSN	6850-01-378-0564 30-gal 6850-01-378-0575 5-gal 6850-01-378-0616 12/15-oz 6850-01-378-0797 55 gal 6850-01-378-0886 6-1-gal	6850-01-0381-3300 5-gal 6850-01-0381-4408 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citra-Safe Deodorized	Breakthrough
Application	Electronic & electrical cleaning. Also for metal preparation, substitute for 1,1,1-Trichloroethane. Surface preparation for printing/welding substitute for MEK/toluene/xylene. For washing parts paint cleanup, substitute for Stoddard Solvent/Mineral spirits. For degreasing, substitute for trichloroethylene. For vapor degreasing/precision cleaning substitute for 1,1,1-trichloroethane or CFC-113.	For washing parts in paint cleanup, substitute for Stoddard solvent/mineral spirits for degreasing
Replaces	(See above for details)	Perchloroethylene
Method of use		
Chemical Ingredients	d-limonene	C-12 C-13 Paraffinic Hydrocarbons
Safety & Health	Low oral, dermal, and ocular toxicity. Prolonged dermal exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral, dermal, and ocular toxicity. Prolonged dermal exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Cost	\$2,000.00 55-gal drum \$214.75 5-gal can	\$1115.00 55-gal \$120.00 5-gal can \$250.00 15-gal can
Water Soluble	No	No
Disposal		
Recycling options		
VOC	840 gm/l	770 gm/l
Vapor Pressure	< 2 mm Hg	< 2 mm Hg
Flashpoint (°F)	132	150
Boiling Point (°F)	340	370
Density (lbs/gal)	6.98	640
NSN	6850-01-381-7081 55-gal 6850-01-381-7169 5-gal	6850-01-378-0666 55-gal 6850-01-378-0679 5-gal 6850-01-378-0698 15-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citrex Solvent	TURCO 5668
Application	For cleaning fiberglass & epoxy resins, substitute for acetone. For paint stripping; cold tank soak resin removal; substitute for methylene chloride	Removes epoxies, polyurethanes, chromated primers, PRC-1560M, and PRC-1560MC
Replaces	See details above	Chlorinated solvents
Method of use		Immersion; tank heated to 160-180 degrees Fahrenheit. High pressure water rinse after immersion.
Chemical Ingredients		Potassium hydroxide, monoethanolamine, N-methyl pyrrolidone, hydrotreated naphthenic distillate, N-butyl-P-toluene sulfonamide
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	Yes
Cost	\$210.00 5-gal can \$1900.00 55-gal drum \$250.00 6/1 gal containers/box	\$28.50/gal (1992)
Water Soluble	Very slightly	No
Disposal		Spent solution will require disposal as a hazardous waste
Recycling options	Distillation, Inland filtration system available	None
VOC		765 g/l
Vapor Pressure	Less than 2 mm Hg	.3 mm Hg
Flashpoint (°F)	144	>200
Boiling Point (°F)	340	250
Density (lbs/gal)	7.31	8.6
NSN	6850-01-378-0618 5-gal 6850-01-378-0624 55-gal 6850-01-378-0838 6/1 gal	8010-01-019-7948 5 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Turco Products Inc. 7300 Bolsa Ave. Westminster, CA 92684-3600 (714) 890-3600

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citra Soak	X-Caliber
Application	For cleaning fiberglass and epoxy resins, substitute for acetone; for paint stripping; cold tank soak; resin removal; substitute for methylene chloride	Solvent based stripper for cleaning and removing unsaturated polyester resins, gel coat lines, paint guns and lines, copper guns, polyurethane foam, most paints, most graffiti, and ink.
Replaces	Aromatic degreasers	Methylene Chloride, chlorinated hydrocarbons, aromatic hydrocarbons, petroleum distillates
Method of use	Manual wipe dip tank	Manual wipe, dip tank
Chemical Ingredients	D-limonene isoprpylamine dodecylbenzene sulfonate	N-methyl pyrrolidone d-limonene
Safety & Health	Low oral, dermal, and ocular toxicity. Prolonged dermal exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Ocular contact can cause redness and temporary corneal clouding. Prolonged dermal contact may cause defatting. Excessive inhalation can cause nasal and respiratory irritation and central nervous system effects. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	Yes
Cost	\$178.00 5-gal can \$1600.00 55-gal drum	\$210.00 5-gal can \$1980.00 55-gal drum
Water Soluble	Slightly	Very slightly
Disposal		
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC		920 gm/l
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	136	136
Boiling Point (°F)	340	370
Density (lbs/gal)	7.15	7.65
NSN	6850-01-378-0649 5-gal 6850-01-378-0687 55 gal	6850-01-378-0582 5-gal 6850-01-378-0662 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Foamflush	Citrix-EB Solvent
Application	Urethane remover, cleans mixing heads, holding tanks, troughs, feeder lines, and spray equipment.	Removes unsaturated polyester resins, gel coat lines, paint guns and lines, chopper guns, uncured polyurethane foam, coating, carbon, grease, most paints, most graffiti, fuel residues, and inks.
Replaces	Methylene chloride	Methylene chloride, acetone, acrylic acid, dichlorobenzene, aromatic hydrocarbons, petroleum distillates
Method of Use		Manual wipe, dip tank
Chemical Ingredients		1-butoxy, 2-propanol, n-methyl pyrrolidone 2-butoxy, 1-propanol D-limonene
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		Yes
Cost	\$135.00 5-gal can \$1067.00 55-gal drum	\$210.00 5-gal can
Water Soluble		Very slightly
Disposal		
Recycling Options		Distillation, Inland filtration system available
VOC		
Vapor Pressure		Less than 2 mm Hg
Flashpoint(°F)		136
Boiling Point (°F)		340
Density (lbs/gal)		7.15
NSN	6850-01-383-3032 5-gal 6850-01-383-3049 55-gal	6850-01-378-0599 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	ISP	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	DR-80
Application	Removes rust from metals or mineral deposits from non-metal surfaces.
Replaces	
Method of use	
Chemical Ingredients	
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	
Cost	\$1446.48 55-gal drum \$183.46 5-gal can
Water Soluble	
Disposal	
Recycling options	
VOC	
Vapor Pressure	
Flashpoint (°F)	
Boiling Point (°F)	
Density (lbs/gal)	
NSN	6850-01-375-9325 55-gal 6850-01-375-9326 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Dominion Restoration Inc. Richmond, VA (800) 835-4456

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citrex Solvent
Applications	Carburetor cleaner and cold tank compound power stripping and cleaning agent for removing paints, coating, carbon, grease, fuel residues, and resin from ferrous and non-ferrous metals.
Replaces	Methylene chloride, cresylic acid, dichlorobenzene
Method of Use	Manual wipe, dip tank
Chemical Ingredients	1-butoxy, 2-propanol n-methyl pyrrolidone 2-butoxy, 1-propanol d-limonene
Safety & Health	Inhalation can cause slight irritation of the respiratory tract. Slight eye irritant. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes
Cost	\$250.00 6-1-gal containers/box \$210.00 5-gal \$1,900.00 55-gal drum
Water Soluble	Very slightly
Disposal	
Recycling Options	Distillation, Inland filtration system available
VOC	100% volatile
Vapor Pressure	Less than 2 mm Hg
Flashpoint (°F)	144
Boiling Point(°F)	340
Density (lbs/gal)	7.31
NSN	6850-01-378-0838 6-1-gal 6850-01-378-0618 5-gal 6850-01-378-0624 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology Inc. 2612 Pacific Highway E. Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Impact Concentrated Industrial Degreaser	Bio T Max
Application	Used in high-pressure systems to clean machinery, trucks, road equipment, engine blocks, roofing equipment masonry, building, and maintenance equipment.	Maximum strength degreaser/cleaner effective in dissolving and removing grease, dirt, oil, and similar tough substances. Ideal for use in dip tanks, pressure spray units, and other industrial equipment.
Replaces	TCA, other chlorinated solvents and petroleum distillates.	Chlorinated solvents, mineral spirits, naphtha based products
Method of Use	Wipe and spray	Varied
Chemical Ingredients	Citrus terpenes, coconut diethanolamide, nonionic surfactant, dye	Natural terpene
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Tar and asphalt, some types of paint	No
Cost	\$2,037.42 55-gal drum \$321.99 5-gal can \$131.71 12-quarts/box	\$110.54 4-1-gal cans/box \$123.48 5-gal can \$1,228.92 55-gal drum
Water Soluble	Yes emulsifier	Dispersible
Disposal	Sanitary system	HW due to low flashpoint
Recycling Options		Parts washer, filter
VOC	90%	780 g/l
Vapor Pressure	Less than 10 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	130	146
Boiling Point (°F)	335	334
Density (lbs/gal)	7.18	7.17
NSN	6850-01-380-4053 55-gal 6850-01-380-4369 5-gal 6850-01-384-0618 12-1-qt	6850-01-381-3785 4/1-gal 6850-01-381-3930 5-gal 6850-01-381-3944 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Allied Enterprises	Golden Technology Co.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	MA 102	Hurri-Safe Special Formula Degreaser
Application	Removes heavy soils, grease, and oil from aircraft surfaces, leaves no residue. Meets or exceeds MIL-C-85570, TY II	Used in cold parts washing for metal cleaning and degreasing; ultrasonic degreasers used at ambient temperatures; wipe-on/wipe-off process to remove contaminants from metals prior to painting.
Replaces	Chlorinated solvents	TCA, methyl ethyl ketone, toluene, and various petroleum solvents
Chemical Ingredients	Di-propylene glycol mono methyl ether	2-butoxyethanol
Safety & Health	Inhalation causes mild respiratory irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	Yes
Cost	\$4.39 16 oz.	\$11.12 1-gal \$665.48 55-gal drum \$41.90 5-gal
Water Soluble	Yes	Yes
Disposal		Sewer discharge
Recycling Options		Clarifier, OCS can provide a recycling unit
VOC	0.084 g/l	0.05%
Vapor Pressure	N/A	Non-volatile
Flashpoint (°F)	More than 200	N/A
Boiling Point (°F)	200	212
Density (lbs/gal)	8.54	8.45
NSN	6850-01-378-0402 16-oz 6850-01-378-042 55-gal 6850-01-378-0401 55-gal	6850-01-369-2474 1-gal 6850-01-369-2475 55-gal 6850-01-369-9303 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	JAD Chemical Inc.	Hurri Kleen Corporation

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Hurri-Safe Hot Immersion Degreaser	Hurri-Safe HK-188 (Aircraft Exterior Wash)
Application	Used in heated immersion tanks; recirculating in-line wash systems, heated ultrasonic degreasers, steam cleaners, and high-pressure washers.	Used in wipe-on/wipe-off cleaning of aircraft metal parts and surfaces prior to painting, bonding, priming, or using adhesives.
Replaces	TCA, MEK, CFC's, various petroleum solvents	MEK, toluene
Method of Use	Wipe-on/wipe-off	Wipe-on/wipe-off
Chemical Ingredients	2-butoxyethanol	2-butoxyethanol
Safety & Health	Low toxicity. Skin exposure can cause dryness and irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Contact can cause eye or skin irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	Yes
Cost	\$17.00 1-gal \$80.00 5-gal \$825.00 55-gal drum	\$588.55 55-gal drum
Water Soluble	Yes, completely	Yes, completely
Disposal	Sanitary sewer	Sanitary sewer
Recycling Options	Clarifier, OCS can provide a recycling system	Clarifier, OCS can provide a recycling system
VOC	206 g/l	0.05 %
Vapor Pressure	14.2 mm Hg	Non volatile
Flashpoint (°F)	N/A	N/A
Boiling Point (°F)	212	212
Density (lbs/gal)	8.48	8.45
NSN	6850-01-373-5866 5-gal 6850-01-373-5867 55-gal	6850-01-373-5865 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Electron 0296-55	Daraclean 282
Application	Non-aqueous; used in electrical maintenance, motors, generators, and general wipe down	Alkaline all-purpose cleaner, multi-metal safe effective between 80-200 degrees Fahrenheit
Method of use		Soaking, agitation, spray
Replaces	TCA, CFC-113	Chlorinated solvent degreasers, 1,1,1-trichloroethane
Chemical Ingredients	Hydro treated light distillate, d-limonene	Glycol ethers
Safety & Health	Dermal and ocular irritation. Excessive inhalation can cause dizziness. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Mild skin, eye, and respiratory irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		
Cost		
Water Soluble	No	Yes
Disposal		
Recycling options		
VOC		
Vapor Pressure	0.30 mm Hg @ 68 F	29 mm Hg @ 23 degrees °C
Flashpoint (°F)	147	None to boiling
Boiling Point (°F)	370 - 380	212
Density (lbs/gal)		8.18
NSN	6850-01-375-5553 55-gal	6850-01-364-8328 5-gal 6850-01-364-8329 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	W.R. Grace and Co. 55 Hayden Avenue Lexington, MA 02173 (617) 861-6600
Manufacturer	Ecolink Inc. (Sentry Chemical) 1481 Rock Mountain Blvd. Stone Mountain, GA 30083 (404) 621-8480	W.R. Grace and Co. 55 Hayden Avenue Lexington, MA 02173 (617) 861-6600

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	MA 102	OCS Systems/Hurri-Safe Special Formula Degreaser
Application	Removes heavy soils, grease, and oil from aircraft surfaces, leaves no Residue. Meets or exceeds MIL-C-85570, TY II	Used in cold parts washing for metal cleaning and degreasing; ultrasonic degreasers used at ambient temperatures; wipe on/wipe-off process to remove contaminants from metals prior to painting.
Replaces	Chlorinated solvents	TCA, methyl ethyl ketone, toluene, and various petroleum solvents
Chemical Ingredients	Di-propylene glycol mono methyl ether	2-butoxyethanol
Safety & Health	Inhalation can cause mild respiratory irritation. Eye contact can cause slight irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Eye contact can cause slight irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	Yes
Cost	\$4.39 16 oz.	\$11.12 1-gal \$665.48 55-gal drum \$41.90 5-gal
Water Soluble	Yes	Yes
Disposal		Sewer discharge
Recycling Options		Clarifier, OCS can provide a recycling unit
VOC	0.084 g/l	0.05%
Vapor Pressure	N/A	non-volatile
Flashpoint (°F)	more than 200 F	N/A
Boiling Point (°F)	200 F	212
Density (lbs/gal)	8.54	8.45
NSN	6850-01-378-0402 16-oz 6850-01-378-0425 5-gal 6850-01-378-0401 55-gal	6850-01-369-2474 1-gal 6850-01-369-2475 55-gal 6850-01-369-9303 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	JAD Chemical Inc. NUWES	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Partsprep	ISO PREP
Application	Penetrates, loosens, removes deposits of carbon, smut, grease, multi-purpose lube oils, and buffing compounds from ball bearings, aluminum, brass, stainless steel, carbon steel, and specialty alloys	Petroleum solvent, removes oil, grease, glues, wax, asphalt, and other deposits.
Replaces	TCA, CFC-113, other halogenated solvents	Chlorinated, fluoridated, or aromatic hydrocarbons
Method of Use		Manual wipe, dip tank
Chemical Ingredients	1-methylpyrrolidone	C12-C13 Paraffinic Hydrocarbons
Safety & Health	If misted at high temperatures can cause nausea and narcotic effects. Dermal exposure can cause redness, swelling, and cracking. Slight ocular irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low active oral and dermal toxicity. Slight eye irritation. Prolonged skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		No
Cost	\$1449.00 55-gal drum \$185.00 5-gal can	\$120.00 5-gal can
Water Soluble	Yes	No
Disposal		
Recycling Options		Distillation, Inland filtration systems available
VOC		100% volatile
Vapor Pressure	Less than 0.30 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	139	150
Boiling Point (°F)	396	370
Density (lbs/gal)		6.40
NSN	6850-01-383-0780 55-gal 6850-01-383-0833 5-gal	6850-01-378-0706 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	ISP	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Partsmaster 140 Solvent	Citra Safe (deodorized)
Application	Parts washer use. Removes oil, grease, glues, inks, asphalt with controlled evaporation, designed to be used with the EDGE TEK Filter System.	Especially made for surface preparation, general cleaning and cleaning prior to sealing.
Replaces	Stoddard solvents/mineral spirits perchloroethylene	1,1,1 Trichloroethane (TCA), MEK, toluene, and blends of MEK and toluene, mineral spirits, thinners, and chlorinated solvents
Method of Use	Parts washer	Manual wipe, dip tank
Chemical Ingredients	C12-C13 Paraffinic Hydrocarbons	D-Limonene
Safety & Health	Low active oral and dermal toxicity. Slight eye irritation. Prolonged skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low active oral and dermal toxicity. Slight eye irritation. Prolonged skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$650.00 55-gal drum	\$2,000.00 55-gal drum \$214.75 5-gal
Water Soluble	No	No
Disposal		
Recycling Options	Distillation, Inland filtration systems available	Distillation, Inland filtration systems available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	150	132
Boiling Point (°F)	370	340
Density (lbs/gal)	6.40	6.98
NSN	6850-01-378-0610 55-gal drum	6850-01-381-7081 55-gal drum 6850-01-381-7169 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	AMEROID OWS
Application	Fast breaking emulsifier for cleaning bilges and degreasing engines.
Replaces	N/A
Method of Use	Place mixture of seawater and OWS in bilges for 24 hours, allowing motion of vessel to provide agitation, or apply the solution with a brush, followed by a warm water rinse.
Chemical Ingredients	Dichlorotoluene 2, aliphatic and aromatic petroleum distillates.
Safety & Health	Prolonged skin exposure can cause defatting and dermatitis. Eye irritation, redness, tearing, or blurred vision. Inhalation can cause nasal and respiratory irritation and effect the central nervous system. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No
Cost	\$11.35/gal (1992)
Water Soluble	Disperses in water, separates when emulsion breaks
Disposal	After emulsion breaks, water may be suitable for disposal as a non hazardous waste or treatment. Oily residue should be incinerated.
Recycling Options	Oily contaminants can be filtered out, leaving water that may be suitable for reuse.
VOC	98 % Volatile
Vapor Pressure	Less than 1 mm Hg
Flashpoint (°F)	140
Boiling Point (°F)	405
Density (lbs/gal)	7.5
NSN	6850 01 298 9823 6 gal 6850 01 298 9822 32 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Drew Ameroid - Marine One Drew Plaza Boonton, NJ 07005 (201) 263-7600

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Electron Aerosol Dielectric Solvent	Electron 22 Dielectric Solvent
Application	Non-aqueous; used in electrical maintenance, motors, generators, and general wipe down.	Non-aqueous, used in electrical maintenance, motors generators, and general wipe down.
Replaces	1,1,1-trichloroethane, CFC-113	1,1,1-trichloroethane, CFC-113
Method of use	Excellent general degreaser/solvent as a spray/wipe cleaner and immersion cleaning. Evaporates completely, leaves no residue.	Excellent general degreaser/solvent as a spray/wipe cleaner and immersion cleaning. Evaporates completely, leaves no residue.
Chemical Ingredients	Severely hydro-treated light distillate > 80%, d-limonene Citrus Terpene < 15%	Severely hydro-treated light distillate > 80%, d-limonene Citrus Terpene < 15%
Safety & Health	Inhalation or high concentrations can cause mild central nervous system effects, chemical pneumoconiosis, or slight skin irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Inhalation or high concentrations can cause mild central nervous system effects, chemical pneumoconiosis, or slight skin irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$7.91 15-oz.	\$7.91 12-oz pump spray \$12.95 1-gal \$95.70 6-gal pail \$712.25 55-gal drum
Water Soluble	Negligible	Negligible
Disposal	Under most circumstances ELECTRON can be disposed as simple waste oil. Its high BTU value is excellent for fuel blending operations.	Under most circumstances ELECTRON can be disposed as simple waste oil. Its high BTU value is excellent for fuel blending operations.
Recycling options	Can be recycled using vacuum distillation. Additionally, solvent which has been used in a large spray on application can be collected via containment and absorption and reused in parts until it is no longer effective.	Can be recycled using vacuum distillation. Additionally, solvent which has been used in a large spray on application can be collected via containment and absorption and reused in parts until it is no longer effective.
VOC	782 g/l	782 g/l
Vapor Pressure	Less than 3 mm Hg	Less than 1 mm Hg
Flashpoint (°F)	147	147
Boiling Point (°F)	320	370-380
Density (lbs/gal)	6.53	6.53
NSN	6850-01-371-8048 12-15 oz.	6850-01-371-8049 12x15 oz 6850-01-375-5554 6x1-gal 6850-01-375-5553 6-gal 6850-01-375-5555 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Ecolink Inc. (Sentry Chemical) 1481 Rock Mountain Blvd. Stone Mountain, GA 30086 (800) 886-8240	Ecolink Inc. (Sentry Chemical) 1481 Rock Mountain Blvd. Stone Mountain, GA 30086 (800) 886-8240

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Lectra Clean II	Citra-Safe and Citra-Safe (deodorized)
Application	Electrical cleaning and degreasing, motors, parts, and other equipment.	Electronic and electrical cleaning. Also for metal preparation, substitute for 1,1,1-trichloroethane. Surface preparation for printing/welding; substitute for MEK/toluene/xylene. For washing parts paint cleanup, substitute for Stoddard solvent/mineral spirits. For degreasing, substitute for trichloroethylene. For vapor degreasing/precision cleaning substitute for TCA or CFC-113.
Replaces	TCA, other chlorinated solvents	See above for details
Method of Use		Manual wipe, dip tank
Chemical Ingredients	Paraffinic hydrocarbons, propylene glycol	D-Limonene
Safety & Health	Slight dermal, ocular, and inhalation irritation. Central nervous system effects. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Prolonged exposure can cause deffating and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		No
Cost	\$1,387.50 55-gal \$113.70 4-1-gal container \$132.00 5-gal can \$67.50 12/20 oz can/box	\$808.00 30-gal \$155.00 5-gal \$650.00 12/15-oz cans/box \$1400.00 55-gal drum \$210.00 6-1-gal (deodorized version only) \$2000.00 55-gal drum \$214.75 5-gal can
Water Soluble	Negligible	No
Disposal		
Recycling Options		Distillation, Inland filtration systems available
VOC		100% volatile
Vapor Pressure	Less than 1 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	214	132
Boiling Point (°F)	>400	340
Density (lbs/gal)		6.98
NSN	6850-01-382-5252 55-gal 6850-01-382-5369 4-1-gal 6850-01-382-5390 5-gal 6850-01-382-5783 12/20 oz	6850-01-378-0564 30-gal 6850-01-378-0575 5-gal 6850-01-378-0616 12-15-oz 6850-01-378-0797 55 gal 6850-01-378-0886 6-1-gal (deodorized version only) 6850-01-381-7081 55-gal 6850-01-381-7169 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer		Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	P-F-145 HP Degreaser	Micropure CDF
Application	Virtually any industrial application via wiping, coarse spraying or dipping, parts washing, ultrasonic cleaners, or flow rinsing systems, used as cleaning solvent for liquid penetrants.	Circuit board cleaner used in immersion cleaning or spray washing
Replaces	TCA, other halogenated solvents	CFC-113, methanol
Method of Use	Wipe, coarse spraying, dipping	
Chemical Ingredients	Non hazardous ingredients	1-methylpyrrolidone, dipropylene glycol methyl ether
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		
Cost	\$89.11 6/1-gal containers/box \$65.24 5-gallon can \$595.00 55-gallon drum	\$ 155.00 5-gal can \$1273.00 55-gal drum
Water Soluble	Negligible	Miscible
Disposal		
Recycling Options		
VOC	100% volatile	100% volatile
Vapor Pressure	< 1 mm Hg	< 1mm Hg
Flashpoint (°F)	145	191
Boiling Point (°F)	> 362	363
Density (lbs/gal)		
NSN	6850-01-378-0944 6/1-gal 6850-01-377-9710 5-gal 6850-01-377-9360 55-gal	6850-01-383-3043 5-gal 6850-01-383-3050 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Warren Oil/Safety Brand	ISP

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Teksol EP	Draclean 282 Solvent
Application	Cleans brakes and other auto applications, cleans motors, switches, relays, and other electrical applications, cleans circuit boards, and other electronic components, as well as other precision cleaning.	Alkaline all-purpose cleaner, formulated to be non-aggressive toward zinc and aluminum alloys, designed specifically for aerospace and electronics applications, used in soaking, agitation, and spray.
Replaces	TCA, perchloroethylene, methylene chloride, other chlorinated or halogenated solvents.	TCA, chlorinated solvent degreasers
Method of Use	Manual wipe, dip tank	Agitation, hand wipe, soak, spray, steam, ultrasonic
Chemical Ingredients	C10-C11 paraffinic hydrocarbons d-limonene	Silicate, surfactants and corrosion inhibitors glycol ethers
Safety & Health	Low order oral and dermal toxicity. Slight eye irritation. Prolonged skin exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low order oral and dermal toxicity. Slight eye irritation. Prolonged skin exposure can cause defatting and dermatitis. Slight irritation through inhalation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$148.50 6/1-gal containers/box \$132.06 5-gal can \$921.25 55-gal drum \$606.00 30-gal drum	\$80.70 5-gal can \$795.72 55-gal drum
Water Soluble	No	Yes
Disposal		
Recycling Options	Distillation, Inland filtration system available	Designed for soil rejection, media filtration ultra filtration
VOC	100% volatile	214 - 403 g/l (using any compound including Carbon)
Vapor Pressure	Less than 10 mm Hg	29 mm Hg
Flashpoint (°F)	112	None to boiling
Boiling Point (°F)	310	212
Density (lbs/gal)	6.40	8.5
NSN	6850-01-378-0581 6/1-gal 6850-01-389-0583 5-gal 6850-01-378-0650 55-gal 6850-01-378-0700 30-gal	6850-01-364-8328 5-gal 6850-01-364-8329 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	W.R. Grace and Co. (617) 861-6000

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Teksol EP	X-Caliber
Application	For electronic & electronic cleaning, metal preparation, substitute for 1,1,1-trichloroethane. For surface preparation for painting or welding, substitute for toluene/xylene/MEK. For degreasing & resin removal, substitute for trichloroethylene.	For paint stripping; cold tank soak; resin removal.
Replaces	Toluene/xylene/MEK, Freon-113	Methylene chloride, chlorinated hydrocarbons, aromatic hydrocarbons, petroleum distillates
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	C10-C11 Paraffinic Hydrocarbons d-limonene	N-methyl pyrrolidone d-Limonene
Safety & Health	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	Yes
Cost	\$148.50 6/1-gal \$132.06 5-gal can \$606.00 30-gal drum \$921.25 55-gal drum	\$210.00 5-gal \$265.00 6-1-gal \$1,980.00 55-gal
Water Soluble	No	Very slightly
Disposal		
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC	100% volatile	
Vapor Pressure	Less than 10 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	112	136
Boiling Point (°F)	310	370
Density (lbs/gal)	6.40	7.65
NSN	6850-01-378-0581 6/1-gal 6850-01-378-0583 5-gal 6850-01-378-0700 30-gal 6850-01-378-0650 55-gal	6850-01-378-0582 5-gal 6850-01-378-0809 6-1-gal 6850-01-378-0662 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Preprite	EP921
Application	Removes paint, coatings, and cured resin.	Surface preparation solvent, resin, and paint application equipment cleanup.
Replaces	Methylene chloride, methanol, toluene, acetone, MEK, ethylene glycol	MEK, MEK/toluene blends, and lacquer washes
Method of Use	Brush on/spray on	
Chemical Ingredients	1-methylpyrrolidone, ethyl-3-ethoxypropionate, gama-butyrolacetone	Propylene carbonate, d-limonene
Safety & Health	If used at high temperatures, can cause nausea and narcotic effects. Low dermal effects. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low ocular toxicity. Prolonged exposure can cause defatting and dermatitis. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		
Cost	\$135.00 5-gal can \$1,081.00 55-gal drum	\$167.75 5-gal can \$1,540.00 55-gal drum
Water Soluble	Yes	Slightly
Disposal		
Recycling Options		
VOC	0%	17% volatile
Vapor Pressure	< 100 mm Hg	< 1.0 mm Hg
Flashpoint (°F)	191	146
Boiling Point (°F)	396	340
Density (lbs/gal)		
NSN	6850-01-383-0445 5-gal 6850-01-383-0445 55-gal	6850-01-381-3300 5-gal 6850-01-381-4408 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	ISP	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citrex Soak
Application	For cleaning fiberglass & epoxy resins, substitute for acetone. For paint stripping; cold tank soak; resin removal; substitute for methylene chloride
Replaces	Aromatic degreasers
Method of use	Manual wipe, dip tank
Chemical Ingredients	D-Limonene Isopropylamine dodecylbenzene sulfonate
Safety & Health	Low dermal and oral toxicity. Slight eye irritation. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes
Cost	\$178.00 5-gal can \$1600.00 55-gal
Water Soluble	Water miscible
Disposal	
Recycling options	Distillation. Inland filtration systems available.
VOC	> 90% volatile
Vapor Pressure	< 2 mm Hg
Flashpoint (°F)	134
Boiling Point (°F)	340
Density (lbs/gal)	7.15
NSN	6850-01-378-0649 5-gal 6850-01-378-0687 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Hurri-Safe Special Formula Degreaser	Hurri-Safe HK-188 (Aircraft Exterior Wash)
Application	Used in cold parts washing for metal cleaning and degreasing; ultrasonic degreasers used at ambient temperatures; wipe-on/wipe-off process to remove contaminants from metals prior to painting.	Used in heated immersion tanks; recirculating in-line wash systems, heated ultrasonic degreasers, steam cleaners, and high pressure washers.
Replaces	TCA, methyl ethyl ketone, toluene, and various petroleum solvents	MEK, toluene
Method of Use	Wipe-on/wipe-off	Wipe-on/wipe-off
Chemical Ingredients	2-butoxyethanol	2-butoxyethanol
Safety & Health	Low dermal and ocular toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low dermal and ocular toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	Yes
Cost	\$41.90 5-gal \$665.48 55-gal drum \$11.12 1-gal	\$588.55 55-gal drum
Water Soluble	Yes completely	Yes, completely
Disposal	Sewer discharge	Sewer discharge
Recycling Options	Clarifier, OCS can provide a recycling unit	Clarifier, OCS can provide a recycling unit
VOC	0.05%	0.05 %
Vapor Pressure	Non-volatile	Non-volatile
Flashpoint (°F)	N/A	N/A
Boiling Point (°F)	212	212
Density (lbs/gal)	8.45	8.45
NSN	6850-01-369-2474 1-gal 6850-01-369-2475 55-gal 6850-01-369-9303 5-gal	6850-01-373-5866 5-gal 6850-01-373-5867 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	OCS Systems/Hurri-Safe Special Formula Degreaser	Preprite
Application	For use in cold parts washing for metal cleaning and degreasing, ultrasonic degreasers used at ambient temperatures, wipe-on/wipe-off process to remove contaminants from metal prior to painting.	Removes paint, coatings, cured resin. May be brushed or sprayed on, one application and rinse away
Replaces	TCA, MEK, toluene, various petroleum solvents	Methylene chloride, methanol, toluene, acetone, MEK, ethylene glycol
Method of Use	Wipe-on/wipe-off	brush on/spray on
Chemical Ingredients	2-butoxyethanol	
Safety & Health	Low dermal and ocular toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Misted at high concentrations causes nausea and narcotic effects. Prolonged skin contact causes redness, swelling, and cracking. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	
Cost	\$11.12 (1-gal) \$665.48 (55-gal drum) \$41.90 (5-gal can)	\$135.00 (5-gal can) \$1,081.00 (55-gal drum)
Water Soluble	Yes, completely	Yes, completely
Disposal	Sewer discharge	
Recycling Options	Clarifier, OCS can provide a recycling unit	
VOC	0.05%	0%
Vapor Pressure	Non-volatile	< 1 mm Hg
Flashpoint (°F)	N/A	191
Boiling Point (°F)	212	396
Density (lbs/gal)	8.45	
NSN	6850-01-369-2474 1-gal 6850-01-369-2475 55-gal 6850-01-369-9303 5-gal	6850-01-383-0445 5-gal 6850-01-383-0445 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437	ISP

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Skysol	Skysol 100
Application	For vapor degreasing: precision cleaning.	For vapor degreasing: precision cleaning; substitute for 1,1,1 TCA or CFC-113.
Replaces	TCA, chlorinated solvents	TCA, CFC-113
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	C12-C13 paraffinic hydrocarbons, d-limonene	C12-C13 paraffinic hydrocarbons, d-limonene
Safety & Health	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$127.50 5-gal can \$1,100.00 55-gal drum	\$134.35 5-gal can \$1,155.00 55-gal can
Water Soluble	No	No
Disposal		
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC	100% volatile	100% volatile
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	152	146
Boiling Point (°F)	340	340
Density (lbs/gal)	6.40	6.48
NSN	6850-01-381-4420 5 gal 6850-01-381-4404 55 gal	6850-01-381-4423 5 gal 6850-01-381-4401 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Skysol 200	Skysol 300
Application	For vapor degreasing; precision cleaning; substitute for 1,1,1 TCA or CFC-113.	For vapor degreasing; precision cleaning; substitute for 1,1,1 TCA or CFC-113.
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	C12-C13 Paraffinic Hydrocarbons, d-limonene	C12-C13 Paraffinic Hydrocarbons, d-limonene
Safety & Health	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$138.25 5-gal \$1,100.00 55-gal drum	\$143.75 5-gal \$1,320.00 55-gal drum
Water Soluble	No	No
Disposal		
Recycling options	Distillation, Inland filtration available	Distillation, Inland filtration available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	144	144
Boiling Point (°F)	340	340
Density (lbs/gal)	6.48	6.48
NSN	6850-01-381-4427 5-gal 6850-01-381-4410 55-gal	6850-01-381-4429 5-gal 6850-01-381-4417 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citra-Safe and Citra-Safe (deodorized)	Skysol 500
Application	Especially made for surface preparation, general cleaning and cleaning prior to sealing.	For vapor degreasing and precision cleaning.
Replaces	1,1,1 Trichloroethane (TCA), MEK, toluene, and blends of MEK and toluene, mineral spirits, thinners, and chlorinated solvents.	TCA, CFC-113
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	D-limonene	C12-C13 paraffinic hydrocarbons, d-limonene
Safety & Health	Low dermal and oral toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Slight ocular irritation. Prolonged skin exposure causes dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$808.00 30-gal \$155.00 5-gal \$650.00 12-15 oz \$1,400.00 55-gal \$210.00 6-1-gal (deodorized only) \$2,000.00 55-gal \$214.75 5-gal	\$154.75 5-gal \$1,375.00 55-gal
Water Soluble	No	No
Disposal		
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	132	144
Boiling Point (°F)	340	340
Density (lbs/gal)	6.98	6.48
NSN	6850-01-378-0564 30-gal 6850-01-378-0575 5-gal 6850-01-378-0616 12-15-oz 6850-01-378-0797 55 gal 6850-01-378-0886 6-1-gal (Deodorized only) 6850-01-381-7081 55-gal 6850-01-381-7169 5-gal	6850-01-381-4400 5 gal 6850-01-381-4412 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Dominion Rust Stain Remover	DR-80 Metal Corrosion Control
Application	Spray on rust remover for concrete and stone without danger of damage by mineral acids or agitation	Dissolves rust on metal and phosphates the surface in one step, prepares rusty metal surfaces for painting, and eliminates rust source.
Replaces	N/A	N/A
Method of Use	Spray	Brush
Chemical Ingredients	Oxalic acid, phosphoric acid, ammonium hydrogen fluoride solution	Phosphoric acid glycol acid
Safety & Health	Low dermal toxicity. Contact can burn eyes. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low dermal toxicity. Contact can burn eyes. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$1446.48 55-gal drum \$183.46 5-gal can	\$1495.00 55-gal drum \$153.00 5-gal can
Water Soluble	Yes	Yes
Disposal	Sanitary system	Sanitary system
Recycling Options	Not established	Not established
VOC		
Vapor Pressure	Same as water	Same as water
Flashpoint (°F)	N/A	N/A
Boiling Point (°F)	212	212
Density (lbs/gal)	7.94	6.73
NSN	6850-01-380-4145 55-gal 6850-01-380-4314 5-gal can	6850-01-375-9325 55-gal 6850-01-375-9326 5-gal can
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Dominion Restoration Inc. Richmond, VA (800) 835-4456	Dominion Restoration Inc. Richmond, VA (800) 835-4456

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Skysol Concentrate	Skysol 100
Application	Designed for aircraft industry as a skydrol remover and general solvent cleaner.	Designed for aircraft industry as a skydrol remover and general solvent cleaner.
Replaces	Carcinogens	Carcinogens
Method of Use	Manual wipe, dip tank	Manual wipe, Dip Tank
Chemical Ingredients	C12-C13, paraffinic hydrocarbons, d-limonene	C12-C13, paraffinic hydrocarbons, d-limonene
Safety & Health	Low oral and dermal toxicity. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$127.50 5-gal can \$1,100.00 55-gal drum	\$134.35 5-gal can \$1,155.00 55-gal drum
Water Soluble	No	No
Disposal		
Recycling Options	Distillation, Inland Filtration system available	Distillation, Inland Filtration system available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	152	152
Boiling Point (°F)	340	340
Density (lbs/gal)	6.40	6.40
NSN	6850-01-381-4420 5-gal 6850-01-381-4404 55-gal	6850-01-381-4423 5-gal 6850-01-381-4401 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Skysol 200	Skysol 300
Application	Designed for aircraft industry as a skydrol remover and general solvent cleaner.	Designed for aircraft industry as a skydrol remover and general solvent cleaner.
Replaces	TCA, chlorinated solvents	TCA, CFC-113
Method of Use		Manual wipe, dip tank
Chemical Ingredients	C12-C13 Paraffinic hydro d-limonene	C12-C13 Paraffinic hydro d-limonene
Safety & Health	Low oral and dermal toxicity. Slight ocular irritation. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Slight ocular irritation. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$138.35 5-gal can \$1,100.00 55-gal drum	\$143.75 5-gal can \$1,320.00 55-gal drum
Water Soluble	No	No
Disposal		
Recycling Options	Distillation. Inland filtration system available.	Distillation. Inland filtration system available.
VOC	100% volatile	100% volatile
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	144	144
Boiling Point (°F)	340	340
Density (lbs/gal)	6.48	6.48
NSN	6850-01-381-4427 5-gal 6850-01-381-4410 55-gal	6850-01-381-4429 5-gal 6850-01-381-4417 5 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Skysol 500	EP921
Application	Designed for aircraft industry as a skydrol remover and general solvent cleaner	Surface preparation solvent, resin and paint application equipment cleanup
Replaces	TCA, CFC-113	MEK, MEK/toluene blends, and lacquer washes
Method of Use	Manual wipe, dip tank	
Chemical Ingredients	C12-C13, paraffinic hydrocarbons, d-limonene	d-limonene
Safety & Health	Low oral and dermal toxicity. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	
Cost	\$154.75 5-gal can \$1,375.00 55-gal drum	\$167.75 5-gal can \$1,540.00 55-gal drum
Water Soluble	No	Miscible
Disposal		
Recycling Options	Distillation. Inland filtration system available.	Distillation. Inland filtration system available.
VOC		
Vapor Pressure	Less than 2 mm Hg	
Flashpoint (°F)	144	
Boiling Point (°F)	340	
Density (lbs/gal)	6.48	
NSN	6850-01-381-4400 5-gal 6850-01-381-4412 55-gal	6850-01-381-3300 5-gal 6850-01-381-4408 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Shipshape	X-Caliber
Application	Cleans painting equipment, urethane foam feeder lines, lay-up tools, spray equipment, and hand tools. Can be used in spray booth, fabrication room, or foam injection areas.	Solvent-based stripper used to clean and remove unsaturated polyester, resins, gel coat, lines, paint gums and lines, copper guns, polyurethane foam, most paints, most graffiti, and ink.
Replaces	Acetone, methylene chloride, water-based emulsifier	Methylene chloride, chlorinated hydrocarbons, aromatic hydrocarbons, petroleum distillates
Method of Use		Manual wipe, dip tank
Chemical Ingredients		N-methyl pyrrolidone, d-limonene
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		Yes
Cost	\$ 140.00 5-gal can \$1007.40 55-gal drum	\$265.00 6/1-gal containers/box \$210.00 5-gal can \$1,980.00 55-gal drum
Water Soluble		Very slightly
Disposal		
Recycling Options		Distillation, Inland filtration system available
VOC		
Vapor Pressure		Less than 2 mm Hg
Flashpoint (°F)		136
Boiling Point (°F)		370
Density (lbs/gal)		7.65
NSN	6850-01-383-3848 5-gal 6850-01-383-3784 55-gal	6850-01-378-0809 6/1-gal 6850-01-378-0582 5-gal 6850-01-378-0662 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	ISP	Inland Technology Inc. 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8739

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	EP921	Citrix-EB Solvent
Application	Surface preparation solvent, resin and paint application equipment cleanup	Removes unsaturated polyester resins, gel coat lines, paint guns and lines, chopper guns, uncured polyurethane foam, most paints, most graffiti, and inks.
Replaces	MEK, MEK/toluene blends, and lacquer washes	Methylene chloride, cresylic acid, dichlorobenzene, aromatic hydrocarbons, petroleum distillates
Method of Use	Manual wipe, dip tank	
Chemical Ingredients	D-limonene, propylene carbonate	d-limonene, glycol ether EB, n-methyl pyrrolidone
Safety & Health	Dermal exposure can cause redness, cracking, swelling or eye irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Dermal exposure can cause redness, cracking, swelling or eye irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	
Cost	\$167.75 5-gal can \$1,540.00 55-gal drum	\$210.00 5-gal can
Water Soluble	Very slightly	
Disposal		
Recycling Options	Distillation, Inland filtration system available	
VOC	980 g/l	
Vapor Pressure	Less than 1 mm Hg	
Flashpoint (°F)	146	
Boiling Point (°F)	Greater than 340	
Density (lbs/gal)	8.14	
NSN	6850-01-381-3300 5-gal 6850-01-381-4408 55-gal	6850-01-378-0599 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology Inc. 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8739	Inland Technology Inc. 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8739

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Rust Stain Remover	DR-80 Metal Corrosion Control
Application	Spray on rust remover for concrete and stone without damage by mineral acids or agitation.	Dissolves rust on metal and phosphatizes the surface in one step, prepares rusty metal surfaces for painting, and eliminates rust source.
Replaces		N/A
Method of Use	Spray on concrete and stone	
Chemical Ingredients	Oxalic acid, Phosphoric acid, Ammonium hydrogen difluoride	Phosphoric acid, glycolic acid
Safety & Health	Low dermal toxicity, can cause eye burns. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low dermal toxicity, can cause eye burns. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		
Cost	\$183.46 5-gal can \$1,446.48 55-gal drum	\$153.00 5-gal can \$1495.00 55-gal drum
Water Soluble	Yes	Yes
Disposal		
Recycling Options		
VOC		
Vapor Pressure		
Flashpoint (°F)		
Boiling Point (°F)	212	212
Density (lbs/gal)		
NSN	6850-01-380-4314 5-gal 6850-01-380-4145 55-gal	6850-01-375-9326 5-gal 6850-01-375-9325 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Dominion Restoration Inc. Richmond, VA (800) 835-4456	Dominion Restoration Inc. Richmond, VA (800) 835-4456

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Flight Deck Cleaner
Application	Carrier flight deck cleaner
Replaces	
Method of Use	
Chemical	
Ingredients	
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	
Cost	\$50.00 5-gal can \$500.00 55-gal drum
Water Soluble	
Disposal	
Recycling Options	
VOC	
Vapor Pressure	
Flashpoint (°F)	
Boiling Point (°F)	
Density (lbs/gal)	
NSN	6850-01-376-1201 5-gal 6850-01-376-1202 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Competitive P/N

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	DR-9000 Corrosion Removing Compound
Application	Use in internal shipboard piping systems, and components such as ballast tanks, boilers, chilled water systems, heat exchangers, potable water, pumps, valves, etc.
Replaces	Mineral acids
Method of Use	Injected into systems
Chemical Ingredients	Phosphoric acid glycolic acid
Safety & Health	Slight skin irritation. Direct contact can burn eyes. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No
Cost	\$160.00 5-gal can \$1,875.72 55-gal drum \$26.00 bulk
Water Soluble	Yes
Disposal	Sanitary system
Recycling Options	Not established
VOC	
Vapor Pressure	Same as water
Flashpoint (°F)	N/A
Boiling Point (°F)	212
Density (lbs/gal)	Same as water
NSN	6850-01-362-4840 5-gal 6850-01-362-3901 55-gal 6850-01-362-3900 bulk
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Dominion Restoration Inc. Richmond, VA (800) 835-4456

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Hurri-Safe HK-188 (Aircraft Exterior Wash)	DG-7 Neutral pH Degreaser
Application	Used in heated immersion tanks; recirculating in-line wash systems, heated ultrasonic degreasers, steam cleaners, and high-pressure washers.	Designed to remove tough oil and grease problems. Restore greasy concrete floors, remove road file from trucks, degrease ship engines, removes oils and silicone residues from windows and frames
Replaces	MEK, toluene	
Method of Use	Wipe-on/wipe-off	
Chemical Ingredients	2-butoxyethanol	
Safety & Health	Slight eye and skin irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Slight dermal toxicity. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes	
Cost	\$588.55 55-gal drum	\$225.00 5-gal container
Water Soluble	Yes, completely	
Disposal	Sewer discharge	
Recycling Options	Clarifier, OCS can provide a recycling unit	
VOC	0.05 %	
Vapor Pressure	Non-volatile	
Flashpoint (°F)	N/A	
Boiling Point (°F)	212	
Density (lbs/gal)	8.45	
NSN	6850-01-373-5866 5-gal 6850-01-373-5867 55-gal	6850-01-384-5205 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437	Dominion Restoration Inc. Richmond, VA (800) 835-4456

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	P-F-145 HP Degreaser
Application	Virtually any industrial application via wiping, coarse spraying, dipping, parts washing, ultrasonic cleaners, or flow rinsing systems, used as cleaning solvent for liquid penetrants.
Replaces	TCA, other halogenated solvents
Method of Use	Wipe, coarse spraying, dipping
Chemical Ingredients	
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	
Cost	\$89.11 6/1-gal containers/box \$65.24 5-gal can \$595.00 55-gal drum
Water Soluble	
Disposal	
Recycling Options	
VOC	
Vapor Pressure	
Flashpoint (°F)	
Boiling Point (°F)	
Density (lbs/gal)	
NSN	6850-01-378-0944 6/1-gal 6850-01-377-9710 5-gal 6850-01-377-9360 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Warren Oil/Safety Brand

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	OCS Systems/Hurri-Safe Exterior Surface Cleaner #HK 188
Application	For use in wipe on/wipe off cleaning of aircraft metal parts and surfaces prior to painting, bonding priming, or using adhesives.
Replaces	MEK, toluene
Method of use	Wipe on/wipe off
Chemical Ingredients	2-butoxyethanol
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	Yes
Cost	\$588.55 55-gal drum
Water Soluble	Yes, completely
Disposal	Sewer discharge
Recycling Options	Clarifier, OCS can provide a recycling unit.
VOC	0.05 %
Vapor Pressure	Non-volatile
Flashpoint (°F)	N/A
Boiling Point (°F)	212
Density (lbs/gal)	8.45
NSN	6850-01-373-5865 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	OCS Systems 429 Madera Street San Gabriel, CA 91778-0370 (818) 458-2471 FAX (818) 458-2437

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Printsolve Ink Remover	X-Caliber Solvent
Application	Cleans all cured aqueous and non-aqueous inks via spray wash from doctors, blades, holders, cylinders, ink pans, transfer pails, drums, and other press equipment.	Solvent-based stripper used to clean and remove unsaturated polyester, resins, gel coat, lines, paint gums and lines, copper guns, polyurethane foam, most paints, most graffiti, and ink.
Replaces	N/A	Methylene chloride, chlorinated hydrocarbons, aromatic hydrocarbons, petroleum distillates
Method of Use		Manual wipe, dip tank
Chemical Ingredients	1-methyl-2-pyrrolidimone propanol, 2-methoxy methylethoxy-dipropylene, glycol methyl ether	n-methyl pyrrolidone d-limonene
Safety & Health	Prolonged skin exposure can cause severe dermatitis. Slight irritation to eyes. If misted at high concentrations can cause pallor, nausea, and narcotic effects. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Ocular irritation, includes redness, temporary corneal clouding. Prolonged skin exposure can cause defatting, excessive irritation, dizziness, fatigue, possible death. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		Yes
Cost	\$1012.00 55-gal drum	\$265.00 6/1-gal containers/box \$210.00 5-gal can \$1,980.00 55-gal drum
Water Soluble		Very slightly
Disposal		
Recycling Options		Distillation, Inland filtration system available
VOC		
Vapor Pressure		Less than 2 mm Hg
Flashpoint (°F)		136
Boiling Point (°F)		370
Density (lbs/gal)		7.65
NSN	6850-01-383-2064 55-gal	6850-01-378-0809 6/1-gal 6850-01-378-0582 5-gal 6850-01-378-0582 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	ISP	Inland Technology Inc. 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Breakthrough Solvent	Partsmaster 140 Solvent
Application	Parts washing and other metal cleaning operations, has moderate solvency and removes oil, grease, inks, wax, and other deposits.	Parts washer use. Removes oil, grease, glues, inks, asphalt with controlled evaporation, designed to be used with the EDGE TEK Filter System.
Replaces	Stoddard solvents/mineral spirits perchloroethylene	Stoddard solvents/mineral spirits perchloroethylene
Method of Use	Dip tank, manual wipe	Parts washer
Chemical Ingredients	C12-C13 Paraffinic hydrocarbons	C12-C13 Paraffinic hydrocarbons
Safety & Health	Low oral and dermal toxicity. Slight ocular irritation. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Slight ocular irritation. Prolonged exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$120.00 5-gal can \$250.00 15-gal can \$1115.00 55-gal drum	\$650.00 55-gal drum
Water Soluble	No	No
Disposal	Non Hazardous waste if uncontaminated	
Recycling Options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC		
Vapor Pressure	2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	132	150
Boiling Point (°F)	340	370
Density (lbs/gal)	6.98	6.40
NSN	6850-01-378-0679 5-gal 6850-01-378-0698 15-gal 6850-01-378-0666 55-gal	6850-01-378-0610 55-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citrix-EB Solvent
Application	Removes unsaturated polyester resins, gel coat lines, paint guns and lines, chopper guns, uncured polyurethane foam, most paints, most graffiti, and inks.
Replaces	Methylene chloride, cresylic acid, dichlorobenzene, aromatic hydrocarbons, petroleum distillates
Method of use	
Chemical Ingredients	d-limonene, glycol ether EB, n-methyl pyrrolidone
Safety & Health	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	
Cost	\$210.00 5-gal can
Water Soluble	
Disposal	
Recycling options	
VOC	
Vapor Pressure	
Flashpoint (°F)	
Boiling Point (°F)	
Density (lbs/gal)	
NSN	6850-01-378-0599 5-gal
POC	Hazardous Technical Information Services (804)209-5168 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	Teksol EP Solvent
Application	Cleans brakes and other auto applications, cleans motors, switches, relays, and other electrical applications, cleans circuit boards, and other electronic components as well as other precision cleaning.
Replaces	TCA, perchloroethylene, methylene chloride, and other chlorinated or halogenated solvents.
Method of Use	Manual wipe, dip tank
Chemical Ingredients	C10-C11 Paraffinic Hydrocarbons, d-limonene
Safety & Health	Prolonged or repeated exposure leads to dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No
Cost	\$148.50 6/1-gal containers/box \$132.06 5-gal can \$921.25 55-gal drum \$606.00 30-gal drum
Water Soluble	No
Disposal	
Recycling Options	Distillation, Inland Filtration system available.
VOC	
Vapor Pressure	Less than 10 mm Hg
Flashpoint (°F)	112
Boiling Point (°F)	310
Density (lbs/gal)	6.40
NSN	6850-01-378-0581 6/1-gal 6850-01-389-0583 5-gal 6850-01-378-0650 55-gal 6850-01-378-0700 30-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology Inc. 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8739

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Citra-Safe and Citra Safe (deodorized)
Application	Especially made for surface preparation, general cleaning, and cleaning prior to sealing.
Replaces	1,1,1 Trichloroethane (TCA), MEK, Toluene, and blends of MEK and Toluene, mineral spirits, thinners, and chlorinated solvents.
Method of use	Manual wipe, dip tank
Chemical Ingredients	d-limonene
Safety & Health	Low oral and dermal toxicity. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No
Cost	\$808.00 30-gal \$155.00 5-gal \$650.00 12-15-oz. \$1,400.00 55-gal \$210.00 6-1-gal (deodorized version only) \$2,000.00 55-gal \$214.75 5-gal
Water Soluble	No
Disposal	
Recycling options	Distillation, Inland filtration system available.
VOC	
Vapor Pressure	Less than 2 mm Hg
Flashpoint (°F)	132
Boiling Point (°F)	340
Density (lbs/gal)	6.98
NSN	6850-01-378-0564 30-gal 6850-01-378-0575 5-gal 6850-01-378-0616 12-15-oz 6850-01-378-0797 55 gal 6850-01-378-0886 6-1-gal (deodorized-version only) 6850-01-381-7081 55-gal 6850-01-381-7169 5-gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Skysol	Skysol 100
Application	For vapor degreasing and precision cleaning.	For vapor degreasing and precision cleaning.
Replaces	TCA, chlorinated solvents	TCA, CFC-113
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	C12-C13 paraffinic hydrocarbons, d-limonene	C12-C13 paraffinic hydrocarbons, d-limonene
Safety & Health	Low oral and dermal toxicity. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$127.50 5-gal can \$1,100.00 55-gal drum	\$134.35 5-gal can \$1,155.00 55-gal can
Water Soluble	No	No
Disposal		
Recycling options	Distillation, Inland filtration system available	Distillation, Inland filtration system available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	152	146
Boiling Point (°F)	340	340
Density (lbs/gal)	6.40	6.48
NSN	6850-01-381-4420 5 gal 6850-01-381-4404 55 gal	6850-01-381-4423 5 gal 6850-01-381-4401 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Skysol 200	Skysol 300
Application	For vapor degreasing and precision cleaning.	For vapor degreasing and precision cleaning.
Method of use	Manual wipe, dip tank	Manual wipe, dip tank
Chemical Ingredients	C12-C13 Paraffinic Hydrocarbons, d-Limonene	C12-C13 Paraffinic Hydrocarbons, d-Limonene
Safety & Health	Low oral and dermal toxicity. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Low oral and dermal toxicity. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No	No
Cost	\$138.25 5-gal \$1,100.00 55-gal drum	\$143.75 5-gal \$1,320.00 55-gal drum
Water Soluble	No	No
Disposal		
Recycling options	Distillation, Inland filtration available	Distillation, Inland filtration available
VOC		
Vapor Pressure	Less than 2 mm Hg	Less than 2 mm Hg
Flashpoint (°F)	144	144
Boiling Point (°F)	340	340
Density (lbs/gal)	6.48	6.48
NSN	6850-01-381-4427 5-gal 6850-01-381-4410 55-gal	6850-01-381-4429 5-gal 6850-01-381-4417 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	Skysol 500
Application	For vapor degreasing and precision cleaning.
Replaces	TCA, CFC-113
Method of use	Manual wipe, dip tank
Chemical Ingredients	C12-C13 Paraffinic Hydrocarbons, d-limonene
Safety & Health	Low oral and dermal toxicity. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal	No
Cost	\$154.75 5-gal \$1,375.00 55-gal
Water Soluble	No
Disposal	
Recycling options	Distillation, Inland filtration system available
VOC	
Vapor Pressure	Less than 2 mm Hg
Flashpoint (°F)	144
Boiling Point (°F)	340
Density (lbs/gal)	6.48
NSN	6850-01-381-4400 5 gal 6850-01-381-4412 55 gal
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Inland Technology 2612 Pacific Highway East Suite C Tacoma, WA 98424 (206) 922-8932

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product Name	MA-102MF Aircraft Cleaning Compound	MA-102NF Aircraft Cleaning Compound
Application	Aircraft Cleaning Compound which removes heavy soils, grease, and oil from aircraft surfaces and does not leave a residue.	Aircraft Cleaning Compound which removes heavy soils, grease, and oil from aircraft surfaces and does not leave a residue.
Replaces	Meets or exceeds MIL-C-85570, Type II	Meets or exceeds MIL-C-85570, Type II
Method of Use	Spray washers, steam cleaners, pressure sprayers, brush and spray-on	Spray washers, steam cleaners, pressure sprayers, brush and spray-on
Chemical Ingredients	dipropylene glycol, methyl ether	dipropylene glycol, methyl ether The propellant is deionized water.
Safety & Health	Mild respiratory irritation. Slight ocular irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Inhalation of high concentrations can cause anesthetic and central nervous system effects and liver and kidney damage. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		
Cost	\$87.88 5 gallon can \$676.70 55 gallon drum	\$4.39 16 oz can
Water Soluble	Yes, completely	Yes, completely
Disposal		
Recycling Options		
VOC (g/l)	0.084	0.084
Vapor Pressure		
Flashpoint (°F)	Greater than 200	Greater than 200
Boiling Point (°F)	200	200
Density (lbs/gal)	8.54	8.54
NSN	6850-01-378-0425 5-gal 6850-01-378-0401 55-gal	6850-01-378-0402 16-oz
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	JAD Chemical Co. P.O. Box 6786 Rancho Palos Verdes, CA 90734 (310) 833-7457 (voice) (310) 548-3420 (fax)	JAD Chemical Co. P.O. Box 6786 Rancho Palos Verdes, CA 90734 (310) 833-7457 (voice) (310) 548-3420 (fax)

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Product	MILITEC-1 Corrosion Inhibitor	Safety Flush
Application	Corrosion inhibitor for lubricating oil which acts as a metal conditioner and creates a super tough barrier that smoothes and seals all types of metal surfaces.	Radiator safety flush which removes rust and scale and is safe for all metals.
Replaces	N/A	
Method of Use		
Chemical Ingredients		
Safety & Health	Inhalation can cause mild respiratory irritation. Low ocular toxicity. Prolonged skin exposure can cause dermatitis and defatting. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.	Slight ocular and dermal irritation. Consult your local Industrial Hygienist, Health and Safety personnel, and MSDS.
Paint Removal		
Cost	\$101.00 48/1 oz. bottles/box \$156.00 12/16-oz. bottles/box \$90.00 1-gal can \$350.00 5-gal can \$2,395.00 55-gal drum	\$23.28 12/22-oz bottles/box
Water Soluble	Negligible	Negligible
Disposal		
Recycling Options		
VOC		
Vapor Pressure	< 1 mm Hg	N/A
Flashpoint (°F)	410	N/A
Boiling Point (°F)	528	240
Density (lbs/gal)		
NSN	6850-01-378-3058 48/1 oz 6850-01-378-3118 12/16-oz 6850-01-378-3151 1-gal 6850-01-378-4186 5-gal 6850-01-378-4297 55-gal	6850-01-383-4030 12/22-oz
POC	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168	Hazardous Technical Information Services (800) 848-4847 DSN 695-5168
Manufacturer	Militec Corp	Warren Oil/Safety Brand

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

CHEMICAL CLEANING AS A SOLVENT ALTERNATIVE

Revision: 1/96
Process Code: Navy: ID-02-01/-02/-03/-04/-05/-14; Air Force: CL03, CL05; Army: CLD
Substitute for: Solvent strippers
Applicable EPCRA Targeted Constituents: N/A

Overview: Chemical cleaning can sometimes be substituted for solvent cleaning to reduce the amount of toxic or hazardous chemicals used for the cleaning operation.

Solvent cleaning can be distinguished from chemical cleaning because a solvent's action is to dissolve the residue in or on the object to be cleaned, whereas a chemical cleaner acts by initiating a chemical reaction to remove the residue from the object. Chemical cleaners include products like bleach, which is an oxidizer. Other frequently used chemical cleaners are acids and bases. Acids are typically used to remove mineral deposits or scale from surfaces, while bases or alkaline solutions react with most carbonaceous residues; for example, oil and grease buildup. The acidity (or alkalinity) of the solutions is also depleted by the chemical action and any excess can easily be neutralized.

An important consideration is that chemical cleaners work only if properly selected. A careful evaluation of the residue for reactivity with a given chemical agent is critical to successful cleaning.

Materials

Compatibility: This will depend on the material to be cleaned. For example, highly alkaline (caustic) chemicals with a pH above 12 can etch aluminum, while acidic substances can cause hydrogen embrittlement in some steels.

Safety and Health: Acids and bases can cause irritation to the skin and mucous membranes. The effects vary with the particular chemical being used. Proper personal protective equipment should always be used.

Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The benefits will vary according to the solvents you will be able to substitute the chemical cleaning process for. In certain circumstances,

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

chemical cleaning will allow you to use less toxic materials to get the same results as cleaning with a solvent.

Disadvantages: The principle disadvantage would be if the chemicals used were more dangerous to human life or the object being cleaned than the alternative solvent. This must be looked at in a case by case basis.

Economic Analysis: The costs incurred will vary depending upon the material being cleaned and the contaminant(s) being removed. So the economics must be looked at on a case by case basis. The principle costs that need to be considered are:

- a comparison of disposal costs for the solvent versus disposal costs for the chemical chosen to replace the solvent;
- any additional personal protective equipment (PPE) which might be necessary; and
- any special handling or storage considerations for the solvent or chemical in question.

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: The following is an example of a chemical cleaning company. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Rust Industrial Cleaning Services, Inc.
19818 East Highway 6
P.O. Box 2416
Alvin, TX 77512-2416
(800) 245-5406, (713) 331-5406, FAX (713) 585-6242

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

IMMERSION SOAKING

Revision: 1/96
Process Code: Navy: 1D-03-01/-07; Air Force: CL03; Army: CLD
Substitute for: Methyl Ethyl Ketone, Methyl Chloroform, and ODS-based solvents
Applicable EPCRA Targeted Constituents: Methyl Ethyl Ketone, Methyl Chloroform, and ODS-based solvents

Overview: Immersion is an effective method of parts washing. It is the simplest and least aggressive cleaning method. It can use non-toxic or non-ODS chemicals. Immersion is useful when dirt is easily removed and low equipment cost is important; however, it is generally slower than other methods of washing and is only viable for smaller components.

Immersion cleaning can be accomplished in several ways, by using different processes exclusively or together. The processes are heat, agitation, enzymes, detergents, or ultrasonic agitation.

1. Heat (aqueous solutions only) - the effectiveness of aqueous solvents increases with temperature; however, there is an optimum temperature for each situation governed by the physical characteristics of the materials involved.
2. Agitation - achieved by constant movement of the cleaning solvent through and around the part being cleaned; this provides faster cleaning than simple soaking.
3. Surfactants (detergents) - useful because they break down dirt and aid in the solvent process; this is faster than simple soaking.
4. Enzymes - added to the washing materials, such as soaps and detergents. Enzymes are proteins that catalyze specific reactions that break down dirt, oils, and greases, enhancing cleaning. Enzyme washing requires time for the enzymes to soak in and act.
5. Ultrasonic agitation - a method of agitating the part being cleaned through high frequency sound. This action literally shakes the dirt off.

Material

Compatibility: Most materials have specifications which they must be cleaned by. For example, some materials can not be exposed to heat or vibration. In addition certain steels are prone to flash rusting and certain preventative measures must be taken. Check with the appropriate cognizant authority prior to using a new cleaning technique.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Safety and Health: Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The principle benefit of using immersion soaking is the simplicity of the process which should lead to lower capital costs and safer chemicals being used.

Disadvantages: Immersion soaking may take more time or repeated applications to return the same results as you are currently receiving.

Economic Analysis: This will vary case to case, but typically immersion soaking is a less capital intensive method of cleaning, so lower costs can be expected.

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendor: The following is an example of a company that deals in immersion soaking products. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Graymills Corporation
3705 North Lincoln Avenue
Chicago, Illinois 60613-3594
(312) 248-6825
FAX: (312) 477-8673

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

EPA'S SOLVENTS ALTERNATIVES GUIDE - SAGE 2.1

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for N/A
Applicable EPCRA Targeted Constituents: ODSs and Chlorinated Solvents

Overview: SAGE 2.1 software is a computer program designed to provide suggestions on alternative cleaning and degreasing technologies based on user-given responses. Solvents targeted for reduction under the US EPA 33/50 program, such as chlorinated solvents, are not included as valid alternatives in this program. Requested responses revolve around the users specific application, i.e., size, shape, and material of product to be cleaned; production needs; and present cleaning methods. A replacement cleaning process will require either an alternative solvent or a combination of alternative solvent and process.

SAGE narrows the list of alternative cleaning technologies to those technologies which best fit the application. The user can either 1) answer questions about the product and cleaning needs, allowing the program to suggest the best alternatives, or 2) go directly to the descriptions of alternative technologies. If the user only needs information about certain technologies, the information is available without having to go through the extensive question and answer process.

To learn which cleaning process is best suited for a particular application, the user should be prepared to answer questions about the product and production process. The program will supply generic responses to questions which the user cannot answer. Questions include the following:

- Metallic or non-metallic?
- Does the product have a coating? Should the coating be removed?
- Does the part have blind holes or a complex shape?
- Type of contaminant?
- Is the part subject to cleanliness inspections?
- What cleaning equipment is available?
- Which chemicals are used for part cleaning?
- Volume of parts to be cleaned?
- Can part withstand ultrasonic vibration? High atmospheric pressure? High pressure spray?

The program lists recommended technologies based on a scoring system which rates the technologies against the desired application. Brief

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

summaries are available for each recommended technology. Information about chemical alternatives includes chemical properties, safety precautions, cleaning processes, and combustibility. Material Safety Data Sheets (MSDSs) are included for all chemistries. In the descriptions about alternative processes, the user can learn about equipment costs, automation possibilities, safety precautions, compatible cleaning solutions, and particular applications.

Detailed reports describe each process and chemistry in greater detail, and can include a glossary of terms and a process conversion checklist. Pertinent subjects such as safety, economics, case studies, references, and vendor lists are all covered in the detailed reports.

Computer Requirements

To benefit from SAGE 2.1 you must have the following minimum computer system:

- PC-AT (286) or compatible computer with hard drive
- EGA/VGA monitor
- Five MB free space on hard drive
- Copy of shareware program PKUNZIP.EXE.

Copy the files SAGE.ZIP and PKUNZIP.EXE into the desired directory and type the command PKUNZIP SAGE. SAGE.ZIP will explode into 71 files. The file READ.ME, which can be read using a standard text editor, is a user's guide for the program, describing the background, installation, and operation of the program. The program can be activated by typing the command SAGE.

Alternatives included in SAGE

Process Alternatives

- Abrasives
- Brushing
- CO₂ Pellets
- CO₂ Snow
- High Pressure Spray
- Immersion Cleaning
- Laser Ablation
- Low Pressure Spray
- Megasonics
- Plasma Cleaning
- Power Washing

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- Semi-Aqueous Cleaning
- Steam
- Supercritical CO₂
- Ultrasonics
- UV/Ozone Cleaning
- Wiping
- Xenon Flash Lamp

Chemistry Alternatives

- Acetone
- Acidic Aqueous Solutions
- Alcohols
- Alkaline Aqueous Solutions
- Dibasic Esters
- Ethyl Lactate
- Glycol Ethers
- Neutral Aqueous Solutions
- N-Methyl Pyrrolidone
- Petroleum Distillates
- Pure Water
- Terpenes

Materials

Compatibility: Materials compatibility information is provided in the software.

Safety and Health: Each replacement product or process should be reviewed for safety and health factors with the manufacturer, your local industrial health specialist, and your local health and safety personnel before implementing. Also, consult product MSDSs for additional information.

Benefits: Provides a quick but detailed reference for a variety of EPA-approved chemical and process alternatives.

Disadvantages: N/A

Economic Analysis: N/A

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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**Points of
Contact:**

The software can be downloaded free of charge from the EPA's Control Technology Center (CTC) Bulletin Board located on the Technology Transfer Network (TTN), modem (919) 541-5742 (1200, 2400, 9600, or 14,400 bps) or off the Internet: ttnbbs.rtpnc.epa.gov. It is also available over the World Wide Web: <http://clean.rti.org>.

The CTC helpline can provide assistance with downloading or running the program. Any suggestions should also be directed to the helpline at (919) 541-0800 or (919) 541-5384.

Developers of SAGE Software:

Mr. Kenneth R. Monroe
Ms. Elizabeth A. Hill
Research Triangle Institute
3040 Cornwallis Road
Research Triangle Park, NC 27709

Mr. Charles H. Darwin
US Environmental Protection Agency
Air and Energy Engineering Research Laboratory
Research Triangle Park, NC 27511

Vendors:

The following list is not meant to be a complete, as there are other manufacturers of this type of equipment.

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(800) 553-6847, (703) 487-4650

Source: US EPA SAGE 2.1 documentation

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SOLVENT RECYCLING

Revision: 1/96
Process Code: Navy: ID-24-00; Air Force: HW01; Army: CLD, VHM, DPT
Substitute for: Single use of Methyl Ethyl Ketone, Methyl Chloroform, and CFC-based Solvents
Applicable EPCRA Targeted Constituents: Methyl Ethyl Ketone, Methyl Chloroform, and other chlorinated organic compounds, including the CFC solvents

Overview: Recycling is a viable alternative to single use/disposal of toxic solvents. It is environmentally benign, and reduces the amount of solvent purchased and disposed. As regulations become tighter, disposal costs will continue to rise. Although capital, operating, and training costs are not negligible, most solvent recycling systems are less expensive to operate than the purchase and disposal of virgin solvent.

Single use of toxic and hazardous solvents has become an environmental and economic impediment to acceptable and efficient operation of solvent cleaning processes. Substitution of a non-toxic solvent is an option, but often a substitute is either less effective or does not exist. In contrast, solvent recycling can be both simple and cost effective. The primary means of recycling solvents include the following:

On-line Filtration: Filtering systems remove the sludge or residue that accumulates from solvent cleaning operations during operation. This allows direct reuse of the filtered solvent, reducing the amount of virgin solvent needed for a given process by extending the solvent life almost indefinitely.

Membrane Separation: A semi-permeable membrane can isolate either solvent molecules with a molecular weight exceeding 500 or particles with a diameter less than 0.5 microns. The two types of membrane separation, ultrafiltration and reverse osmosis, differ with respect to the size of the molecules which are to be removed.

Solvent Separation: Solvent separation is an expensive process for separating the wastestream components. A liquid is added to the waste solvent to react with one component and stay immiscible with the other. The wastestream then separates into phases, and the solvent is extracted.

Distillation: Another alternative for recycling solvents is distillation, best suited for excessive contamination, large degreasers, continuous cleaning operations (but not necessarily continuous distillation), and where the contamination needs to be kept out of the degreaser. Applications run the gamut of industrial processes: paint thinner

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recovery, degreasing fluids, electronics cleaning, printing, etc. However, the principal application remains recovery of one component, single-use spent solvents. Solvent recovery distillation units, or stills, process spent solvents in separate, stand-alone or on-line batch or continuous systems. The solvent is recovered as a condensate in a separate container and is ready for reuse.

Thin Film Evaporation: Similar to distillation, thin film evaporation (TFE) has been used with success by Martin Marietta Energy Systems to recycle trichloroethylene, 1,1,1-trichloroethane, nickel stripper solution, co-contaminated oil, and lacquer thinner. The used solvent is deposited on a hot metal surface, where the solvent is vaporized off and the contaminants are left behind. The solvent is then condensed and reused.

Downgrading: The reuse of solvents by “downgrading” is most effective where many cleaning processes take place. Use the virgin solvent to clean parts which begin relatively clean. The used solvent can be readily downgraded for cleaning dirtier parts.

Gravity Separation: Some solvents, especially paint thinners, can be recycled if the solids are allowed to settle out (sedimentation). Decantation is the separation of immiscible liquids slowly fed into a decant tank, a simple, compact piece of equipment. A centrifuge can accelerate the separation of liquids or solids with similar densities.

Moisture Removal: Moisture in a solvent can cause problems such as corrosion and coating defects on the part and hydrolytic breakdown of certain chlorinated solvents. Therefore, moisture removal is a necessary step in recycling solvents for certain applications.

Stripping: Air or steam stripping is used to remove solvents from oils cleaned out of hydraulic systems, water from anti-freeze, and solvents from soils and other solids. The air can then be passed through activated charcoal to remove the stripped solvents. Steam stripping the charcoal will release the solvent for reuse.

Off-site Reclamation: In many cases, off-site reclamation is a reasonable alternative for disposal. When the recycled solvent is returned to the company for reuse, minimum batch sizes range from 1,000 to 2,000 gallons and require separation of the solvent streams. As the batch size grows, the cost of off-site recycling decreases. Typically, the reclaimed solvent is returned to the generator at a cost similar to virgin solvent; the savings are equal to the cost of disposing the spent solvent.

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Another potential alternative is a waste exchange and brokerage. The waste exchange matches up a waste generator with a potential user who can reprocess the waste as a feedstock.

Materials

Compatibility:

Distillation equipment should be made of high-alloy stainless steel to prevent corrosion from either the solvents or the heating oil, which degrades with time. The alloys also protect against iron contamination of the recovered solvent. Using a liner adds an extra layer of protection to the still's boiling chamber and greatly simplifies cleaning, as the liner containing the solvent residue is simply lifted out of the unit for disposal..

Safety and Health:

Inhalation of solvent vapors can cause irritation to the respiratory tract and mucous membranes. Prolonged exposure may result in damage to the lungs and central nervous system. Contact with the skin can cause dryness, irritation, and possibly dermatitis. Only use in well ventilated areas with proper protective equipment.

Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

Reduces the amount of toxic, hazardous, or ODS-based solvents going into the environment and reduces hazardous waste disposal costs.

Disadvantages:

Requires trained personnel to operate the machinery.

Economic

Analysis:

Self-contained, batch-distillation recycling units vary in price from \$2K to more than \$30K depending on the size, materials of construction, and options chosen; for example, agitation, hoist and removable tank system for fast reloading of a hot machine, etc. Capacities typically range from 1- to 250-gallon batches.

Solvent recycling has been used at Fort Shaw, where \$114,763 were saved over 3 years, and the initial cost was recovered in 70 days.

Distillation units are available by ordering one of the following two NSNs and specifying the desired volume: 2-, 3.7-, 5.2-, 7.5-, 15.7-, 25-, or 40-gallon units - NSN 4940-01-395-9468 or NSN 4940-01-395-9469. Small units are single phase; the large units three-phase; and all models are 220 VAC, although a 440 VAC versions are available.

In many cases, solvent recycling systems have to be specific to the solvent, the contaminants being removed, batch size or throughput, and type of cleaning operation, leading to a wide range of costs.

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Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of

Contact:

Mr. Tim Woods
Materials Engineering Laboratory
Naval Aviation Depot, North Island
(619) 545-9757

Technical Sgt. Ken Parks
437th EMS
Charleston AFB, SC
DSN 673-4656, (803) 566-4656

Operating experience at Charleston AFB has shown recoveries of 90 to 95 percent for solvents recycled by batch vacuum distillation. Five-gallon batches of methyl ethyl ketone or paint thinner in nominal 5-gallon stills typically require 3.5- to 3.75-hour cycles to complete evaporation. Test operations at higher temperatures to try to achieve shorter cycle times demonstrated entrapment of residue into the clean condensate.

Vendors:

The following is a list of companies that carry solvent recycling equipment. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Branson Ultrasonics Corporation
41 Eagle Road
Danbury, CT 06813-1961
(203) 796-0400.

Detrex Corporation
322 International Parkway
Arlington, TX 76011
(800) 525-1496

Sources: PA Technical Bulletin # 2791, August 94, Finish Thompson and PBR Industries product literature. Whinnery, W. N., "Thin Film Evaporation for Reuse/Recycle of Waste Organic Solutions," *Solvent Substitution for Pollution Prevention*, US Department of Energy, Washington, D.C., pp. 204-210, 1993.
Salvesen, Robert H., "On-Site Reuse and Recycle of Solvents," *Solvent Waste Reduction*; US Environmental Protection Agency, Cincinnati, OH; ICF Consulting Associates, Inc., Los Angeles, CA; pp. 78-89, 1990.

THE CLEAN-IN-PLACE (CIP) METHOD TO MINIMIZE HAZARDOUS WASTE

Revision: 1/96
Process Code: Navy: ID-03-99; Air Force: CL04; Army: Not available
Substitute for: Hydroblasting, chemical cleaning, and solvent cleaning
Applicable EPCRA Targeted Constituents: N/A

Overview: Clean-In-Place (CIP) is a method designed to “automatically” clean pipes and process equipment without the time and labor requirement of manually dismantling equipment components. Long-term, CIP is less expensive and more consistent than conventional manual cleaning methods. CIP is not a substitute for toxic solvents, but rather, a more efficient way to use them.

CIP is more of a design method than a cleaning process. The CIP method works “automatically” by eliminating the places where residue can accumulate. This is achieved by placing pipes at an angle to the horizontal (minimum 3%) to improve drainage and by using instruments and valves that connect flush to pipes, eliminating “dead legs” (places where residues can be trapped). CIP is perhaps best applied to batch process operations because the amount of residual product from a batch can contaminate subsequent batches and given the frequency of these operations, the CIP method is ideally suited to fast turnarounds and to achieving a high degree of piping and equipment cleanliness.

The CIP method can be improved with specially designed process equipment, piping, and fittings which have ducts and spray balls for cleaning the equipment internally. As of July 1994, only diaphragm valves have been used with CIP; ball and slide valves can be modified with injection ports for use with CIP, but this makes them very complex.

To enhance the CIP method, use a CIP cleaning system which consists of a centralized control unit with satellite spray-washing and rinsing units to clean the process equipment, pumps, valves, and pipes. Also, use gear pumps with a low “dead” volume (where “dead” volume refers to the amount of void space that does not drain freely and as a consequence can be difficult to clean because material is stagnant and then dries or polymerizes). Mechanical drives have internal parts which have void spaces where residue can be deposited; these must be removed for cleaning, so for difficult applications with rotating equipment such as agitators, magnetic drives should be used.

The CIP cleaning system is procured as a package consisting of a recirculation system: storage tank, pump, heat exchanger, and rotary

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strainer; a chemical feeder which makes the cleaning solutions; a cleaning system with spray balls and piping to supply and return the various solutions; solution-return tanks; and control instrumentation. After the chemical process is complete, activate the CIP cleaning system to clean and rinse the equipment, the cleaning can even be integrated into the process program.

Materials

Compatibility: As the CIP cleaning system does not alter the actual chemicals used for cleaning, material compatibility should not be an issue.

Safety and Health: Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: For most process plants, the use of CIP systems increases overall capital costs by about 10%. However, the return on investment due to lower labor, raw material, and energy costs can mean pay back in less than a year.

Disadvantages: Requires redesigning the current system.

Economic Analysis:

N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendor: The following is a company that can assist you in setting up the Clean-in-Place technology. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Hartel Corp.
201 North Marx Street
Ft. Atkinson, WI 53578
Mr. Gene Bond (414) 563-8461

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

STEAM CLEANING AS A SOLVENT ALTERNATIVE

Revised: 1/96
Process Code: Navy: ID-02-13; Air Force: CL05; Army: CLD
Substitute for: Solvent Cleaning
Applicable EPCRA Targeted Constituents: Acetone, n-butanol alcohol, methyl ethyl ketone, toluene, and xylene

Overview: Steam cleaning to remove grease and oily residues is a viable solvent alternative for some cleaning applications. It is most effective when using a degreasing agent (often a surfactant) simultaneously to enhance the solubility of grease in water.

Cleaning with steam is an effective method for removing oily or greasy residue and dirt from soiled fabrics and machinery. Steam is used because its high temperature yet low specific heat allow surfaces to be heated to relatively high temperatures, but only long enough for the steam to vaporize or liquefy the oil, grease, or dirt so that it can be effectively washed away with the condensate remaining from the condensed steam.

Materials

Compatibility: Flash rusting may be a problem for certain types of steel. Preventative measures may have to be taken. Try a small piece before doing a large scale job.

Safety and Health: Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Reduces the amount of toxic and hazardous chemicals going into the environment and the amount of waste water after the completed operation.

Disadvantages: Never steam clean any equipment, component, or material that is temperature or moisture sensitive or that has a temperature or moisture sensitive element.

Economic

Analysis: N/A

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: N/A

Vendors: N/A

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MECHANICAL CLEANING PROCESSES AS SOLVENT ALTERNATIVES

Revision: 1/96
Process Code: Navy: ID-01-08/-09/-10/-11; Air Force: CL04; Army: CLD, PNT, VHM
Substitute for: Solvent cleaning
Applicable EPCRA Targeted Constituents: Solvents such as benzene, toluene, acetone, trichloroethane, xylenes, methyl ethyl ketone, methyl isobutyl ketone, methylene chloride, and perchloroethylene

Overview: Mechanical cleaning processes are viable alternatives to traditional solvent-based cleaning operations for reducing not only waste production, but also for eliminating potential safety problems with handling and use of toxic, ozone depleting, and often flammable solvents. These cleaning processes are many and varied. Cleaning or surface preparation of almost any piece of equipment, surface, or component is possible if it is sturdy enough to withstand the friction and force produced by the mechanical work of cleaning operations such as sanding, grinding, polishing, brushing, scraping, snaking, or pigging.

Mechanical cleaning processes offer a wide range of cleaning and surface preparation options to solvent cleaning.

1. Brushing - wire or plastic brushes are used to remove product, grime, or grease buildup from equipment. Metal and wooden surfaces can be prepared for painting or repainting by vigorous brushing of the surfaces to remove dirt, loose paint, scale, or corrosion.
2. Grinding - a rotating abrasive stone or disc is used to grind down (or off) some of the hardest and most difficult to remove materials like accumulated dirt, dry paint, long-standing corrosion, and mineral scale.
3. Polishing and buffing - light surface dirt, residue, tarnish, or scale is removed by polishing and buffing. These operations typically use a soft device like a fabric or fiber cloth or belt and slightly abrasive polishing cream to remove dirt, corrosion, scale, tarnish, oxidized paint, and grease residue from painted or bare metal surfaces.
4. Sanding - sanding is an abrading operation using a fiber (paper, cloth, plastic, etc.) sheet embedded with sand or other mineral grit particles that removes surface dirt or loose paint. It can be done manually or with many varieties of motor driven sander.
5. Pigging - material buildup on the walls of pipes or obstructions in lines can drastically reduce a fluid's flowrate, resulting in capacity bottlenecks or sometimes even complete loss of fluid flow. A pig is a device that can often clear the obstruction, clean the pipe walls, or even push out and clear residual product after a transfer. The pig

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accomplishes this by being pressured through the line, typically with nitrogen (or compressed air, depending on the service). Because of its shape, weight, and the speed at which it travels through the line, the pressure it exerts on an obstruction or wall buildup is usually sufficient to clear and clean the line. Pigs come in a variety of materials as well as in numerous shapes, sizes (from 1/4" to 12' in diameter), and configurations to enhance pipe wall cleaning, facilitate turning 90 degree elbows, or clear residual fluid.

6. Snaking - A plugged or stopped drain or pipe can be cleared using a snake, a long flexible coil of wire that is manually or electrically twisted through a pipe until the obstruction is reached and the force of the twisting coil of wire tears through the obstruction.

Materials

Compatibility: These technologies are not meant to be used on precision or delicate parts. Check with your local cognizant authority prior to implementing any of these technologies.

Safety and Health: Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Mechanical cleaning avoids the use of toxic or dangerous chemicals by substituting mechanical work for chemical work. This tends to make mechanical cleaning operations the most efficient in terms of producing the least amount of hazardous waste, as no other materials are added. In addition, when compared to chemical cleaning, mechanical cleaning is also one of the most rapid cleaning methods since chemical action typically must rely on slow surface transport phenomena such as diffusion to achieve reaction and effect cleaning.

Economic Analysis:

Will vary on a case by case basis. Ensure that if one of these technologies is chosen that it will result in the same finished product as you desire.

Approval Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mr. Alvin Day, Systems Engineering
Air Force Civil Engineering Support Agency
HQ AFCESA/ENM
DSN 523-6357

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Vendors: The following is a list of companies that carry mechanical cleaning equipment. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Girard Polly Pig Inc. (manufacturer of the Aqua Pig)
6531 N. Eldridge Parkway
Houston, Texas 77041
(713) 466-3100
Mr. Dave Henry

Knapp Polly Pig, Inc.
1209 Hardy Street
Houston, Texas 77020
(713) 222-7403, (800) 231-7205, FAX (713) 222-7403

Pipeline Pigging Products, Inc.
P.O. Box 692005-300
Houston, Texas 77269
(713) 351-6688

NLB Corp.
29830 Beck road
Wixom, MI 48096-2824
(313) 624-5555, FAX (313) 624-0908

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

BILGE AND OILY WASTEWATER TREATMENT SYSTEM (BOWTS)

Revision 11/95

Process Code: Navy: SR-15-99; Air Force: N/A; Army: N/A

Substitute for: N/A

Applicable EPCRA Targeted Constituents: Benzene, Antimony, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Zinc. Pesticides, PCB, Phenolic Compounds

Overview: The Naval Facilities Engineering Service Center has developed a shore-side system for treating bilge and other oily waste waters. The Bilge and Oily Wastewater Treatment System (BOWTS) removes all major contaminants found in bilge waters.

BOWTS has been successfully operating 150 gpm units at Naval Shipyard Long Beach and Naval Air Station Alameda. It is scheduled to be installed in the near future at Subase San Diego, Fleet Industrial Support Center Oakland, Naval Station Pearl Harbor, Naval Station San Diego, Naval Station Guantanamo Bay, and Naval Station Guam.

The BOWTS hardware is a stationary system with secondary containment equipped with redundant (duty/standby) intake pumps, each fitted with upstream strainers. After the ship's bilge water is transferred to a large holding tank, the feed is then passed through a first stage oil/water separator, and is then introduced into a series of three chambers for performing chemical treatment. Two chemical metering pumps feed a reverse emulsion breaker and sodium hydroxide, respectively, into this subsystem, resulting in the removal of the emulsified oil and precipitation of the heavy metals. The effluent is then pumped into an induced-air flotation unit, where the generated residues are removed. Two slop oil tanks are provided for collecting the free oil separated in the oil/water separator, and a sludge tank is provided for holding the sludges collected in the oil/water separator and the induced-air flotation device. The water fraction leaving the system will be of a quality that can be discharged directly into the sanitary sewer.

Although the pollutants found in ship bilge and other oily wastewater vary from ship to ship, the approach followed was to categorize and quantify the principal pollutants. The data collected was used in designing the basic BOWTS. Additional process units could be added where local discharge requirements indicate the need for more rigorous treatment than is available from the basic system design. BOWTS lowered the contaminant levels to less than the permissible limits for discharge into navigable waters.

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Materials

Compatibility: N/A

Safety and Health: BOWTS chemicals are irritants to skin, eyes, and mucous membranes. Inhalation of these fumes can be dangerous. Pesticides and polychlorinated biphenyls are suspected carcinogens. Proper personal protection equipment is, therefore, recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

- BOWTS can potentially reduce the amount of bilge water disposed at a site by as much as 95 percent.
- BOWTS is a proven off-the-shelf technology.
- The system is flexible to accommodate a wide range of concentrations and flow ranges and each system is designed to site specific requirements (e.g., configuration, modifications, etc.).
- The BOWTS operation is completely automated but requires one person to monitor the process.

Disadvantages: N/A

Economic Analysis: Based on 1995 dollar values and for a 150 gpm flow, the cost for BOWTS is broken down as follows:

- \$80,000 to install BOWTS.
- \$450,000 to purchase each unit. However, the money for the equipment can be obtained from the oil spill program.
- Activity provides costs associated with site preparation and the equalization tank. This cost can vary from \$100,000 to over \$1,000,000.
- Payback period for BOWTS is 1 to 4 years (per NAVFAC P-442).

Approval

Authority: Implementation of the BOWTS technology requires coordination between major claimant, the base environmental office, and a contracting vehicle. Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Points of Contact:

James Harlowe
Naval Facilities Engineering Service Center ESC 422
1100 23rd Avenue
Bldg. 1500
DSN 551-4873
(805) 982-4873
FAX (805) 982-4832

Tom Torres
Technical POC
Naval Facilities Engineering Service Center ESC 421
1100 23rd Avenue
Bldg. 1500
DSN 551-1658
(805) 982-1658

Vendors: N/A

BIOLOGICAL AQUEOUS WASTEWATER TREATMENT SYSTEM

Revision 1/96
Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents : Pentachlorophenol, creosote

Overview: The BioTrol Aqueous Treatment System (BATS) is a biological treatment system for contaminated wastewater. This system uses naturally occurring microbes; however, where highly toxic or recalcitrant target compounds are present microbial amendments are introduced.

The process flow consists of contaminated water flowing to a mix tank, where its pH is adjusted and inorganic nutrients are added. If necessary, the water is heated to an optimum temperature, using both a heater and a heat exchanger to minimize energy costs. The heated water then flows to a bioreactor where the contaminants are biodegraded. The degrading microorganisms are then immobilized in a multiple-cell, submerged, fixed-film bioreactor. Each cell is filled with a highly porous packing material, to which the microbes adhere. For aerobic conditions, air is supplied by fine bubble membrane diffusers mounted at the bottom of each cell. This system can also operate under anaerobic conditions.

As water flows through the bioreactor, contaminants are degraded to biological end products, predominantly carbon dioxide and water. The resulting effluent may be discharged to a publicly-owned treatment works (POTW) or may be reused on site.

This technology can be applied to a wide variety of wastewaters. Contaminants amenable to treatment include pentachlorophenol, creosote components, gasoline and fuel oil components, chlorinated hydrocarbons, phenolics, and solvents. Other potential target waste streams include coal tar residues and organic pesticides. BATS has performed successfully at forty different locations..

Materials

Compatibility: N/A

Safety and Health: Pesticides and herbicides must be handled with care. Skin adsorption can be a concern when handling wastewater contaminated with these chemicals. Pentachlorophenol is an experimental teragen and carcinogen. It is also poisonous when inhaled and causes dermatitis. Proper personal protective equipment is, therefore, recommended.

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Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The Biological Aqueous Treatment System was tested at the MacGillis and Gibbs Superfund Site in New Brighton, Minnesota. The system was operated continuously for 6 weeks at three different flow rates. The demonstration showed the following:

- reduced pentachlorophenol concentrations from 45 to 1 ppm in a single pass
- achieved 96 to 99 percent removal of pentachlorophenol
- minimal sludge production and no air emissions of pentachlorophenol,
- mineralized chlorinated phenolics
- eliminated biotoxicity in the wastestream
- BATS requires minimal operator attention

Disadvantages: N/A

Economic Analysis: The capital cost for this technology depends on the flow rate.

- capital cost for 1 to 2 gallons per minute is \$15,000
- capital cost for 100 gallons per minute is \$150,000
- operating costs were \$0.75 per 1,000 gallons for a 5 gallon per minute unit and \$0.40 per 1,000 gallons for a 30 gallons per minute unit

Factors determining costs of treatment are the technology used, the flow rate, and the level and type of contamination. Each naval must examine the cost effectiveness of the technology needed before selecting the system.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact: Mary Stinson
US EPA
Risk Reduction Engineering Laboratory
2890 Woodbridge Avenue
Edison, NJ 08837
(908) 321-6683

Vendors: Sandra Clifford
BioTrol, Inc.
10300 Valley View Road
Eden Prairie, MN 55344-3456
(612) 942-8032

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

RECYCLING WASH WATER USING CLOSED LOOP WASH RACKS

Revision: 1/96
Process Code: Navy: SR-15-99; Air Force: CL05; Army: N/A
Substitute for: Wastewater treatment
Applicable EPCRA Targeted Constituents: Benzene, Cadmium, Chromium, Toluene, Methylene Chloride, Tetrachloroethene, Mercury, Lead, Zinc, Copper, Xylenes

Overview: The closed loop wash rack allows complete recycling of wash water used for vehicle cleaning. Facilities installing closed loop wash racks will attain zero discharge, and therefore eliminate any possibility for NPDES violations.

A typical process flow consists of the mechanical equipment (trucks, cars, etc.) stopping over a wash pad collection pit. The wash water will go through three treatment units (alpha, beta, and omega) before being recycled for reuse.

The purpose of the alpha unit is to separate free oil and dirt from the waste water. Water in the alpha unit goes through a vertical zigzag solids-liquid separator unit with 150 sq. ft. solids separator area, a polypropylene oil coalescent pack with 850 sq. ft. of oil coalescing area, a high density adsorption filter for removal of very small droplets, an engineered flow baffling, and an oil/skimmer for removal of floating oil and dirt. From the alpha unit, water will be pumped to the beta unit.

The beta unit removes fine dirt particles and remaining hydrocarbons in the effluent alpha. Water in the beta unit goes through a 400 sq. ft., 20 micron quad cartridge filter, an adsorbent media filter for filtration down to 5 to 20 microns, a 30 lb. carbon filter for removal of trace contaminants, and an enclosed cabinet with thermostatically controlled heater for freeze protection. Finally, the effluent from the beta unit flows to the omega unit.

The omega unit stores the water in a holding tank and then transfers it for reuse. The omega unit consists of a corrosion-proof polyethylene tank 1/4 inch thick, a centrifugal pump with surge tank and switch to draw reclaimed water from the holding tank for reuse by the pressure cleaner, a level control valve for maintaining proper recycled water level, an overload drain system and an ozone generator.

Materials

Compatibility: N/A

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Safety and Health: Care should be taken when handling these chemicals. They are irritants to the skin, eyes, and mucous membranes. Inhalation of the fumes can be dangerous. Proper personal protection equipment is, therefore, recommended.

Consult your local Industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The closed loop wash rack can handle a flow range of 1 to 50 gpm. It requires minimal maintenance. All the units are available as fully assembled modular units that are simple to install. The closed loop wash rack removes trace amounts of solvents, hydrocarbons, and dirt.

The closed loop wash rack has been operating successfully at various locations in the USA. The following table shows the Closed Loop Wash Rack treatment efficiency:

Pollutants	Typical Equipment Pressure Cleaning Water Sample	Closed Loop Wash Rack Recycled Water
Oil and Grease	57,500 ppm	5 ppm
Lead	270 ppm	0.03 ppm
Cadmium	2.2 ppm	5 ppb
Mercury	0.067 ppm	0.2 ppb
Chromium	1.54 ppm	0.95 ppm
Benzene	5,250 ppb	5 ppb
Toluene	55,200 ppb	5 ppb
Xylenes	654,000 ppb	400 ppb
Methyl chloride	260,000 ppb	5 ppb
Barium	1,150 ppm	1 ppm
Silver	14 ppb	0.05 ppb
Detergents	49,200 ppm	0.5 ppm

Disadvantages: N/A

**Economic
Analysis:**

The closed loop wash rack comes in four different units. The alpha unit costs \$5,000, the beta unit costs \$7,000, the Omega unit costs \$3,500, and the ozone generator costs \$1,500. These cost estimates are based on 20 gpm flow rate. In addition to the four units, there are some consumable items that have to be replaced. These items are: 1) D.E.C. Media 30# (5 to 6 lb. charges), \$60; 2) Cartridge Element, \$43 (2) 50 sq. ft.; and 3) Carbasorb filter media, 30 lbs., \$75. It will cost an

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additional \$10,000 for piping, electrical wiring, and installation. Based on 10% discount factor, the expected payback period is 4 years.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

Abe Nachabe
Naval Facilities Engineering Service Center
ESC 423/AN
1100 23rd Avenue
Bldg. 1500
Port Hueneme, CA 93043-4370
DSN 551-3016, (805) 982-3016, Fax: (805) 982-4832

The following facilities are currently using a Closed Loop Wash System

- NAS Willow Grove
- Norfolk Naval Shipyard
- NAS El Centro
- NSWC Indian Head

Vendors:

The following is a list of Closed Loop Wash Rack Vendors. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

Mike Maddock
LANDA Inc.
8270 Belverde Avenue, Suite 100
Sacramento, CA 95826
(800) 432-7999

Robert A. Still
N/S Corporation
235 West Florence Avenue
Inglewood, CA 90301
(800) 782-1582

The following are vendors that supply equipment through the GSA System.

Philip Kircher
RGF Environmental Systems, Inc.
3875 Fiscal Court
West Palm Beach, FL 33404
(800) 842-7771
email: kirch@ix.netcom.com

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

ELECTROLYTIC RECOVERY TECHNOLOGY FOR SILVER CYANIDE RECYCLING

Revision 1/96
Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A
Substitute for: Wastewater Disposal
Applicable EPCRA Targeted Constituents: Silver

Overview: Wastewater generated from the rinsing of silver cyanide plated parts contains silver metal and cyanide containing compounds (cyanides). Silver metal and cyanides are toxic hazardous materials. The waste stream requires pretreatment to reduce these toxic materials prior to discharge. This treatment requires the use of hazardous chemicals including acids, alkalis, and chlorine-containing chemicals.

Electrolytic recovery technology uses an electrical current to plate out the silver metal and oxidize the cyanides in the rinse waters. The silver metal is recovered from the electrolytic recovery unit (ERU) as a metal foil that can be returned to the silver cyanide plating bath as an anode source. The purity of the recovered silver should meet the specifications for anode purity as long as the water from the rinse tank is used to rinse parts that are only plated in the silver cyanide tank. The ERU is plumbed to a stagnant rinse tank (the first rinse tank that the plated parts would see) in a closed loop fashion. The cyanides are partially oxidized to cyanates in the ERU. Electrolytic recovery technology can remove more than 90 percent of the silver metal in the rinse stream and oxidize up to 50 percent of the cyanides.

Materials

Compatibility: N/A

Safety and Health: Silver is known to be a mild skin irritant. It is also an equivocal tumorigenic agent. Cyanide compounds are very poisonous in nature, and prolonged exposure to high concentrations can be detrimental to human beings. It can be absorbed through skin and through inhalation. Proper personal protective equipment should be used.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The benefits of electrolytic recovery for silver cyanide recycling include cost savings and reduction of hazardous waste. The cost savings will vary for each installation. The cost savings result from the following:

- Reduction in the use of treatment chemicals for cyanides and heavy metals in the wastewater treatment plant;

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- The recovery and reuse of silver metal, which reduces the costs for silver anodes or chemicals
- Reduction in the volume of silver-containing hazardous sludge at the wastewater treatment plant

Disadvantages: N/A

Economic Analysis: The cost to implement an ERU assumes that the rinse system for the silver cyanide plating line is a dedicated rinse (only used to rinse silver cyanide plated parts) and that the rinse system consists of a two-tank rinse system (a stagnant rinse followed by a final rinse connected to a wastewater treatment plant).

Capital costs are based on a 800 gallon cadmium cyanide plating bath:

- Electrolytic Recovery Unit - \$15,000
- Labor and Installation Costs - \$3,000

Operational costs: The ERU will only be operated when the concentrations of the silver and cyanides reach predetermined concentrations in the stagnant rinse tank. Once turned on, the ERU will run continually until these concentrations are reduced to acceptable levels. By using the ERU in a batch mode, existing personnel should be able to operate the unit. Therefore, no additional operational costs are associated with the implementation of the ERU.

Assuming that a given naval facility generates 300,000 gallons of silver cyanide rinse waters a year, the following savings are estimated:

- Waste treatment costs (300,000 gals. x \$0.50 per gallon) = \$15,000
- Savings for purchasing fewer silver anodes = \$500
- Total savings = \$15,500
- Total costs = \$18,000
- Payback period = approximately 15 months

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Points of Contact: Michael Viggiano, Code 423
NFESC, Information and Technology Transfer Branch
1100 23rd Avenue
Bldg. 1500
Port Hueneme, CA 93043-4370
Comm: (805) 982-4895, DSN: 551-4895

The following are using an ERU on their silver cyanide plating line:

Tony Grasso
NADEP Norfolk
Norfolk, Virginia
(804) 445-2474, DSN: 565-2474

Mel Flores
NSY Long Beach
Long Beach, California
(310) 547-6269, DSN: 360-6269

Bill Semaine
NADEP Pensacola
Pensacola, Florida
(904) 452-2120, DSN: 922-2120

Vendors: This is not meant to be a complete list, as there are other manufacturers and vendors of ERUs.

ECO-Tec Limited
925 Brock Road South
Pickering, Ontario Canada 11W2X9
(905) 831-3400

ELTECH International
625 East Street
Fairport Harbor, OH 4407
(216) 357-4037

Covofinish Co., Inc.
North Scituate, RI 02857
(401) 568-9191

BEWT Recovery Technologies, Inc.
Whittier, CA 90608
(310) 945-6957

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

HYDROBLASTING WASTEWATER RECYCLING SYSTEM

Revision: 1/96
Process Code: Navy: SR-15-99; Air Force: N/A; Army: N/A
Substitute for: Wastewater disposal
Applicable EPCRA Targeted Constituents: Heavy Metals, Sodium Nitrite

Overview: This technology has been used to successfully recycle wastewater generated during the hydroblasting of ship's boilers. Hydroblasting is a time consuming process that generates 12,000 to 20,000 gallons of wastewater containing heavy metals and sodium nitrate. Sodium nitrate is added to the water used in the hydroblasting process and acts as a surface conditioner that prevents flash rusting of boiler tube surfaces during hydroblasting operations. It has been found that this water/sodium nitrate mixture can be reused in the hydroblasting process without adversely effecting finished product only if the solids have been removed.

The recycling system consists of collection, settling, filtration, reconditioning, and reuse of the hydroblasting water. The water is continuously recycled during the hydroblasting operations until the operation has been completed. Initially, potable water is mixed with sodium nitrate before being pumped under pressure to spray wands. The water is pressurized and sprayed on to the steam side surfaces of the boiler tubes to remove scale build-up. The wastewater from the blasting operation is collected and pumped out of the boiler.

Utilizing the recycling unit, wastewater is sent to two 650-gallon settling tanks. Once enough water has been collected, the fresh water is shut off and the wastewater is recycled through the unit. The wastewater is pumped to the first collection tank, where it is gravity fed to the second tank, allowing larger, suspended particles to settle out. It is then pumped from the second settling tank through two filter trains, three fabric filters (50, 25, and 5 microns), and a cartridge filter. The recycled water passes through a heat exchanger before being returned to the hydroblasting operation for reuse. The filters remove small suspended material that can't be removed through gravity settling. The filters do not remove sodium nitrate, which remains above 1,200 ppm, the level needed prevent flash rusting. This means that no additional sodium nitrate needs to be added to recycled water.

Materials
Compatibility: N/A

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Safety and Health: Heavy metals and sodium nitrate are irritants to skin, eyes, and mucous membranes. Inhalation of these fumes can be toxic. Proper personal protection equipment is, therefore, recommend.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The recycling unit has resulted in no known mechanical failures during the hydroblasting operations, nor does it cause a decrease in the quality of the cleaning operation. The sodium nitrate stays above the 1,200 ppm threshold, preventing rusting and surface damage. After inspection, no residuals were observed on the tube surfaces of boilers cleaned with the hydroblasting recycling unit and the cleaning operation was completed satisfactorily.

- System reduces the amount of wastewater generated by hydroblasting operations by more then 90%.
- With the use of the recycling unit, the amount of wastewater generated can be reduced by 90%
- Since less potable water was used in the operation, the amount of sodium nitrate used can be dramatically reduced
- No additional personnel are needed to operate the recycling unit.

Disadvantages: This process does generate spent filters that must be disposed as hazardous waste.

Economic Analysis: The process has been used successfully throughout the Navy for the hydroblasting of ship's boiler and may have application to other hydroblasting operations. It has been implemented at several shipyards and Shore Intermediate Maintenance Activities (SIMA) by the former Naval Energy and Environmental Support Activity (NEESA) and Naval Ship System Engineering Station (NAVSSSES).

The cost of the recycling unit is around \$25,000. This payback is achieved from two boiler cleaning operations. The cost savings come from the reduction of water usage, the reduction in the amount of sodium nitrate used, and the reduction of wastewater needing disposal.

Approval Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Points of Contact: Mike Viggiano
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(805) 982-4895, DSN 551-4895

Joe McGillian
Naval Ship Systems Engineering Station (NAVSSSES)
(215) 897-7706, DSN 443-7706

LASER REDUCTION OF TOXIC ORGANIC COMPOUNDS IN WASTEWATER

Revision: 1/96
Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: Methylene chloride, carbon tetrachloride, chlorinated fluorocarbons, and spent solvent mixtures/blends used in degreasing

Overview: The Laser-Induced Photochemical Oxidative Destruction (LIPOD) is a method to photochemically oxidize organic compounds in wastewater. Using a laser, ultraviolet radiation can be applied to organic compounds to achieve complete oxidation of a variety of organic compounds.

The LIPOD process oxidizes low levels of toxic organic chemicals in aqueous solutions. The toxic organic compounds include unsaturated and chlorinated organic compounds. These compounds rank high on the EPA's list of priority pollutants. Because of low concentrations (parts per billion) removal of these compounds from wastewater can be difficult.

The oxidation process uses a UV laser to excite organic compounds in the presence of an oxidant to initiate a chain oxidation reaction. The UV source is an excimer laser, which excites gas to produce a high-intensity coherent energy source. The oxidant is hydrogen peroxide, which mixes with water. The laser's energy initiates hydrogen peroxide oxidation of the organic compounds. Hydroxyl radicals, which are powerful oxidants, are produced when the laser impacts the hydrogen peroxide.

Sufficient oxygen or hydroxyl radicals are formed to completely oxidize the organic compounds to carbon dioxide, water, and inorganic ions. The narrow band UV radiation is preferentially absorbed by the organic molecules and hydrogen peroxide. Little radiation is absorbed by the surrounding water molecules. The process requires no ozone use. The wastewater needs to be exposed to the UV light for a short time (less than 50 seconds) to initiate the oxidative chain reaction. Only a portion of the contaminated water is exposed to the UV radiation source in the presence of hydrogen peroxide. The exposed water can be mixed with unexposed water to cause a chain oxidation reaction. These chain reactions can last 40 to 62 hours. In the LIPOD process, the feed stream containing the toxic organic compounds and hydrogen peroxide flows countercurrent to the laser beam in a photochemical reactor where the compounds are irradiated. When oxidizing halogenated solutions, the reaction byproducts are carbon dioxide, water, and the halide ion.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Materials

Compatibility: N/A

Safety and Health: There are safety and health concerns when dealing with compounds like carbon tetrachloride, 1,1,1-trichloroethane, etc. Carbon tetrachloride is a suspected carcinogen; therefore, caution should be taken when handling wastewater contaminated with it. In addition to that, carbon tetrachloride is also a skin and eye irritant, along with trichloroethane. They are toxic by inhalation. Proper personal protection equipment is therefore recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The LIPOD is effective in destroying benzene, chlorobenzene, chlorophenol, dichloroethene, benzidine, and phenol. Destruction percentages of the test compounds measure using LIPOD ranged from 89% to greater than 99%. Destruction of other contaminants can be achieved by varying the electromatic.

The destruction of the chemicals occur during the initiation phase of the reaction when reactants are exposed to the light source and continues as the reaction proceeds in the absence of light. Limited destruction is also achieved during the photochemical initiation phase for all compounds irradiated. Increased destruction can occur during this phase only when a greater irradiation dose is applied. After several days changes in the percent destruction is dependent on the concentrations of toxic organic compounds and hydrogen peroxide, and the irradiation dose applied during the initiation phase.

Disadvantages: N/A

Economic Analysis: Capital cost ranges from \$25,000 to \$60,000, depending on the size of the reactor.

Based on a 50 mg/L initial toxic concentration, the cost to operate the LIPOD range from \$0.01/L to \$0.02/L (\$0.03/gal. to \$0.07/gal.). The cost reflects the complete conversion of toxic organic compounds to carbon dioxide and water.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

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TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

PEROXIDE ADVANCED OXIDATION WASTEWATER TREATMENT

Revision 1/96

Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A

Substitute for: N/A

Applicable EPCRA Targeted Constituents: Trichloroethene, tetrachloroethene, chlorinated solvents, pesticides, polychlorinated biphenyls, phenolics, fuel hydrocarbons, and other organic compounds.

Overview: The hydrogen peroxide oxidation process is designed to destroy dissolved organic contaminants through an advanced chemical oxidation process using ultraviolet (UV) radiation and hydrogen peroxide. Hydrogen peroxide is added to the contaminated water, and the mixture is fed into the treatment system. The treatment system contains one or more oxidation chambers. Each chamber contains one high-intensity UV lamp mounted in a quartz tube. The contaminated water flows in the space between the chamber wall and the quartz tube in which each UV lamp is mounted.

This technology has been successfully applied at over 100 sites throughout the United States, Canada, and Europe. The units at these sites have treated groundwater, industrial wastewater, landfill leachates, potable water, and industrial reuse streams.

The hydrogen peroxide oxidation technology was demonstrated at the Lawrence Livermore National Laboratory site 300 Superfund site. The results of the demonstration successfully reduced trichloroethene and tetrachloroethene to below analytical detection limits.

UV light catalyzes chemical oxidation of organic contaminants in water by its combined effect upon the organic substances and reaction with hydrogen peroxide. First, many organic contaminants that absorb UV light may undergo a change in their chemical structure or may become more reactive with chemical oxidants. Second, and more importantly, UV light catalyzes the breakdown of hydrogen peroxide to produce hydroxyl radicals, which are powerful chemical oxidants. Hydroxyl radicals react with organic contaminants destroying them and producing the harmless carbon dioxide, halides, and water byproducts. The process produces no hazardous by-products or air emissions.

The hydrogen peroxide oxidation equipment includes circular wipers attached to the quartz tubes. These wipers periodically remove solids that may accumulate on the tubes, a feature designed to maintain treatment efficiency.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Materials

Compatibility: N/A

Safety and Health: Proper operation, design, and maintenance of the system will ensure its safe use. Hydrogen peroxide can be poisonous to the skin, eyes, and mucuous membranes. Polychlorinated biphenyls are experimental carcinogens and teratogens; therefore, proper personal protective equipment is highly recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The hydrogen peroxide oxidation technology treats wastewater contaminated with a variety of pollutants. These include: chlorinated solvents, pesticides, polychlorinated biphenyls, phenolics, fuel hydrocarbons, cyanides, and other organic compounds ranging from a few thousand milligrams per liter to less than 1 microgram per liter. In some cases, the process can be combined with air stripping or biological treatment for optimal treatment results.

Disadvantages:

- High capital cost
- High operational cost

Economic Analysis: The capital cost for the hydrogen peroxide oxidation system is between \$100,000 and \$200,000 for a 200,000 gallons per day treatment facility. Equipment capacities can range up to several thousand gallons per minute. The operational cost for the 100,000 gallons per day treatment facility varies between \$3,000 and \$10,000 per day.

The chemical oxidation process in the hydrogen peroxide oxidation process is dependent upon a number of reaction conditions which can affect both performance and cost. The process variables that are related to the contaminated water condition are the type and concentration of organic contaminant, total organic substances present, light transmittance of the water (turbidity or color), type and concentration of dissolved inorganic substances (e.g., carbonates and iron), and pH. The process variables that are related to the treatment process design and operation are UV and hydrogen peroxide dosage, pH and temperature conditions, use of supplementary catalysts, and treatment mode (batch, recycle, or continuous).

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

POWDERED ACTIVATED CARBON WASTEWATER TREATMENT

Revision 1/96
Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: Trichloroethene, tetrachloroethene, chlorinated solvents, pesticides, polychlorinated biphenyls, phenolics, fuel hydrocarbons, and other organic compounds.

Overview: The powder activated carbon wastewater treatment system combines biological treatment (such as the activated sludge process) with adsorption on powdered activated carbon (PAC). The technology removes organic contaminants from wastewater and minimizes the inhibitory effects of process wastewater containing toxic organic compounds. Mobile powder activated carbon wastewater treatment systems can be furnished as continuous flow or batch treatment systems. Continuous flow systems come mounted on a mobile trailer, with treatment capacities from 2,500 to 10,000 gallons per day. Batch operated or continuous flow package plants can be provided for flows to 100,000 gal/d. In-ground systems of up to 53,000,000 gal/day are currently in operation.

Typically, living micro-organisms (biomass) and PAC contact wastewaters in an aeration basin (anaerobic systems are also available). Biomass removes biodegradable organic contaminants through biological assimilation, while the carbon physically adsorbs conventional and toxic organics.

The degree of removal achieved by the system depends on the influent waste characteristics and the system's operating parameters. Important considerations are biodegradability, absorbability, and concentrations of toxic inorganic compounds, such as heavy metals.

Powder activated carbon wastewater treatment systems can be adjusted to specific waste stream feeds by varying the concentration of the PAC in the system, adjusting the retention time of the mixed liquor, and adjusting the waste to biomass ratio. If necessary, the temperature and the pH of the incoming waste can be adjusted, and nutrients can be added.

After the aeration cycle, solids (PAC, with adsorbed organics, biomass, and inert solids) are removed through settling. The removed solids are mostly returned to the aeration tank, with only excess solids being removed. Solids may be regenerated to recover PAC, or may be dewatered and disposed.

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A two-stage powder activated carbon wastewater treatment system may be applied where environmental standards require an even higher degree of treatment. In the first stage aeration basin, a high level of biomass and PAC removes most contaminants. The second stage aeration basin polishes the first stage effluent. The virgin PAC, added just ahead of the second stage, and the counter flow of solids to the first stage increases process efficiency. Excess solids are removed from the first stage and treated as described above.

Material

Compatibility: N/A

Safety and Health: Care should be taken when handling wastewater polluted with organic substances. They have a high order of dermal toxicity. Proper personal protection equipment is, therefore, highly recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

A powder activated carbon wastewater treatment system has been applied for:

- Pretreatment and end-of-pipe treatment of industrial process wastewaters
- Combined industrial/municipal wastewaters
- Contaminated surface runoff and groundwater
- Landfill leachates

The technology can be very useful at naval installations that have a combined industrial and municipal collection system.

Powder activated carbon wastewater treatment systems can treat liquid wastes with a chemical oxygen demand (COD) in excess of 60,000 parts per million (ppm), including toxic volatile organic compounds in excess of 1,000 ppm. Treatability studies have shown that the system can reduce the concentration of specific toxic organic chemicals to below the detection limit.

Other benefits of the system include:

- Stability in the face of shock loadings
- Color and ammonia removal
- Improved sludge settleability
- The process can be retrofitted into an existing activated sludge system at minimal cost.

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- Disadvantages:**
- High capital cost
 - High operating cost

Economic Analysis: The capital and operating costs of a powder activated carbon wastewater treatment system depends on the influent quality and the effluent standards. The budget level capital cost estimate for a mobile powder activated carbon wastewater treatment system ranges from \$100,000 to \$300,000. The operational costs range from less than \$0.50 to greater than \$1.00 per 1,000 gallons, depending upon a number of variables. Costs of wastewater treatment vary from one location to another. Factors determining the wastewater treatment costs are: the treatment technology used, the flow rate, and the level and type of contamination. Each naval activity will have to examine the cost effectiveness of the treatment technology needed before selecting the appropriate treatment system.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

PRECIPITATION AND MICROFILTRATION WASTEWATER TREATMENT SYSTEMS

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: Heavy Metals

Overview: The precipitation and microfiltration process uses a combination of treatments on a variety of wastes. Chemical precipitation of heavy metals is the first treatment in this process. Precipitates and all particles larger than 0.1 to 0.2 micron size are filtered through a unique tubular fabric crossflow microfilter. Concentrate is dewatered using conventional processes, such as filter press or centrifuge.

Microfiltration modules are fabricated from a tubular woven polyester material. Wastes pumped into these polyester tubes form a dynamic membrane that produces a high quality filtrate and removes all particles larger than 0.1 to 0.2 micron. Turbulence continually maintains the membrane and maximizes treatment efficiency.

Metals are removed via precipitation by adjusting the pH in a reaction tank. Metal hydroxides or oxides form a dynamic membrane with other suspended solids. The concentrate, which contains up to 50 percent solids by volume, is periodically discharged to solids concentration and drying systems (filter press, centrifuge, or sludge thickener). Water from solids concentration is recycled to the feed tank.

Constituents are removed using seeded slurry methods in the microfilter. Hardness can be removed through traditional precipitation reactions. Oil and grease can be removed by adding adsorbents. Organics and solvents can be removed using activated carbon, bone char, or powdered ion exchange resins as adsorbents.

Materials

Compatibility: The polyester membrane support cloth is suitable for use in all conditions except high concentrations of caustic at elevated temperatures. All other system components are either plastics (PVC, polyethylene, fiberglass) or type 316 stainless steel.

Safety and Health: Care should be taken when handling wastewater contaminated with heavy metals. They can be poisonous, and skin absorption is the major route. Proper personal protection equipment is, therefore, highly recommended.

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Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits:

Advantages of this system are:

- Modular construction allows flow rates from a few gallons per minute to virtually any capacity required
- Can treat any contaminant which can be converted to solid form either through precipitation or through adsorption on any of a variety of adsorbents

Commercial applications include removal of heavy metals from semiconductor and components manufacturing, oil and grease removal from industrial laundry effluent, and silica removal through water softening reactions from reverse osmosis concentrate.

Disadvantages:

- High capital cost
- High operating cost

Economic Analysis: The capital cost of the precipitation, microfiltration, and sludge dewatering treatment process will vary, depending on the particular removal challenge presented. A typical capital cost is approximately \$1.00 to \$2.00 per gallon per day of capacity. For example, the capital cost of a system to treat a wastewater flow of 100,000 gallons per day would be between \$100,000 and \$200,000. Operating costs consist of normal mechanical maintenance, neutralization chemicals, and adsorbents. Typical operating costs are in the range of \$1.00 to \$2.50 per 1,000 gallons.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

RECYCLING ACTIVATED CARBON

Revision: 01/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: Single Use/Disposal of Spent Activated Carbon Waste Streams
Applicable EPCRA Targeted Constituents: Toxic Organic Compounds

Overview: Carbon adsorption is a process in which a contaminated waste liquid or vapor phase waste stream is treated by removing the targeted contaminant (the adsorbate) through contact with a solid surface (the adsorbent). Activated carbon which has been processed to significantly increase the internal surface contact area, is widely used in many applications as the adsorbent material. Use of different raw materials (e.g., coal, wood, coconut shells) and processing techniques has resulted in a range of carbon types, in both powdered and granular forms. These types have various adsorption characteristics which tend to make them better suited for specific environmental applications. Granular activated carbon (GAC) is most commonly used for removal of a wide range of toxic organic compounds from contaminated groundwater, industrial wastewater, and vapor phase waste streams. Powdered activated carbon (PAC) is used extensively in biological waste treatment systems, and typically involves different handling and disposal practices than those used for GAC systems.

Activated carbon waste stream can be classified into a variety of possible categories, including both hazardous and non-hazardous waste. The handling and disposal of activated carbon waste streams can pose a significant economic and logistical burden on the waste generator. The incentives for recycling spent activated carbon wastes include financial benefits and reduced liabilities associated with improper handling or disposal of the activated carbon waste stream.

There are companies which offer activated carbon recycling services as part of an overall service arrangement or as a stand-alone service. The specific service offered will depend on such factors as the characteristics of the GAC treatment system, the volume of spent carbon to be handled, and the capabilities of the selected vendor. Spent carbon waste can be handled in either bulk shipments via tanker truck or rail cars, or in drums or alternative containers. Virtually all spent carbon waste to be regenerated is processed using a thermal destruction/scrubbing system, which destroys the organic contaminants as well as regenerates the carbon for reuse. Some vendors which offer activated carbon regeneration services will segregate the waste batches handled from each customer, if required, while other vendors will "blend" together waste carbon batches from multiple customers prior to

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processing. This can be an important factor if a customer is interested in minimizing liability associated with mixing and disposal of their waste stream with other unidentified wastes from other sources.

Materials

Compatibility: N/A

Safety and Health: Activated carbon may contain toxic impurities that can be irritating to the eyes, skin, and mucous membranes. Proper personal protective equipment is recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: There are many benefits that can be attained through recycling spent activated carbon. Recycling carbon eliminates the cost, handling, and related liabilities associated with spent carbon disposal at off-site facilities. Recycling activated carbon will also significantly reduce the volume of fresh carbon that must be purchased to regenerate the system.

Disadvantages:

- Regeneration of PAC is typically not practical.
- If carbon is contaminated with PCB's, dioxins, heavy metals, or DCBP (dichlorobromopropane), regeneration may not be an option.
- Special packaging may be required if carbon has certain chemical properties (ex. $2 < \text{pH} < 11$, haylide and sulfur contamination, etc.)
- Not economically feasible to regenerate on-site unless more than 400,000 pounds of spent AC is generated per year.

Economic Analysis: It is recommended that activated carbon be purchased from a virgin activated carbon supplier that will accept the spent carbon for regeneration. Typically, AC sample analysis and shipping fees are paid by the user, however, there is no charge for regeneration. The economics associated with recycling spent activated carbon will vary based on the volume, system characteristics, contaminants, and handling mode (i.e., bulk or packaged units).

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

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(412) 777-8000, (800) 422-7266

Carbtrol Corporation
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Westport, CT 06880
(203) 226-5642

Envirotrol, Inc.
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P.O. Box 61
Sewickley, PA 15143
(412) 741-2030

Tigg Corporation
P.O. Box 11661
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(412) 563-4300, (800) 242-1150, Fax: (412) 563-6155

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

REVERSE OSMOSIS AND ULTRAFILTRATION WASTEWATER TREATMENT PROCESS

Revision 1/96

Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A

Substitute for: N/A

Applicable EPCRA Targeted Constituents: Xylene, Acetone, Ethylbenzene, Methyl Isobutyl Ketone, N-Butyl Alcohol, Methanol, Cresols, and Nitrobenzene

Overview:

Reverse osmosis (RO) technology uses membrane separation systems to typically remove inorganic salts from wastewater. However, reverse osmosis can also be used to treat wastewater containing some organic solvents. The RO system uses a semipermeable membrane to separate pure water from contaminated liquids. Osmotic theory implies that when a contaminated solution is separated from pure water by a semipermeable membrane, the higher osmotic pressure of the contaminated solution will cause the water to diffuse into the contaminated solution. Water will continue to permeate into the contaminated solution until the osmotic pressure of the contaminated solution equals that of the pure water. RO occurs when an external pressure is exerted on the contaminated solution, water will flow in the reverse direction from the contaminated solution into pure water. RO systems can be used to separate pure water from contaminated matrices, such as the treatment of some hazardous wastes through concentration of hazardous chemical constituents, where pure water can be recovered on the other side of the membrane.

Ultrafiltration (UF) is a pressure-driven, membrane filtration process that is used to separate and concentrate macromolecules and colloids from wastewater. A fluid is placed under pressure on one side of a perforated membrane having measured pore size. All materials smaller than the pore pass through the membrane, leaving large contaminants concentrated on the feed side of the process. UF is used as a pretreatment step to RO or as a stand-alone process. Control of pass-through constituents can be achieved using a membrane with a limiting pore size, or by installing a series of membranes with successively smaller pores. The UF process cannot separate constituents from water to the same level of purity that RO can achieve. However, the two technologies can be used in tandem, with UF removing most of the relatively large constituents of a process stream before RO application selectively removes water from the remaining mixture.

Membrane technology can be used to treat a variety of wastes, including sanitary landfill leachate containing both organic and inorganic chemical species, water-soluble oil wastes used in metal fabricating and

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manufacturing industries, solvent-water mixtures, and oil-water mixtures generated during washing operations at metal fabricating facilities.

Waste feed, process permeate, and rinse water are potential feed materials to the skid-mounted RO-UF modules that consist of a tank and a high-pressure feed system that itself consists of a centrifugal feed pump, a prefilter cartridge housing, and a triplex plunger pump. The processing units themselves are self-contained and need only electrical and interconnection process piping to be installed prior to operation.

Materials

Compatibility: N/A

Safety and Health: There are health concerns when dealing with hydrocarbons. Inhalation of vapors can be toxic and dangerous to human health. There can be oral, dermal, and ocular effects. Personal protective equipment is recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: This technology can be applied to a variety of wastewaters and the units are compact for use at sea.

Disadvantages:

- High capital cost
- The UF process cannot separate constituents from water to the same level of purity that RO can achieve

Economic Analysis: The costs of a 40,000 gallons per day (gpd) membrane treatment unit are as follows:

- Capital cost is approximately \$350,000
- Electrical cost per 1 gallon of wastewater treated is \$0.000024
- Maintenance cost per 1 gallon of wastewater treated is \$0.0003.

Treatment of gray water:

- capital cost of 1,000 to 20,000 gpd RO-UF treatment unit for treating gray water is approximately \$500,000
- Electrical and maintenance costs would be similar to the single membrane treatment unit.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

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TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SECONDARY USE OF ACIDS AND ALKALIS FOR WASTEWATER TREATMENT

Revision 1/96
Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: The secondary use of acids and alkalis as treatment chemicals in an Industrial Wastewater Treatment Plant (IWTP) is a feasible waste reduction method, effectively reducing the disposal of used or excess acids and alkalis. The secondary use of acids and alkalis can reduce problems associated with disposal of acid and alkali wastestreams, such as the high cost and the liability of normal waste disposal.

Activities generate appropriate secondary use acids and alkalis from expired shelf-life material, pickling baths, rinsewaters, metal plating operations, battery shop effluents, and boiler cleaning operations. These acids and alkalis can replace treatment chemicals such as sulfuric acid and sodium hydroxide in chromic reduction, cyanide oxidation, metal precipitation, and neutralization processes in an IWTP.

Prior to implementing an acid and alkali secondary use program, regulations require that a shop area be serviced by the IWTP in order for the activity to participate in a secondary use program. Participating activities must strictly segregate all acids and alkalis and test them to establish viability of each wastestream. In addition, the IWTP processes must be evaluated to ensure that the addition of the secondary use material to the wastewater will not interfere with the present design and operation of the treatment plant. Similarly, the program must operate without disrupting normal shop operations.

If use of the material is feasibility, the lab establishes mixture ratios for the plant operators. The plant operator then uses the secondary use acids and alkalis in the batch processing of wastewater.

Materials

Compatibility: The IWTP should not use secondary use acids and alkalis for the final pH adjustment prior to discharge due to the amount of metals found in many of the wastestreams. The IWTP should keep in stock sufficient commercial process chemicals for use during waste shortages and for final neutralization.

Safety and Health: The safety and health concerns vary with the type of acids/alkalis chemicals being used. Proper personal protective equipment is recommended. Consult your local Industrial Health specialist, your

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: The secondary use of acids and alkalis in the IWTP eliminates the need to dispose of these materials as hazardous waste. It also reduces the amount of commercial chemicals kept on hand and the problems associated with the purchase and storage of these chemicals.

Disadvantages:

- Prior to implementing an acid and alkali secondary use program, regulations require that a shop area be serviced by the IWTP in order for the activity to participate in a secondary use program.
- The IWTP should not use secondary use acids and alkalis for the final pH adjustment prior to discharge due to the amount of metals found in many of the wastestreams.

Economic Analysis: A substantial savings results from the secondary use of acids and alkalis. The purchases of commercial chemicals will drop, as will the amount of used/excess material requiring disposal, resulting in a substantial cost savings. According to one report, reuse of acids and alkalis in an existing IWTP required an initial capital investment of \$45,000 and had a payback period of 7 months.

Approval Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: NA

INFILTRATION TRENCHES FOR TREATING STORM WATER RUNOFF

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview:

Infiltration trenches are used to capture and treat storm water runoff by means of filtering pollutants while slowly dispersing excess storm water into surrounding soils and groundwater. An infiltration trench consists of an excavated trench lined with filter fabric, ranging in depth from 3 to 12 feet, with a width dependent upon the anticipated captured volume of runoff. The trench is located underground or at grade, and is backfilled with stone aggregate. During a storm event, a small portion of runoff, or the first flush, is diverted to the infiltration trench, which allows for infiltration into the surrounding soils. Filtration through the surrounding soils is the primary mechanism for pollutant removal. Infiltration trenches also provide groundwater recharge, maintain base flow in nearby streams, and can be constructed at sites with limited land availability.

Infiltration trenches effectively remove suspended solids, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from storm water runoff. Runoff containing high levels of sediments or hydrocarbons should be pretreated by another best management practice (BMP) to prevent clogging of the trench. Removal rates for sediments, metals, coliform bacteria, and organic matter are estimated to be around 90 percent; 60 percent for phosphorous and nitrogen; and 70 to 80 percent for biochemical oxygen demand (BOD).

Sediment and pollutant removal can be improved by using washed stone aggregate and substituting pea gravel for stone aggregate in the top 1 foot of the trench. Stone aggregate should be 1 to 3 inches in diameter and provide a void space of 40 percent. The addition of organic matter and loam to the subsoil will enhance metal and nutrient removal through adsorption. Optional performance of infiltration trenches typically occurs in warmer, less arid regions of the US, where cold climates will not freeze surrounding soils, reducing runoff infiltration into the soils and groundwater.

Infiltration trenches should be constructed within permeable soils (i.e., sand, loamy sand, sandy loam, and loam), and consequently above the water table, to allow runoff to filter into the surrounding soils and

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eventually into the underlying groundwater. The drainage areas generally should not exceed 10 acres, and be fully developed and stabilized with vegetation before constructing an infiltration trench. Infiltration trenches are not effective at treating peak flow and should be used in conjunction with another BMP if they are to be used for this purpose.

Infiltration trenches require a minimum drainage time of 6 hours to provide satisfactory pollutant removal. Infiltration trenches should be monitored using a monitoring well mounted vertically at the bottom of the trench. Most infiltration trenches partially or completely fail after 5 years; however, longevity can be increased by a careful preconstruction evaluation, use of a pretreatment BMP, and regular maintenance.

Materials

Compatibility: N/A

Safety and Health: Safety and health concerns are dependent on the types of contaminants in the storm water. Metals and phosphorus, for instance, require caution in handling. Proper personal protection equipment is, therefore, recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Infiltration trenches are useful for removing large percentages of pollutants from storm water runoff and dispersing excess storm water in areas with limited land availability. Groundwater recharge is an additional benefit.

Disadvantages:

- Infiltration trenches are not effective at treating peak flow
- Infiltration trenches require monitoring using a monitoring well mounted vertically at the bottom of the trench.
- Most infiltration trenches partially or completely fail after 5 years; however, longevity can be increased by a careful preconstruction

Economic Analysis: The capital and annual operation and maintenance costs for infiltration trenches:

- 6 feet deep by 4 feet wide and a 2,400 cubic foot volume ranges from \$8,000 to \$19,000, O&M of \$700
 - The cost for a smaller trench 3 feet deep by 4 feet wide with a 1,200 cubic foot volume is estimated at \$3,000 to \$8,500, O&M of 325
- O&M costs include buffer strip maintenance, trench inspection, and rehabilitation.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: N/A

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

SAND FILTER FOR TREATING STORM WATER RUNOFF

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview:

Sand filters can be used for storm water quality control and managing storm water runoff volumes. Sand filters are composed of at least two components: a sedimentation chamber and a filtration chamber. The sedimentation chamber removes floatables and heavy sediments, while the filtration chamber removes additional pollutants by filtering flow through a sand bed. Treated filtrate is normally diverted back to the storm drainage system via an underdrain system or pipe network. Pollutants such as suspended solids, biochemical oxygen demand (BOD), and fecal coliform bacteria are effectively removed from storm water flows when treated by a sand filter system. Other pollutants removed include nitrogen, phosphorus, and some metals. Sand filter designs include the surface sand filter basin (AKA Austin Sand filter), the underground vault sand filter (Washington, DC sand filter), the double trench sand filter (Delaware sand filter), the stone reservoir trench sand filter, and the peat sand filter system. Modifications are often made to these designs based on site-specific conditions.

Sand filters provide a highly effective means of removing pollutants from storm water while remaining flexible in application to allow for modifications in basic design structure to accommodate site-specific criteria. Modifications to the basic structure arise due to site differences, including drainage area served, filter surface areas, land requirements, and quantity of runoff treated. Sand filters are currently popular best management practices (BMPs) used in Delaware; Florida; Austin, Texas; Alexandria, Virginia; and Washington, DC

The Austin sand filter was designed to detain runoff in a sedimentation chamber where heavy sediments and floatables are removed. Estimates of pollutant removal efficiencies for various Austin sand filters, based on the preliminary findings of the city's storm water monitoring program, are as follows:

- 76 % Fecal Coliform
- 70 % Total Suspended Solids (TSS)
- 70 % Biochemical Oxygen Demand (BOD)
- 48 % Total Organic Carbon (TOC)
- 46 % Total Kjeldahl Nitrogen (TKN)

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45 % Iron (Fe)
45 % Lead (Pb)
45 % Zinc (Zn)
33 % Total Phosphorous (TP)
21 % Total Nitrogen
0 % Nitrate as Nitrogen (NO₃--N)

The percentages listed include partial and full sedimentation systems with different drainage areas. Current monitoring data from the Austin sand filters indicates phosphorous removal efficiencies of up to 60 percent. The Austin sand filter has been used in Alexandria, Virginia; monitoring of these units indicated a phosphorus removal of up to 40 percent. Nitrate was not removed nor is it known what the removal efficiencies are for other dissolved pollutants.

The underground vault (Washington, DC) sand filter is designed for use in highly urbanized areas, and can be placed underneath parking lots, alleys, and driveways. The sand filter works best when treating the first 0.5 inch of runoff from an impervious drainage area of less than 1 acre. Sediments and floatables such as oil, grease, and leaves are effectively removed from runoff, which is diverted through a submerged weir connecting the sedimentation chamber and the filtration chamber. Trash collected by the weir must be cleaned out every 6 months for proper functioning.

The double trench (Delaware) sand filter is designed for drainage areas of less than 5 acres. It has been determined that this design results in 80 percent removal of suspended solids.

The stone reservoir trench system incorporates concepts of the Austin and the District of Columbia sand filters, but adapts the design to small and less complex applications where infiltration trenches, an alternate BMP, would be impracticable.

The Austin sand filter can be modified to use peat within the filtration process. Modifications include a 12- to 18-inch thick surface layer of hemic or fibric peat, underlain by a layer of calcitic limestone, and finally underlain by a 4 inch well-mixed layer of half sand and half peat, all of which sits atop the normal sand filter. Addition of peat to the filtration chamber appears to increase microbial growth within the sand filter and improve pollutant removal rates.

Performance of sand filters may be sustained through frequent inspections and replacement of the filter fabric and media every 3 to 5 years, depending on the pollutant load being treated. Accumulated trash

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and debris should be removed from the sand filters every 6 months or as necessary. Performance can also be increased by stabilizing the drainage area to minimize sediment loading, ensuring that the sedimentation chamber adequately removes suspended solids sediments prior to the filtration chamber and allowing for adequate detention times for both sedimentation and filtration.

The design of sand filters with impermeable chambers that prevent groundwater infiltration are preferred in situations where groundwater contamination is a concern. The Austin; Delaware; and Washington, DC, sand filters may substitute for water quality inlets when hydrocarbons are of concern. Due to the size of the Austin sand filter, it can also be used instead of wet ponds for treatment of contaminated runoff in areas where evaporation exceeds rainfall.

Materials

Compatibility: N/A

Safety and Health: Safety and health concerns are dependent on the types of contaminants in the storm water. Metals and phosphorus, for instance, require caution in handling. They are skin irritants. Protection should be worn when handling contaminants like fecal coliform. Proper personal protection equipment is, therefore, recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Sand filters, in particular those mentioned previously, achieve high removal efficiencies for suspended solids, BOD, and fecal coliform bacteria. Hydrocarbons and nutrients are also removed by sand filters. Sand filters designed with impermeable basins limit the potential for groundwater contamination while treating storm water.

Disadvantages:

- Nitrates are not removed
- Ineffective at removal of dissolved pollutants

Economic Analysis: Construction costs vary depending on the sand filter system being designed. The Austin sand filtration system costs approximately \$18,500 for treatment of a 1-acre drainage area. In this instance, the cost decreases with increasing drainage area. The precast cost for a 1 acre drainage area for a Washington, DC, sand filter range from \$6,600 to \$11,000. Similar costs exist for the Delaware sand filter.

Maintenance costs for a sand filter average 5 percent of the construction cost. Material costs for the gravel layer, filter fabric, and top portion of

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sand for the Washington, D.C., sand filter amounted to approximately \$1,700.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: N/A

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VORTEX SOLIDS SEPARATORS FOR TREATING STORM WATER RUNOFF

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview:

A vortex solids separator is a wastewater treatment unit, containing no moving parts, designed to physically remove solids and floatables from wastewater or storm water. The unit is cylindrical in design so that, as flow enters the unit tangentially, it induces a swirling vortex which concentrates solids at the bottom of the unit in the underflow. Vortex solids separators are used for both combined sewer overflows (CSOs) and separate storm events. During CSO events, concentrated solids are collected and removed from the bottom of the unit through a sanitary sewer and discharged to a wastewater treatment plant. During separate storm water events, concentrated solids can be removed through the bottom of the unit and sent to a holding tank or pond, where further sedimentation will take place. Clarified effluent exits through the top of the unit and is returned to the receiving water. Vortex units can be installed on line or off line in a system. The units can also be designed to be used individually or in a series of units. Vortex units can be designed to be used in combination with other best management practices (BMPs).

The design of a vortex solids separator should be based on the anticipated type and quantity of pollutants to be removed, as well as the settleability characteristics of those pollutants. The quantity of flow to be treated should be established prior to the design phase to achieve the desired treatment level. Pilot-scale testing should be conducted during the design phase to determine the swirl treatability at each site.

Unit performance is based on the vortex separation mechanism for which each type has its own design criteria for solids/liquids separation. The design criteria for the Swirl, which is available to the public from the EPA, is based on settleability studies developed in the 1970s. Design specifications and pilot-scale treatability studies are required for each site-specific application.

Data collected from solids removal studies indicate vortex solids separators are effective at removing gritty materials, heavy particulates, and floatables from storm water, but ineffective in removing materials with poor settleabilities. The net solids have been calculated for various units in use for CSO applications. Net solids account for those solids collected as a result of swirl concentrating. Net solids removal ranged

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between 7 and 34 percent. During separate storm water applications, the average net mass solids removal ranged from 12 percent for the pilot-scale Storm King in Bradenton, Florida, to 17 percent for the Swirl in West Roxbury, Massachusetts. The following table presents average performance characteristics of commercial Vortex Separators collected from four units.

Unit	Location	Effluent Hydraulic Loading Rate (gpm/sf)	Volume Reduction %	Total Solids Removal %	Net Solids Removal %
Swirl	Washington, DC	10	24	38	12
Fluid sep	Tengen, Germany	11	47	54	7
Storm King	James Bridge, UK	7.5	39	53	14
Storm King	Columbus, GA	4.3	23	61	34

Vortex solids separators have limited effectiveness in use with wet-weather flows, as evidenced by the low net solids removal percentages (7 to 34 percent). The low removal rates documented for vortex separators may not meet water quality treatment objectives for proposed locations. Little information is available for vortex solids separators treating pollutants other than solids.

An advantage of vortex separators is the small land requirement as compared to other BMPs (i.e., wet ponds). Vortex unit construction constraints include the ability of the soil to support the unit, the depth of soil, and the slope of the site, which may determine whether an above- or below-ground unit is used. Improvement to the separator includes using pretreatment to reduce the pollutant load to the separator. Maintenance for most separators includes a wash down after every CSO event to prevent odors. This would not be necessary for a storm water application. Some units have a self-washing mechanism.

Materials

Compatibility: N/A

Safety and Health: Proper design, operation, and maintenance of the equipment is required for its safe use.

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Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Vortex solids separators are able to separate solids and floatables from storm water and waste water using a swirling vortex. They can be used in instances where a separation technology is limited by space or land constraints, such as surface slope or soil composition. Vortex separators have no moving parts and, therefore, are not maintenance intensive.

Disadvantages:

- Vortex solids separators have limited effectiveness in use with wet-weather flows;
- may not meet water quality treatment objectives for proposed locations.
- Limited information is available for vortex solids separators treating pollutants other than solids

Economic Analysis: Budgeting for construction of a vortex separator unit should include predesign costs, capital costs, and operation and maintenance costs. The predesign costs for a Storm King are typically \$21,000, and between \$27,000 and \$106,000 for the Fluidsep. Settleability curves published for the Swirl can be used as the basis for design and eliminate predesign costs. Capital costs for vortex solid separator treatment facilities in the US are site specific and vary between \$3,200 and \$5,600 per acre of drainage basin. The capital cost for an individual unit alone is approximately \$5,200 per mgd.

Energy requirements for most vortex solid separators is nonexistent unless the facility requires pumping. Washdown costs for vortex separators primarily include labor or energy costs for an automatic washdown. The Surrey Heath Storm King facility lacks a foul sewer line and collects residuals in a collection zone. These residuals are periodically emptied every 2 to 3 years, which is estimated to cost between \$300 and \$500 per cleaning.

**Approval
Authority:**

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: N/A

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WATER QUALITY INLETS TO CONTROL STORM WATER RUNOFF

Revision 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: Water quality inlets (WQIs) are structures designed to separate pollutants from the first flush of storm water using a series of chambers for pollutant sedimentation, screening, and separation. A water quality inlet typically consists of a sedimentation chamber, an oil separation chamber, and a discharge chamber. Because of their separation capabilities, WQIs are occasionally referred to as oil/grit separators or oil/water separators. These best management practices (BMPs) may be constructed on site, precast, or manufactured by a vendor.

Water quality inlets are widely used in the US for improving storm water runoff quality where space is limited and funding prohibits the use of larger BMPs, such as ponds or wetlands. Water quality inlets are able to effectively separate hydrocarbons from storm water runoff. During the first 5 years of use, over 95% of all WQIs were in operation as designed. WQIs do not manage the volume of storm water flow, due to limited capacity, and have limited removal efficiencies when not properly maintained. For these reasons, WQIs are often used to pretreat runoff prior to discharge to other BMPs.

The WQI should be located within close proximity to a storm drain network to allow for future discharge from the WQI to the sewer system. WQIs are typically used as an off-line treatment process where lower flows will be encountered; high flows result in resuspension of settled material. Construction activity should be complete and the drainage area stabilized to minimize sediment loading to a WQI. The WQI should be located in a small, impervious area and be watertight.

Storm water runoff enters the sedimentation chamber in a water quality inlet where coarse materials settle. Flow from the sedimentation chamber is conveyed to the second chamber through an orifice covered with a trash rack and located halfway down the wall separating the two chambers. The second chamber functions as an oil separation chamber. Water that enters the third sequential chamber discharges through a storm water outlet pipe. The design should include permanent pools within the chambers, to reduce sediment resuspension during storm events, and manholes located above the chambers, to provide access for cleaning and inspection.

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The limited capacity of most WQIs typically means that the discharge rate is high and the detention time is relatively short. Most water quality inlets have an average detention time of less than a half hour. Efficient pollutant removal is dependent upon proper maintenance; the lack thereof may result in resuspension and discharge of settled pollutants and separated oil. The required maintenance will vary from site to site, but cleaning before the start of each season and inspection after every storm event should ensure proper functioning of the WQI.

Water quality inlets generally have minimal effect on the removal of nutrients, metals, and organic pollutants other than free petroleum products. The sedimentation chamber can be expected to partially reduce grit and sediments. Separation of dissolved or emulsified oil from water is rarely achieved, although WQIs are effective in separating free oil and grease from storm water.

Materials

Compatibility: N/A

Safety and Health: The safety and health issues are dependent on the types of contaminants in the storm water. Carbon can be a minor irritant to mucous membranes and eyes. Handling hydrocarbons requires caution. proper personal protection equipment is recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: WQIs are useful for separating sediments and oil from storm water runoff. If properly maintained, these pollutants are removed from the WQI, and the quality of the downstream storm water is improved.

Disadvantages:

- WQIs do not manage the volume of storm water
- Limited removal efficiencies when not properly maintained
- WQI residuals may require disposal as a hazardous waste.

Economic Analysis: Cast-in-place WQIs may range in cost from \$5,200 to \$16,700. The cost for a precast WQI is generally lower than for other manufactured units. Practical and acceptable maintenance procedures for clean out and disposal of residuals have not been adequately determined for the WQIs currently in operation. Major costs would be the removal, analysis, and disposal of the residuals.

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Sources: American Petroleum Institute (API), 1990. *Monographs on Refinery Environmental Control - Management of Water Discharges*. Publication 421, First Edition.
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WET DETENTION PONDS TO TREAT STORM WATER RUNOFF

Revision 1/96
Process Code: Navy: N/A, Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: N/A

Overview: A wet detention pond is a constructed pond that maintains a permanent pool of water within a designated area, and relies on physical, biological, and chemical processes to remove pollutants from storm water runoff. Pollutants removed include sediment, organic matter, dissolved metals, and nutrients. In addition, wet detention ponds control storm water flow which prevents downstream flooding. As storm water enters the pond, treated water is displaced and discharged into a receiving body of water. Enhanced treatment of storm water runoff can be achieved through extended detention and the use of aquatic plants in the perimeter of the pond. Sediment removal can also be increased through the use of a sediment forebay.

Before construction of a pond begins, local, state, and federal permits should be confirmed and approved for all aspects of construction including wetlands, water quality, dam safety, grading, erosion control, and land use. Wet detention ponds rely on the existence of a permanent pool of water within the pond and, therefore, should be placed in areas with adequate baseflow from groundwater or from the drainage area to maintain the permanent pool. Soils under the pond should have a low permeability (10^{-5} to 10^{-6} cm/sec) to ensure future existence of the pond. Pond placement should take into consideration a topographic area that allows for maximum detention while requiring minimal earth removal, thus lowering construction costs. Pond construction should not be considered near land constraints such as utilities or underlying bedrock.

Pollutant removal in the pond is determined using one of two methods: solids settling and eutrophication. The solids settling method relies on pollutant removal through sedimentation and the eutrophication method removes nutrients using natural biological processes. According to the National Urban Runoff Program (NURP), up to 2/3 of the sediments, trace metals, and nutrients are removed as a result of sedimentation within 24 hours. Other studies that looked at biological removal suggest hydraulic residence times (HRTs) close to 2 weeks to get adequate phosphorus removal. Documented removal efficiencies for wet detention ponds are as follows:

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Parameter	Percent Removal	
	Schueler, 1992 ¹	Hartigan, 1988 ²
Total Suspended Solids	50-90	80-90
Total Phosphorous	30-90	
Soluble Nutrients	40-80	50-70
Lead		70-80
Zinc		40-50
Biochemical Oxygen Demand		20-40
Chemical Oxygen Demand		20-40

¹ hydraulic residence time varies

² hydraulic residence time of 2 weeks

Two ratios are useful at predicting pollutant removal efficiencies: volume ratio and area ratio. Volume ratio (VB/VR) is the ratio of permanent pool storage (VB) to the mean storm runoff (VR). Area ratio (A/As) is the ratio of the contributing drainage area (A) to the permanent pool surface area (As). Both of these ratios are correlated with treatment efficiencies. Large volume ratios result in increased retention and treatment between storms while low pollutant efficiencies are achieved with low volume ratios.

Pool depth can play a critical role in pollutant removal and storage, but caution should be taken when increasing the depth of the pool. A pond with an HRT of 2 weeks would function optimally at depth ranges from 3 to 9 feet; shallower depths with the same pond surface area have shorter HRTs.

Water within the pond is discharged through a wet pond outlet. A wet pond outlet consists of a vertical riser, either concrete or corrugated metal, attached to a horizontal barrel that conveys storm water flow under the embankment to a receiving stream. The outlet is designed to pass excess water while maintaining a permanent pool. Risers are typically placed in or on the edge of the embankment and are capped with a trash rack to prevent clogging.

As with any storm water best management practice (BMP), proper maintenance will ensure continued proper functioning of the wet detention pond. Proper maintenance may include any or all of the following:

- Clearing trash and debris
- Conducting routine inspections of the embankment and spillway to check structural integrity and look for signs of erosion or animal habitation

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- Conducting periodic repairs on the embankment, emergency spillway, inlet, and outlet
- Removing sediment and algae
- Removing large vegetation or trees from the embankment that could potentially weaken the embankment
- Maintaining the outfall area (i.e., replacing rip-rap, removing sediments, etc.)

Sediments collected by the wet detention pond typically meet toxicity limits and can be landfilled safely. Testing of the sediments may be required if the upstream drainage area is industrial and/or results in highly contaminated runoff. Non-toxic sediments can also be disposed on site, but away from the shoreline to prevent their re-entry into the pond. The removal of sediments in a pond may be necessary every 20 years. This can be decreased to every 50 years if a sediment forebay is used prior to the wet pond. The sediment forebay would require maintenance every 5 to 7 years.

Materials

Compatibility: N/A

Safety and Health: N/A

Benefits: Wet detention ponds can decrease the potential for downstream flooding and streambank erosion, and provide increased downstream water quality. Water quality is improved through removal of suspended solids, metals, and dissolved nutrients using natural biological and physical processes. Properly designed and maintained wet detention ponds can also enhance landscape aesthetics as well as provide wildlife habitat.

Disadvantages:

- Pond construction should not be considered near land constraints such as utilities or underlying bedrock.
- Sediments from upstream industrial or highly contaminated runoff areas may be a hazardous waste requiring special disposal/treatment.

Economic Analysis: Budgeting for construction of a wet detention pond should include costs for permitting, designing, constructing, and maintaining the pond. Costs will vary for permitting from state to state as will the construction of a pond in a developing area versus a developed area. Developing areas tend to be less costly, as there are less problems with existing utility and structure constraints. An average cost for a 1 acre, 5 foot deep pond with a storage volume of 180,000 cubic feet is \$75,000.

Annual maintenance and operation costs typically range between 3 to 5 percent of construction costs. Maintenance costs include sediment

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removal, grass mowing, nuisance control (problematic animals), trash removal, and routine inspections. On-site sediment disposal should be utilized when possible, as costs can be reduced by as much as 50 percent.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: N/A

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CRYOGENIC CONDENSATION AND RECOVERY OF VOCs USING LIQUID NITROGEN

Revision: 1/96
Process Code: Navy: N/A; Air Force: N/A; Army: N/A
Substitute for: CFC-12 and Treatment Processes such as Absorption, Adsorption, and Incinerators
Applicable EPCRA Targeted Constituents: Acetaldehyde, Acetone, Acetonitrile, CFC-11, CFC-12, CFC-113, Chloroform, Ethylene Oxide, Methanol, Methyl Bromide, Methyl Chloroform (1,1,1-trichloroethane), Methyl Isobutyl Ketone, Methylene Chloride, Styrene, Toluene, Trichloroethylene, Vinyl Chloride

Overview: A process that allows recovery of the VOCs for reuse is cryogenic condensation. The condensation process requires very low temperatures so that VOCs can be condensed. Traditionally, chlorofluorocarbon (CFC) refrigerants like CFC-12 have been used to condense the VOCs, but with the phase-out of these ozone-depleting substances (ODSs), liquid nitrogen has emerged as a viable substitute for use in the extremely low temperature or cryogenic (less than -110 degrees C) condensation process. Cryogenic condensation is best suited to exhaust streams with low flowrates (below 600 standard ft³/min) and/or vapor concentrations above 40 parts per million on a volumetric basis (ppmv).

Cryogenic condensation is a versatile process which is not VOC specific. Typically, condensation takes place with liquid nitrogen as the refrigerant in a straightforward heat exchange process. Non-toxic, non-corrosive, and non-flammable, liquid nitrogen is a versatile, zero ODS coolant with a normal boiling point of -196 degrees C.

As the organic-laden vapor stream is cooled, VOCs will condense when the dew point is reached. Fluctuations in VOC stream velocity or content are easily handled by quick response controls on liquid nitrogen injection. Typically, the only constraint on the VOC itself is that its freezing point should be below about -30 degrees C; otherwise, freezing is likely to occur.

Cryogenic condensation systems generally consist of one or a series of shell-and-tube heat exchangers. The VOC stream and the liquid nitrogen stream flow through the heat exchanger countercurrently, maximizing heat transfer. The VOC condenses on the shell side of the exchanger then drains into a collection tank, from which it can be recycled, reclaimed, recovered for reuse, or, at worst, accumulated for disposal.

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During condensation, the presence of water vapor or VOCs with a high melting point can cause freezing on the external surface of the tubes inside a cryogenic condenser. A solid buildup will blanket the heat transfer area and thus reduce the efficiency of the process, unless suitable precautions are taken. One method of preventing buildup due to freezing is to periodically flush the pipes with the condensed phase. Another method is to use two condensers in parallel so that one condenser is in operation while the other is out of service being cleaned or defrosted. Another option when excessive moisture is a concern is to arrange two condensers in series. In the first or pre-cooling stage, the VOC stream is cooled to about 1 degree C, condensing the majority of water so that it will not be present to freeze at condensing temperatures below 0 degrees C. In the second, or main, condensing stage, the temperature of the VOC stream can be lowered as needed to drop out the required/desired amount of VOCs without concern of ice formation.

For some VOCs, substantial cooling -40 to -50 degrees C below the compound's dew point may cause fog to form. This occurs when the rate of heat transfer exceeds the rate of mass transfer to the liquid stage, causing the bulk of the gas to quickly cool below its dew point. This causes the nucleation of tiny droplets of the VOC which, instead of coalescing and condensing on the surface of the tube, become a colloidal suspension in the bulk gas stream. The formation of fog, like the formation of solids, can be minimized by splitting the cooling process into steps, allowing better control of temperature changes. Other options to minimize fog formation include the use of a mist elimination device or reduction of the gas stream velocity by using a larger diameter inlet pipe.

Air sweeps can sometimes be replaced with nitrogen sweeps to enhance the recovery of VOCs from the vent gas. Because the amount of VOC recovered is proportional to the fraction of VOC in the vapor (expressed as the partial pressure of the component), recovery rates are increased at higher vapor concentrations. For example, if a 5 percent concentration of VOC in a gas stream is technically feasible, but the vent stream concentration is controlled at 0.5 percent in air to eliminate the risk of explosion, that is, the concentration is controlled below the lower explosion limit, (LEL), then the addition of nitrogen can render the atmosphere inert and at the same time allow a VOC concentration of 5 percent, without which the mixture would be explosive. Thus, VOC recovery is increased, while maintaining safe operating conditions.

Cryogenic condensation has been selected as the Best Achievable Control Technology (BACT) by environmental regulators for VOC control in a few processes.

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Materials

Compatibility: There are virtually no material compatibility problems from a chemical standpoint with the cryogenic condensation process because the VOC stream and the nitrogen stream never come in direct contact. Heat exchanger materials of construction must, of course, be compatible with both streams and the low temperature operation. Typically, 316 stainless steel is used, since no carbon steel or cast iron is allowed in cryogenic service.

Safety and Health: High pressure gases and cryogenic fluids should be handled with great care. Always chain or secure high pressure cylinders to a stationary support such as a column after moving, but before using. Always wear personal protective equipment when using cryogenic fluids, since exposure to skin could cause severe frostbite. Volatile organic compounds should be used only in areas with adequate ventilation, in enclosed process equipment, or by personnel wearing the proper protective equipment (respirator or supplied air).

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDSs prior to implementing this technology.

Benefits:

- Reduces the amount of VOCs and ODSs emitted into the environment.
- Does not contaminate the recovered product.
- Good reliability due to the low number of moving parts.
- No secondary pollution is created, e.g., no wastewater, no nitrogen oxides, no acid gases, no dioxins.
- Very low operating costs if liquid nitrogen is already being used at a facility for blanketing tanks or purging equipment.
- Systems have essentially 100% turndown and are excellent in intermittent applications having a big variation in demand.
- Typical outlet VOC concentrations range from 5 to 2,000 ppmv, depending on emission requirements and the system in place. The efficiencies of these systems approach those of incinerators, but offer more flexibility in operation and lower operating costs compared to incinerators.
- If inlet gas is contaminated with just a single VOC, reuse is especially promising. Multiple VOCs in a vent stream will be recovered, but cryogenic condensation is not a fractionation operation; thus, if high purity components are required for reuse, separation of a VOC mixture must be done with a separate alternative technology. See Major Assumptions for a more detailed explanation of this point.

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- Installation costs are low, since the units come essentially fully assembled.

Disadvantages:

- VOCs are often released or captured as mixtures in large volume gas streams
- Condensed mixtures are typically not easily separated even by subsequent reclamation
- To maximize purity and minimize cross-contamination, batches may have to be separated by purging and flushing of the system

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Economic Analysis: Commercially available system capacities vary from small units handling 25 scfm of spent gas to large systems handling 10,000 scfm. Units with capacities greater than 500 scfm are custom designed and assembled on skids or a number of skids for transport. Typically, units 500 scfm and smaller are standard modules that are customized to the application. Approximate costs for essentially fully assembled cryogenic recovery systems are as follows:

- \$50K for a 25 scfm unit
- \$150K to \$200K for a 100 scfm unit
- \$500K for a 500 scfm unit
- Units larger than 500 scfm can cost up to several million dollars.

Operating costs are relatively low, provided a ready source of liquid nitrogen is used at the site for some other purpose such as tank blanketing. A typical 500 scfm system consumes about 10 kW of power and 200 to 300 scfm of liquid nitrogen. For facilities with no continuous source of liquid nitrogen, several options are available:

1. For an intermittent, single-use installation, e.g., VOC recovery from semi-annual ship off-loading, the required amount of liquid nitrogen could be brought in for the duration of off-loading.
2. For continuous use, combination systems with mechanical refrigeration (for the bulk condensation) and liquid nitrogen (only for polishing) can be assembled. This type of combination system is much more efficient if liquid nitrogen has to be purchased solely for this process.

A more meaningful economic analysis can only be done knowing the value of the VOC and the concentration, flowrate, and availability of liquid nitrogen at the facility. In general, greater efficiency can be gained by designing the system for countercurrent contact of the streams

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using the cooling capacity of the “warm” liquid nitrogen from the main condenser to cool the incoming warm or ambient temperature VOC vapors in the pre-condenser.

Assumptions: Cryogenic condensation technology using liquid nitrogen is not a fractionation process. It will condense essentially all the components of a vapor stream with the exception of elemental gases like hydrogen, helium, and neon, including gases as light as methane. Recovery and reuse of pure VOC streams from a cryogenic condensation system is the ideal application of this technology. However, VOCs are often released or captured as mixtures in large volume gas streams. Although the cryogenic condensation process will recover these materials, condensed mixtures are typically not easily separated even by subsequent reclamation. Another possibility for mixtures includes sale for another application that tolerates a mixture. Cryogenic condensation systems can also accommodate different VOC streams if production processes allow batches, e.g., single contaminant streams. To maximize purity and minimize cross-contamination, batches may have to be separated by purging and flushing of the system.

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Tel.: 46-8-731-1000 (Lidingö, Sweden)

Vendors: BOC Gases (formerly AIRCO)
575 Mountain Avenue
Murray Hill, NJ 07974
(908) 771-1620, Fax (908) 771-1672
Manufacturer of the Kryoclean™ Vapor Recovery Systems: Kryoclean™ units 500 scfm to 10,000 scfm and the Mini-Kryoclean™ units 25 scfm to 500 scfm. All units delivered ready to connect to utilities and process, minimum amount of assembly required. Controls with programmable logic controllers (PLCs).
Mr. Michael J. Barrasso

Source(s): Environmental Engineering World, Jan.-Feb. 1995, p. 26-29.
Thomas, S. T., “Process Changes to Meet New Regulations,” *Proceedings of National Conference Minimization & Recycling of Industrial & Hazardous Waste '92*, pp. 89-91, Sep 92.

SODIUM NITRITE WASTEWATER TREATMENT SYSTEM

Revision: 1/96
Process Code: Navy; SR-15-99; Air Force: N/A; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: Sodium Nitrite, Heavy Metals

Overview: The Navy generates over 10 million gallons of sodium nitrite-contaminated wastewater from marine steam boiler maintenance operations, which include hydroblasting cleaning, hydrostatic pressure testing, lay up, and rinsing. The sodium nitrite added to feed water prevents the flash rusting of the boiler's metal surfaces. The nitrite level of 800 mg/l prohibits the discharge of the wastewater. Currently, NPDES prohibits the discharge to surface water of wastewater containing 1 mg/l of nitrites.

The addition of sulfamic acid to the wastewater effectively removes sodium nitrite by reducing the nitrites to form sodium bisulfate, diatomic nitrogen, and water. The addition of sodium hydroxide to the wastewater results in the formation of a precipitate effectively removing heavy. The treatment process generates sludge from the initial settling and heavy metal flocculation which must be dewatered and disposed as a hazardous waste. The unit removes sodium nitrite to a level below the NPDES level of 1 mg/L. Therefore the wastewater can be discharged to the sanitary sewer system. The unit will be implemented sometime in FY96.

The system consists of mixing tanks, metering pumps, filters, and chemical sensors. The influent enters a feed settling tank for gravity settling of large suspended particles. The wastewater then undergoes nitrite reduction through the addition of a 15% solution of sulfamic acid (NH₂SO₃H). For heavy metal precipitation, sodium hydroxide is added to the wastewater. The sodium hydroxide forms a precipitate that removes heavy metals through coagulation and flocculation. Anionic polymer are added to aid in the precipitation of the heavy metals. The final addition of sulfuric acid neutralizes the wastewater prior to discharge. Filters, as small as 5 microns, clean the effluent subsequent to its discharge to the sanitary sewer system. Sludge produced from the settling tank and the heavy metal precipitation is dewatered prior to disposal.

Materials
Compatibility: N/A

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Safety and Health: Heavy metals and sodium nitrite are irritants to skin, eyes, and mucous membranes. Inhalation of these fumes can be toxic. Proper personal protection equipment is, therefore, recommended.

Consult your local Industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: This system demonstrates an effective process to convert nitrite to nitrogen gas. It will allow for treatment of wastestream produced by the marine steam boiler maintenance which had gone to contractors for disposal. This will result in a substantial cost savings. This technology will potentially be available in stationary and mobile treatment units.

Disadvantages: Effective only on waste stream generated from boiler steam cleaning.

Economic Analysis: The 600-gallon transportable unit is currently under development by NFESC and will be implemented by the Naval Surface Warfare Center, Carderock Division. The projected annual cost savings Navy-wide will be \$17 million. The unit should reduce disposal costs by 95% from \$3.50 per gallon contracted disposal, to \$0.15 per gallon treatment costs.

Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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SODIUM SULFIDE/FERROUS SULFATE WASTEWATER TREATMENT PROCESS

Revision 1/96
Process Code: Navy: SR-15-99; Air Force: FA09; Army: N/A
Substitute for: N/A
Applicable EPCRA Targeted Constituents: Chromium and Other Heavy Metals

Overview: The Naval Facilities Engineering Service Center is demonstrating a sodium sulfide/ferrous sulfate process (patented by the United States Air Force) to remove heavy metals from wastewater. A pilot plant study was conducted at Naval Air Station Pensacola and the process is being demonstrated at Naval Undersea Warfare Center Keyport.

This physical/chemical treatment process uses sodium sulfide and ferrous sulfate to remove heavy metals from wastewater through precipitation at normal or alkaline pH. Ferrous and sulfide ions act together to reduce hexavalent chromium to trivalent chromium to form a precipitate. The ferrous ion acts with the sulfide, aiding in the reduction of chromium at neutral or alkaline conditions. The ferrous and sulfide precipitate further removes suspended and dissolved metals through coagulation and flocculation.

The coagulation and flocculation system used by sodium sulfide and ferrous sulfate is similar to other chemical-physical treatment methods used to remove metals from wastewater. The system consists of two mixing tanks with chemical feeds and a clarifier, followed by an activated sludge basin and final clarifier. The influent must be kept above a pH of 7.0 to prevent offgassing of hydrogen sulfide from the addition of sodium sulfide. The wastewater must also be kept between a pH of 7.2 and 7.5 when the ferrous sulfate is added to ensure the proper coagulation and reduction of chromium. External recycled sludge and anionic polymer are added to the chemical tank effluent to aid in the flocculation process. This mixture enters the clarifier for settling and clarification.

The clarifier is used to settle flocculant from the wastestream. The clarifying chamber contains internal sludge recycling to aid in settling. The effluent from the clarifier must pass through a sludge blanket, which aids in the removal of fine particles. The floc produced from this process is very light in weight and volume, and has a tendency to form very fine particles. The process must operate at optimum conditions to ensure discharge levels below regulatory standards.

**Material
Compatibility:** N/A

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Safety and Health: Sodium sulfide and ferrous sulfate have mild dermal and oral effects. Chromium, on the other hand, is known to have shown carcinogenic effects, thus making it a potentially dangerous substance to handle. It also has corrosive effects on skin and mucous membranes. Care should be taken when handling other heavy metals. Most of them are absorbed by the skin and have detrimental effects. Proper personal protective equipment is, therefore, highly recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: This system has several benefits over treatment methods currently in use. This method substantially decreases the amount of sludge generated and chemicals used while producing lower metal levels in treated effluent. Sludge generation is reduced 90% by volume (when compared to sulfuric acid/sulfur dioxide/lime treatment method). This means a tremendous savings in sludge disposal costs for most wastewater treatment plants. Chemical usage is cut by 40% (when compared to sulfuric acid/sulfur dioxide/lime treatment method). No pretreatment or post treatment (i.e., water softening) is needed, which results in operational cost savings.

This process is highly efficient at removing suspended and dissolved metals from a wastewater stream. It can effectively reduce hexavalent to trivalent chromium, allowing it to be removed by flocculation. This process can also remove cadmium, copper, lead, and zinc, among other contaminants. It has an application in treatment of metal-bearing wastewater generated by operations such as plating, paint stripping, and metal cleaning.

Disadvantages: If the batch becomes acidic (pH less than 7), then there is the possibility of hydrogen sulfide generation. However, this should not occur because the process is not designed to operate in acidic conditions.

Economic Analysis: The cost for this treatment system must be determined on a site-by-site basis. Costs of wastewater treatment will vary from one location to the other. The capital cost is approximately \$250,000 regardless of plant capacity. Other factors that affect cost include: flow rate, and the level and type of contamination. Each naval activity will have to examine the cost effectiveness of the treatment technology needed before selecting the treatment system.

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Approval

Authority: Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

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Vendors: N/A

SUPERCRITICAL FLUID CLEANING AS A SOLVENT ALTERNATIVE

Revision: 1/96
Process Code Navy: ID-03-99; Air Force: CL01; Army: LOP
Substitute for: Solvent cleaning operations such as vapor degreasing
Applicable EPCRA Targeted Constituents: Trichlorotrifluoroethane (CFC-113) and Methyl Chloroform (MCF)

Overview: Supercritical fluid is a high pressure cleaning process that takes advantage of the fact that the fluid chosen becomes an extremely effective solvent for many organic materials, once in its supercritical state. It is a cleaning process that penetrates small openings and is especially useful for precision or intricate components like gyroscopes, accelerometers, nuclear valve seals, laser optic components, special camera lenses, electromechanical assemblies, and porous ceramics. The process works well removing liquid contaminants, including silicone, petroleum and dielectric oils, flux residues, lubricants, adhesive residues, and fats and waxes. However, it is not very effective on heavy soils, nor for removal of particles or salts, except in circumstances where it is used in conjunction with agitation or ultrasonic cleaning.

The supercritical point is the pressure and temperature condition above which a chemical can no longer be vaporized, but, at the same time, the fluid does not retain its liquid-phase characteristics. Supercritical fluids have qualities unique to their fluid state; that is, unlike the characteristics and properties of either the vapor or the liquid phases. Small changes in temperature and pressure produce significant changes in density and solvent power. This combination of characteristics allows for greater mass transfer rates, effectively decreasing the time required to move the contaminants into the bulk supercritical fluid stream, thus providing rapid cleaning.

Carbon dioxide is probably the most widely used fluid in supercritical cleaning applications. CO₂ is especially useful, since it is non-toxic, non-flammable, and non-ozone depleting; has a supercritical temperature near ambient temperatures (good for temperature sensitive parts); and exhibits excellent solvent properties in its supercritical state. Carbon dioxide supercritical cleaning does require high operating pressures in the range of 1,500 to 2,000 psig, but operating temperatures of only 35 to 65°C. As a result, most supercritical cleaning equipment has been designed for high pressure operation and is relatively small.

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High pressure cylindrical chambers of supercritical cleaning equipment are intended to hold primarily small, intricate parts or parts with deep crevices, tiny holes, or very tight tolerances that normal alternative precision cleaning processes, specifically aqueous or semi-aqueous processes, have difficulty cleaning.

A basic CO₂ supercritical cleaning system has two primary cleaning vessels: the extraction vessel, in which the component to be cleaned is placed and flooded with supercritical carbon dioxide and, as the CO₂ dissolves the contaminants, it flows to a separator vessel where the fluid is subjected to a pressure and temperature change (pressure is reduced and the carbon dioxide vaporizes). As that occurs, the solubility of the contaminant in the carbon dioxide decreases, causing the contaminant to separate from the bulk fluid. Once all the CO₂ is evacuated from the separator, the concentrated contaminant is usually in residue form, often as an oily or tar-like liquid that is simply drained from the separator. The residue can then be recovered, recycled, or reused, if suitable; otherwise, the residue is disposed as the sole component; no solvents, wastewater, or other contaminants are present to increase the volume of waste disposed.

The greatest concern when using supercritical cleaning processes is the safety risk of high operating pressures. Equipment must be properly maintained to prevent over pressure or failure of high-pressure components. Although carbon dioxide is non-toxic and non-flammable, it can displace oxygen and cause asphyxiation if leakage occurs in closed, occupied spaces. A CO₂ monitor may be useful for closed areas, despite the fact that there are early warning symptoms, primarily difficulty in breathing (unlike nitrogen, which can quickly cause asphyxiation without warning).

Materials

Compatibility:

Carbon dioxide, in its supercritical state, is compatible with virtually all metals; however, non-metallic components, such as plastics, gaskets, and o-rings must be checked for compatibility. In general, cross-linked polymers and high density polyethylene are not affected by CO₂ supercritical cleaning. Cellulose acetate butyrate is one plastic that is not compatible with supercritical carbon dioxide. Other plastics that are susceptible to damage from supercritical cleaning are generally affected because the carbon dioxide solvates the plasticizers within the plastic and once removed, the absence of plasticizer tends to make the cleaned plastics more brittle. This is usually an undesirable

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result for plastic components. Compatibility should always be checked and tested, if necessary.

The extremely high pressures at which supercritical cleaning takes place make it unsuitable for components containing gas or evacuated spaces because they could implode or deform during the cleaning cycle.

Safety and Health: The primary safety concern when using supercritical fluids is the high pressure operating range of the equipment. Proper design, operation, and maintenance are critical to safe use of the equipment. In addition, the hydrocarbon gases are flammable; thus, their use requires excellent maintenance measures to safeguard against leaks.

Consult your local industrial health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Some of the benefits are an equally high degree of cleanliness; relatively short cleaning times, typically 15 to 30 minutes; completely dry parts at room temperature (no supplemental drying is needed); low operating costs; contaminants are the sole waste; and systems are typically closed-loop, designed to maximize recycling of the carbon dioxide. For difficult applications, the addition of agitation will usually provide a significant improvement in a supercritical fluid system's cleaning ability, as well as reduce the time required for cleaning.

Disadvantages: The disadvantages of supercritical carbon dioxide cleaning are high capital costs, poor removal of hydrophilic (polar molecules) contaminants, high-pressure operation, and, as a result, limited component size, due to equipment design pressure constraints. Development work using co-solvents to aid cleaning of hydrophilic contaminants is in progress.

**Economic
Analysis:**

Supercritical cleaning systems are expensive, but operating and waste disposal costs are usually low.

- Installed cost of a supercritical carbon dioxide system can range from \$60K to \$300K for once-through CO₂ use, depending on the complexity of the controls and other components. Recovery and recycling of the CO₂ will add \$25K to \$50K. (Sometimes liquid CO₂ at 800 to 900 psig can be used as an alternative to supercritical CO₂ if the

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contaminant is readily soluble in liquid CO₂. This can reduce the equipment cost by 10 to 15%.)

- Operating costs are low; power costs are minimal because cycles are short and no heat is input into the process. Furthermore, liquid CO₂ is approximately \$0.10/lb (in bottles).
- Maintenance costs under contract can run \$15K per year, according to one manufacturer.
- Waste disposal costs are lower than competing cleaning technologies that require disposal of spent solvent, wastewater, or blasting media, since the waste residue is 100% contaminant. In some cases, there is no disposal of waste, since the contaminant can be recovered, recycled, or reclaimed.

Approval

Authority:

Navy: Approval is controlled locally and should be implemented only after engineering approval has been granted. Major claimant approval is not required.

Points of Contact:

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DSN 633-3787, (916) 643-3787

National Defense Center for Environmental Excellence
(800) 282-4392

Vendors:

The following is a list of companies that deal with super critical equipment. This is not meant to be a complete list, as there are other manufacturers of this type of equipment.

CF TECHnologies, Inc.
Hyde Park, MA (617) 364-2500, Fax (617) 364-2550
Mr. Bill McGovern

EnviroPro Technologies
P.O. Box 5051, 2930 West 22nd Street, Erie, PA, 16512-5051
(814) 838-5888, Fax (814) 838-5755

TRI-SERVICE POLLUTION PREVENTION OPPORTUNITY DATA SHEET

Sources: EPA Solvent Alternative Guide, SAGE 2.0, EPA and ICOLP guides for “Eliminating CFC-113 and Methyl Chloroform in Aircraft Maintenance Procedures,” Oct 93, and “Eliminating CFC-113 and Methyl Chloroform in Precision Cleaning Operations,” revised Oct 94.
Pirrota, R. and T. Pava, “Replacement of CFCs with Supercritical Carbon Dioxide for Precision Parts Cleaning,” *Proceedings of the International Conference on CFC and Halon Alternatives '94*, p. 532-539, October 94.
Mr. Bill McGovern, CF TECHnologies, Inc., Hyde Park, Massachusetts.